VOLUME 62
Number 1
March, 1972

Journal of the WASHINGTON ACADEMY OF SCIENCES

Issued Quarterly
at Washington, D.C.

CONTENTS

Features:

ALPHONSE F. FORZIATI: Detergent Composition and Water Quality 2

EDWARD S. AYENSU: The Need for Training in Technological Management in Developing Countries – Ghana, A Case in Point 17

Research Reports:

ROBERT D. GORDON: The Tribe Noviini in the New World (Coleoptera: Coccinellidae) 23

ASHLEY B. GURNEY: The South American Katydid Genus Acanthacara: Descriptive Notes and Subfamily Position (Orthoptera: Tettigoniidae, Agraeciinae) 32

E. L. TODD: Descriptive and Synonymical Notes for Some Species of Noctuidae from the Galapagos Islands (Lepidoptera) 36

WILLIS W. WIRTH and ALEXANDER A. HUBERT: A New Oriental Species of Culicoides Breeding in Tree Rot Cavities (Diptera: Ceratopogonidae) 41

Academy Affairs:

Board of Managers Meeting Notes – November and December, 1971 43

Elections to Fellowship 46

Scientists in the News 46

Washington Academy of Sciences

Founded in 1898

EXECUTIVE COMMITTEE

BOARD OF MANAGERS

All delegates of affiliated Societies (see facing page)

EDITOR

EDITORIAL ASSISTANT

ACADEMY OFFICE

9650 Rockville Pike (Bethesda)
Washington, D. C. 20014
Telephone (301) 530-1402

The Journal

This journal, the official organ of the Washington Academy of Sciences, publishes historical articles, critical reviews, and scholarly scientific articles; proceedings of meetings of the Academy and its Board of Managers; and other items of interest to Academy members. The *Journal* appears four times a year (March, June, September, and December) – the September issue contains a directory of the Academy membership.

Subscription Rates

Members, fellows, and patrons in good standing receive the *Journal* without charge. Subscriptions are available on a calendar year basis only, payable in advance. Payment must be made in U.S. currency at the following rates:

U.S. and Canada	$8.00
Foreign	9.00
Single Copy Price	2.50

There will no longer be special 2- and 3-year rates after December 1969. Those subscribers who have paid for special rates and are now receiving the Journal at these rates will continue to receive the publication until the date of expiration of their agreement.

Back Issues

Back issues, volumes, and sets of the *Journal* (Volumes 1-58, 1911-1968) can be purchased direct from Walter J. Johnson, Inc., 111 Fifth Ave., New York, N.Y. 10003. This firm also handles the sale of the *Proceedings* of the Academy (Volumes 1-13, 1898-1910) and the *Index* (to Volumes 1-13 of the *Proceedings* and Volumes 1-40 of the *Journal*). Single issues from 1969 to present may be obtained directly from the Academy office (address elsewhere this page).

Claims for Missing Numbers

Claims will not be allowed if received more than 60 days after date of mailing plus time normally required for postal delivery and claim. No claims will be allowed because of failure to notify the Academy of a change in address.

Changes of Address

Address changes should be sent promptly to the Academy office. Such notification should show both old and new addresses and zip number.

Published quarterly in March, June, September, and December of each year by the Washington Academy of Sciences, 9650 Rockville Pike, Washington, D.C. Second class postage paid at Washington, D.C.

DELEGATES TO THE WASHINGTON ACADEMY OF SCIENCES, REPRESENTING THE LOCAL AFFILIATED SOCIETIES

Philosophical Society of Washington	Edward Beasley
Anthropological Society of Washington	Jean K. Boek
Biological Society of Washington	Delegate not appointed
Chemical Society of Washington	Joseph C. Dacons
Entomological Society of Washington	Reece I. Sailer
National Geographic Society	Alexander Wetmore
Geological Society of Washington	Charles Miller
Medical Society of the District of Columbia	Delegate not appointed
Columbia Historical Society	Delegate not appointed
Botanical Society of Washington	Conrad B. Link
Society of American Foresters	Robert Callaham
Washington Society of Engineers	George Abraham
Institute of Electrical and Electronics Engineers	Leland D. Whitelock
American Society of Mechanical Engineers	William G. Allen
Helminthological Society of Washington	Edna Buhrer
American Society for Microbiology	Lewis Affronti
Society of American Military Engineers	H.P. Demuth
American Society of Civil Engineers	Carl H. Gaum
Society for Experimental Biology and Medicine	Carlton Treadwell
American Society for Metals	Melvin R. Meyerson
International Association for Dental Research	N.W. Rupp
American Institute of Aeronautics and Astronautics	Robert J. Burger
American Meteorological Society	Harold A. Steiner
Insecticide Society of Washington	H. Ivan Rainwater
Acoustical Society of America	Alfred Weissler
American Nuclear Society	Delegate not appointed
Institute of Food Technologists	George K. Parman
American Ceramic Society	J.J. Diamond
Electrochemical Society	Kurt H. Stern
Washington History of Science Club	Morris Leikind
American Association of Physics Teachers	Bernard B. Watson
Optical Society of America	Elsie F. DuPré
American Society of Plant Physiologists	Walter Shropshire
Washington Operations Research Council	John G. Honig
Instrument Society of America	H. Dean Parry
American Institute of Mining, Metallurgical and Petroleum Engineers	Bernardo F. Grossling
National Capitol Astronomers	William Winkler

Delegates continue in office until new selections are made by the respective societies.

FEATURES

Detergent Composition and Water Quality

Alphonse F. Forziati

Chief, Measurements and Instrumentation Branch, Environmental Protection Agency, Washington, D.C.

It is a pleasure to speak to you tonight on the effects of components of detergents on the quality of our nation's waters. The problems caused by phosphorus in waterways, the role of phosphorus in detergents, the consequences of introducing substitutes for phosphorus in detergents, and the costs of removing phosphorus in municipal sewage by modern treatment plants are complicated by many factors. In the short time allowed me this evening, I can only present a very rapid overview of these four basic problem areas.

Phosphorus in Natural Waters

Let us start with an examination of some natural waters. Lakes, rivers, streams, and even oceans are living systems. They are born, proceed through childhood to maturity, become old, and finally die. This process occurs whether man is present or not. It is due to siltation of the waters by erosion of the drainage areas, rain-washed inflow of nutrients from the decay of vegetation on the slopes, and the growth and decay of aquatic plants in the water itself. The three stages in the life cycle of lakes and waterways are referred to as "oligotrophic" (from the Greek *oligos*, few or little; and "*trophe*," nourishments); "mesotrophic" (from *mesos*, middle or intermediate); and "eutrophic" (from *eu*, good or well nourished). Without the intervention of man, the ageing process is very slow. It is estimated that Lake Erie would probably have attained its present state of eutrophication around the year 50,000 by natural processes. Similarly Lake Superior may not become eutrophic until the year 100,000 if not polluted by man.

Before one can proceed to improve the trophic state of a lake or stream, one must have a quantitative, objective method of measuring the current trophic level. Such a method is also needed to monitor the changes brought about by any treatment or control process. Water courses are often characterized by measuring chemical and biological parameters. Chemical analyses alone are not sufficient to establish the trophic level of watercourses. The results of biological analyses, however, are very significant and can be used as a trophic index. For example, oligotrophic waters may contain many species of organisms but only a few of each species. The system is well diversified and in balance. Eutrophic waters, on the other hand, generally contain few species but a very large number of each species. In most eutrophic waters, certain organisms usually referred to as algae predominate. Thus a study of the number and diversity of organisms present in a body of water is very

[1] A semipopular address delivered to a mixed audience of scientists and non-scientists present at the Academy meeting of May 19, 1971 by the Academy's retiring President. The opinions expressed do not necessarily represent the views of EPA.

helpful in assessing its trophic state. However, such studies are less useful to measure the short term changes that might result from the elimination of a nutrient or pollutant. Considerable time is required for a biological system to equilibrate. A rapid assay method is needed. The Pacific Northwest Water Research Laboratory of the Environmental Protection Agency was assigned the task of developing such a method. In cooperation with the detergent, chemical and food industries, the Tennessee Valley Authority and the U.S. Department of Agriculture, this laboratory developed an algal assay procedure[2] which can be carried out in three different ways: 1) in a flask, referred to as the "bottle test"; 2) in a continuous flow chemostat system; and 3) *in situ*. The simplest of the three is the "bottle test." Here one simply places a filtered sample of the water to be tested in a flask, adds a known inoculum of the test organism, exposes the flask to light of known constant intensity at a controlled temperature, counts the number of cells at prescribed time intervals, and plots a growth curve. The second method involves the use of a continuously flowing water system to which is added the test organism. The flow rate is adjusted until the number of cells per unit volume remains constant. This system gives a truer measure of growth rate, but is more time-consuming and expensive. The third method consists of immersing a large glass or plastic container into the lake or river of interest, adding the test organism to the water in the container, and allowing the organism to grow under the natural environmental conditions that prevail over the lake or river. Samples are taken out periodically and the number of cells counted. This procedure is the best approximation to the natural system but again is slower and much more expensive than the "bottle test." Thus we shall confine our discussion to the "bottle test." The organisms recommended for this test are: *Selenastrum capricornutum*, a nitrogen fixer; and *Microcystis aeruginosa*, a non-nitrogen fixer. These organisms are grown under standard conditions to a preset number of cells per milliliter and are then used to inoculate waters under test.

In the fall of 1970, a program was initiated to conduct a series of algal assays on waters from nine Oregon lakes on a quarterly basis[3]. The objectives of the study were to 1) determine the effects of seasonal changes on the ability of the waters to support algal growth, 2) correlate the chemistry of the waters with their ability to support algal growth, and 3) evaluate the effects on algal growth of adding various nutrients to the waters. The assays were carried out in 500-ml Erlenmeyer flasks each containing 250 ml of water sample which had been filtered through a 0.45-micron filter to remove organisms naturally present in the water. Each flask was inoculated with a seven-day-old culture of *Selanastrum capricornutum*. The contents were incubated at $24 \pm 2°C$ for 21 days under continuous cool-white fluorescent lights producing an intensity of 400 foot-candles and shaken gently. The number and size of organisms were then measured by means of an electronic particle counter equipped with a "mean-cell volume" computer. The chemical compositions of the waters in the nine lakes are listed in Table 1 (see footnote 3). Upper Klamath Lake is obviously the most polluted and Waldo Lake the least. Let us see how their waters respond to inoculation with *Selenastrum capricornutum*. Table 2 (see footnote 3) contains the data from such studies. Note that water from Lakes Diamond and Triangle with the highest dissolved phosphorus concentration also show the greatest algal growth rate, whereas Upper Klamath Lake water with the highest dissolved inorganic carbon and dissolved nitrogen but intermediate dissolved phosphorus concentrations yielded intermediate *S. capricornutum*

[2]Algal Assay Procedure, Battle Test; National Eutrophication Research Program, Environmental Protection Agency, August 1971, Corvallis, Oregon 97330.

[3]Algal Responses to Nutrient Additions In Natural Waters: Laboratory Assays; Thomas E. Maloney, William E. Miller and Tamotsu Shiroyama; National Eutrophication Research Program, National Environmental Research Center, Environmental Protection Agency, Corvallis, Oregon 97330.

Table 1.–Chemical properties of filtered lake waters

Determination[1]	Lake								
	Woahink	Tahkenitch	Ten Mile	Lake of the Woods	Upper Klamath	Diamond	Odell	Waldo	Triangle
pH	6.7	7.0	7.0	7.1	7.7	7.0	6.9	6.1	7.2
Alkalinity (as $CaCO_3$)	9	16	21	14	54	22	17	2	14
NH_3-N	<0.010	0.100	<0.010	<0.010	0.350	0.290	0.020	<0.010	0.220
NO_3-N	0.024	0.066	0.004	0.014	0.038	0.032	0.010	0.010	0.012
Kjeldahl-N	0.400	0.500	0.500	1.000	1.200	0.800	0.300	0.100	0.700
Ortho-P	0.001	0.004	0.001	<0.001	0.017	0.038	0.026	0.001	0.040
Total Dissolved P	0.006	0.016	0.009	0.009	0.040	0.058	0.029	<0.005	0.063
Sol. inorganic C	1.0	3.0	5.0	3.0	13.0	5.0	4.0	<1.0	3.0
Sol. organic C	2.0	5.0	3.0	2.0	10.0	4.0	1.0	<1.0	2.0

[1] All chemical concentrations in mg/l.

growth rates. Fig. 1–9 (see footnote 3) show the effect on the algal growth rates when soluble nutrients containing nitrogen, phosphorus, and carbon are added to the lake waters. Note that 20 times as much nitrogen and 200 times as much carbon as phosphorus was added to produce the observed growth rates. In the case of Upper Klamath Lake water, it was already so rich in nutrients that further additions produced only a slight increase over the very high control growth rate. Nontheless, 200 times as much carbon as phosphorus was required to produce the same algal growth rate observed. Diamond and Triangle Lake waters also produced high growth rates without the addition of nutrients, and again, additions produced little or no effect. Waldo Lake water, on the other hand, was so deficient in all nutrients that additions of nitrogen, phosphorus, carbon, and even combinations of these nutrients produced a relatively small increase in the algal growth rate. Several additions would have been required to significantly affect the growth rate.

If one plots the algal growth rate in all the lake waters against the nitrogen content of the lake waters (fig. 10) (see footnote 3), there appears to be no correlation. A similar plot for growth rate versus soluble inorganic carbon (fig. 11) (see footnote 3), likewise shows no correlation. On the other hand, if the growth rates are plotted against the concentrations of phosphorus in the waters, the points fall essentially on a straight line (fig. 12) (see footnote 3). This plot is very strong evidence that phosphorus is the algal growth rate controlling element in these nine lake waters. Studies on other water bodies have produced similar results in most cases. There are a few exceptions. Some lakes are so deficient in carbon and nitrogen nutrients that these two elements appear to be the growth-controlling substances. Some marine waters tend to show this behavior. By and large though, the algal growth rate is proportional to the phosphorus concentration. Thus, the input of phosphorus into our waters should be carefully limited. True, it cannot be eliminated entirely, but reducing the phosphorus content of many waters by even 50% will cut the algal growth rate in two. In waters where the phosphorus content is close to the critical eutrophic level reducing the phosphorus input by a factor of two may protect the lake from algal blooms indefinitely. Of course, there are differences of opinion as to how this reduction is to be achieved. As detergents account for about 60% of the phosphorus in municipal sewage, some advocate complete elimination of all forms of phosphorus from detergent formulations. Others point out the problems associated with the use of some phosphorus-free substitutes and strongly recommend removal of the phosphorus compounds at the municipal sewage treatment plant rather than banning them from detergent formulations. A look at the role of phosphorus in detergents and at the costs of removing phosphorus from municipal sewage may shed some light on this controversy.

Phosphorus in Detergents

The Detergent Process

A detergent must accomplish three basic actions to effectively wash clothing or clean any substance: 1) it must preferentially wet the substrate, in this case the cloth, be it cotton or synthetic fiber, so that the soil is lifted off the substrate; 2) once the soil has been released from the substrate, the detergent solution must either dissolve the soil or keep it in suspension in such a manner that it is not redeposited on the fabric; and 3) it must remove the ions which would interfere with this suspension process. These ions are responsible for the "hardness" of the water and usually consist of calcium, magnesium and iron in the ferric state. Thus, a detergent formulation must include at least three constituents: 1) a surfactant to "wet" the fabric and the soil particles; 2) a protective colloid, to coat the soil particles with a very thin film to prevent their coalescing into large clumps which would then deposit on the fabric; and 3) a precipitant or sequestering agent, to either precipitate the undesirable "hard" ions or bind them into uncharged complexes which can no longer interfere with the soil suspension process.

Precipitating Detergents

Soap—For years soap was used to accomplish all three functions. However, soap is successful only to a limited extent for the following reasons. Soap is made by the reaction of animal and vegetable fats with lye (sodium hydroxide) or for special soaps, potash. Thus soap is the sodium or potassium salt of stearic, palmitic, or oleic acids, depending upon the fat used (beef fat or oils such as palm, olive, corn, or cottonseed). When soap is "dissolved" in water, it does not really dissolve. Most of the soap remains suspended in the water in groups of molecules known as micelles. The suspended soap is capable of wetting both the fabric and many soil particles, thereby removing the soil from the fabric and suspending it within the micelles. A small amount of soap does dissolve. The dissolved soap dissociates into sodium or potassium ions and ions of the

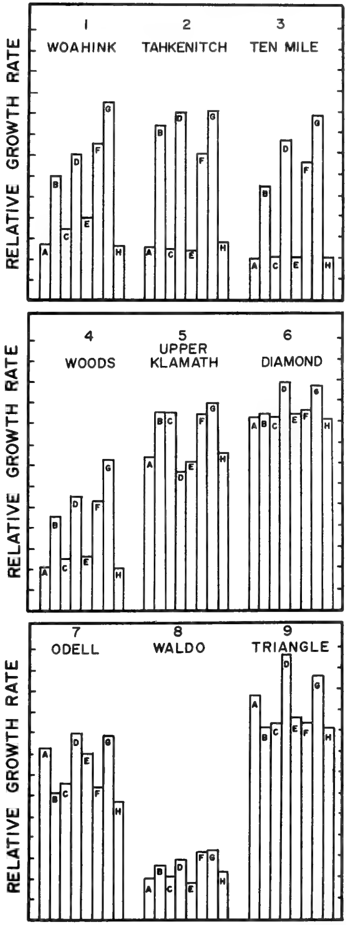


Fig. 1-9.—Effect of various nutrient additions to lake waters on the growth rate of *S. capricornutum*. A = 1.0 mg nitrogen/l; B = 0.05 mg phosphorus/l; C = 10.0 mg carbon/l; D = 1.0 mg nitrogen + 0.05 mg phosphorus/l; E = 1.0 mg nitrogen + 10.0 mg carbon/l; F = 0.05 mg phosphorus + 10.0 mg carbon/l; G = 1.0 mg nitrogen + 0.05 mg phosphorus + 10.0 mg carbon/l; and H = control (no nutrient added).

Table 2.—Comparison of average daily growth rates of *S. capricornutum* with dissolved nitrogen and phosphorus concentrations in lake waters.

Lake	Ave. Algal Growth Rate	Dissolved P mg/1	Dissolved N[1] mg/1
Woahink	0.23	0.006	0.034
Tahkenitch	0.28	0.016	0.166
Ten Mile	0.21	0.009	0.104
Lake of the Woods	0.21	0.009	0.204
Upper Klamath	0.76	0.040	0.388
Diamond	0.92	0.058	0.322
Odell	0.58	0.029	0.030
Waldo	0.23	$<$ 0.005	0.020
Triangle	0.92	0.063	0.232

[1] NH_3-N+NO_3-N

fatty acid characteristic of the fat from which the soap had been made. Some of the fatty acid ions combine with the hydrogen ions in the water to form undissociated fatty acid molecules which remain suspended in the water. The remaining hydroxyl ions enhance the process of soil suspension as they are negatively charged and tend to stabilize the colloid formed. The hydroxyl ions also convert some soil substances to forms which are more soluble in water. Thus soap appears to be a reasonably effective cleaning agent. Unfortunately, calcium, magnesium, and iron ions, commonly found in hard waters, form insoluble salts with fatty acid ions. These salts precipitate as a scum of varying hardness depending upon the fatty acid used to make the soap; salts of stearic acid are the hardest and those of the oleic acids are the softest (hard and soft as used here refer to their tactile (feel) properties and not to their chemical properties as when speaking of water hardness).

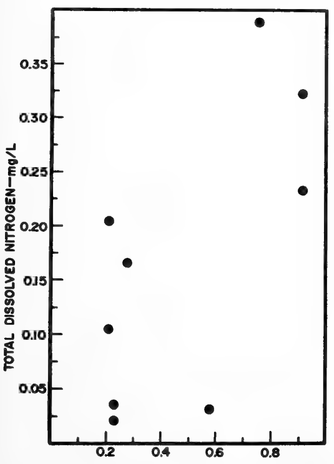


Fig. 10.—Effect of the concentration of total dissolved nitrogen on the growth rate of *S. capricornutum*.

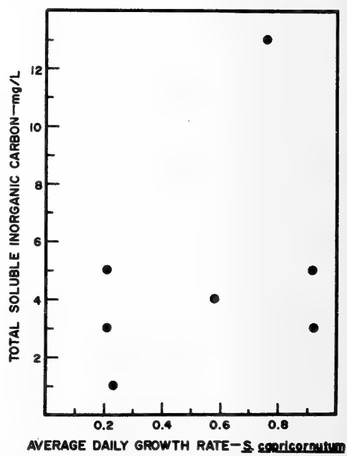


Fig. 11.—Effect of the concentration of total soluble inorganic carbon on the growth rate of *S. capricornutum*.

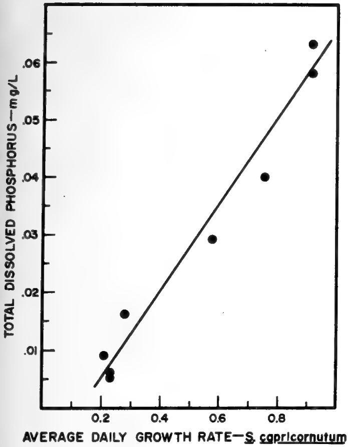


Fig. 12.–Effect of the concentration of total dissolved phosphorus on the growth rate of *S. capricornutum*.

Scum formation not only uses up soap, requiring more soap for effective cleaning, but also has a tendency to deposit a sticky layer on clothing and laundry equipment. This layer attracts and holds other dirt on fabric surfaces thereby imparting the characteristic "tattle-tale gray" to clothing after a dozen or so washings. On laundry equipment, the deposits interfere with proper functioning of machine items with close tolerances (pumps and valves) thereby increasing service frequency. Fig. 13 contains a table of commonly used fats, the corresponding fatty acids, melting point of the fatty acids, a typical saponification reaction using beef fat and lye, and the ionization and combination reactions of dissolved soap. As shown in the figure, soap consists of a long, water insoluble tail and a short water-soluble head. The long, water insoluble, organic tail can wet and stick to many dirt surfaces which are not wet by water. As the water-soluble head of the soap molecule has a strong affinity for water, dirt particles wet by the organic tail are removed from the fabric or other articles and suspended in the water. This process is illustrated schematically in fig. 14. Laboratory studies showed that the more soluble the head of the molecule was in water and the more soluble the tail in organic substances, the more powerful the surfactant. This observation served as the basis for the synthesis of the very effective surfactants used in modern detergents.

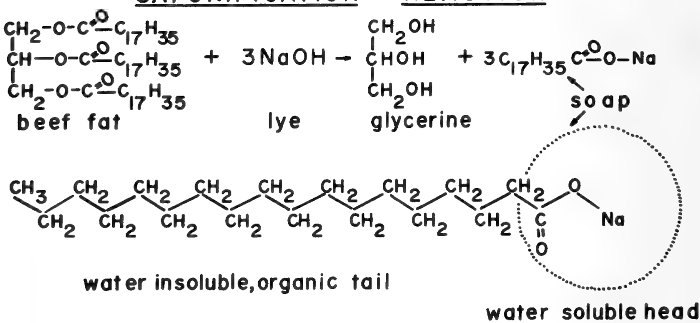
Washing Soda Formulations.–From the above discussion, it is obvious that the prevention of scum formation is highly desirable. Thus some soap makers included sodium carbonate (washing soda) into their mix when pressing the bars. The sodium carbonate in these soaps precipitated the calcium, magnesium and iron as insoluble, powdery salts thereby reducing the tendency to form sticky scums. As the fatty acids competed with the carbonate for the "hardness" ions, some scum still formed. The marketing of washing soda in a separate box was tried. The user was advised to add the soda to the wash water before adding the soap. This precipitated the hardness ions in the desired fine, powdery, non-adhering form without interference by the soap. To some extent, this was reasonably successful. However, some of the precipitated material still deposited on the fabric and machine parts as the water level dropped during the wash-water discharge cycle.

With the discovery of synthetic surfactants (wetting agents) in 1930, combinations of surfactant and sodium carbonate were marketed. These were more successful than the soap/carbonate mixtures as they did not contain fatty acids to form sticky residues. Nonetheless, some of the precipitated calcium, magnesium and iron carbonates did adhere to the fabrics giving the material a harsh feel. When the water contained iron salts, the precipitate was particularly undesirable as it imparted a yellow color to white items in the wash. To minimize these effects, antiredeposition agents (carboxymethylcellulose), blueing, and even bleaches were added to the products marketed in the twenty-year period from 1930 to 1950.

In 1970, sodium carbonate-based formulations reappeared on the consumer market.

FAT	PRINCIPAL FATTY ACID	EMPIRICAL FORMULA	M.P. °C
beef fat	stearic	$C_{17}H_{35}COOH$	69–70
palm oil	palmitic	$C_{15}H_{31}COOH$	63–64
olive oil	oleic	$C_{17}H_{33}COOH$	14
cotton seed	linoleic	$C_{17}H_{31}COOH$	~ –18

SAPONIFICATION REACTION



Reactions of Soap with Water and Hardness Ions

$$C_{17}H_{35}COO\text{-}Na + H_2O \rightarrow C_{17}H_{35}COO\text{-}H + Na^+ + OH^-$$

(free fatty acid)

in water → $[C_{17}H_{35}COO-]^- + Na^+$

(stearate ion)

$$2[C_{17}H_{35}COO-]^- + Ca^{++} \rightarrow (C_{17}H_{35}COO-)_2Ca$$

(hardness ion) (soap scum)

Fig. 13.–Soap and its reactions.

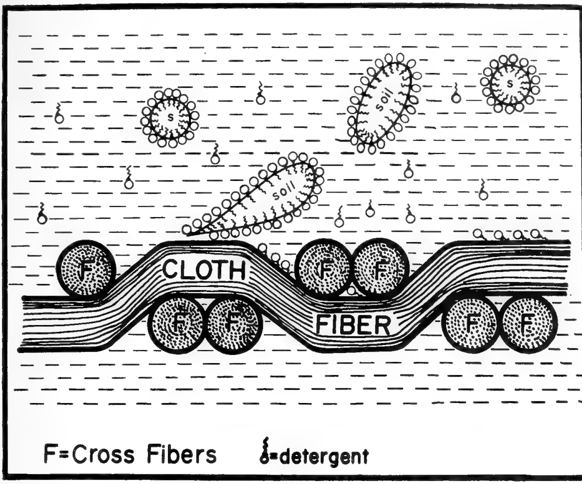


Fig. 14.–The removal of organic soil from a cloth fiber.

Current formulations may include from 50-85% sodium carbonate, about 6% modified sodium silicate ($Na_2O.2SiO_2$), 20 to 10% surfactant (usually of the non-ionic type), about 1% carboxymethylcellulose and the rest optical brighteners and fillers. The pH of solutions of these formulations is about 10.5. This value is higher than that of solutions of soap (about 9) or the formulations which will be discussed later. As pointed out above, these formulations depend upon the precipitation of calcium, magnesium, and iron ions as insoluble carbonates, thereby softening the water. The surfactant then releases the soil from the fabric. The carboxymethylcellulose prevents the redeposition of the soil and, to some extent, of the precipitated carbonates. Although one manufacturer claims that no problems are encountered by users of his product, regardless of water hardness, our research indicates there is a definite buildup of inorganic solids in fabrics washed with these materials. Buildup of inorganics is referred to as "ash buildup" because of the manner in which the inorganics are determined analytically. The cloth is slowly charred in a crucible, the crucible is then heated to a dull red heat, cooled and weighed. High inorganic salt content not only imparts a coarse feel to the fabric but also decreases its wear resistance. Of course, in high-iron areas, white items will appear yellowish after a few washings just as with the earlier formulations. Furthermore, private information suggests that at least one large home washer manufacturer is experiencing interference with proper functioning of his washers when carbonate-based formualtions are used.

Borax.–The compound borax (sodium tetraborate decahydrate) has been marketed as a cleaning agent with no additives for many years. Its cleaning power is due to the alkalinity developed when the compound is hydrolyzed by water and also on the formation of insoluble borates with the "hardness" ions previously discussed. Borax never enjoyed wide acceptance as a household laundry detergent but has maintained consistent, though small, sales as a hard-surface cleaner.

Recently, a formulation containing 30% sodium perborate ($NaBO_3.H_2O$) has been introduced as a phosphate-free detergent. However, most formulations which include perborates use only about 2% to impart mild bleaching action. This occurs only at high water temperatures. As the water temperature used by American home washers is generally about 135°F, very little if any bleaching takes place. The product has been more or less successful in Europe where 180°F water is used. Humans are very tolerant to borates. About 10 to 20 mg may be ingested daily in food with no apparent ill effects.

The U.S. Public Health Service recommends that drinking water contain not more than 1 mg of boron per liter of water, but western U.S. waters may contain 5-15 mg/liter. However, because of its phytotoxicity (0.5 to 1.0 mg/liter damaging sensitive plants), boron containing formulations should not be encouraged.

Surfactant/Soap Combinations.—There are a number of liquid, all-purpose cleaners which consist of 80% saponified vegetable oils, 10-15% surfactant of the non-ionic type, a few percent of an organic solvent such as butylcellosolve, sometimes free ammonia, and an optical brightener. These perform satisfactorily as general purpose, hard-surface cleaners. Their performance in the household-type washer is being checked. One formulation consists of about 80% saponified vegetable oil, 15% ethoxylated alcohols, assorted impurities, and 0.1% optical brightener. Its manufacturer claims it to be completely biodegradable and it well may be. How well it washes is unknown at this time. Scum formation may be a problem.

Non-Precipitating Detergents

Water Softeners.—It is now clear that for the best washing efficiency, one must either remove the interfering "hardness" ions by a completely separate operation, not in the presence of soap, or render these ions inactive by binding them into neutral complexes which are very soluble, do not precipitate out, and are discharged with the wash water. The first alternative may be accomplished by installing a water softener for the entire household, or more economically by attaching a small water softener to the wash water intake of the home washer. One machine manufacturer did develop such a device about 15 years ago. It consisted of a cylinder about 18" long and 5" in diameter filled with conventional water softening zeolites which could be regenerated by adding a pound of salt to the cylinder. About 6 months wash use between regenerations, for the average family, was claimed. The item never reached the consumer market because of the advent of the highly efficient, chelating (sequestering) detergent which obviated its need. Today synthetic ion-exchange resins in replaceable or regenerable cartridges could be readily attached to the home washer at very reasonable cost. Information from the home laundry industry indicates that the device is being reconsidered by machine manufacturers.

Sequestering Formulations.—In 1946 the discovery that sodium tripolyphosphate (STPP) was able to bind the hardness ions into soluble, noninterfering complexes revolutionized the detergent industry. Within the next decade, practically all of the formulations intended for heavy duty use contained from 25 to 50% STPP by weight; presoaks contained as much as 70-80% STPP. They also contained enzymes. However, enzymes are a completely separate problem so they will not be discussed in this paper.

Sodium Tripolyphosphate (STPP).—Having discussed the functions of a detergent, we are now in a position to appreciate the composition of a modern, high efficiency detergent given below:

Each item in this formulation was included after extensive research and testing. Therefore, the deletion of any one would result in some reduction in the performance of the product. Substitutes should be carefully considered before changes are made lest the cure be worse than the disease.

From a performance standpoint, STPP appears to be the ideal builder. It is capable of sequestering the "hardness" ions into soluble, neutral complexes; it is mild, pH of solutions of formulations are about 9.9; and

Typical Heavy-Duty Granular, Detergent Formulation

Material	Percent by wt.	Purpose
sodium dodecylbenzene sulfonate	18.0	surfactant
sodium xylene sulfonate	3.0	antidusting agent
dethanolamide of coconut fatty acids	3.0	foam booster
sodium tripolyphosphate	50.0	builder (sequestrant)
sodium silicate	6.0	anticorrosion agent
carboxymethylcellulose	0.5	soil redeposition preventive
optical brightener[a]	0.3	fluorescent whitener
benzotriazole	0.1	antitarnishing agent
other inorganic salts and water	19.1	fillers (usually sodium sulfate)

[a]This is usually a 50/50 mixture of a fluorescent dye which attaches itself to cotton and a fluorescent dye which combines with synthetic fibers. Typical examples are bis stilbenedisulfonate and triazolylstilbenesulfonate.

it possesses sufficient reserve alkalinity to saponify (convert to soluble salts) oily soil removed from clothing. Furthermore, sodium tripolyphosphate readily hydrolyzes into sodium orthophosphate which has no appreciable sequestering power, thereby releasing the metal ions previously solubilized. These ions combine with the orthophosphate ions to form insoluble salts which then precipitate out. Thus the hardness ions are held in solution during the washing process but are released to precipitate out later either during the sewage treatment process or in septic tank drain fields. It is interesting to note that the phosphates of heavy metals such as mercury, cadmium, and lead are also only slightly soluble. Thus the presence of orthophosphate ions in water tends to limit the concentration of these toxic metal ions to values frequently less than one part per million. The exact value will depend upon the pH of the water and upon the dissolved oxygen content, that is, whether the system is predominatly in an oxidized or a reduced state.

Unfortunately, as discussed above, orthophosphate ions have been identified as contributing to accelerating the growth of undesirable algal species, thereby contributing to the premature aging of watercourses. Legislation limiting the amount of STPP, or any other phosphate, in detergents has been enacted by some communities; others are planning to ban the use of all phosphates in detergent products sold within their jurisdiction.

The furor about the use of phosphates has led to the appearance of many phosphate-free formulations with varying degrees of washing efficacy. Most formulations are rehashes of the precipitating detergent formulas discussed in the earlier parts of this paper. A few detergent manufacturers substituted some other sequestering agent for STPP. Some of the sequestrants used were:

NTA (nitrilotriacetic acid).—Until very recently, NTA appeared to be the most promising sequestering substitute for STPP. However, serious questions as to its teratogenicity have been raised by the early work by the Public Health Service. The soap and detergent industry is voluntarily withholding this compound until further studies prove or disprove the existence of the hazards suggested.

EDTA (ethylenediamine tetracetic acid).—EDTA has been known to be a very effective chelating agent (sequestrant) long before NTA. However, it was also known to biodegrade very slowly so its use in household detergents was not pushed by the industry. It has been and is used to a very limited extent in special purpose cleaners.

Sodium Citrate.—The citrates should be ideal substitutes as they biodegrade readily, are not toxic, and can be prepared in large quantities at reasonable cost. Unfortunately, citrates are only good chelators at high pH values—about 12. Products with such a high pH would not meet product safety standards. Recent research indicates that citrates are effective at lower pH values if special surfactants are used. Several new formulations are being evaluated.

SODA (disodium oxydiacetate).—SODA is a new compound which has chelating properties midway between STPP and NTA. It is said to biodegrade readily with practically no acclimitization period. As it does not contain phosphorus, nitrogen, or potassium, biostimulatory effects would not be anticipated. Being weaker in chelating power than NTA, it may not transfer metals across the placental barrier and into the fetus as appears to be the case with NTA. However, no experimental information is available on this point. SODA can be prepared cheaply and in the amounts required as the raw materials are formaldehyde, carbon monoxide and water. At this time, all that can be said is that the compound is "of interest."

Pollution Potential vs. Detergent Type

A simple way of estimating the amounts of components of a detergent formulation which would be added to receiving waters if that particular formulation were adopted by all users is to compute the amount of phosphorus presently contributed by detergents and compute the equivalent amount of detergent formulation involved. Then assume that the same weight of any other formulation would be used. From the percent composition of the formulation, the amount of a particular component can be readily calculated. This method is superior to determining the total sales of detergent products and using that figure as a base because the amount used by owners of septic tank systems is difficult to determine and most of the discharge from these systems remains in the ground. Furthermore, the computation method given below will furnish data on the upper limit of resulting concentrations without requiring extensive rainfall or river flow data. It is understood that the computed values are estimates which may be in error by 50% (that is, may be higher or lower by ½ of the value assigned) but nonetheless they are useful estimates. The procedure is as follows:

A. *Assumptions:*

1. 60% of the elemental phosphorus in municipal sewage effluent is contributed by detergents; the other 40% is probably from human excreta, discarded food products, discharges from various process industries, etc.

2. 15% of the elemental phosphorus entering a municipal sewage treatment plant is removed, in the activated sludge or trickling filter, etc. Thus we may assume a 15% phosphorus loss in passing through the plant.

3. The average detergent contains 40% by weight, STPP. Until very recently, this has been a representative value. During the last few months, manufacturers have attempted to reduce the STPP content, but for the purposes of our calculations 40% is valid.

4. The increment of phosphate from tap water to secondary effluent is 25 mg/liter. This value is based on the fact that municipal drinking water has a practically zero phosphate content, whereas, secondary effluent contains 25 mg/liter phosphate. The 25 mg/liter phosphate content of the municipal sewage effluent must represent the increase through one water-use cycle. The equivalent amount of elemental phosphorus is 8.3 mg/liter.

B. *Calculations:*

1. If 15% is removed during treatment, the true P increment per use is 8.3 x 100/85 = 9.8 mg/liter, or approximately 10 mg/liter.

2. However, only 60% is from detergents, so .6 x 10 = 6 mg/liter of P is from detergents.

3. This corresponds to 6 x 3.95 = 23.7 mg/liter of STPP.

4. The corresponding concentration of the total detergent formulation is 23.7 x 100/40 = 59.3 mg/liter.

5. To simplify calculations, it is a justifiable assumption that 60 mg/liter be used instead of 59.3. Thus, regardless of the composition of the detergent, the total dissolved solids (TDS) increment would be 60 mg/liter. This is about 10% of the average TDS present in effluents.

6. Suppose a carbonate-based, non-chelating detergent completely replaced phosphate-based detergents and it contained 40%, by weight, sodium carbonate and 10% modified sodium silicate, $Na_2O.2SiO_2$. The carbonate, silicate, and sodium ions added to the effluent would be:

a. amount of Na_2CO_3 would be 40/100 x 60 = 24 mg/liter, and the corresponding $CO_3^{=}$= 24 x $CO_3^{=}/Na_2CO_3$ = 24 x 60/106 = 13.6 mg/liter. If acidified this would generate about 14 mg/liter of bicarbonate, an increase of less than 5% of the amount now present in sewage effluent. Thus, insofar as bicarbonate formation may be of concern, even complete substitution does not appear to constitute a threat to the aquatic environment. The addition of 14 mg/liter of carbonates to the 310 already present can hardly be critical. Formulations containing 60% sodium carbonate would add 1.5 times the amounts calculated above. These amounts still do not appear to be cause for alarm.

b. The amount of modified sodium silicate introduced would be 6 mg. The corresponding amount of silicate is 6 x 152/182 = 5 mg, or about 10% of the amount already present in sewage effluent. Here again, it is difficult to foresee how this increase could be deleterious but firm data is lacking.

c. The sodium ion introduced by both the sodium carbonate and modified silicate is 24 x 46/106 = 10.4 mg/liter (from the carbonate) and 6 x 46/182 = 1.5 mg/liter (from the silicate), giving a total of 11.9 or 12 mg/liter. This again is about 10% of the amount already present. In judging the effects of carbonate/silicate formulations, it should be remembered that many current phosphate formulations contain 6% silicate, so at the most the change from the amount of sodium ions now being introduced, due to the increased silicate content, would be half the amount calculated above, i.e., 1.5 x 1/2 = 0.8 mg/liter of Na^+. As 23.7 mg of STPP contribute 7.3 mg/liter of sodium ions, the Na^+ contribution by the sodium carbonate formulations is only 3.9 mg/liter greater than that introduced by STPP formulations. This is about 3% of the amount now present in municipal sewage effluent.

7. Calculations for sulphate will not be discussed in detail as the amount of sodium sulphate used in the phosphate-free formulations is usually about the same as in the STPP-based detergents now in use. At the most a 4% increase could be anticipated; this is unlikely.

8. Assuming the new 30% sodium perborate formulation completely replaced the STPP detergents, the amount of boron discharged to our waterways would be 30/100 x 60 x $B/NaBO_2.H_2O$ = 30/100 x 60 x 11/100 = about 2 mg/liter. Although one could drink water of this boron content without harm, the water would be unsuitable for irrigation purposes. As mentioned before, boron at the 0.5-1.0 mg/liter level damages sensitive plants; 4 mg/liter damages all plants. Thus, if boron containing detergents captured 25% of the market, an environmental problem might result. This could be particularly acute in areas where effluents are used downstream or directly for crop irrigation or in areas where septic tanks were used extensively. The accumulation of boron in the drain fields would soon render the area unsuitable for any plant life. On the other hand, fish seem to be very tolerant to boron compounds; i.e., 96 hour TL_{50} values in excess of 3000 mg/liter have been recorded.

9. Since surfactant/liquid soap formulations are said to be completely biodegradable, the problem seems to be one of biochemical oxygen demand load on the rivers and streams. This load should be no greater than if ordinary soap were used. There is good reason to believe that the components of these detergents would degrade at about the same rate as other biodegradable organics in municipal sewage. Thus the load would be on the treatment plant; a properly operating plant would discharge no more than at present. Septic tank systems should also be able to degrade these materials as effectively as materials now in use. The performance of liquid soap formulations in the home laundry remains to be established.

10. NTA is a more effective chelating agent than STPP. On a weight basis, 1 gram of NTA will chelate as much calcium or magnesium as 1.4 grams of STPP. Thus a formulation using 40 wt % of STPP will require 40/1.4 or 28.6 wt % NTA. This corresponds to 17.2 grams of NTA if 60 grams of formulation are used as assumed above. The nitrogen added will be 17.2 x N/NTA = 17.2 x 14/257 = about 1 mg/liter. This is only about 3% of the total nitrogen currently present in waste waters. It is difficult to see how this small increment could generate environmental problems. Unfortunately, NTA is a powerful chelating agent. Experiments suggest that cadmium chelates of NTA may be transported across the placental barrier with consequent damage to the fetus. Use of NTA has been voluntarily withheld by the detergent soap industry until additional experiments are completed.

11. On a weight basis, SODA (disodium oxydiacetete) is said to be 1.4 times as effective as NTA and 2.1 times as efficient as STPP. In addition, SODA is said to biodegrade without acclimatization; if so, it may impose no discernible environmental load. Its chelates are said to be intermediate in stability to those of NTA and STPP. Thus, heavy metal chelates may not be transported past the placental barrier. On the basis of very preliminary information, SODA appears to have some promise as a substitute builder. Considerable research on its degradation mechanism and the toxicity of intermediate degradation products remains to be done.

Costs of Phosphorus Removal from Sewage

The sewage treatment process used by various cities and municipalities may consist of a simple sedimentation basin to remove suspended solids or an elaborate series of sedimentation basins, activated sludge aeration tanks to microbiologically degrade dissolved organics in the sewage, adsorption towers to remove organics that resist microbiological degradation, and finally chlorination to destroy bacteria and viruses before the sewage is discharged to the receiving waters.

Phosphorus may be removed from the sewage microbiologically. By carefully controlling the concentration of nutrients (raw sewage) fed to the activated sludge tanks the bacteria are made to "take-up" the maximum amount of phosphorus. However, even under optimum conditions, the maximum phosphorus removal achieved by this technique is about 80%. As it is difficult to maintain optimum conditions continuously, only 15-20% phosphorus removal is attained by most treatment plants. The simplest and most effective method of removing phosphorus from sewage is by the use of chemical precipitants after the activated sludge treatment. The chemicals used and their reactions with phosphate ions are given in Table 3. The particular chemical selected

TABLE 3

Removal of Phosphate by Chemicals

$$\underset{\text{alum}}{Al_2(SO_4)_3 \cdot 14\,H_2O} + \underset{\text{phosphate ion}}{2PO_4^{3-}} \rightarrow \underset{\text{solid precipitate}}{2AlPO_4\downarrow} + 3SO_4^{2-} + 14\,H_2O$$

$$FeCl_3 \text{ (in pickle liquor)} + PO_4^{3-} \rightarrow FePO_4\downarrow + 3Cl^-$$

$$Fe_2(SO_4)_3 \text{ (in pickle liquor)} + 2PO_4^{3-} \rightarrow 2FePO_4\downarrow + 3SO_4^{2-}$$

$$\underset{\text{slaked lime}}{10\,Ca(OH)_2} + 6PO_4^{3-} \rightarrow \underset{\text{hydroxyapatite}}{Ca_{10}(OH)_2(PO_4)_6\downarrow} + 18\,OH^-$$

will, of course, depend upon the location of the treatment plant and the price of the chemicals delivered to the plant. For example, a plant located close to a steel processing mill will find it advantageous to use "pickle liquor" which is rich in ferric ion and is a waste product the steel mill is anxious to dispose of. On the other hand, a plant located close to a bauxite mine might find it most economical to use an aluminum salt as a precipitant. As lime is available everywhere at low cost, it is the most universally used chemical precipitant. However, all three metallic ions (aluminum, ferric, and calcium) may be used at reasonable cost at all locations. Whereas the cost to treat 1000 gallons of sewage decreases as the plant size increases, the cost for the chemicals used is relatively constant, except for the small advantage of large quantity purchasing. The values listed in Table 4 are based on a phosphorus concentration of 10 mg/liter in the influent sewage, 80% removal, and the assumption that all chemicals are purchased at average delivered prices.

Of course, there are additional costs. Chemical storage tanks, feeders, and mixers must be installed. The additional sludge formed by the chemical precipitants must be handled and disposed of. Additional power and labor will be required. Taking all these factors into consideration, some representative cost figures are listed in Table 5. The costs are very reasonable. Perhaps removal at the treatment plant may be the solution to the phosphorus in detergents dilemma.

TABLE 4

Cost of Phosphorus Removal[3]

(in cents per thousand gallons, 80% removal)

Plant Size mgd[1]	Chemical Cost	Cost including Amortization of Treatment Equipment[2]
1	1.4	16
10	1.4	9
100	1.4	6

[1]million gallons per day. [2]does not include costs for chemical storage tanks and sludge handling equipment. [3]more detailed cost data in reference 3.

TABLE 5 [4]

Cost of Phosphorus Removal[3]

Average Total % P Removed	Cost in Dollars/Year/Capita[1,2]
80	2.50
90	4.00
98	5.00

[1]100 mgd plant. [2]120 gallons of water per capita per day. [3]more detailed cost data in reference 3.

May I conclude with a few words in reply to the claims that the detergent industry is over-selling detergents by recommending the use of more than is necessary. Figure 15 is a plot of the amount of STPP required to sequester varying amounts of calcium ions in water and the calcium ions in the soil of the wash load. (It is assumed that all the hardness is present in the form of calcium ions; magnesium and iron ions would show a similar relationship.) It is obvious that 1 cup of detergent product is insufficient for waters containing more than about 60 mg/

---

[4]Process Design Manual for Phosphorus Removal, U.S. Environmental Protection Agency, Technology Transfer Program No. 17010 GNP, Contract No. 14-12-936, October 1971.

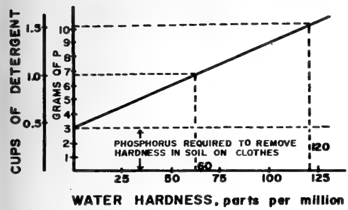


Fig. 15.–Phosphorus and detergent required to bind the hardness in water and soil, assuming a detergent product containing 35% sodium tripolyphosphate and a 17-gal capacity household washing machine.

liter (60 parts per million) of hardness ions. Approximately 90% of the U.S. population is using water containing more than this amount of hardness. As an example, the drinking water distributed to consumers in the District of Columbia contains, on the average, about 120 ppm of hardness ions. Assuming the household wash load is soiled with particulate matter equivalent to 3 grams of phosphorus, about 10.25 grams of phosphorus or 1½ cups of detergent formulation per wash load (using a top loading household washing machine) would be required. Of course, not all clothing is soiled to this extent. For example, ladies garments frequently are soiled with only a small amount of perspiration. But even in this case, 1 cup of detergent is required to sequester the hardness ions in the water if District of Columbia water is used. Thus, "experts" who claim that it is possible to wash clothes with small quantities of detergents (1/2 to 1/10 cup) either are unaware of the basic principles of chemical stoichiometry or are deliberately misrepresenting the facts, to the detriment of the public.

Summary

1. At the present state of the art, sequestering detergent formulations appear to be superior to precipitating formulations in laundering performance.

2. No environmentally acceptable, effective sequestrants have been positively identified to date. Sodium citrate would be an environmentally acceptable sequestrant if it could be used at lower pH values, e.g. 10 to 10.5. Research to develop suitable surfactants to produce effective washing formulations incorporating sodium citrate as the builder is in progress. A new compound, disodium oxydiacetate (SODA) has been announced as possibly meeting the requirements of being a nonpollutant and a satisfactory sequestrant. Little is known about its degradation mechanism, degradation end products, and the membrane transport characteristics of its chelates.

3. Some phosphate-free detergent formulations containing sodium carbonate and modified sodium silicate as builders have appeared on the market. Tests indicate at least one is not as effective as phosphates in its ability to remove soil form permanent press or synthetic fiber fabrics. However, preliminary calculations revealed no detrimental impact on the environment. Further research may improve the washing performance of such formulations.

4. An interim solution to the detergent problem may be to limit the amount of phosphorus compounds in detergents to that required to sequester 120 ppm hardness in water. This will accommodate the residents of 71 of the 100 largest cities of the United States which account for 25% of the total population of the U.S. (This does not mean that 75% of the people use water harder than 120 ppm. It simply indicates a lack of data for the very small municipalities and the individual well supplies.) The amount of STPP required to sequester 120 ppm hardness corresponds to about 7.25 grams phosphorus per wash load.. (This value does not include the phosphorus required to sequester the hardness in the soil.) Users in other areas could use proportionate amounts of formulation. An alternative might be to publish "hardness values" for different areas of the country and to package the phosphate separately. Each user would add the phosphate required to sequester the hardness in the water and the soil in the clothing, as indicated by the published table. (Soil values would be simply light, medium, and heavy and correspond to 1, 2, and 3 grams of phosphorus, respectively.)

5. Phosphorus may be removed to any desired degree by most treatment plants at nominal cost, averaging about $5.00 per year per capita. Thus removal at the treatment plant may prove to be the ultimate solution to the problem of eutrophication of the nation's waters by phosphorus.

The Need for Training in Technological Management in Developing Countries-- Ghana, A Case in Point[1]

Edward S. Ayensu

Chairman, Department of Botany, U.S. National Museum of Natural History, Smithsonian Institution, Washington, D.C. 20560

ABSTRACT

The need for the development of a cadre of scientific and industrial managers in the developing countries is discussed by citing Ghana as an example. Suggestions are made to the developing countries to establish clear-cut definitions of their needs, in terms of the utility of science and technology, the selection and training of suitable administrators to man programs, and the proper financial backing from government and industry. These and other discussions are indicative of the concerns shown by citizens in developing countries who are sensitive to the need for cultivating a sound crop of scientific and industrial managers.

The need for training managers and administrators in science and technology activities in developing countries is more acute now than ever before because of the desire of most developing countries to catch up with the developed countries. It is therefore necessary that before any serious technology is undertaken certain criteria have to be met.

The first task that a developing country must address itself to, in my opinion, is to establish a clear-cut definition of the role that science and technology can and must play in the industrial development of that particular country.

The second task is the selection of qualified persons, preferably science administrators, who understand and appreciate the kinds of technology that will answer to the needs of that country.

The third task involves the realization of the government in power that sound financial backing of both basic and applied research would ultimately redound to the advancement of most sectors of that country's growth.

The fourth and perhaps the most critical is the proper utilization of the available manpower in the country and how best this manpower can be supplemented and fortified with the assistance of willing developed countries.

Ghana is definitely one of the developing countries that has need for training of managers in its scientific and industrial concerns. Unfortunately this need has not been met successfully partly because of the lack of definition of the scientific goals, partly because of the poor utility of the available manpower, and partly because of unnecessary duplication of efforts aimed at a single goal. Furthermore, various "bio-political" activities among the management have obscured many steps that should otherwise be taken to improve the overall image and usefulness of the scientific and industrial activities of the country.

In 1966 the Ghana Government, i.e. the National Liberation Council, appointed a committee[2] headed by the late Sir John Cockcroft of Cambridge University to advise on the future of the Ghana Academy of Sciences (fig. 1) which was set up in 1959 by

[1]Remarks presented before the Advisory Panel on Training Opportunities for The Management and Senior Staff of Technological Institutes in Developing Countries, National Academy of Sciences, Washington, D.C., June 17, 1971.

[2]Report of the Committee of Experts to advise on the Future of the Ghana Academy of Sciences. Ghana Information Services. Accra 1966.

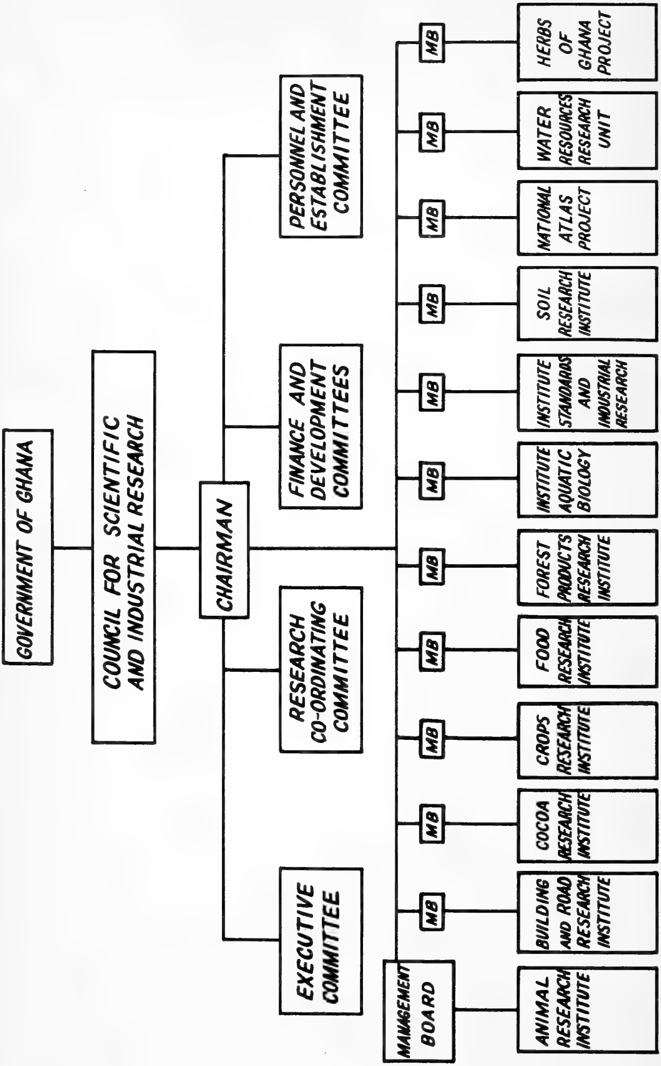


Fig. 1.–Administrative structure of the Ghana Academy of Science during the First Republic.

the First Republic to oversee and to manage all scientific and technological endeavours in the country. The Cockcroft Committee's report was published in 1967 and I am glad to say that many of their recommendations have been implemented. However, there are many areas of crucial concern bearing on the theme of this meeting that have not been carried out.

For example, the Cockcroft Committee recommended that the Crops Research Institute and the Soil Research Institute, which until 1962 was a single organization under the Ministry of Agriculture, should be amalgamated and placed under the Ministry of Agriculture again.

While it is desirable to encourage amalgamation of units where necessary, it should be pointed out that the importance and the effective contributions that the above Institutes can make to the total agricultural impact on the nation can easily be relegated to the background, especially if careful examination of all the facts is not undertaken before they are placed under the Ministry of Agriculture. In my own opinion, the Ministry of Agriculture itself can stand drastic reorganization before its own usefulness can be felt in the nation's economy.

Likewise, the Cockcroft Committee recommended that the Institute of Aquatic Biology under CSIR and the Volta Basin Research Project based at the University of Ghana should be merged and placed under the University. Again, while on the surface this seems to be a worthwhile approach in an effort to eliminate "unnecessary duplication of effort and dispersal of resources," the basic interests of the Institute of Aquatic Biology and the Volta Basin Research Project should be carefully examined and analyzed before any such amalgamation is effected.

The Cockcroft Committee also observed that certain administrative problems have contributed to the frustrations of the Research Institutes. For example, it was clear from the Committee's report that shortage of funds, particularly operating funds, has affected the performance of the Institutes. Of their total budget the Committee learned that 90% of the Institutes' funds were allocated for salaries and wages and only 10% were available for research activities.

The Committee strongly recommended that the Government should take steps to rectify this situation. The following specific recommendations were put forth:

(i) that in the preparation of budgets, the proportion of the budget devoted to research and operating expenses should be increased to be approximately equal to the budget for personal emoluments, even though this may require some retrenchment in non-technical supporting staff;

(ii) that negotiations should be opened with the Cocoa Marketing Board and the Timber Marketing Board for contributions from commodity funds;

(iii) overseas organizations such as the United Kingdom Ministry of Overseas Development who second staff to work in Research Institutes might be asked to contribute sufficient foreign exchange to ensure that their staff on arrival will have the equipment and supplies required to make them effective.

A few months ago a branch of the U.S. National Academy of Sciences conducted a workshop in Ghana, following discussions with the Vice Chancellor of the University of Ghana here in Washington, to address itself on some of the problems I have mentioned. I visited Ghana soon after the workshop and you will be delighted to know that the discussions that emenated from the workshop are receiving serious consideration. It is hoped that the results of the workshop and other inputs from the technological and scientific concerns in this country will ultimately be translated into an effective Ghana-U.S. scientific cooperation.

Current Management

Council for Scientific and Industrial Research.—This Council (fig. 2) was established in October 1968 following the recommendations of the Cockcroft Committee. However,

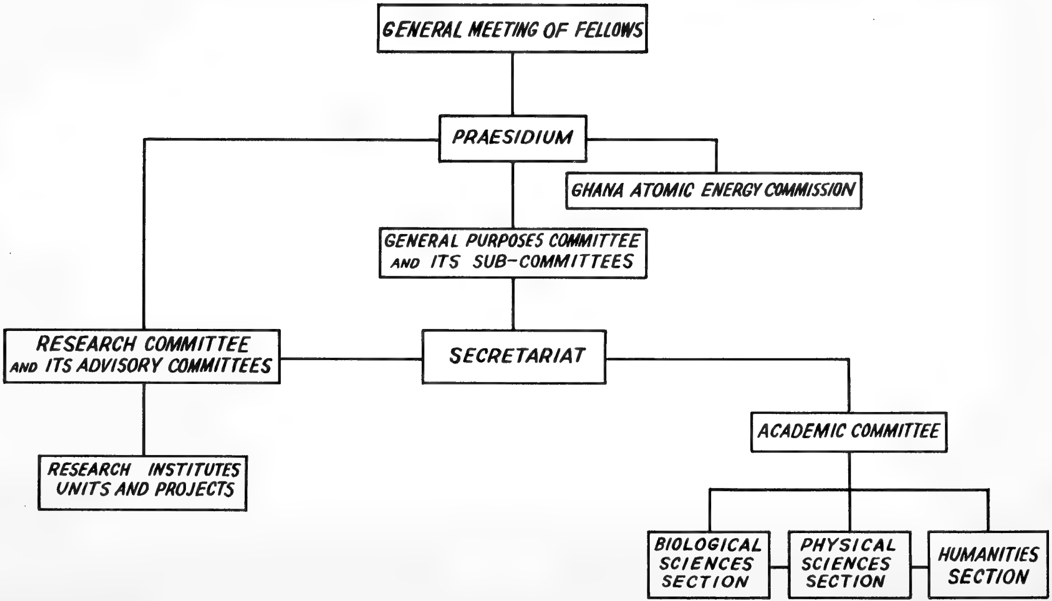


Fig. 2.—Current structure of the Council for Scientific and Industrial Research.

the Council's history dates back to August 1958 when the dissolved National Research Council was created by the Ghana Government to organize and to co-ordinate scientific research in the country.

The Council is made up of 26 members representing the universities of Ghana, research institutes, certain specified Government Ministries and Departments, and a number of production and development agencies from both private and public sectors.

The following table represents the current make-up of the Council:

Council for Scientific and Industrial Research (CSIR)
Membership of Council (26)

1 *Chairman* (appointed by Government)

2 other appointments by Government–Head Research Branch, Bank of Ghana, Director of Medical Services

6 appointed by Government after consultation with the Ghana Academy of Arts and Sciences–Director Cocoa Research Inst., Dept. of Chemistry, University of Ghana, Principal, Cape Coast University Coll., Dept. of Medicine & Therapeutics Med. School, Dean, Faculty of Agriculture University of Ghana, Chief Executive, Volta River Authority

2 appointed by Directors of the Research Institutes of the CSIR–Director, Crop Research, Director, Institute of Aquatic Biology

1 Secretary of the Ghana Academy of Arts and Sciences

1 Representative of the Atomic Energy Commission

6 Representatives of Government Ministries

3 Representatives of the Universities

2 Representatives of the Ghana Chamber of Commerce

1 Director of the National Standard Board

1 Representative, National Council for Higher Education

Council is further serviced by the following committees:

Executive Committee.–Takes decisions on behalf of the Council in between Council Meetings.

Research Co-ordinating Committee.–Co-ordinates the Research being done in the Institutes of the Council.

Finance and Development Committee.–Advises Council on financial matters, including annual budgets submitted by the various institutes.

Personnel and Establishment Committee.–Advises Council on personnel and administrative matters.

The number of Research Institutes of the Council is currently twelve:

Animal Research Institute
Building & Road Research Institute
Cocoa Research Institute
Crops Research Institute
Food Research Institute
Forest Products Research Institute
Institute of Aquatic Biology
Institute of Standards & Industrial Research
Soil Research Institute
National Atlas Project
Water Resources Research Unit
Herbs of Ghana Project

Each Research Institute is semi-autonomous and is managed on behalf of the Council by a Management Board established by Council. For example, the Food Research Institute Management Board is composed of the following:

Director of Medical Services of Ghana (Chairman)
Agricultural Co-ordinator, Ministry of Agriculture
Dept. of Biochemistry, Univ. of Science & Technology
Deputy Director, Ghana Medical Services
Director, Food Research Institute
Nutrition Division, Ministry of Health
Research Officer, Food Research Institute

Department of Biochem, Food and Nutrition, Univ. of Ghana

Principal Project Officer, Ministry of Trade & Industry

Representative, Ghana Manufacturers Assoc.

The Food Research Institute was established by the Ghana Government in October 1963. It became part of the CSIR when this Council was established in October 1968. The Institute started with the assistance of United National Development Program acting through FAO. Assistance in the form of post-graduate fellowships for Ghanaian research scientists, the acquisition of laboratory and processing equipment, and the development of research projects by international experts were obtained.

The FRI was conceived to assist the local food industries at all levels of organization, to improve on and diversify operations and thereby promote agricultural productivity in the country.

To achieve the aim of the Institute, the following research activities were undertaken.

1. Food processing
2. Preservation
3. Storage
4. Marketing and distribution

The Institute also provides services and advice to private industries and public organizations in the following areas:

1. Food analysis
2. Quality control
3. Product improvement and development
4. Marketing and distribution of food.

The above example is presented to demonstrate how each Research Institute operates.

Research Administration and Management

It is often assumed that every Ph.D. holder is capable of teaching at a university or is well equipped to manage a research unit by virtue of his degree. One does not have to look hard enough to come to the conclusion that such is not the case. In fact, most Ph.D. holders are not good administrators. Furthermore, good scientists who are also good administrators are few and far between. In developing countries, where the production of scientists is low keyed, the general tendency is to call on the available scientists to become "instinct managers," not because of their ability as administrators but because of their academic achievements. I may point out that in some cases these persons are neither. In some cases scientists are applinted managers because of their political inclinations. These types of makeshift administrators have governed the scientific institutions of the developing countries and to some extent the developed countries over the years. Some of the managers have made tremendous strides; others have proved abysmal failures.

As I mentioned earlier, in an ideal situation qualified science administrators should be appointed to the posts of managers. Whereas most developing countries have schools of administration organized to train competent staff to man the various government agencies, similar schools are nonexistent for the manning of the scientific and industrial concerns.

It is therefore necessary that selected scientists who have demonstrated the ability to become good managers of research units are given the opportunity to have on-the-job training in developed countries such as the United States where science administration has been developed with considerable sophistication. The idea is not to give only specialized administrative technique. Rather it will be more profitable for the managers from developing countries to be exposed to formal instructions supplemented with on-the-job training that will have general applicability in their areas of study.

The Tribe Noviini in the New World (Coleoptera: Coccinellidae)

Robert D. Gordon

Systematic Entomology Laboratory, Agr. Res. Serv., USDA, c/o U.S. National Museum, Washington, D.C. 20560

ABSTRACT

The genera and species belonging to the tribe Noviini in the New World are reviewed. The genus *Vedalia* is removed and placed in the Exoplectrini. Four new *Anovia* species, *punica, peruviana, weisei* and *mexicana*, are described. Keys to genera and species are included, and pertinent morphological characters are illustrated.

Korschefsky (1931) lists 5 genera in the Noviini. All of these except *Eurodolia* Weise (1895) and *Novius* Mulsant (1850) are represented in the New World. One genus, *Vedalia* Mulsant, is at present erroneously included in the Novini and is here placed in the Exoplectrini near *Chnoodes* Chevrolat. With *Vedalia* removed, the tribe Novini becomes an easily defined, compact group characterized as follows: dorsal surface with dense, short pubescence, finely and densely punctured; head with labrum obviously on a lower plane than clypeus; eye densely pubescent, not emarginate; antenna 8-segmented, basal segment expanded (fig. 1); prosternum with intercoxal process protuberant, extending beyond the anterior coxa (except *Novius*); tarsus trimerous; abdomen with 6 visible sterna, apical sternum more or less emarginate in male (figs. 6, 7); postcoxal line narrow, complete or nearly so.

It is quite possible that some of the species presently placed in *Novius* will have to be transferred to *Rodolia*. A series of specimens from Australia identified as *Novius bellus* Blackburn in the USNM collection belongs to *Rodolia*, and chances are excellent that at least some of the Australian species belong to *Rodolia* also. To further complicate matters, my preliminary examination of male and female genitalia suggests that at least some of the Australian and Asian species presently in *Rodolia* should be removed to other genera. Lack of specimens of many species has prevented a complete study at present.

Rodolia cardinalis (Mulsant) is perhaps the best known member of the Noviini, at least in North America, due to the publicity given the successful control of the cottony cushion scale. *Rodolia cardinalis* was introduced into California from Australia by Albert Koebele. Less well known, but as effective a predator of cottony cushion scale, is *Rodolia koebelei* (Coquillett), also introduced from Australia by Koebele.

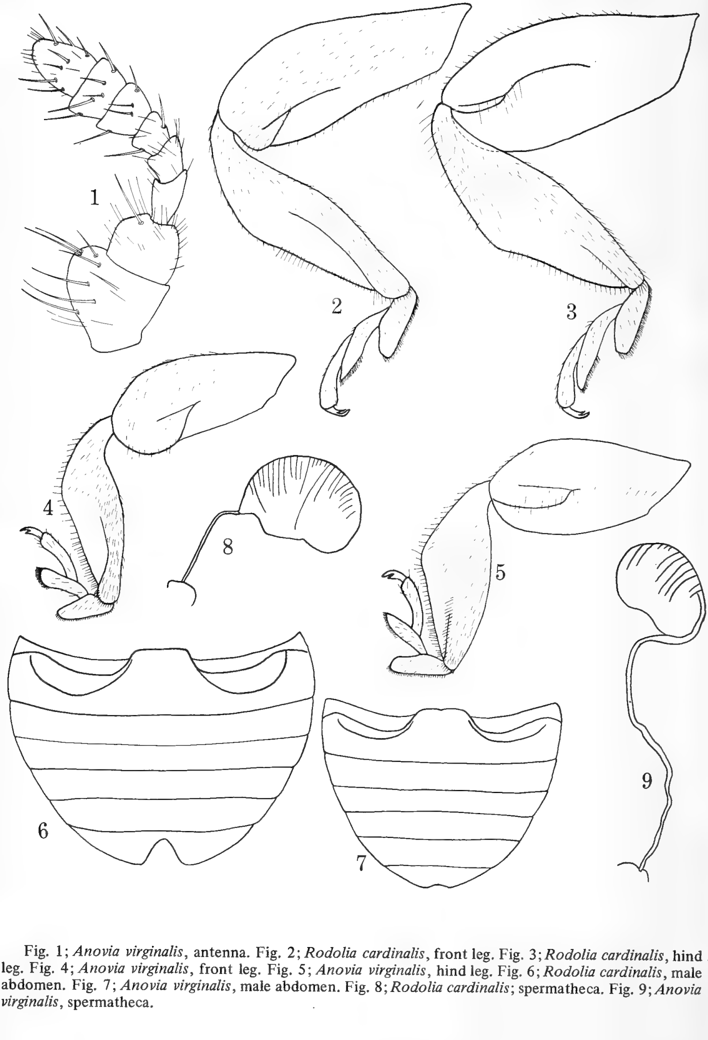


Fig. 1; *Anovia virginalis*, antenna. Fig. 2; *Rodolia cardinalis*, front leg. Fig. 3; *Rodolia cardinalis*, hind leg. Fig. 4; *Anovia virginalis*, front leg. Fig. 5; *Anovia virginalis*, hind leg. Fig. 6; *Rodolia cardinalis*, male abdomen. Fig. 7; *Anovia virginalis*, male abdomen. Fig. 8; *Rodolia cardinalis*; spermatheca. Fig. 9; *Anovia virginalis*, spermatheca.

Key to genera of New World *Noviini*

Prosternum with intercoxal process densely pubescent, margined anteriorly; pronotum with sides not completely arcuate, posterior angles apparent .... **Rodolia** Mulsant

Prosternum with intercoxal process sparsely pubescent, not margined anteriorly; pronotum with sides completely arcuate, posterior angles not apparent .... **Anovia** Casey

Genus **Rodolia** Mulsant

Rodolia Mulsant, 1850, p. 280. Type-species: *Rodolia ruficollis* Mulsant, by subsequent designation of Crotch, 1874, p. 280. Korschefsky (1931) mistakenly records *rubea* Mulsant as the type species of *Rodolia*.

Macronovius Weise, 1885, p. 63 (subgenus of *Rodolia*).–Weise, 1895, p. 149 (synonym of *Rodolia*).–Sicard, 1907, p. 68.–Korschefsky, 1931, p. 98.

Priore (1963) gives an exhaustive account of the internal and external morphology of the adult and immature stages of *Rodolia cardinalis* (Mulsant). Priore's findings will not be reiterated here. Priore does not illustrate the receptaculum seminis which is short, stout, lacks an accessory gland, and has a relatively short sperm duct (fig. 8).

Rodolia and *Anovia* adults are quite difficult to separate on the basis of morphological characters and the temptation to unite the 2 genera would be great if it were not for larval characters. Rees (1947) compared the larvae of *R. cardinalis, R. koebelei* and *A. virginalis* (Wickham) and found those of *Rodolia* to have 2-segmented antennae, while those of *Anovia* have only 1 segment. This, with adult characters and differences in distribution, warrant the continued separation of the genera.

Key to the New World species of *Rodolia*

Elytron always red with numerous black markings .... **cardinalis** (Mulsant)

Elytron varying from entirely red to red with an elongate, sutural spot and broad black spot laterally .... **koebelei** (Coquillett)

Rodolia cardinalis (Mulsant)

Fig. 2, 3, 6, 10, 11, 12

Vedalia cardinalis Mulsant, 1850, p. 906.
Novius cardinalis: Crotch, 1874, p, 283.
Eurodolia cardinalis: Weise, 1895, p. 150.
Rodolia cardinalis: Weise, 1905, p. 220.–Weise, 1916, p. 50 (*Macronovius* group).
Rodolia aegyptiaca Sicard, 1907, p. 67.–Korschefsky, 1931, p. 99.
Macronovius cardinalis: Weise, 1922, p. 104.
Macronovius cardinalis ab. *obnubilatus* Weise, 1922, p. 104.–Korschefsky, 1931, p. 99.

Male and Female.–Length 2.65 to 4.18 mm, width 2.00 to 3.33 mm. Form elongate, elytron nearly parallel-sided, widest at middle. Color red, basal area of pronotum and head black; meso- and metasternum, femora and median area of first 2 abdominal sterna piceous; elytron with black maculation. Front leg with tibia and femur narrower than hind leg (fig. 2). Hind leg with tibia broad, femur with pubescence nearly absent on inner side (fig. 3). Male abdomen with last segment deeply emarginate medially (fig. 6). Male genitalia short, stout; basal lobe bent upward in apical one-third; paramere abruptly widened, sides parallel in apical one-half (fig. 10, 11); sipho wide, widened at base with a dorsal projection (fig. 12).

Type locality.–"la Nouvelle Hollande (collect. Hope)".

Type depository.–Oxford University, England.

Distribution.–Australia, southern Europe, North and South Africa, Java, North and South America.

The elytral color pattern is quite constant considering the wide geographic range of this species. The elytral variation is limited primarily to the partial fusion of some of the spots. The basal balck area on the pronotum may entirely cover the pronotum.

Rodolia cardinalis has had a confused history of generic placement. Mulsant (1850) erred when he placed *cardinalis* with the New World species *sieboldii* In the genus *Vedalia*. Crotch (1874) further confused the matter by placing *cardinalis* in the genus *Novius* and erroneously transferring 2 Mulsant species from *Rodolia* to *Vedalia*. The name *Macronovius* was proposed by Weise (1885) as a subgenus of *Novius* Mulsant for *Novius limbatus* Motschulsky and *Rodolia* *concolor* Lewis. The character used to separate *Novius* s. str. and *Macronovius* was the presence of an expanded and emarginate tibia allowing for the concealment of the tarsus in *Macronovius*, the tibia not being expanded or emarginate in *Novius*. Weise apparently was not aware that *Rodolia* had an expanded, emarginate tibia. In 1895, Weise again discussed *Novius* and related genera, describing a monobasic new genus, *Eurodolia*, and giving a key to separate *Novius*, *Rodolia* and *Eurodolia*. He listed 15 species of *Rodolia*, divided them into 2 unnamed groups on the basis of whether the claws were toothed or cleft, and *limbatus*, the type species of *Macronovius*, was placed in the first group (claws toothed). In the same paper he stated that *Macronovius* was a synonym of *Rodolia*. After the description of *Eurodolia* he stated that *Vedalia cardinalis* might belong in *Eurodolia*. In 1905, Weise placed *cardinalis* in *Rodolia*, stating that it belonged in the *Macronovius* group because of the toothed claws. In 1916, Weise referred to "*Eurodolia cardinalis*" from "W. Australien" (sic). In 1922, Weise referred again to "*Macronovius cardinalis*", describing an aberration, *obnubilatus*. Korschefsky (1931) treated *Macronovius* as a synonym of *Rodolia* and placed *cardinalis* in *Rodolia*. There is little doubt that this arrangement is correct. I have examined several species of *Rodolia* and have concluded that the claw character Weise used to separate his 2 groups within the genus is sexual. Males have a cleft claw and females have only a basal tooth on the claw.

Rodolia koebelei (Coquillett)
Fig. 13, 14, 15

Novius koebelei Coquillett, 1893, p. 20.–Lea, 1901, p. 493.–Leng, 1920, p. 214.
Rodolia koebelei: Korschefsky, 1931, p. 101.

Male and Female.–Length 2.55 to 3.10 mm, width 2.00 to 2.65 mm. Form elongate-oval, widest anterior to middle of elytra. Color red; pronotum and head black; meso- and metasternum and legs except tarsi piceous; elytron with a dark brown, elongate area on suture, a small. lateral, submarginal spot medially. Male abdomen with last sternum slightly emarginate. Male genitalia elongate; basal lobe flattened dorso-ventrally, broad, narrowed to a blunt tip at apical one-sixth; paramere narrow (fig. 13, 14); sipho wide, base unmodified (fig. 15).

Type locality.–Los Angeles, California.
Type depository.–USNM (neotype here designated).
Distribution.–Australia, California.

The elytra vary from completely red to having large sutural and lateral areas dark, these dark areas becoming contiguous postmedially.

Coquillett (1893) was apparently the first to describe *koebelei*, and he did so by describing the egg, 4 larval instars, and the pupa. No adult description was given. Lea (1901) stated that the name *koebeli* was a manuscript name in the A. S. Olliff collection and that the species was introduced into the United States under this name. There are 3 larvae and 1 pupa of *koebelei* in alcohol in the USNM collection received from Coquillett in 1892. There is no indication that these are actually the specimens upon which Coquillett based his description, but they were received from him and are possibly type material. There are also 7 first-instar and 1 second-instar larvae mounted on points in the USNM collection which may also be type material, as well as several adults, all labeled "5575". In addition, the adults are labeled "Coquillett, Los Angeles, Calif.", which is the type locality. Since it cannot definitely be established that these immature stages are type material, no lectotype is designated here. A neotype is here selected instead, a fourth-instar larva in the USNM alcohol collection matching Coquillett's description and bearing the label "No.-896 P.O.-13 No.-16, Rodolia (Vedalia n. sp.) on Icerya". Larval specimens of *R. cardinalis* bearing the same data are also labeled "Los Angeles, Calif., July '92, Coquillett", so it is assumed that the neotype of *koebelei* is also from Los Angeles.

Anovia Casey
Fig. 1, 4, 5, 7, 9

Anovia Casey, 1908, p. 408. Type species: *Scymnus virginalis* Wickham, by monotypy.

Head pubescent, clypeus thick, labrum on a distinctly lower plane than clypeus; eye finely faceted, pubescent, not emarginate; antenna 8-segmented, club 3-segmented (fig. 1); maxillary palpus with last segment large, securiform. Pronotum pubescent, deeply emarginate anteriorly, finely margined laterally and posteriorly in middle, hind angle obliterated, evenly rounded. Elytron pubescent, short, stiff setae present internally, lateral margin slightly explanate, epipleuron descending externally, not foveolate for reception of legs. Prosternum with intercoxal area strongly protuberant, extending beyond coxa, usually sparsely pubescent, not margined anteriorly. Proleg with femur deeply emarginate apically for reception of tibia (fig. 4); meso- and metafemora shallowly emarginate apically for reception of tibiae (fig. 5); tarsus 3-segmented. Abdomen with postcoxal line shallow, complete or nearly so, last sternum emarginate in male (fig. 7). Male genitalia with basal lobe curved upward and apex more or less bent downward in lateral view; paramere long, slender; sipho long, slender, pointed at apex, expanded basally. Female genitalia with receptaculum seminis short, stout, narrowed basally, lacking cornu and accessory gland (fig. 9).

Anovia is the only known native New World member of the Noviini; it closely resembles *Rodolia*, differing as noted in the generic key and discussion of *Rodolia*. Until now *virginalis* (Wickham) has been the only species placed in *Anovia*. A syntype of *Zenoria circumclusa* Gorham was loaned by R. D. Pope of the British Museum, and this species belongs in *Anovia* rather than *Zenoria* (Gordon, 1971).

Key to species of *Anovia*

Each elytron dark with a median red spot of varying size and sometimes a red subhumeral area 2
Each elytron unicolorous or red with a dark submarginal band .3
Epipleuron red or light reddish brown; elytron with a red subnumeral area . . . . **virginalis** (Wickham)
Epipleuron black or piceous; elytron without a red subnumeral area . . . . **mexicana,** n. sp.
Elytron black; inner margin of eye not parallel, farther apart at lower margin than at upper margin; peru . . . . **peruviana,** n. sp.
Elytron not black; inner margin of eye usually nearly parallel; not known from Peru 4
Male genitalia with basal lobe broad in ventral view, abruptly narrowed at apical one-third (fig. 23); dorsal color usually purple or reddish brown . . . . **punica,** n. sp.
Male genitalia with basal lobe not as described above; dorsal color variable 5
Dorsal color reddish purple; pronotum with lateral one-third red; male genitalia with apical one-half narrower than basal one-half in ventral view (fig. 26) . . . . **weisei,** n. sp.
Dorsal color uniformly red or red with a dark submarginal border; male genitalia with basal lobe slender, evenly tapered to apical point in ventral view (fig. 19) . . . . **circumclusa** (Gorham)

Anovia virginalis (Wickham)

Fig. 16, 17, 18

Scymnus virginalis Wickham, 1905, p. 166.
Anovia virginalis: Casey, 1908, p. 408

Male and Female.–Length 2.43 to 3.05 mm, width 2.00 to 2.44 mm. Form elongate-oval, widest anterior to middle of elytron. Color red; pronotum except anterior angle, head, and basal portion of femur piceous; elytron with a median red spot and a subhumeral red area. Male abdomen with last sternum slightly emarginate medially (fig. 7). Male genitalia with basal lobe broad, pointed, very slightly bent downward at apex, ventral surface with lateral margin extending inward medially; paramere long, narrow (fig. 16, 17); sipho slender, pointed, basal end abruptly expanded (fig. 18).

Type locality.–Chad's Ranch, Utah (Virgin River Valley).

Type depository.–USNM.

Distribution.–United States: Arizona, New Mexico, Texas, Utah. Mexico: Sonora, San Luis, Vera Cruz, Victoria.

The red median spot on each elytron varies from a small discal area to a large spot occupying most of the elytron. This species has been recorded as attacking *Steatococcus plucheae* (Cockerell) and *Icerya rileyi* Cockerell in New Mexico.

Anovia circumclusa (Gorham)

Fig. 19, 20, 21, 31, 32, 33, 34

Zenoria circumclusa Gorham, 1899, p. 262.–Korschefsky, 1931, p, 108.–Blackwelder, 1945, p. 443.
Anovia circumclusa: Gordon, 1971, p. 1.

Male and Female.–Length 2.60 to 3.10 mm, width 2.43 to 2.59 mm. Form elongate-oval,

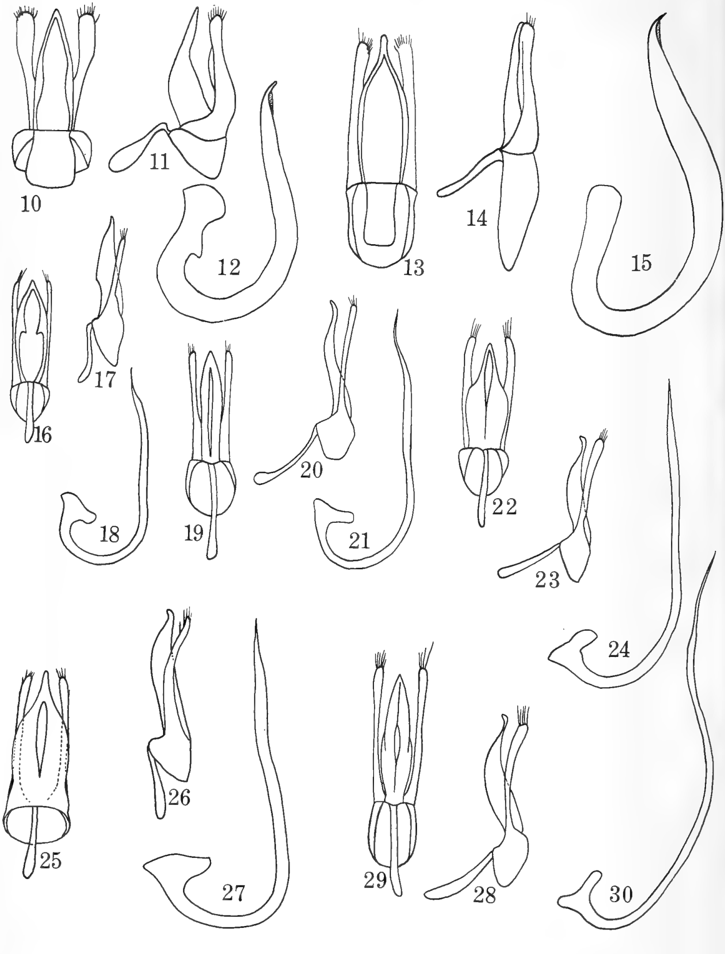


Fig. 10-30, male genitalia. Fig. 10-12, *Rodolia cardinalis*. Fig. 13-15; *Rodolia koebelei*, Fig. 16-18; *Anovia virginalis*. Fig. 19-21; *Anovia circumclusa*. Fig. 22-24; *Anovia punica*. Fig. 25-27; *Anovia mexicana*. Fig. 28-30; *Anovia weisei*.

widest anterior to middle of elytra. Color reddish yellow; a black band completely encircling elytron and extending onto basal part of pronotum, discal spot and elytral margin reddish yellow (fig. 31); ventral surface pale yellow. Male abdomen with last sternum slightly emarginate medially. Male genitalia with basal lobe long, slender, curved downward at apex, in ventral view evenly tapered to pointed apex; paramere long, slender (figs. 19, 20); sipho slender, pointed, gradually curved upward near apex, basal end abruptly expanded (fig. 21).

Type locality.—Panama; Volcan de Chiriqui.

Type depository.—British Museum (lectotype here designated).

Distribution.—Guatemala: Salama. Honduras: Tegucigalpa; La Ceiba. Mexico: Tampico. Panama: Volcan de Chiriqui.

The specimens from Tampico lack the black zonate band on the elytron. The male genitalia of the Tampico specimens are identical to those of the zonate specimens, and since this zonate color pattern is quite variable in several genera of Neotropical Coccinellidae, these specimens are here considered to be *circumclusa* (fig. 32-34). A syntype of *circumclusa* in the British Museum bearing the following labels is here designated lectotype: "Syntype"; V. de Chiriqui, 4000-6000 ft., Champion"; "circumclusa Gorham."

Anovia punica, n. sp.
Fig. 22, 23, 24

Male.—Length 3.42 mm, width 2.97 mm. Form oval, widest anterior to middle of elytra. Color reddish purple; narrow lateral margin of elytron, anterior margin and angles of pronotum and ventral surface red. Head finely punctured, punctures separated by 1 to 2 times their diameter; covered with grayish white, semi-decumbent pubescence; inner margin of eye nearly parallel. Pronotum finely punctured, punctures separated by 1 to 4 times their diameter; covered with grayish white, semi-decumbent pubescence. Elytron finely punctured, punctures separated by 2 times their diameter; covered with grayish white, semi-erect pubescence. Abdomen with last sternum slightly emarginate. Genitalia with basal lobe broad, abruptly narrowed to a blunt point in apical one-third; paramere long, slightly widened apically (fig. 22, 23); sipho long, slender, apex pointed, base suddenly expanded (fig. 24).

Female.—Similar to male in all respects except sexual characters.

Variation.—Length 3.00 to 3.30 mm, width 2.71 to 3.00 mm. Four specimens from Colombia have the dorsal surface entirely red with no trace of purple. Two specimens from Trinidad have the dorsal surface red with the black band as in typical *circumclusa*.

Holotype.—Male. Venezuela: Edo. Aragua, Maracay, 22-VII-41, C. H. Ballou, eating *Icerya purchasi* (USNM 71725).

Paratypes.—Total 83. Colombia: Candelaria, 17-X-39; La Esperanza, Feb. 21, 1938, L. M. Murillo; Buga, 21-II-38, L. M. Murillo. Honduras: La Ceiba, March 21-20, WM Mann. Panama: Canal Zone, Oct. 29, 1918, F. F. Dietz; Cristobal, Canal Zone, July 5, 1918, H. F. Dietz, Zetek & Molina; Panama City, July 30, 1918, H. F. Dietz; XX Plantation, Feb. 11, 1930, Blackwelder. Trinidad: Warren, III, 1953, F. D. Bennett; Balandra, Feb. 1965, F. D. Bennett; V-9-1911, A. Busck. Venezuela: same data as holotype; El Valle, C. H. Ballou; Yuma, E. Carabobo, 3-VI-1950, F. Fernandez. (USNM) (Inst. Zoology. Agric., Maracay, Venezuela).

This species has been recorded feeding on *Icerya purchasi* Maskell and *Icerya montserratensis* Riley and Howard in Venezuela and Panama.

The color pattern shows the same range of variation from red to red with a zonate band to dark purple that is found in several species of *Zenoria* and *Epilachna*, as well as *A. circumclusa*. In some instances, particularly in *Zenoria*, this is apparently linked with the maturity of the specimens, but this does not seem to be the case for *A. punica*.

Anovia mexicana, n. sp.
Fig. 25, 26, 27

Male.—Length 3.00 mm, width 2.60 mm. Form oval, widest anterior to middle of elytra. Color black; narrow lateral margin of pronotum, labrum and entire ventral surface except epipleuron and pro- and mesosternum red; elytron with a small, red discal spot. Head finely punctured, punctures separated by their diameter; covered with grayish white, semi-decumbent pubescence; inner margin of eye nearly parallel. Pronotum finely punctured, punctures separated by their diameter or less; covered with grayish white, semi-decumbent pubescence. Elytron finely punctured, punctures separated by less than to twice their diameter; covered with grayish white, semi-erect pubescence.

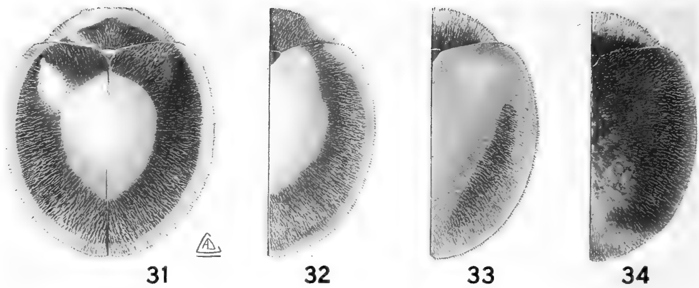


Fig. 31-34; habitus views, *Anovia circumclusa*.

Abdomen with last sternum feebly emarginate. Genitalia with basal lobe broad, narrowed to a blunt point in apical one-third; paramere slender, angled upward in apical one-third (fig. 25, 26); sipho short, broad, apex pointed (fig. 27).

Female.–Similar to male except last abdominal sternum more deeply emarginate.

Variation.–Length 3.00 to 4.00 mm, width 2.60 to 3.48 mm. The red, discal spot on the elytron is slightly larger in some specimens than others.

Holotype.–Male. Mexico: Morelos, 16 mi. south Cuernavaca, Aug. 22, 1958, H. Howden (Canadian National Collection, Ottawa).

Paratypes.–Total 4. Mexico: Guerrero, 17 mi. N. Mexcala, Aug. 23-24, 1958, H. F. Howden; Guerrero, 13 mi. N. Chilpancingo, Aug. 25, 1958, H. F. Howden; Guerrero, 8 mi. N. Iguala, Aug. 23, 1958. H. F. Howden. (CNC) (USNM)

The male genitalia of this species are nearest those of *punica* but the sipho is short and stout in *mexicana*, long and slender in *punica*. In addition the dorsal color is predominantly black in *mexicana*, reddish purple in *punica*. In external appearance *mexicana* resembles *virginalis*, but *mexicana* is larger and has the punctures on the head and pronotum denser than does *virginalis*.

Anovia weisei n. sp.
Fig. 28, 29, 30

Male.–Length 4.00 mm, width 3.66 mm. Form nearly round, slightly elongate, widest at middle of elytra. Color yellowish red; vertex of head and median one-third of pronotum black; elytron entirely reddish purple. Head finely punctured, punctures separated by their diameter or less; covered with dense, grayish white pubescence; inner margin of eye feebly rounded. Pronotum finely punctured, punctures separated by 1 to 4 times their diameter; covered with grayish white, semi-decumbent pubescence. Elytron with punctures coarser than on pronotum, separated by their diameter or less; covered with grayish white, semi-erect pubescence. Abdomen with last sternum slightly emarginate. Genitalia with basal lobe shorter than paramere, anterior one-half narrower than basal one-half in ventral view, narrowed before blunt apex in lateral view; paramere gradually widened toward apex (fig. 28, 29); sipho long, slender, acuminate at apex (fig. 30).

Female.–Not known.

Holotype.–Male. Guatemala: "ex Guatemala", N. Orleans 60-20819 (USNM 71726).

Paratype.–Total 1. Same data as holotype. (USNM).

Externally *weisei* most nearly resembles the dark form of *A. punica*, but the lateral red area of the pronotum occupies one-third of the elytron in *weisei* and is only a narrow border in *punica*. The male genitalia are quite different in the 2 species. The 2 type specimens were intercepted by Plant Quarantine inspectors at New Orleans and are labeled as being from Guatemala.

Anovia peruviana, n. sp.

Female.–Length 4.00 mm, width 3.59 mm. Form oval, widest near middle of elytra. Color black; metasternum, anterior and middle tibiae, hind legs and abdomen brownish yellow. Head finely punctured, punctures separated by their diameter or less; covered with grayish white, nearly erect pubescence; inner margin of eye distinctly rounded, not parallel, divergent toward lower margin of eye. Pronotum very finely punctate, punctures finer than on head, separated by 1 to 4 times their diameter; covered with grayish white pubescence. Elytron finely punctured, punctures subequal to punctures on head, separated by 1 to 2 times their diameter; covered with grayish white, nearly erect pubescence.

Holotype.—Female. Peru: Tingo Maria, 1949, J. Dieguez (USNM 71727).

The type is unique and is the only specimen of the genus seen from as far south as Peru. The large size, divergent eyes and shining, black dorsal surface separate it from any presently known species of *Anovia.*

References Cited

Blackwelder, R. E. 1945. Checklist of the Coleopterous Insects of Mexico, Central America, the West Indies, and South America, Part 3. United States National Museum Bulletin 185, 188 p.

Casey, T. L. 1908. Notes on the Coccinellidae. Can. Entomol. 40: 393-421.

Coquillett, D. W. 1893. Report on some of the beneficial and injurious insects of California. U. S. Department of Agriculture Entomol. Bull. 30: 9-33.

Crotch, G. R. 1874. A Revision of the Coleopterous family Coccinellidae. 311 p. London.

Gordon, R. D. 1971. A revision of the genus *Zenoria* Mulsant (Coleoptera: Coccinellidae). Smith. Contr. Zool. No. 86, 22 p.

Gorham, H. S. 1899. Biologia Centrali-Americana, Insecta, Coleoptera, Supplement to Endomychidae and Coccinellidae 7: 257-265.

Korschefsky, R. 1931. Pars 118, Coccinellidae I. Volume 16, p. 1-224, in Coleopterorum Catalogus.

Lea, A. M. 1901. New species of Australian Coleoptera. Proc. Linnean Soc. New South Wales 36: 448-513.

Leng, C. W. 1920. Catalogue of the Coleoptera of America, North of Mexico. 470 p. Mount Vernon, New York.

Mulsant, E. 1850. Species des coléoptères trimères securipalpes. Annales des Sciences Physiques et Naturelles, Lyon 2(2): 1-1104.

Priore, R. 1963. Studio morfo-biologico sulla *Rodolia cardinalis* Muls., Bolletino del Laboratorio de Entomologia Agraria Filippo Silvestri di Portici 31: 63-193.

Rees, B. E. 1947. Taxonomy of the larvae of some North American Noviini (Coleoptera, Coccinellidae). Pan-Pac. Entomol. 23: 113-119.

Sicard, A. 1907. Description d'une nouvelle espece de Coccinellide palearctique (Col.). Bull. Soc. Entomol. France 5: 67-68.

Weise, J. 1885. Bestimmungs-Tabellen der europaischen Coleopteren, II. Coccinellidae. 83 p.

________1895. Über die mit *Novius* Muls. verwandten gattungen. Ann. Soc. Entomol. Belgique 39: 147-150.

________1905. Ueber Coccinelliden. Deutsche Entomol. Zeitschr. 2: 217-220.

________1916. Results of Dr. E. Mjöberg's Swedish Scientific Expedition to Australia 1910-1913, II. Chrysomeliden und Coccinelliden aus West-Australien. Arkiv Zool. K. Svenska Vetenskaps. 10: 1-51.

________1922. Ueber einige amerikanische und australische, nach Sudfrankreich eingeführte Coccinelliden. Wiener Entomol. Zeitung 29: 104.

Wickham, H. F. 1950. New species of Coleoptera from the western United States II. Can. Entomol. 37: 165-171.

The South American Katydid Genus Acanthacara: Descriptive Notes and Subfamily Position (Orthoptera: Tettigoniidae, Agraeciinae)

Ashley B. Gurney

Systematic Entomology Laboratory, Agr. Res. Serv., USDA, c/o U.S. National Museum, Washington, D.C. 20560

ABSTRACT

The katydid genus *Acanthacara*, based on the single species A. *acuta* Scudder, is found to belong to the tettigoniid subfamily Agraeciinae. The taxonomic basis for this assignment is given. In early U.S. literature the name *Acanthacara* was applied to the present genus *Belocephalus.*

During recent studies of various Copiphorinae, I became interested in the genus *Acanthacara*, based by Scudder (1869) on a single species from Ecuador, which Karny (1913a: 10) tentatively placed in the Copiphorinae. After having been privileged to examine the unique type specimen of *A. acuta* Scudder belonging to the Museum of Comparative Zoology, and finding the specimen to belong to the subfamily Agraeciinae instead of the Copiphorinae, it appears worthwhile to publish clarifying notes and photos of the previously unfigured and scantily described holotype. A sidelight of this study has been the examination of several early mistaken uses of the name *Acanthacara* for North American species which in reality belong to *Belocephalus*. This old usage is now chiefly of historical interest, but it is documented briefly for students who otherwise may be confused.

The unique holotype of *Acanthacara acuta* (Fig. 1-3) is a female, apparently in the last instar prior to maturity. It is labelled "Quito to Napo" and was collected by Professor James Orton of Vassar College while on an 1867 expedition in Ecuador. According to Orton (1876: 177-182), the journey from Quito to Napo occurred between October 30 and about mid-November, 1867, but it is uncertain whether the type specimen was collected east of the main mountain ridge and thus in Atlantic drainage.

Of the specimen's legs, only the right middle one remains, though a posterior one was described by Scudder. The ovipositor, even in his time, was damaged. The following descriptive notes supplement Scudder's: A transverse line of demarcation between base of fastigium and front, but no sulcus; prosternum unarmed; posterior margin of pronotum very broadly concave; vestiges of immature tegmina present; middle femur unarmed on ventral or dorsal margins, genicular lobes each with 1 apical-ventral spine, the anterior one clearly shorter than posterior one; tibia with 5 pairs of small ventral spines in apical half; tarsal segments 1 and 2 with lateral linear furrows; last tergum prior to epiproct with posterior margin deeply emarginate with sharply V-shaped incision; apex of subgenital plate nearly entire, with trace of emargination at narrowed apex. Measurements in millimeters: Overall, 20.5; fastigium in front of anterior margin of compound eyes, 2.0; pronotal length, 3.7, greatest width, 3.3; length of posterior genicular spine of middle femur, 0.45.

Although Scudder (1869) initially did not give a subfamily assignment for *Acanthacara*, he later (Scudder, 1896: 210) referred it to the Pseudophyllinae. Contrary to his announced reason, however, I do not find the margins of the antennal sockets as strongly formed as in most Pseudophyllinae, and the structure of the vertex is different from

Figs. 1-3.–Holotype of *Acanthacara acuta* Scudder. 1, lateral view; 2, dorsal view; 3, lateral view (slightly ventral) of head and thorax (all much enlarged) (Photos by Victor E. Krantz, Smithsonian Institution).

Pseudophyllinae with which I am familiar. The logical choice of subfamily position thus appears to be either Copiphorinae, as favored by Karny (1913a), or Agraeciinae, and my judgement is that the characters of *Acanthacara* place it in the subfamily Agraeciinae, where it seems closely related to *Agraecia* and *Eschatoceras*.

The following characters indicate an agraeciine rather than a copiphorine position: 1) vertex separated from frons only by a line of demarcation; 2) vertex without a ventral tooth near base; 3) basal part of fastigium above narrower than first antennal segment; 4) ovipositor curved dorsally; 5) general color brownish instead of green.

Several described species of *Eschatoceras* occur in the region of the Upper Amazon River (Karny, 1913b: 19), and the fastigium of *Agraecia subulata* Redt. likewise is suggestive of *Acanthacara*. In the absence of more adequate material of *Acanthacara acuta*, especially mature specimens, a final decision on the generic distinctness of *Acanthacara* cannot be made.

The misapplication of *Acanthacara* to North American species probably occurred because of the superficial resemblance of the sharp, curved fastigium of *Belocephalus* to that of true *Acanthacara*, though in reality the ventral tooth and wide transverse sulcus at the base of fastigium in *Belocephalus* indicate a fundamentally different relationship. Thomas (1874: 71) used the name *Acanthacara acuta* Scudder for a female from an unstated locality; from his description, it belongs to *Belocephalus*. Also in 1874, Glover completed but did not publish an illustration (Pl. 16, fig. 17) which he labelled *Acanthacara*; it is cited by Hebard (1926: 148), but Scudder (1875) referred to the illustration as unpublished. Dodge (1888) reviewed Glover's work in detail; the first 13 plates of Orthoptera in Glover's Illustrations were published in 1872 and the same plus 5 additional ones of Orthoptera were included in his final large work in 1878. In an April 10, 1874 letter to Osten-Sacken (see Dodge, *l.c.*, page 49) Glover wrote "I am busy revising and correcting names, notes and figures of my Orthoptera, and have etched from additional plates from Thomas' new species collected by Hayden and Wheeler." It is likely that copies of the new Orthoptera plates were sent to Cambridge, Mass. at the same time he corresponded about Diptera plates with Osten-Sacken, who then was in Cambridge, and that Scudder saw them. At any rate, *Belocephalus* was first proposed a year later (Scudder, 1875), and on Plate 16 of Glover's work distributed in 1878 the name *Belocephalus subapterus* appeared with the notation "in Scudder's letter," showing that Glover received from Scudder the correction of the earlier wrong use of *Acanthacara*. Scudder (1901: 1) cited Glover's 1874 use without further comment.

One further use of *Acanthacara* occurred when Riley and Howard (1889) published the name *Acanthacara similis* as quoted from a letter to a correspondent who had submitted a specimen from Florida with an inquiry. There is now in the National Museum a female specimen identified as *Belocephalus davisi* R. & H. by Hebard in 1926 and also seen by him in 1915. It is from Florida and bears a Thomas manuscript type label, but the name was never validated. The specimen may be the same one Thomas called *A. acuta* in 1874; I do not know of active work on Orthoptera publications by him after 1880.

Acknowledgments

In addition to the cooperation of Dr. Howard E. Evans, Harvard University, in making a type specimen available for study, I am indebted to Dr. Irving J. Cantrall, University of Michigan, for comparing photos of *Acanthacara acuta* with specimens of Tettigoniidae in the Museum of Zoology.

References Cited
(with annotations)

Dodge, C.R. 1888. The life and work of the late Townend Glover, first entomologist of the U. S. Department of Agriculture. U. S. Dept. Agr., Div. Entomol., Bull. 18: 1-68, illus. (Includes complete list of publications with detailed account of Glover's *Illustrations of North American Entomology*.)

Glover, Townend. 1872. Illustrations of North American Entomology (United States and Canada). Orthoptera. i-v+11 p., 13 pl. (Some copies with colored plates, others lacking color; each plate with opposite sheet bearing printed list of names; 50 copies distributed; no new species included.)

________1878. Illustrations of North American Entomology in the orders of Coleoptera, Orthoptera, Neuroptera, Hymenoptera, Lepidoptera, Hemiptera and Diptera. 273 pl., Washington, D.C. (Includes 18 plates on Orthoptera; for all orders except Lepidoptera the names were hand-lettered at the bottom of the plates; some lists of names also included; 12 copies distributed, a few others preserved; some plates colored; no new species included; probably constitutes publication though issue was very small; as cited by Dodge (1888), the title included Homoptera instead of Hemiptera, and this form has been cited elsewhere.)

Hebard, M. 1926. A revision of the North American genus *Belocephalus* (Orthoptera; Tettigoniidae). Trans. Amer. Entomol. Soc. 52: 147-186, illus.

Karny, H. 1913a. Orthoptera, Fam. Locustidae, Subfam. Copiphorinae. Genera Insectorum, Fasc. 139: 1-50, illus.

________1913b. Orthoptera, Fam. Locustidae, Subfam. Agraeciinae. Genera Insectorum, Fasc. 141: 1-47, illus. (Both Karny publications bear the imprint 1912 but were distributed in early to mid-1913.)

Orton, James. 1876. The Andes and the Amazon; or across the continent of South America. 3rd ed., 645 p., illus. (General account, written following a second trip, 1873.)

Riley, C.V., and L.O. Howard (Editors). 1889. *Acanthacara similis* injuring pineapple in Florida. Insect Life 1(7): 217-218. (Consists of 2 letters from a correspondent and 1 reply giving name of specimen submitted, with notes.)

Scudder, S.H. 1869. Notes on Orthoptera collected by Professor James Orton on either side of the Andes of Equatorial South America. Proc. Boston Soc. Nat. Hist. 12: 330-345. (Also distributed as a reprint under the heading Entomological Notes, pp. 15-30; Karny (1913a) gave 1868 as the year of publication, but published Society records indicate that the paper appeared in 1869.)

________1875. A century of Orthoptera. Decade II. Locustariae. Proc. Boston Soc. Nat. Hist. 17: 454-462. (Also issued in reprint form in 1879, pp. 7-15.)

________1896. List of exotic Orthoptera describec by S.H. Scudder, 1968-1879, with a revision of their nomenclature. Proc. Boston Soc. Nat. Hist. 27: 201-218.

________1901. Alphabetical Index to North American Orthoptera Described in the Eighteenth and Nineteenth Centuries. Separate publication, Boston Soc. Nat. Hist., 398 p.

Thomas, C. 1874. Description of some new Orthoptera and notes on some species but little known. Bull. U. S. Geolog. & Geograph. Surv. Terr. 1(2): 63-71.

Descriptive and Synonymical Notes for Some Species of Noctuidae from the Galapagos Islands (Lepidoptera)[1]

E.L. Todd

Systematic Entomology Laboratory, Agr. Res. Serv., U.S. Department of Agriculture; c/o U.S. National Museum, Washington, D.C. 20560

The following comments pertaining to species of the genera *Spragueia* Grote, 1875, and *Catabena* Walker, 1865, have been lifted from manuscript revisions of those genera and are presented herein in order that Mr. Alan Hayes of the British Museum (Natural History) might use the appropriate names in a proposed catalog of the Macroheterocera of the Galapagos Islands.

Spragueia creton Schaus

Spragueia creton Schaus, 1923, Zoologica 5(2): 38, pl. 1, fig. 9.

Spragueia plumbeata Schaus, 1923, Zoologica 5(2): 38, pl. 1 fig. 10. [New synonymy].

When Schaus proposed the specific names cited above he was studying material collected by William Beebe during the Williams Galapagos Expedition of the New York Zoological Society, 1923. The number of individuals collected, the localities, the dates and usually the sexes of the specimens are listed on pages 23 through 31. Schaus stated in the introductory comments that the types of the new species were deposited in the collections of the United States National Museum, but he usually did not indicate either in the list or in the descriptions that follow which specimen was the type. He did cite a type catalog number for each species. In the case of *Spragueia creton* Schaus, a male and a female from Tower Island [Isla Genovesa] collected April 28, 1923 and a male from South Seymour [Isla Baltra] collected April 23, 1923 were available for study by Schaus. The specimen in the United States National Museum is labeled: "Spragueia creton Schs., type"; "Tower Island, Galapagos, April 28, 1923"; "Type No. 26512 U.S.N.M."; "Photo Noc. 151"; and "o genitalia on slide E.L.T. 4601". The specimen has been selected, labeled, and is presently designated as lectotype. *Spragueia plumbeata* was based on a unique female from Conway Bay, Indefatigable [Isla Santa Cruz]. The holotype is in the collection of the United States National Museum. The types of the two names are illustrated in figs. 1 and 2.

In the original description of *creton*, Schaus stated: "Allied to *S. dama* Guenée." *Spragueia dama* (Guenée) is very closely related to *creton*. It is one of the most variable species of the genus in coloration of the wings and is a common, wide-spread species. It occurs in the Gulf States of the United States of America, in the Greater Antilles, México, Central America and South America south to Chile and Argentina. There is considerable sexual dimorphism in the coloration of the forewings of *dama*. Some females have the forewings colored as in dark males, but most females are very decidedly darker, the forewings largely black with the orange areas generally greatly reduced. In consideration of the color variation and dimorphism in *dama* and because of the close relationship of *dama* and *creton*, it is my opinion

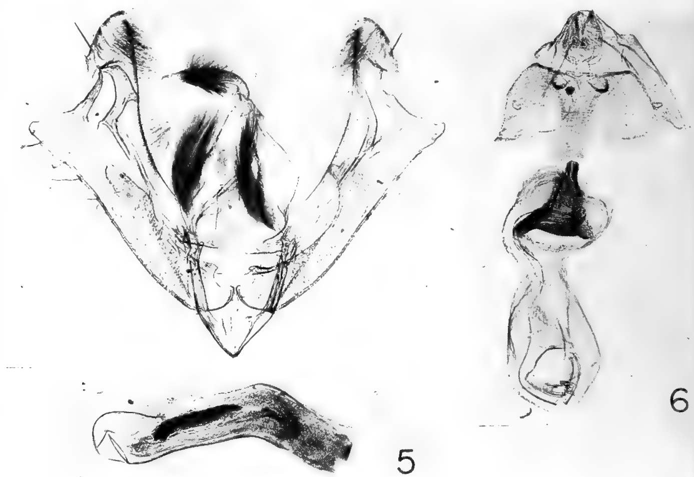
---

[1]Contribution No. 138 of the Charles Darwin Foundation.

Figs. 1-4. Dorsal view of adults: 1, *Sprагueia creton* Schaus, lectotype ♂, Tower Island [Isla Genovesa], Galapagos, USNM; 2, *S. plumbeata* Schaus, holotype ♀, Conway Bay, Indefatigable [Isla Santa Cruz], Galapagos, USNM; 3, *Catabena seorsa* n. sp., paratype ♂, Academy Bay, Isla Santa Cruz, Galapagos, USNM; 4, same, paratype ♀, Charles Island [Isla Santa Maria], Galapagos, BMNH.

that *plumbeata* represents an extremely dark example of *creton*. Therefore, I have placed *S. plumbeata* Schaus in the synonymy of *S. creton* Schaus.

Initially I believed that *creton* and *plumbeata* would probably fall as synonyms of *dama*, but examination of the types of the Schaus species, study of the original descriptions, and comparison with specimens of *dama* have dictated a change in opinion. Differences appear to exist, but I have been able to examine only the types of *creton* and *plumbeata*, and subsequent study of other material from the Galapagos Islands will be required in order to determine whether the differences noted are consistent. It appears that the fringe of the forewing of *creton* is black or black tipped with white. In the very large series of *dama* available for study the fringe of the forewing at the apex and on the caudal half is bright orange, even in the darkest females. In other species of *Spragueia* the coloration of the fringe of the forewing is rather constant for a species and usually characteristic. The male genitalia of the lectotype of *creton* differs from those of specimens of *dama* examined in the nature of the apical part of the costal margin of both the left and right sacculi (see figs. 7, 8). The projection of the apical part of the costal margin of the left sacculus in *creton* is very broad and rounded while in *dama* both the distal margin and the middle of the costal margin of the sacculus of the left valve are more or less emarginate, resulting in a narrower, more digitiform process. The degree of emargination of the margins of the left sacculus and the width of the projection is somewhat variable in the genitalia of *dama*, but none of those examined approached closely that of *creton* in width of the process. The corresponding area of the sacculus of the right valve is developed into a short process in *creton* while in *dama* that process



Figs. 5-6. Male and female genitalia of *Catabena seorsa* n. sp.: 5, ♂ genitalia, caudal view, aedeagus removed and shown in lateral view, genitalic preparation no. 2147, E. L. Todd, paratype, Academy Bay, Isla Santa Cruz, Galapagos; 6, ♀ genitalia, ventral view, genitalic preparation no. 2151, E. L. Todd, paratype, Academy Bay, Isla Santa Cruz, Galapagos.

is either not developed or only slightly so. When more material of *creton* is available perhaps the consistency of the differences and their significance may be determined and the relationship of *creton* and *dama* better understood. On the basis of present knowledge it seems best to consider *creton* as distinct.

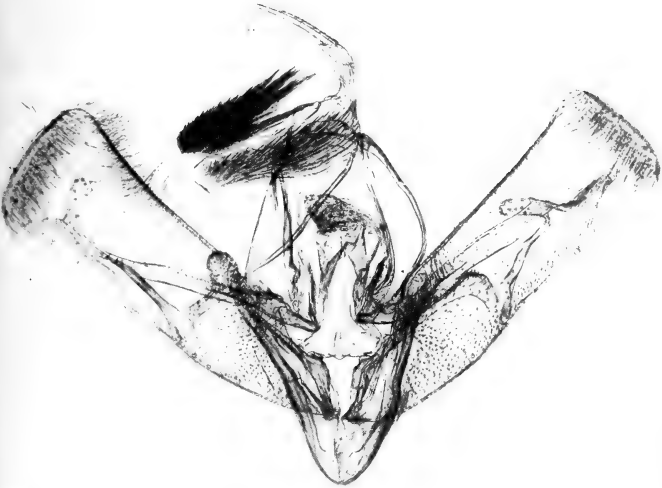
Catabena seorsa, new species

Catabena sp. ? Schaus, 1923, Zoologica 5(2): 25.

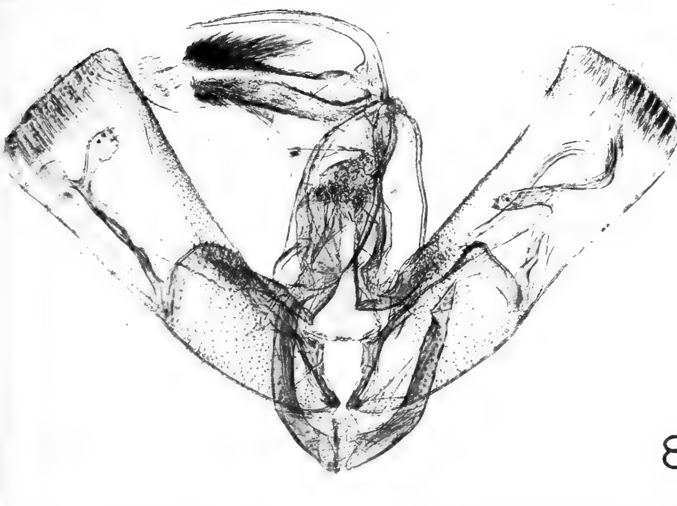
Head with proboscis well developed; labial palpi slightly upcurved, reaching about to middle of frons, third segment shortest, only about one-third length of second segment, palpi loosely-scaled especially ventral margins, nearly white, second segment with some scattered gray scales, third segment darker; frons slightly bulbous, exceeding anterior margin of eye approximately one-third length of eye, vestiture of frons white except a transverse band of dark brown scales below antennae; antennae filiform in both sexes. Vestiture of thorax, patagia, and abdomen of pale gray and white-tipped scales; thorax and abdomen lacking tufts. Pectus clothed with white scales and hair; tympanum moderate and only partially shielded by abdominal hood; legs unmodified, hindleg nearly white with only a small area of dark brown scaling near base of each tarsal segment, midleg and hindleg progressively darker in coloration.

Pattern of maculation as illustrated (figs. 3, 4), reniform, orbicular, and claviform spots not developed. Ground color of forewing cream white or pale gray; antemedial line, postmedial line, and short subterminal striae in cells M_2 M_3 Cu_2, and 1st Anal dark brown or black, other maculation gray brown; fringe checkered, interrupted at the veins. Hindwing white with conspicuous fuscous marginal band and weakly checkered fringe in both sexes. Undersurface of forewings pale with darker shading in apical half, but without definite maculation of dorsal surface, discal cell clothed with sparse, long pale hairs; undersurface of hindwing like dorsal surface except marginal band not as well developed. Length of forewing, male, 9-11 mm, female, 8-12 mm.

Male genitalia as illustrated (fig. 5). Size moderate for species size, distance from base of uncus to tip of vinculum approximately 2 mm, length of aedeagus also 2 mm. Shape of valvae characteristic, ventral margin of each valve triangularly produced ventrad immediately distad of sacculus; clasper of right valve rather long and slightly sinuous, that of left valve swollen apically, with a



7



8

Figs. 7-8. Male genitalia of *Spragueia* species: 7, *S. dama* (Guenée), genitalic preparation no. 4605, E.L. Todd, Cayuga, Guatemala; 8, *S. creton* Schaus, genitalic preparation no. 4601, E.L. Todd, lectotype, Tower Island [Isla Genovesa], Galapagos.

short costal lobe near middle, foot-shaped; aedeagus with a moderately large (1/3 length aedeagus) cornutus; costal margin of right sacculus strongly concave, a short, rounded dorsal process at apex.

Female genitalia as illustrated (fig. 6). Length from ostial opening to anterior end of corpus bursa approximately 5 mm. Sclerotization of proximal part of corpus bursa as wide as long, irregularly triangular in outline.

Holotype, male, Academy Bay, Isla Santa Cruz, Galapagos Arch., Feb. 7, 1964, R.O. Schuster; 3♂ and 3♀ paratypes, same data; 1♂ and 4♀ paratypes, same place and collector, Feb. 6, 1964; 1♂ and 6♀ paratypes, same place and collector, Feb. 8, 1964, 1♂ paratype, same place and collector, Feb. 3, 1964; 4♀ paratypes, same place and collector, Feb. 10, 1964; 1♀ paratype, same place and collector, Feb. 18, 1964; 1♀ paratype, same place, Feb. 20, 1964, D. Q. Cavagnaro and D.O. Schuster; and 1♀ paratype, same place and collectors, Feb. 23, 1964, in the collection of the California Academy of Science, San Francisco. Two female paratypes, Charles Island, Galapagos, July 31, 1924, C. L. Collenette, St. George Expedition, in The British Museum (Natural History), London, England. One male paratype, Academy Bay, Isla Santa Cruz, Galapagos Arch., Feb. 10, 1964, R. O. Schuster; 1♂ paratype, same place and collector, Feb. 8, 1964; 1♂ paratype, same place and collector, Feb. 6, 1964; 1♀ paratype, same place, Feb. 24, 1964, D. Q. Cavagnaro and R. O. Schuster, in the United States National Museum, Washington, D.C.

This species is a member of the *vitrina* complex of the genus *Catabena*. It resembles *Catabena terens* (Walker) in maculation, but the forewing is paler, the antemedial and postmedial lines more contrasting, the median shade broader, and the marginal band of the hindwing broader and developed farther toward the anal angle. It differs from all the described species of the *vitrina* complex in that the ventral margins of the valves of the male genitalia are triangularly produced ventrad beyond the sacculus (see figure 5). The actual relationship of *seorsa* to the other species of the complex cannot be discussed at this time and must of necessity await the descriptions of several other undescribed species.

Acknowledgments

The author wishes to acknowledge the assistance of the authorities of the California Academy of Sciences and of the British Museum (Natural History). The loan of material from these institutions has made possible the study and description of *Catabena seorsa*, new species. The photographs utilized for the illustrations were made by the staff of the National Museum of Natural History Photographic Laboratory.

A New Oriental Species of Culicoides Breeding in Tree Rot Cavities (Diptera: Ceratopogonidae)

Willis W. Wirth and Alexander A. Hubert

Systematic Entomology Laboratory, Agr. Res. Serv., USDA, c/o U.S. National Museum, Washington, D.C. 20560; and Lt. Colonel, MSC, Department of the Army, 406th Medical Laboratory, APO San Francisco 96343, respectively.

ABSTRACT

Culicoides dryadeus Wirth and Hubert, new species, is described. It was reared from wet soil in a tree hole in Selangor, Malaya.

In this paper we describe a new species of *Culicoides* Latreille to make the name available for workers reporting on biting midges in India. The description was extracted from a comprehensive revision that we have in preparation on the *Culicoides* of Southeast Asia. Our terminology was explained in papers by Wirth and Blanton (1959) and Wirth and Hubert (1959).

Culicoides dryadeus
Wirth and Hubert, new species
(Fig. 1-8)

Female.—Length of wing 0.97 mm.

Head: Eyes narrowly separated, bare. Antenna (fig. 1) with lengths of flagellar segments in proportion of 20-15-15-16-15-16-16-19-23-24-24-25-28, antennal ratio 0.95; sensoria present on segments 3, 11-15. Palpal segments (fig. 2) with lengths in proportion of 13-33-35-14-10; third segment moderately swollen subapically, with a small, round, shallow, subapical, sensory pit; palpal ratio 2.5. Proboscis moderately long, P/H Ratio 0.80; mandible with 15 teeth.

Thorax: Dark brown, without apparent pattern in slide-mounted specimen. Legs (fig. 5) dark brown, femora slightly paler at bases; femora with faint subapical pale rings, tibiae with distinct subbasal pale rings; knee spots blackish; hind tibial comb (fig. 3) with 4 spines, the one nearest the spur longest.

Wing (fig. 4): Pattern as figured; intensely dark gray, even more so in region between radius and costa; with 4 prominent yellowish spots, a moderately large transverse spot over r-m crossvein not quite reaching costa or vein M, a small round spot on anterior margin just distad of second radial cell, a small transverse spot straddling base of media a third of distance between basal arculus and r-m crossvein, and a larger transverse spot straddling mediocubital stem almost halfway to its fork, the latter spot sometimes absent (in one paratype) or broken into 2 spots, over mediocubital stem and over anal vein. Macrotrichia very long and abundant, reaching to base of cell M2 and anal cell abundantly; costal ratio 0.58; second radial cell moderately broad, with distinct lumen. Halter deeply infuscated.

Abdomen: Brown. Spermathecae (fig. 6) 2, ovoid with slight taper to very short, slender, sclerotized necks; subequal, each measuring 0.058 by 0.044 mm.

Male Genitalia (fig. 8).—Ninth sternum with broad, shallow, caudo-median excavation, the ventral membrane not spiculate; ninth tergum moderately long and tapered, caudal margin transverse with a pair of very long, slender, slightly flaring, apicolateral processes. Basistyle with ventral root very slender, moderately long, dorsal root longer and stouter; dististyle moderately slender, nearly straight, with bent, bluntly pointed tip. Aedeagus with basal arch extending to about a third of total length, the basal arms stout, nearly straight with ends abruptly bent caudolaterad, main portion tapering to broad distal tip with 3 small teeth. Parameres (fig. 9) each with short, laterally directed basal arm with enlarged basal knob; stem moderately swollen a short distance at base, tapering distally and straight in midportion, with fine pointed apex abruptly bent laterad and then ventrad.

Distribution.—India, Malaya, Sarawak, Sumatra, Thailand.

Types.—Holotype, female, Ampang Forest Reserve, Selangor, Malaya, 20 September 1960, C. Manikumar, reared from soil in tree hole (Type no. 71177, USNM). Allotype, male, same data but reared 28 June 1961.

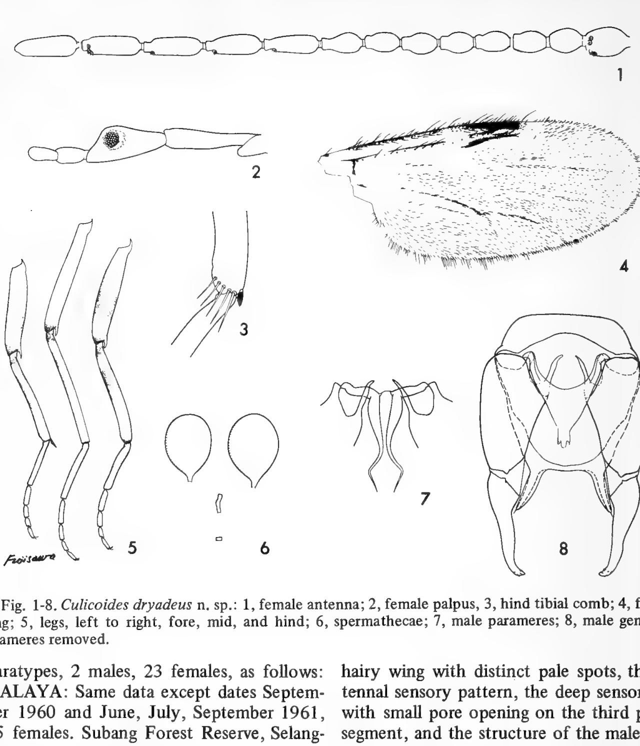


Fig. 1-8. *Culicoides dryadeus* n. sp.: 1, female antenna; 2, female palpus, 3, hind tibial comb; 4, female wing; 5, legs, left to right, fore, mid, and hind; 6, spermathecae; 7, male parameres; 8, male genitalia, parameres removed.

Paratypes, 2 males, 23 females, as follows: MALAYA: Same data except dates September 1960 and June, July, September 1961, 15 females. Subang Forest Reserve, Selangor, 4 May 1962, C. Manikumar, reared from tree hole, 2 females. INDIA: Calcutta, 3 September 1924, P. J. Barraud, 2 males, 2 females (in British Museum (Nat. Hist.), London). SARAWAK: Matang, 15 September 1958, Maa and Gressitt, at light, 1 female (Bishop Museum, Honolulu). SUMATRA: King Ke, Fairchild Coll, 1 female. THAILAND: Chiengmai, April-May 1958, V. Notananda, light trap, 1 female; July 1962, J. E. Scanlon, light trap 1 female.

Discussion.–*Culicoides dryadeus* is easily recognized by the wing pattern, intensely infuscated and with 4 distinct pale spots on the anterior and proximal portions. The hairy wing with distinct pale spots, the antennal sensory pattern, the deep sensory pit with small pore opening on the third palpal segment, and the structure of the male genitalia identify this species as a member of the *Culicoides neavei* group. The wing pattern of *dryadeus* differs from that of members of this group, such as *bifasciatus* Tokunaga, *claggi* Tokunaga, *geminus* Macfie, *javae* Tokunaga, *mackerrasi* Lee and Reye, *marginatus* Delfinado, *neavei* Austen, and *shermani* Causey, in lacking pale spots on the distal portion and along the posterior margin.

References

Wirth, W.W., and F.S. Blanton. 1959. Biting midges of the genus *Culicoides* from Panama (Diptera-Heleidae). Proc. U.S. Nat. Mus. 109: 237-482.

Wirth, W.W., and A.A. Hubert. 1959. *Trithecoides*, a new subgenus of *Culicoides* (Diptera, Ceratopogonidae). Pacific Insects 1: 1-38.

BOARD OF MANAGERS MEETING NOTES

November, 1971

The 616th meeting of the Board of Managers of the Washington Academy of Sciences was called to order at 5:03 p.m. November 18, 1971 in the New South Faculty Lounge at Georgetown University.

Announcements.–The minutes of the 615th meeting, which were distributed prior to the meeting, were discussed and corrected. At the close of the discussion, President Robbins declared the minutes to be approved as corrected. Dr. Treadwell, Dr. Watson and Dr. Weissler, who were not present at the last meeting, were introduced to the new delegates and committee chairman.

Dr. Patricia Sarvella was recognized in her new position of Chairman of the Joint Board on Science Education. She moved up from Vice Chairman upon the resignation of Dr. Roy Foresti. In other related developments, Dr. Robbins stated that she had appointed Dr. John K. Taylor and Dr. Edward Hacskaylo to represent the Academy on a six-member blue ribbon committee that will study the JBSE and make recommendations to the parent organizations. The committee will be directed: 1) to look into the activities of the JBSE as it functions as a single body to serve the two parent organizations, 2) to determine whether the present objectives of the JBSE are relevant, and (3) to recommend organizational and bylaws changes if such are found necessary. The six-member committee is scheduled to meet on November 20, 1972 with Dr. Robbins, Dr. Sarvella, and Mr. William A. Foster, Chairman of the D. C. Council of Engineering and Architectural Societies.

Membership Committee.–In the absence of Chairman Landis, Dr. Honig moved that Bernard K. Dennis, K. C. Emerson, and Frank Reggia be accepted as Fellows of the Academy. Following a second by Dr. Forziati, the candidates were accepted by voice vote. Two new candidates for fellowship were offered by the committee. Pertinent citations for each were read in preparation for formal decision at the next meeting.

Policy and Planning Committee.–Chairman Stern offered for consideration first a change in the bylaws and a change in the standing rules. The bylaws change would be in line 3 of Section 9sd Article IV, Officers: Read "two or more persons" instead of present "one person". A new standing rule, Number 14 was proposed as follows:

> "The President shall appoint each year a Special Committee, called the Nomination Advisory Committee, consisting of the most-recent available past president and five fellows, at least three of whom served as delegates during the previous year. This committee will meet prior to the first regular meeting of the Board of Managers to consider candidates for the offices of President-elect, Secretary, Treasurer, and Managers-at-Large for the Board. The committee shall prepare a recommended slate, containing two or more candidates for each available position, for consideration by the Nominating Committee".

Dr. Stern expressed his belief that such changes would fulfill the wants of the Board of Managers as voted in the meeting of May 10, 1971. Although he was not present at that meeting, he thought that it was the intent to provide the Nominating Committee, many of whose members are newly appointed delegates, with more information concerning qualified candidates that it would otherwise have. He noted further that the Nominating Committee would not be bound by the recommendations of the Nomination Advisory Committee. As initially conceived, the changes in bylaws from single slate to multiple slate would make the election of officers more meaningful.

Dr. Stern moved and R. Rupp seconded a motion to adopt the bylaws changes as stated. In the discussion that followed Dr. Cook stated that the proposed changes were considerably different from what he had proposed on May 10. In his proposal a committee similar in make-up to the Nomination Advisory Committee would replace and carry out the functions of the Nominating Committee. Further discussion showed that some members of the Board favored Dr. Cook's one-step procedure for producing a slate of officers because the committee could be a small efficient working group. While other members of the Board recognized possible efficiency, they expressed concern for possible input from the affiliated societies acting through the delegates, and the further possibility that a two-step procedure would provide a bulwark against inbreeding in the one-step Nominating Committee. Dr. Forziati moved and Dr. Cook seconded a motion to refer the matter to the Bylaws and Standing Rules Committee. Such action was accomplished by voice vote. An informal vote was then taken to sense the present thinking of the Board. For one-step there were nine in favor, for two-step there were six, and six did not commit themselves.

Dr. Stern next presented the application of the Maryland-District of Columbia Section of the Mathematical Association of America for affiliation. Following a motion by Dr. Stern and a second by Dr. Weissler, the Board voted to submit the application to the full membership for vote.

Completing the work of his committee, Dr. Stern proposed that the Academy establish a competition for undergraduate college students in each of the broad areas of science covered by the present science awards. Topics would be chosen by the Academy and the competitions would begin with the 1972–73 academic year. When offered as a motion, Dr. Weissler seconded; however, Dr. Honig proposed that an ad hoc committee contact the local universities to determine the extent of interest. Dr. Honig's proposal was accepted as a substitute motion which carried by voice vote.

Meetings Committee.—Dr. Irving was prepared to give more definition to the plans for monthly meetings. On December 16, there will be a tour of the Goddard Space Flight Center. The Symposium will constitute the January meeting. In February, Dr. E. E. Saulmon from USDA will speak. Speakers for March and April are not firm yet.

Grants in Aid.—Dr. Sarvella presented a proposal that grants be made to four boys and to one girl in amounts ranging from $40 to $95 to support specific research. Her proposal in the form of a motion was seconded by Dr. Forziati and passed by voice vote.

Encouragement of Science Talent.—Dr. Ederer presented members present with a copy of WJAS Proceedings which listed basis for membership. WJAS now wants to change procedure to accept members based on letter of recommendation from teacher or from supervisor in a summer research program. The Board of Managers voted approval of this change.

Public Information.—Symposium brochures have been mailed to all Government agencies, and a special letter went to the scientific counselors of embassies requesting that they designate an office or individual that would be contacted when the subject matter of meetings would be of special interest to them.

December, 1971

The 617th meeting of the Board of Managers of the Washington Academy of Sciences was called to order at 8:04 p.m. on December 14, 1971 in the Conference room of the Lee Building at FASEB.

Announcements.—Minutes of the previous meeting had been distributed prior to the meeting. An opportunity was given for comments or discussion of the minutes and then President Robbins declared the minutes accepted as prepared.

Dr. Robbins stated that she has a letter from the Instrument Society of America to the effect that the delegate did not wish to continue. Discussion indicated that the matter should be pursued further through an informal contact by Dr. Robbins with the president of that Society.

Treasurer.—Treasurer Honig presented a report labeled "Treasurer's Dilemma" because anticipated funds toward expenses could be several thousand dollars less that the expenses. The estimated symposium expenses seemed to be the surprising element of the report. The Treasurer recommended that $7,500 of stocks be liquidated to meet these expenses. The stock holdings were estimated to be $69,000.

Many alternatives to the liquidation were offered in the ensuing discussion. President Robbins acknowledged the need for the 1972 budget and promised to meet with the President-elect, the Treasurer, and the Chairman of the Ways and Means Committee to prepare it.

A plea to delay the liquidation until a firmer figure was available to define the financial need. Dr. Forziati offered a interest-free loan and Grover Sherlin urged that it be accepted together with a supplement from him. After extended discussion, a motion was made that the Treasurer be authorized to accept an interest free loan up to $8,000 from Forziati and Sherlin. By voice vote the motion was approved.

Membership Committee.—Two nominees for fellowship had been presented at the previous meeting. Following the second reading of the nominations, Sam Detwiler seconded the nominations and then by voice vote Rev. Charles L. Currie, S.J. and Dr. Wharton Young were elected Fellows of the Academy.

Meetings.—Dr. Irving urged that all note that the December meeting at Goddard Space Flight Center would start at an earlier time that usual, 7:30 p.m. He then reviewed his plans for monthly meetings in February, March, April and May. The Symposium will be considered the January meeting.

Awards for Scientific Achievement.—Chairman Dickson reported that a number of nominations had been received and that the panels will be making their selections in January. Some panel chairman had inquired about the possibility of multiple awards. The awards chairman was urged to limit the selections to one person or one team per panel.

Grants-in-Aid.—Chairman Sarvella reported that letters had been sent to the students informing them of the grants approved at the last meeting and that AAAS had also been notified in anticipation of the usual refund for the grants. The students who received the grants are listed with their schools: Michael R. Maroney, Western High School; Howard N. Moore, McKinley High School; Kathy O'Donnell, Washington Lee High School; Harrell Shoun, Jr., Luther Jackson Intermediate School; Wayne E. Paxton, Calvin Coolidge High School.

Public Information.—Chairman Noyes described the extensive publicity that he has carried out for the Symposium to the professional societies, the school systems, the chamber of Commerce, newspapers, etc. Dr. Noyes stated that he planned to count bona fide newspaper reporters as guests, particularly at refreshment time. Copies of the final brochures of the Symposium were distributed.

ByLaws.—Dr. Cook reported for Dr. L. A. Wood with a draft of the proposed amendments to change the procedure for nomination of officers. An amendment to the proposed changes was offered by Dr. Honig and Dr. Boek. Parliamentary procedures brought about approval of the following wording to be submitted to the full voting membership for approval:

Article VI, Section 2

The President, with the approval of the Board of Managers, shall appoint a Nominating Committee of six fellows of the Academy, at least one of whom shall be a Past President (see Article IV, Section 9).

Article IV, Section 9

The Nominating Committee (Article VI, Section 2) shall prepare a slate listing two or more persons for each of the offices of President-elect, of Secretary and of Treasurer, and four persons for the two Managers-at-Large and at least two persons to fill each vacant unexpired term of Manager-at-Large whose terms expire each year. The slate shall be presented for approval to the Board of Managers at its first meeting in October. Not later than November 15, the Secretary shall forward to each Academy member and fellow an announcement of the election, the committee's nomination for the offices to be filled, and a list of the incumbents. Additional candidates for such offices may be proposed by any member or fellow in good standing by letter received by the Secretary not later than December 1. The names of any eligible candidate so proposed by ten members or fellows shall be entered on the ballot."

Joint Board on Science Education.—Dr. Oswald asked that the Academy provide office services to the JBSE as a contribution. The discussion was a reminder to Dr. Robbins that the $300 contribution had not yet been made, but should be made without delay. Dr. Cook phrased a motion to the effect that the Executive Committee consider promptly the request of the JBSE for office service, meeting with the JBSE Executive Committee to work out the details of a proposal. After Sam Detwiler's second, a voice vote gave approval.

ELECTIONS TO FELLOWSHIP

The following persons were elected to fellowship in the Academy at the December, 1971, Board of Managers meeting:

Charles L. Currie, S. J., Assistant Professor of Chemistry, Georgetown University, Washington, D.C., in recognition of his contribution in the field of photochemistry, and in particular his researches at the forefront of flash photolysis techniques.

M. Wharton Young, Professor of Neuroanatomy, Howard Medical College, Washington, D.C., for his outstanding contribution to teaching and research in anatomy, and in particular his work on the anatomical basis for labyrinthine hydraulics in hearing and deafness.

SCIENTISTS IN THE NEWS

Contributions to this section of your Journal are earnestly solicited. They should be typed double-spaced and sent to the Editor in care of the Academy office by the 1st of the month preceding the issue for which they are intended.

NATIONAL INSTITUTES OF HEALTH

Benjamin H. Alexander has been named assistant chief of the General Research Support Branch, Division of Research Resources.

Dr. Alexander will assist the branch chief in administering GRSB programs and in developing new responses for institutional support of biomedical research.

He comes to DRR from the Health Services and Mental Health Administration where he has been serving as health science administrator since 1968.

Dr. Alexander was special assistant to the Director for the Disadvantaged, National Center for Health Services Research and Development, HSHMA, from 1968 to 1969.

He was administrator from 1969 to 1970 with the New Health Career Projects, and

Leonard M. Murphy receiving 1971 NOAA award December 3, 1971. Pictured left to right are: Murphy, NOAA Deputy Administrator Howard W. Pollock, and NOAA Administrator Robert M. White.

served on a part-time basis as Deputy Equal Employment Opportunity Officer.

Dr. Alexander received his B.A. at the University of Cincinnati, his M.S. at Bradley University, and his Ph.D. from Georgetown University.

He is the author of over 45 published research papers in chemical and related fields, and has written some 150 articles on educational subjects, community and racial problems, and ecology.

NOAA

Leonard M. Murphy of Rockville, Md., has been selected by the Commerce Department's National Oceanic and Atmospheric Administration as one of the seven winners of the 1971 NOAA awards for unusually significant achievements. The award includes a plaque and $1000.

Murphy received the award for "his outstanding contributions to engineering seismology and earthquake science." The recipient is connected with the NOAA Environmental Research Laboratories' Earth Sciences Laboratories in Rockville, Md.

The award winners were selected by the Special Awards Panel of the National Academy of Sciences-National Academy of Engineering Advisory Committee to NOAA.

In announcing the award, NOAA stated that Murphy "has played a leading role in the establishment of the Tsunami Warning System, the seismic and tidal network throughout the Pacific Basin; in the development of the Global Earthquake Location Program, which provides rapid earthquake location reporting service never before available; and in the establishment of the Worldwide Network of Seismograph Stations." The latter is a network of 115 stations in 61 countries that provides data for earthquake studies and in developing a program for evaluating the seismicity of proposed sites for nuclear reactors.

"His achievements have resulted in better understanding of earthquake phenomena," said NOAA, "and contributed to the development of engineering measures that can significantly relieve the devastating impact of earthquakes."

Murphy's entire career since 1942 has been in the field of seismology with the Commerce Department's Coast and Geodetic Survey, National Ocean Survey and Environmental Research Laboratories. He was chief of the Seismology Division for eight years until the unit was transferred to ERL headquarters in Boulder, Colo. He now heads the Seismology Investigation Group in Rockville.

A native of Whitehall, N. Y., he graduated from Whitehall High School in 1934, then received a bachelor of science degree from Fordham College in 1938 and a master's degree in 1940. He resides with his wife, the former Mary Ann Murray, of Poughkeepsie, N. Y., and family in Rockville. Murphy is the son of the late Mr. and Mrs. Maurice Murphy of Whitehall. He is a member of numerous scientific bodies, including the Seismological Society of America, American Geophysical Union (President, Seismology Section, 1959-61), Washington Academy of Sciences, Philosophical Society of Washington and American Institute of Geology.

JOURNAL OF THE WASHINGTON ACADEMY OF SCIENCES

Instructions to Contributors

General

Type manuscripts on white bond paper either 8½ by 11 or 8 by 10½ inches. Double space all lines, including those in abstracts, tables, legends, quoted matter, acknowledgments, and references cited. Number pages consecutively. Place your name and complete address in the upper right hand corner of the title page.

Title, Author, and Affiliation

Page 1 of your manuscript should contain only this information and your name and address. Choose a concise but complete and meaningful title. In research papers concerning biological subjects, include an indication of the order and family of the taxa discussed. Academic degrees will not normally be included unless the author so specifies. If possible, combine your affiliation and mailing address (including Zip) so that readers can write to you directly.

Abstract

Type on a separate sheet at the end of the manuscript. Make the abstract intelligible without reference to the text of the paper. Write an informative digest of the significant content and conclusions, not a mere description. Generally, the abstract should not exceed 3% of the text.

Footnotes

Use footnotes as sparingly as possible. Number text footnotes consecutively with Arabic numerals and type them on a separate sheet of paper at the end of the manuscript. Type table footnotes, if any, below each pertinent table on the same page.

Illustrations and Legends

The quality of all original illustrations must be high enough to facilitate good offset reproduction. They should have ample margins and be drawn on heavy stock or fastened to stiff cardboard to prevent bending. They should be proportioned to column (1 x 3) or page (2 x 3) type-dimensions, leaving space for legend material. Photographs should have a glossy finish. They reproduce best when the contrast is fairly high. Identify each illustration with number and author in light pencil marks on the reverse side. Submit all illustrations separately – please do not glue or clip them to the pages of the manuscript.

Do not type or write legends directly on the illustrations. Type legends on a separate sheet or sheets at the end of the manuscript. Indicate where you want illustrations to appear in the printed paper by writing the figure numbers lightly in the text margins, and be sure that each figure is properly referenced in the text itself. Original "art" will be returned only at the author's request and expense.

Tables

Include tables only when the same information cannot be presented economically in the text, or when a table presents the data in a more meaningful way. Consider preparing extremely complicated tabular matter in a form suitable for direct reproduction as an illustration. In such cases, the use of the typewriter is not recommended.

References to Literature

Limit references within the text and in synonymies to author and year (and page if needed). In a "Reference Cited" section, list alphabetically by senior author only those papers you have included in the text. Likewise, be sure all the text references are listed. Type the "References Cited" section on a separate sheet after the last page of text. Abbreviations should follow the *USA Standard for Periodical Title Abbreviations*, Z39.5-1963.

Submission of Manuscripts

Send completed manuscripts and supporting material to the Academy office (see address inside front cover) in care of the Editor. Authors will be requested to read Xerox "proofs" and invited to submit reprint orders prior to publication.

Reprints - Prices for reprints may be obtained on request.

Washington Academy of Sciences
Room 29, 9650 Rockville Pike (Bethesda)
Washington, D.C. 20014
Return Requested with Form 3579

2nd Class Postage
Paid at
Washington, D.C.

Smithsonian Inst.
Library Acquisitions
Washington, D.C. 20560

J-WAS

VOLUME 62
Number 2
June, 1972

Journal of the WASHINGTON ACADEMY OF SCIENCES

Issued Quarterly
at Washington, D.C.

Symposium Issue

CONTENTS

Editorial 50

Symposium – Science and the Environment (II): The Fate of the Chesapeake Bay

MARY LOUISE ROBBINS: Welcome 51
RITA R. COLWELL: Introduction to the Symposium 52

The Current Status of the Chesapeake Bay

MICHAEL J. PELCZAR, JR.: Opening Remarks 54
J.R. SCHUBEL: The Physical and Chemical Conditions of the Chesapeake Bay 56
FRANCIS S.L. WILLIAMSON: Biology and the Chesapeake Bay 88
JOHN J. BOLAND: The Fate of the Chesapeake Bay: Socio-Economic Aspects 102
ROBERT H. ROY: Chesapeake Research Consortium, Inc. 109
QUESTIONS AND ANSWERS 112

The Major Threats to the Chesapeake Bay

RUTH PATRICK: Opening Remarks 118
WILLIAM J. LOVE: Hydrodynamic Changes in the Chesapeake Bay 118
GERALD E. WALSH: Insecticides, Herbicides, and Polychlorinated Biphenyls in Estuaries 122
RUTH PATRICK: The Potential of Various Types of Thermal Effects on Chesapeake Bay 140
M.E. BENDER, R.J. HUGGETT, and H.D. SLONE: Heavy Metals– an Inventory of Existing Conditions 144
F.C. YOUNG: Trace Element Analysis by Proton-Induced X-ray Excitation 153
THOMAS D. MCKEWEN: Human Wastes and the Chesapeake Bay 157
QUESTIONS AND ANSWERS 161

(Continued on Back Cover)

Washington Academy of Sciences

Founded in 1898

EXECUTIVE COMMITTEE

President
Mary Louise Robbins

President-Elect
Richard K. Cook

Secretary
Grover C. Sherlin

Treasurer
John G. Honig

Board Members
Samuel B. Detwiler, Jr.
Kurt H. Stern

BOARD OF MANAGERS

All delegates of affiliated Societies (see facing page)

EDITOR

Richard H. Foote

EDITORIAL ASSISTANT

Elizabeth Ostaggi

ACADEMY OFFICE

9650 Rockville Pike (Bethesda)
Washington, D. C. 20014
Telephone (301) 530-1402

The Journal

This journal, the official organ of the Washington Academy of Sciences, publishes historical articles, critical reviews, and scholarly scientific articles; proceedings of meetings of the Academy and its Board of Managers; and other items of interest to Academy members. The *Journal* appears four times a year (March, June, September, and December) – the September issue contains a directory of the Academy membership.

Subscription Rates

Members, fellows, and patrons in good standing receive the *Journal* without charge. Subscriptions are available on a calendar year basis only, payable in advance. Payment must be made in U.S. currency at the following rates:

U.S. and Canada	$10.00
Foreign	11.00
Single Copy Price	3.00

Back Issues

Back issues, volumes, and sets of the *Journal* (Volumes 1-58, 1911-1968) can be purchased direct from Walter J. Johnson, Inc., 111 Fifth Ave., New York, N.Y. 10003. This firm also handles the sale of the *Proceedings* of the Academy (Volumes 1-13, 1898-1910) and the *Index* (to Volumes 1-13 of the *Proceedings* and Volumes 1-40 of the *Journal*). Single issues from 1969 to present may be obtained directly from the Academy office (address elsewhere this page).

Claims for Missing Numbers

Claims will not be allowed if received more than 60 days after date of mailing plus time normally required for postal delivery and claim. No claims will be allowed because of failure to notify the Academy of a change in address.

Changes of Address

Address changes should be sent promptly to the Academy office. Such notification should show both old and new addresses and zip number.

Published quarterly in March, June, September, and December of each year by the Washington Academy of Sciences, 9650 Rockville Pike, Washington, D.C. Second class postage paid at Washington, D.C.

DELEGATES TO THE WASHINGTON ACADEMY OF SCIENCES, REPRESENTING THE LOCAL AFFILIATED SOCIETIES

Philosophical Society of Washington	Edward Beasley
Anthropological Society of Washington	Jean K. Boek
Biological Society of Washington	Delegate not appointed
Chemical Society of Washington	Fred E. Saalfeld
Entomological Society of Washington	Reece I. Sailer
National Geographic Society	Alexander Wetmore
Geological Society of Washington	Charles Milton
Medical Society of the District of Columbia	Delegate not appointed
Columbia Historical Society	Paul H. Oehser
Botanical Society of Washington	Conrad B. Link
Society of American Foresters	Robert Callaham
Washington Society of Engineers	George Abraham
Institute of Electrical and Electronics Engineers	Leland D. Whitelock
American Society of Mechanical Engineers	William G. Allen
Helminthological Society of Washington	Aurel O. Foster
American Society for Microbiology	Lewis Affronti
Society of American Military Engineers	H.P. Demuth
American Society of Civil Engineers	Carl H. Gaum
Society for Experimental Biology and Medicine	Carlton Treadwell
American Society for Metals	Glen W. Wensch
International Association for Dental Research	Norman H.C. Griffiths
American Institute of Aeronautics and Astronautics	Robert J. Burger
American Meteorological Society	Harold A. Steiner
Insecticide Society of Washington	H. Ivan Rainwater
Acoustical Society of America	Alfred Weissler
American Nuclear Society	Delegate not appointed
Institute of Food Technologists	Lowrie M. Beacham
American Ceramic Society	J.J. Diamond
Electrochemical Society	Kurt H. Stern
Washington History of Science Club	Delegate not appointed
American Association of Physics Teachers	Bernard B. Watson
Optical Society of America	Elsie F. DuPré
American Society of Plant Physiologists	Walter Shropshire
Washington Operations Research Council	John G. Honig
Instrument Society of America	Delegate not appointed
American Institute of Mining, Metallurgical and Petroleum Engineers	Delegate not appointed
National Capitol Astronomers	William Winkler
Mathematical Society of America	Delegate not appointed

Delegates continue in office until new selections are made by the respective societies.

EDITORIAL

The articles in this symposium issue represent talks presented at the Academy's symposium *Science and the Environment–II* sponsored jointly by the Washington Academy of Sciences, the American Ordnance Association, and the Department of Natural Resources of the State of Maryland. The program, approximated by the table of contents, was conducted during three half-day sessions on January 7 and 8, 1972 in the Adult Education Center on the campus of the University of Maryland at College Park.

The symposium committee was as follows:

Dr. Mary Louise Robbins, President, Washington Academy of Sciences; George Washington University.

Dr. Rita R. Colwell, Chairman, Symposium Committee; Georgetown University.

Dr. Frances Allen, Environmental Protection Agency.

Dr. Richard H. Foote, U.S. Department of Agriculture.

Dr. Alphonse F. Forziati, Environmental Protection Agency.

Dr. John G. Honig, Office, Chief of Staff, U.S. Army, Pentagon.

Mr. William Jabine, II, Maryland Department of Natural Resources.

Mr. Paul W. McKee, Maryland Department of Natural Resources.

Dr. Howard E. Noyes, Walter Reed Army Institute of Research.

Norman I. Shapira, Col. (USA-Ret.), Advance Planning Consultant, Dunkirk, Md.

Dr. Louis G. Swaby, Environmental Protection Agency.

Miss Elizabeth Ostaggi, Office Manager, Washington Academy of Sciences.

This symposium is the second in a series being conducted by the Washington Academy of Sciences. A primary purpose of these symposia is to lay before the concerned public the scientific facts underlying the environmental issues of the day. The present symposium was designed to deliberate the fate of the Chesapeake Bay in a scientific framework, and its three major sessions treated the current status of the Bay, the major threats to it, and the research currently being conducted to counter those threats.

This printed version of the symposium was made possible by the prompt and willing cooperation of the participants, for which this editor gratefully extends his appreciation.

A large share of the cost of publishing this Symposium was borne by a grant from the Environmental Protection Agency.

Welcome

Mary Louise Robbins[1]

President, Washington Academy of Sciences; George Washington University School of Medicine, Washington, D.C. 20005

This welcome is from me personally as the President of the Washington Academy of Sciences and from the other sponsors. A little less than a year ago, under the very capable direction of Dr. Alphonse F. Forziati, who was then President of the Academy, we had our first symposium on Science and the Environment. We did not have the temerity to call it our first annual symposium, but that is what it turned out to be. It was entitled "Lead in Gasoline–Good or Bad." As I say, we did not call it the first annual symposium but by the time it was published we were calling it Science and the Environment–I. That meant that we had to have Science and the Environment–II about a year later, and the result is today's symposium, "The Fate of the Chesapeake Bay." I want to acknowledge the sponsorship by the American Ordnance Association of both last year's and this year's symposia, and for this year I acknowledge the sponsorship of the Department of Natural Resources of the State of Maryland.

I asked Governor Mandel to participate in our symposium. Unfortunately, he was unable to do so, but he did write a note ending with this message:

> "Please accept and convey my sincere regrets and extend my best wishes to all in attendance. Sincerely, Marvin Mandel, Governor."

Today, I received another letter addressed to all of you. It reads:

> "To the participants of the second symposium on Science and the Environment. The subject of your symposium, The Fate of the Chesapeake Bay, is one of special interest to me. Having served as Governor of the State of Maryland I can attest to the singular value which the Chesapeake Bay has to the people of the State of Maryland, the region and the nation. The participants of this symposium deserve commendation for their demonstrated interest in the ecology of the Bay and their concern for the effect of the manifold activities of man upon the Bay's environment. Only by properly directed and comprehensive research of the effect of competing uses of the Bay upon its exceedingly complex ecosystems can we obtain sufficient facts upon which to base future planning for maintenance and enhancement of the Bay environment. Because of its importance to the life of all those within the Chesapeake Bay region it is essential that this conference and others like it

[1]Dr. Robbins received her B.A. in biology at American University and her M.A. and Ph.D. in bacteriology at George Washington University, and has taken additional training at Harvard Medical School and Cold Spring Harbor. Her academic appointments include experience in Camp Detrick, Md.; Martinsburg, W. Va.; Cairo, Egypt; Baghdad, Iraq; and Fukuoka, and Tokyo, Japan. She was the recipient of an Alumni Recognition Award in 1966 from American University and a Public Health Service Special Research Fellowship in 1968-69. A member of nine professional organizations, she has served in prominent offices in the Society of the Sigma Xi, Graduate Women in Science (formerly Sigma Delta Epsilon), and the American Society for Microbiology. She is author of 45 scientific publications. At present she is full Professor of Microbiology at the George Washington University School of Medicine.

provide the stimulus and direction through research and continuing exchange of information as data are developed for other estuarian areas throughout the nation. The interdisciplinary nature of your presentations is evident from the broad scope of subjects considered by your symposium and the interest of the organizations you represent. I extend my best wishes to you for a successful and fruitful meeting." (Signed, Spiro T. Agnew.)

Now I want to introduce the Chairman of this Symposium Committee. My job on this Symposium was to appoint a committee. I made up my mind that it was going to be a very, very good committee, as indeed it has been under the chairmanship of Dr. Rita R. Colwell, who is Associate Professor of Biology at Georgetown University. As a specialist in marine biology, especially the biology of the Chesapeake Bay, she is ideally suited to chair this Symposium. It is my pleasure to present to you Dr. Rita R. Colwell.

Introduction to the Symposium

Rita R. Colwell[1]

Department of Microbiology, University of Maryland, College Park, Maryland 20742

The significance of estuaries has been amply demonstrated by research showing that the major estuaries of the United States serve as nursery grounds for fishes (Cronin and Mansueti, 1971) and shellfish (Wallace, 1971), as highways for commerce, in recreational boating and swimming, as sources of sand and gravel, and as repositories for industrial and domestic wastes (Lauff, 1967). Estuaries are zones of ecological transition between fresh water and salt water. As defined by Pritchard (1967), an estuary is a semi-enclosed coastal body of water which has a free connection with the open sea and within which sea water is measurably diluted with fresh water derived from land drainage. The Chesapeake Bay, a coastal plain estuary, i.e., a "drowned river valley," is the largest, most varied and most important estuary for aquatic organisms in the mid-Atlantic coastal area (Massmann, 1971). The Chesapeake Bay is vitally involved in the economics of the States bordering the Bay, since, for example, Maryland ranks fifth in the United States following Alaska, Washington, Oregon and Maine in terms of manpower involved in some aspects of fisheries and seafood production.

A meaningful and useful series of symposia on the environment is being provided by the Washington Academy of Sciences. The first in the series dealt with air pollution (Forziati, 1971) and this symposium, of course, concerns the aquatic resource comprising Chesapeake Bay. The underlying purpose of this Symposium is to bring together the working scientists knowledgable of the science, both practical and theoretical, presently being applied and that which ought to be applied to the problems of our Chesapeake Bay. It was the intent of the Symposium Committee to bring together the interested and the actively practicing scientists

[1] Dr. Colwell received her B.S. (Bacteriology) in 1956 and M.S. (Genetics) from Purdue University and her Ph.D. (Marine Microbiology) from the University of Washington at Seattle. She subsequently served as a Guest Scientist at the National Research Council of Canada (1961-1963) before joining the faculty at Georgetown University in Washington, D.C. Dr. Colwell is now Professor of Microbiology at the University of Maryland and is a member of a number of different Societies, including the American Society for Microbiology, and has authored over 100 papers and 4 books on marine microbiology and microbial systematics.

in a public forum, with the dialogue appearing in the open scientific literature, i.e., via publication of the proceedings in the *Journal of the Washington Academy of Sciences*. Although a number of conferences on Chesapeake Bay have been held, publications are not, in general, available in the open scientific literature. The Proceedings of the Governor's Conference on Chesapeake Bay, held at the Wye Institute in Maryland, September 12-13, 1968, published by the Westinghouse Ocean Research and Engineering Center, Annapolis, Maryland, and the RANN (IRRPOS) Project Report No. 4 & Sea Grant Program Report No. 4 (Hargis, 1971) contain much useful information and many valuable statistics, as well as thought-provoking ideas. Fortunately, many such documents are reaching print as a result of the National Sea Grant Program efforts. It is our hope that the dialogue established through this Symposium will strengthen communication among the many physical, chemical, and social scientists involved in various aspects of research and study in Chesapeake Bay. The event of this Symposium is not only of local or specifically parochial interest, but draws focus of the nation since Chesapeake Bay is but one of a number of estuaries in the United States.

This Symposium will, we hope, identify the many needs that must be met from the natural resources of the Bay. These range from the commercial to the recreational for those inhabitants who enjoy the sailing that is so pleasant in the Chesapeake Bay. There is, indeed, a litany of usages imposed on the Bay that can be recited, beginning with the major one, the use of the Bay as a repository for domestic and industrial wastes. The question facing us, then, is simply stated: How do we provide for the many demands made on Chesapeake Bay and yet preserve this resource? That is what we must ponder during this Symposium and thereafter. Our time grows short and the problems loom large.

References Cited

Cronin, L.E., and A.J. Mansueti. 1971. The biology of the estuary. *In*: A Symposium on the Biological Significance of Estuaries. Sport Fishing Institute, Washington, D.C., (Houston, Texas, February 13, 1970), pp. 14-39.

Forziati, A.F. 1971. Introduction to the Symposium. Proc. Symposium on Science and the Environment (I). Lead in Gasoline. J. Wash. Acad. Sci. 61(2): 55-56.

Hargis, W.J., Jr. 1971. Research on Chesapeake Bay and Contiguous Waters of the Chesapeake Bight of the Virginian Sea. RANN (IRRPOS) Project Report No. 4 & Sea Grant Program Report No. 4. Virginia Institute of Marine Science, Gloucester Point, Va. 192 pp.

Lauff, G.H. 1967. Estuaries. Amer. Assoc. Adv. Sci., Publ. 83, Washington, D.C. 757 pp.

Massmann, W.H. 1971. The significance of an estuary on the biology of aquatic organisms of the middle Atlantic region. *In*: A Symposium on the Biological Significance of Estuaries. Sport Fishing Institute, Washington, D.C., (Houston, Texas, February 13, 1970), pp. 96-109.

Pritchard, D.W. 1967. What is an estuary: physical viewpoint. *In*: Estuaries, Amer. Assoc, Adv. Sci., Publ. 83, pp. 3-5.

Wallace, D.H. 1971. The biological effects of estuaries on shellfish of the middle Atlantic. *In*: A Symposium on the Biological Significance of Estuaries. Sport Fishing Institute, Washington, D.C. (Houston, Texas, February 13, 1970), pp. 76-85.

The Current Status of the Chesapeake Bay
Opening Remarks

Michael J. Pelczar, Jr.[1]

Vice President for Graduate Studies and Research, University of Maryland, College Park 20742

It is a real pleasure for me to have the opportunity to make a few remarks to this large group gathered here for the purpose of exchanging information on the Chesapeake Bay. This, incidentally, is at least the third major conference of this academic year which has centered attention to an assessment of the Bay. The attendance at each can be characterized by a "standing room only" participatory audience. This fact in itself denotes the keen interest and priority given to the status of the Bay by professionals and laymen alike.

All of us in this room are familiar to greater or lesser degrees with facts about the Bay. It might serve a useful purpose to summarize, albeit briefly, some of the salient statistics associated with the Chesapeake Bay and the contiguous land mass.

The Bay is the largest estuary in the United States; it is 195 mi in length and varies from 4 to 30 miles in width. The water surface area measures 4,300 mi^2; as a drainage basin, the measurement is 64,170 mi^2. The total shoreline measures 4,600 mi. The deepest point in the Bay is at Bloody Point where there is a depth of 174 ft. Nine major river streams feed into the Bay, namely, the Choptank, Patuxent, Pocomoke, Potomac, Nanticoke, Susquehanna, York, Rappahannock, and James.

The commercial seafood harvest, in recent years, has exceeded one-half billion pounds annually at a value in excess of $65 million. To this must be added the numbers caught by sports fishermen—the rockfish catch by sports fishermen may match that of the commercial catch. Waterborne commerce exceeds 100 million tons annually. The population within the drainage basin's tributary to the Bay was estimated at 11 million in 1960 and is projected to reach 30 million by the year 2020. These facts, impressive as they are, fail to convey the personality of the Bay—that is, the great variety in the scenery, the life and life styles, and the activities of the inhabitants by day and by season.

I would like to surface another matter that I am sure will be discussed during this symposium, namely, the multiplicity of agencies (together with their studies) that are associated with investigations of the Bay. This has pointed up the need for coordination, if not direction, of a "total plan" or, as they say, a holistic approach to performance of our studies on the Bay. We are moving in that direction. As some of you are aware, a Consortium is being organized that will provide a holistic design for Bay studies. Johns Hopkins University, the Smithsonian Institution, Virginia Institute of Marine Sciences, and the University of Maryland comprise this Consortium. Along this same line it is appropriate to mention that the Governor of

---

[1]Dr. Pelczar received his B.S. and M.S. degrees from the University of Maryland and his Ph.D. degree from the University of Iowa in bacteriology and biochemistry. He is a member of 4 honorary and 9 professional societies, in several of which he has held prominent positions. His former national and international committee positions are numerous and now include 3 in the Council of Graduate Schools in the U.S.; Governor's Science Advisory Board; IUBS; ONR; WHO; and the Association of American Universities. He is Past-President of the Maryland Chapter, American Association of University Professors; Washington Branch of the American Society for Microbiology; and the University of Maryland Chapter of Sigma Xi. His awards include a Distinguished Citizenship Certificate from Gov. Mandel and a Sigma Xi Annual Award for Scientific Achievement. He is author or co-author of 6 books, has written numerous scientific papers, and has held his present university position since 1966.

Maryland created the "Chesapeake Bay Interagency Planning Committee" which will make its report during the year. This committee, in addition to other objectives, is directed to defining appropriate institutional arrangements for Bay resource management. Indeed "management" becomes a key word. Not only do we need to develop and adopt practices that are consistent with maintenance of a high quality environment, but these must be under some program of management to provide surveillance of the total system.

This leads me to another point which I am sure will receive your attention, namely, the necessity for interdisciplinary studies. A basic component essential toward arriving at realistic, workable solutions to environmental problems is the development of integrated knowledge about the environment for which we must depend upon our best scientific and technological skills. The paucity of such comprehensive knowledge and understanding of the interfacial relationships of environmental parameters makes it essential that we adopt new and innovative organizational mechanisms that foster multidisciplinary studies. No single field of science can possibly bring into use the broad range of insights necessary to understand, let alone deal with, the totality of problems associated with the Bay. It is not simply the Bay alone; it is the land-air-water interactions; it is biology, chemistry, physics, and economics; it is recreation, employment, and commerce; it is all of these and more!

As you have already noted from the program, the thrust of this symposium is directed toward 3 major concerns, namely an assessment of the *current status of the bay, major threats* to the present environment; and *means to counter the threats*. Stated in a less sophisticated manner, they are: where are we now, where are we going, and what do we have to do to get there!

The Physical and Chemical Conditions of the Chesapeake Bay

J. R. Schubel[1]

Chesapeake Bay Institute, The Johns Hopkins University, Baltimore, Md. 21218

ABSTRACT

As assessment of the physical and chemical conditions of the Chesapeake Bay estuarine system indicates: (1) that there are marked natural spatial and temporal variations of temperature, and that man has had a measurable effect, in local areas, on the temperature distribution, but that the present inputs of heated waters from power plants do not pose a threat to the Bay; (2) that there are large natural spatial and temporal variations of salinity, and that man has had almost no effect on the salinity distribution; (3) that man's activities have increased the frequency, duration, and extent of low oxygen zones in the upper reaches of a number of the tributaries; (4) that man's activities have resulted in large inputs of nutrients which have produced undesirable conditions in a number of the tributaries, but that the nutrient levels in the main body of the Bay are at an acceptable level; (5) that the Bay is being rapidly filled with sediments, and that the fine-grained sediments have a number of deleterious indirect effects on the ecology of the Bay; and (6) that there are large natural variations in the distributions of heavy metals, and suggests that levels have probably always been relatively high.

The Chesapeake Bay is an estuary—a semi-enclosed coastal body of water having free access to the ocean and within which seawater is measurably diluted by freshwater from land drainage (Pritchard, 1967). Freshwater from numerous rivers and streams is mixed within the semi-enclosed Chesapeake Bay basin with seawater that enters through the Virginia capes. The mixing, primarily by tides, produces density gradients that drive the characteristic two-layered circulation pattern that eventually leads to the discharge of the freshwater into the Atlantic Ocean. The Chesapeake Bay is actually a complex estuarine *system* comprising the Bay proper and its tributary estuaries.

The Chesapeake Bay estuarine system was formed by the most recent rise in sea level which began approximately 15,000-18,000 years ago. With the retreat of the glaciers at the end of the Wisconsin glaciation, sea level rose rapidly from a position approximately 125 m below its present level. As it rose it advanced across the previously exposed continental shelf, reaching the present mouth of the Chesapeake Bay basin less than 10,000 years ago. The sea penetrated into the Bay basin, drowning the ancestral river valley system which was carved during the previous low stand, transforming the riverine system into an estuarine system.

The Chesapeake Bay is a classic example of a drowned river valley estuary. The age of the *estuary* decreases from mouth to head; the northern Chesapeake Bay is probably no more than 3,000-4,000 years old. The Chesapeake Bay estuary then, is very young geologically. Like other estuaries it is an ephemeral feature on a geologic time scale. It is being rapidly filled with sediments; sedi-

---

[1]Dr. Schubel received his Bachelors degree from Alma College, his Masters degree from Harvard University, and his Ph.D. degree in Oceanography from The Johns Hopkins University. He has taught oceanography at The Johns Hopkins University, the University of Maryland, the University of Delaware, and Franklin and Marshall College. He has published more than 25 papers on various aspects of estuaries, and in 1972 convened an American Geological Institute short course entitled *The Estuarine Environment*. He is a member of Sigma Xi and of the Maryland Academy of Sciences' Advisory Panel on the Environmental Impact of Power Plants, and is also a member of a number of professional and scientific societies.

ments from rivers, from shore erosion, from primary productivity, and from the sea. As the Bay contracts in volume, depth, and eventually in area, the intruding sea will be progressively displaced seaward, transforming the estuary back into a river valley system. Finally, the Susquehanna will reach the sea through a depositional plain and the transformation will be complete. If relative sea level remains nearly constant, this process will take, at most, a few tens of thousands of years to complete. If relative sea level falls, the estuary's lifetime will be shortened. If relative sea level rises, the life of the estuary will be increased.

Man's activities can greatly accelerate the rate of infilling, thus shortening the Bay's geological lifetime. But, more important, the by-products of his activities such as sewage, pesticides, herbicides, heavy metals, and sediment may alter the estuarine system, or segments of it, to the extent that its useful biological and recreational lifetimes will be cut drastically shorter than its geological lifetime—perhaps several orders of magnitude shorter.

The Chesapeake Bay, like other estuaries, is a dynamic environment characterized by marked natural fluctuations of many of its physical and chemical properties. The fluctuations, both short- and long-term, may be produced by processes active within the Bay, or they may be inherited from processes active in the drainage basin, perhaps hundreds of kilometers away. The water that enters the Bay from each of the tributaries carries with it a set of properties produced by that water's history; a history in part natural and in part man-made.

The purposes of this paper are to describe some of the prevailing physical and chemical conditions of the Chesapeake Bay estuarine system and to assess man's impact on these conditions. This requires the establishment of the existing spatial and temporal distributions of several of the important characteristic properties and an evaluation of how these characteristics have been affected by man and his activities. Some of the more important properties are: (1) temperature, (2) salinity, (3) dissolved oxygen, (4) nutrients, (5) sediment, (6) heavy metals, (7) pesticides, (8) herbicides, and (9) oil. Because of limitations of time, space, and data, I will confine my remarks to the first 6 items. The last 3—pesticides, herbicides, and oil—may represent major threats to the Bay, but there are very few data.

Temperature

Water temperature is important because of its effect on density, on oxygen solubility, and on a number of other important physico-chemical properties of seawater. Temperature is also very important biologically. It is one of the most important factors governing the occurrence and behavior of all forms of life.

During the past 20 years the Chesapeake Bay Institute has determined the distribution of temperature in the main body of the Chesapeake Bay and its major tributaries a relatively large number of times. The results have been presented in a series of graphical summary reports (Whaley and Hopkins, 1952; Stroup and Lynn, 1963; Seitz, 1971).

There are marked natural temporal and spatial variations of water temperature in the Chesapeake Bay estuarine system. Fig. 1 illustrates the spatial variations in surface

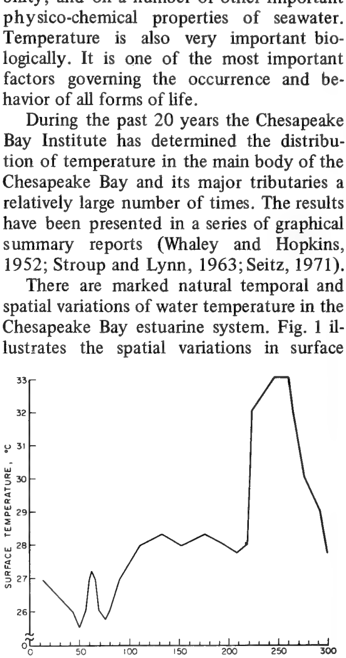


Fig. 1. Longitudinal profile of surface temperature (°C) along axis of Chesapeake Bay during August, 1961.

temperature that can occur along the longitudinal axis of the Bay. These data depict the distribution of surface temperature along the axis of the Bay in August, 1961. The data show a range in surface temperature

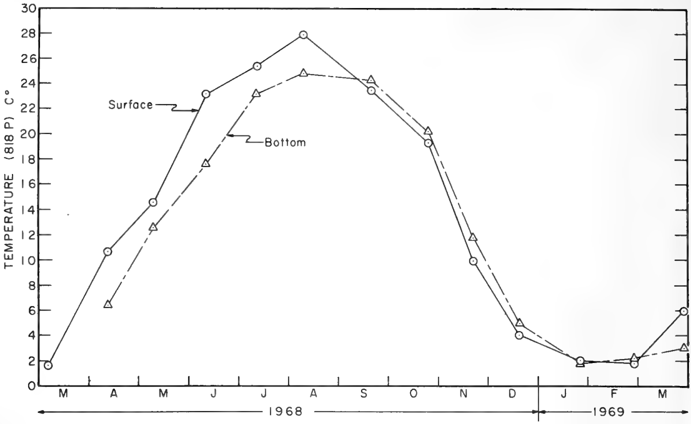


Fig. 2. Monthly variation of temperature (°C) at a station (818P) in the mid-Bay (from Seitz, 1971).

greater than 7°C and local gradients sometimes exceeding 1°C/km. This distribution is somewhat unusual in the magnitude of the variation, but the general features of the spatial variation are representative. More- or -less randomly-spaced variations of 1.5-2.5°C are not unusual. In addition, temperatures in the Virginia portion of the Bay are, on the average, about 0.5°C warmer than those in the Maryland portion.

There are also marked temporal variations in water temperature. The average diurnal variation of water temperature at a depth of about 1.2 m below mean low water (MLW) in the mouth of the Patuxent estuary was 1.2°C during 1947 (Beaven, 1960). The maximum diurnal variation Bevan observed at this depth was 3.0°C, which occurred several times in late winter, spring, and early fall.

The annual range in temperature in the open Bay is from about 0°C to approximately 29°C. Fig. 2 shows the variations of surface and bottom temperature over a 13-month period in 1968-1969 at a 34-m station in the mid-Bay. The surface temperature ranged from about 1.7°C in March to more than 28°C in August. The temperature of the bottom waters showed a similar pattern of seasonal heating and cooling, with only a slightly smaller range.

In addition to the seasonal changes, there are relatively large short- and long-term variations of water temperature. Daily measurements of surface temperature were taken for more than 50 years by the Coast and Geodetic Survey at selected tidal observation stations in some of the tributary estuaries. Similar data are not available for the Bay proper,

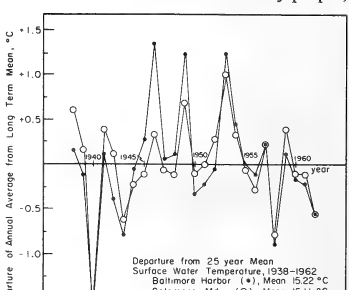


Fig. 3. Departures of mean annual surface temperatures (°C) from 25-year mean surface temperatures at Fort McHenry (Baltimore Harbor) and Solomons, Maryland (Patuxent estuary).

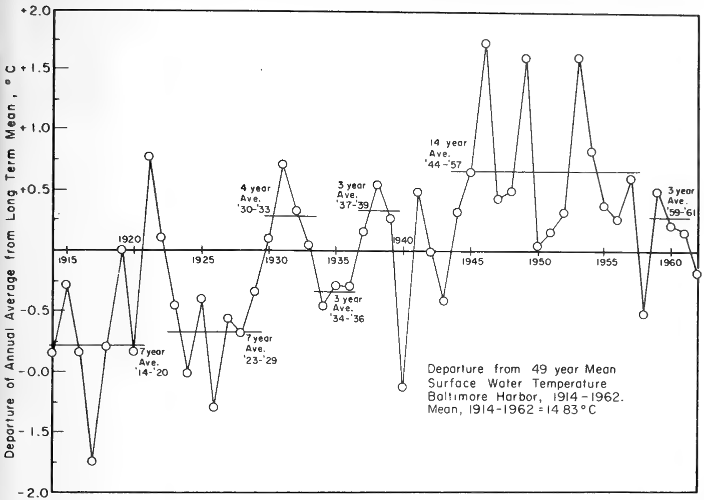


Fig. 4. Departures of mean annual surface temperatures (°C) from 49-year (1914-1962) surface temperatures off Fort McHenry. Mean surface temperatures averaged over periods of several years are also shown.

but comparison of the monthly or yearly averages of the data taken at stations in widely separated tributaries indicates that these data are quite representative of large segments of the Bay. This is shown by fig. 3, which summarizes surface-temperature data collected at Fort McHenry in Baltimore Harbor and at Solomons, Maryland on the lower Patuxent estuary more than 100 km away. The *departures* of the average annual temperatures from their long-term 25-year mean temperatures are plotted for each of these stations. The 2 curves track each other very well, indicating that the annual variations in water temperature occur over a large segment of the Bay system and suggesting that these data are representative of conditions in the Bay proper.

An extended temperature record for Fort McHenry is presented in fig. 4, which is a plot of the *departure* of the annual mean surface temperature from the long-term, 49-year mean for the period 1914-1962. The figure shows that the mean annual temperature had a range over the 49-year period of about 3.5°C, and the maximum difference between consecutive years was greater than 1.5°C. The data also show that the mean temperature, averaged over periods of several years, departs significantly from its long-term, 49-year mean. For example, over the 14-year interval from 1944 through 1957, the mean temperature was about 0.7°C higher than the 49-year mean of 14.8°C.

There are then, marked *natural* spatial and temporal variations in water temperature. Superimposed upon these natural fluctuations are the thermal effects of man's activities. Man directly affects the distribution of temperature in segments of the Bay and its tributaries where he utilizes part of the available water as cooling water for the condensers of electric generating plants (fig. 5). It might be useful to look at examples of the magnitude and the areal extent of the temperature increases associated with 2 power plants—one in operation and the other under construction.

The Chalk Point power plant is a fossil fuel plant located on the upper Patuxent

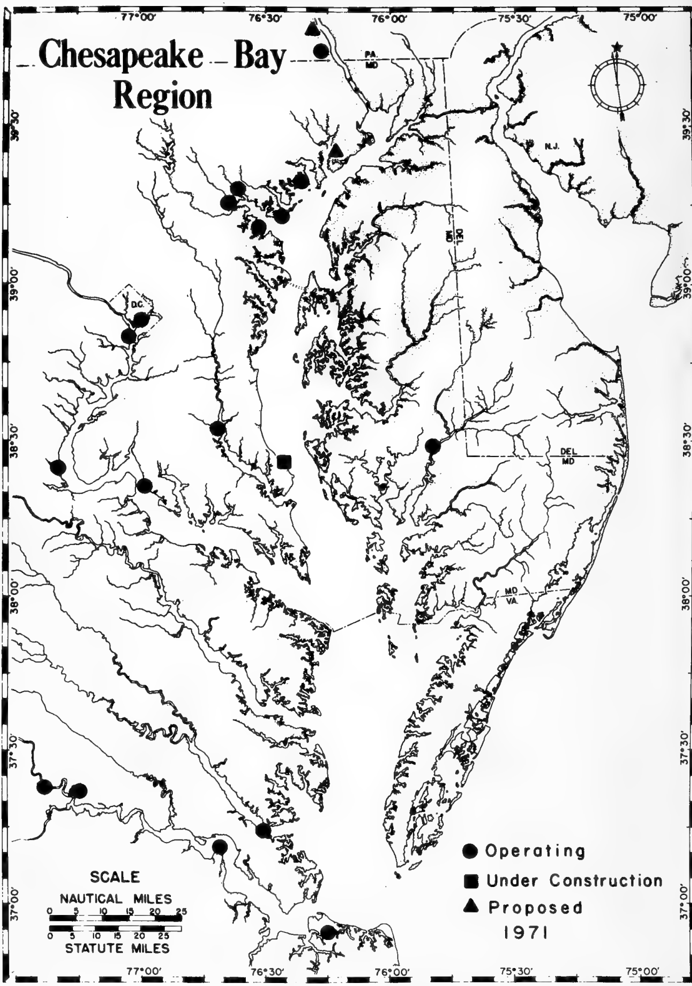


Fig. 5. Map of electric generating plants in Chesapeake Bay region.

estuary. The plant has a design power production of 710 MWE from 2 units. At this loading, the plant rejects heat to the environment at a rate of about 1.2×10^{10} cal/sec (2.8×10^9 BTU/hr). When operating near full capacity the plant utilizes cooling water at the rate of about 31 m^3/sec, or approximately 1/3 of the total available dilution water from the Patuxent. After the cooling water passes through the condensers it flows through a long canal and discharges into the Patuxent approximately 2.4 km upstream from the plant.

The Chesapeake Bay Institute made a detailed study of the temperature and salinity distributions in the vicinity of the plant between 25 September and 5 October 1967 (Carter, 1968). Carter used these data to compute the distribution of excess temperature produced by the plant—the temperature elevation above that which would occur if

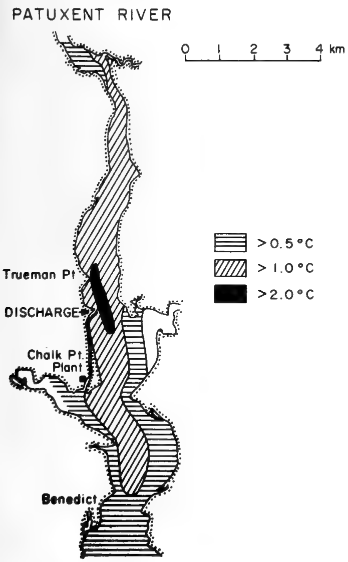


Fig. 6. Horizontal distribution of *excess* temperature *minimum* (°C) of Chalk Point Plant (H.H. Carter, personal communication).

the plant were not operating. The excess temperature was greater than 1°C over the entire cross-section of the estuary adjacent to the plant, and the sectional mean value of the excess temperature in this segment was about 2°C. The effects on the longitudinal distribution of temperature were also quite pronounced. The mean sectional excess temperature exceeded 0.5°C for a distance of about 18.5 km along the estuary.

The horizontal distribution of the excess temperature *minimum* is shown in fig. 6. The figure represents the minimum excess temperatures observed during a tidal cycle. Superimposed upon this distribution is a plume of higher excess temperature which oscillates with the tide. The plume is not shown in fig. 6. The maximum excess temperatures in the plume and in the discharge canal reach more than 5°C higher than those shown.

Clearly the Chalk Point power plant has a demonstrable effect on the *temperature distribution* of the Patuxent estuary. The more important question however, is whether the observed temperature increases have a measurable ecological effect on the system. Since the plant has been operating, there have been 2 mass mortalities; one of finfish, including many striped bass, and the other of blue crabs. Both of these kills were confined to the discharge canal. The finfish kill was very probably caused by an overdose of chlorine, and not by thermal effects as originally reported. The cause of the crab kill may have been a combination of high temperature and high levels of chlorine in the canal.

The massive finfish kill occurred some time in the early morning of 27 September 1967. On the evening before the kill, members of the Chesapeake Bay Institute fished in the discharge canal and did not observe any dead fish. The plant operated near full capacity the day of the kill, and throughout the 5-day periods preceding and succeeding the kill. The continuous record of temperature in the canal, near its mouth, shows clearly that on the day of the kill there was not an increase in temperature (fig. 7). In fact, higher temperatures were observed both before and after the massive kill with-

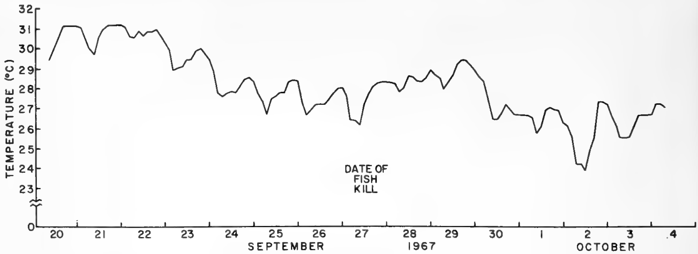


Fig. 7. Temperature record (°C) from Chalk Point Plant discharge canal covering period of massive fish kill on 27 September 1966.

out any apparent harmful effects. Fig. 7 shows no evidence to indicate the possibility of thermal shock, and indicates that a stress other than temperature must be sought to explain the massive mortality of fish.

At the time of the kill a dye tracer, Rhodamine B, was being injected into the plant discharge. It is well known that this dye is not a biocide and would not have caused the kill. The dye however, gives a clue to the probable cause of the kill. At the time of the kill there was a sharp loss of dye within the canal; a loss which could not be explained by physical processes. Since it was known that chlorine destroys the dye, the plant's chlorination log was inspected and it was found that at the time of the mass kill the concentrations of free chlorine in the cooling water reached levels as high as 6 ppm—approximately 12 times the normal level (H.H. Carter, personal communication).

A massive kill of blue crabs (*Callinectus sapidus*) occurred in the discharge canal near the end of August, 1966. It was estimated that there were at least 40,000 dead crabs, both juveniles and adults, in the canal (Mihursky, et al, 1967). Temperatures in the canal are not available for this period, but the water temperature at a location approximately 0.3 km off the mouth of the canal reached a maximum temperature of 34.6°C (Mihursky, et al., 1967). Many of the dead crabs were discolored, and Mihursky, et al. (1967) suggested that "The reddish color of many crabs may indicate a heat kill; however, at this time we cannot rule out the possibility of a chemical kill." Temperatures in the canal probably did not exceed 36°C.

Crabs are among the most temperature-tolerant of all Chesapeake Bay organisms. The temperatures in the canal were however, near the lethal limit for blue crabs (Tagatz, 1969). Tagatz acclimated blue crabs to various temperatures for 21 days and then exposed adult and juvenile crabs to test temperatures at 2°C intervals near the estimated upper and lower limits of their temperature tolerances for 48 hours. The results of Tagatz's experiments with adult female crabs in 20% sea water are shown as a tolerance

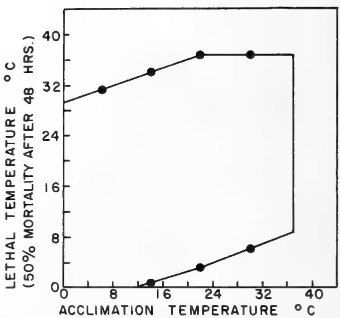


Fig. 8. Thermal tolerance of adult (mature female) blue crabs in 20%seawater (after Tagatz, 1969).

diagram in fig. 8, which is a plot of lethal temperatures (temperatures at which 50% mortality occurs after 48 hours) against acclimation temperatures. The area inside the curve represents the thermal possibilities under which adult crabs survive for a presumably indefinite time. The results of Tagatz's experiments indicate that crabs in the canal were probably near their upper lethal limit—about 36°C—at the time of the kill. Temperatures in the canal were probably near 36°C for a number of days, and since the crabs had to work to stay in the discharge canal, there may have been an additional and important stress. Crabs do not turn red at temperatures of 36°C. They can turn red however, when free chlorine levels are high. In view of this, and the more recent evidence of a chlorine kill of finfish, it seems likely that the crab kill may have been caused by a combination of factors—temperature and chlorine. The additional stress of high chlorine levels on organisms living near their upper limit of temperature tolerance may have been sufficient to produce the massive kill. Unfortunately, the plant's chlorination and temperature records are no longer available for examination.

The only unequivocally documented ecological effects of the waste heat from the Chalk Point plant are the mortalities of plankton which occur during passage through the plant and discharge. The extent of such mortalities is increased by the poor design of the discharge system. The time of passage through the canal is excessive—nearly 2½ hours—and there is very little cooling within the canal. Organisms are subjected to excess temperatures of greater than 5°C for about 2½ hours.

The comments above are not meant to imply that there are no subtle, long-term ecological effects from the observed increases in temperature. These can only be documented through very careful and detailed long-term studies. Their documentation will be difficult however, because man is affecting the Patuxent estuary in other ways. The concentrations of nutrients in the upper Patuxent have risen markedly in the past 10 years, the concentration of inorganic nitrogen has increased by at least an order of magnitude, and there has been a substantial increase in the level of inorganic phosphorous.

Another power plant which has received a considerable amount of attention is the Calvert Cliffs Nuclear Power Plant which is being built by the Baltimore Gas and Electric Company. The plant is scheduled to begin operations some time in 1973. The plant design calls for two nominal 875 MWE units. The predicted rate at which heat will be rejected to the environment is about 5.0 x 10^{10} cal/sec (1.2 x 10^{10} BTU/hr). At a temperature rise across the condensers of 5.5°C, approximately 153 m^3/sec of cooling water will be required. This represents approximately 6% of the available water. The cooling water will be drawn into the plant from the Bay below 8 m and discharged as a submerged jet. The time of travel from the point of intake to the point of discharge is about 3 minutes.

Pritchard (1969) has made first-order estimates of the probable distribution of excess

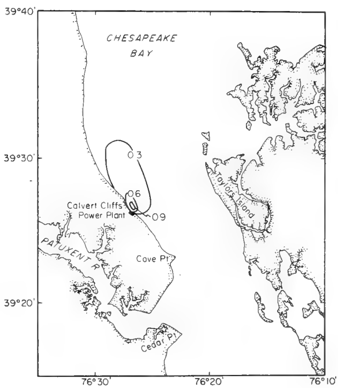


Fig. 9. Estimate of horizontal distribution of *excess* temperature, °C, in vicinity of Calvert Cliffs Nuclear Power Plant, for the period of flood tide (from Pritchard, 1969).

temperature that will be produced by the Calvert Cliffs plant. The predicted horizontal distribution of excess temperature in the layer having maximum excess temperature is presented in fig. 9. The distribution is for the end of a flood period. On the ebb tide the plume will be bent over and elongated down the Bay.

The vertical distribution of excess temperature at slack water along the axis of the

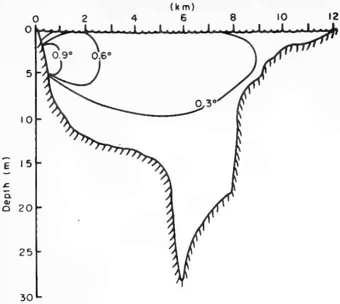


Fig. 10. Distribution of excess temperature, °C, on a vertical section along axis of plume at slack water (from Pritchard, 1969).

plume is shown in fig. 10. The predicted mean sectional excess temperature in the tidal segment of the Bay opposite the plant is about 0.2°C, and only about 1% of the entire cross-section adjacent to the plant will have excess temperatures greater than 1°C.

Clearly, the impact of the Calvert Cliffs Plant on the temperature distribution of the adjacent Bay will be much less than that the Chalk Point Plant now has on the temperature distribution of the Patuxent. The biological effects should also be less. The mortality rate during entrainment should be considerably lower, since the time of entrainment is only about 3 minutes compared to 2½ hours at the Chalk Point Plant.

In summary, there are marked natural, temporal, and spatial variations of water temperature throughout the Chesapeake Bay estuarine system. Superimposed upon the natural temperatures are the "excess temperatures" which result from the discharge of condenser cooling water from power plants. These excess temperatures can be predicted and determined with a reasonable degree of accuracy. The ecological effects of the man-made temperature elevations however, are more difficult to ascertain. No significant ecological damage to the Chesapeake Bay has been unequivocally documented from *present* inputs of heated discharges, nor is any likely to occur from the plants now under construction (Fig. 5). But additional plants will be needed. Man's power consumption is increasing at an alarming rate—a doubling approximately every decade.

Salinity

Salinity is important because of its affect on density, and on a number of other important physico-chemical properties. Salinity is also very important biologically. It exerts a marked influence on the distribution and activity of many organisms that inhabit the Bay.

The distribution of salinity in the main body of the Bay and its tributaries has been studied by the Chesapeake Bay Institute for over 20 years. The results have been presented in a series of graphical summary reports (Whaley and Hopkins, 1952; Stroup and Lynn, 1963; Seitz, 1971).

The spatial and temporal distributions of salinity in the Chesapeake Bay and its tributary estuaries are determined by the freshwater inflow. The mixing of the freshwater and the seawater is produced primarily by tidal action, with the total freshwater inflow to the Chesapeake Bay system averaging approximately 1950 m^3/sec from 1951 through 1970. The major source of freshwater is the Susquehanna River, which accounts for approximately 50% of the total input of freshwater. The discharge of the Susquehanna accounts for more than 90% of the total freshwater input above Annapolis and more than 85% of the freshwater entering the Bay above the mouth of the Potomac. The Susquehanna has a long-term (38-year) annual average flow of about 985 m^3/sec. The range in the annual average flow of from about 550-1525 m^3/sec represents a fluctuation about the 38-year mean flow of greater than ± 44%. The yearly averages show a standard deviation greater than 20% of the 38-year mean. Seasonal fluctuations in the average flow are even greater; the minimum monthly discharge averages about 215 m^3/sec, and the maximum monthly flow averages approximately 3256 m^3/sec. Relatively large short-term fluctuations also occur. For example, during March of 1964 the average discharge of the Susquehanna was approximately 4200 m^3/sec, while the

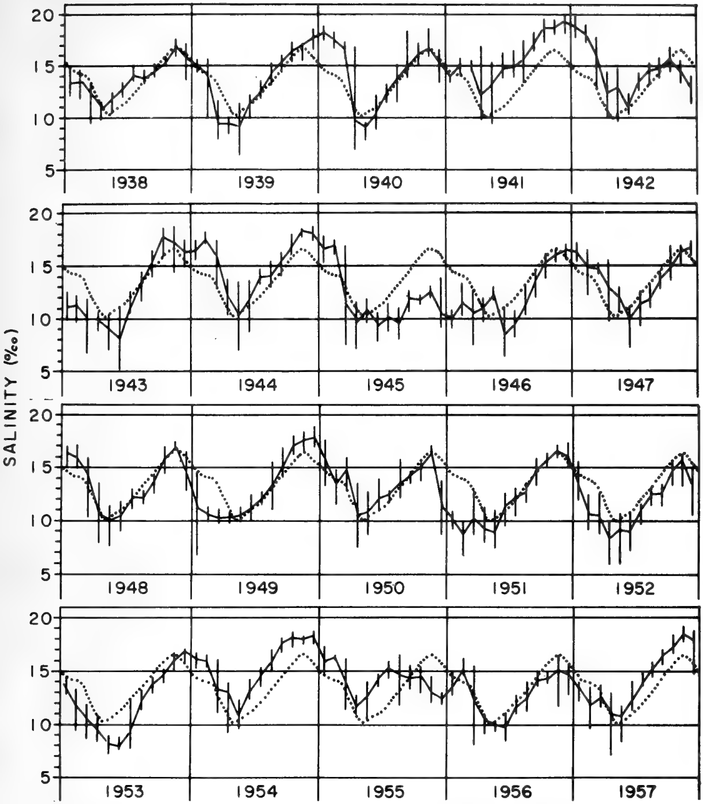


Fig. 11. Surface salinity at Solomons in the Patuxent estuary between 1938 and 1957. The monthly means are connected by solid lines, the monthly extremes are indicated by vertical lines, and the dotted curve represents a moving ten-day average of twenty-year daily means (from Beaven, 1960).

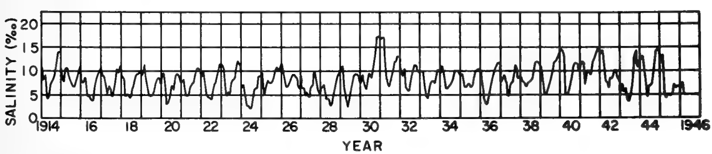


Fig. 12. Monthly average salinities at Fort McHenry in Baltimore Harbor between 1914 and 1948 (from Beaven, 1946).

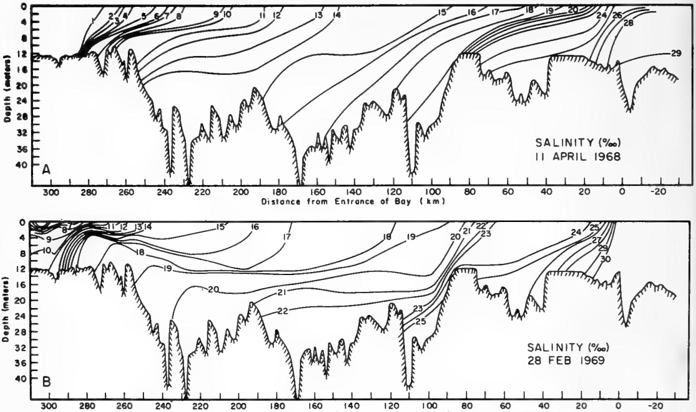


Fig. 13A (above). Longitudinal salinity distribution along axis of Chesapeake Bay during a period of high river flow (from Seitz, 1971).

Fig. 13B (below). Longitudinal salinity distribution along axis of Chesapeake Bay during a period of low to moderate river flow (from Seitz, 1971).

maximum daily discharge during the month was about 14160 m^3/sec. At present there is no significant regulation of the flow of the Susquehanna.

The second largest river debouching into the Bay is the Potomac, which contributes approximately 16% of the total freshwater input to the Bay. The Potomac has a long-term average discharge of about 310 m^3/sec. It is a flashy river with a recorded range in flow of 20 m^3/sec to about 1360 m^3/sec. There is no significant regulation of its flow. The third largest source of freshwater is the James River.

The marked variations of the freshwater inflow produce large temporal variations of salinity. The variations are most marked, of course, in the upper reaches of the Bay and its tributary estuaries. Near Pooles Island in the upper Chesapeake Bay the salinity during 1960, a year of relatively high river flow, ranged from 0.4‰ in April to 8.3‰ in December—more than a 20-fold range. During 1964, a year of relatively low river flow, the range in salinity was from 0.8‰ in March to 13.3‰ in December.

Long-term records of the variations of salinity observed at 2 stations in the Bay are shown in figs. 11 and 12. Fig. 11 is a record of the monthly mean salinities, and the extremes, at Solomons, Maryland, near the mouth of the Patuxent estuary between 1938 and 1957 (Beaven, 1960). A curve is also shown depicting the results of a moving 10-day average of the 20-yr daily mean salinities.

Fig. 12 is a plot of the monthly average salinity values between 1914 and 1945 at Fort McHenry in Baltimore Harbor (Beaven, 1946). These figures show relatively large monthly, seasonal, and longer-term variations in salinity at these locations.

The longitudinal variation in surface salinity over the length of the Bay ranges from the salinity of the Susquehanna River water, about 0.1‰, near the head of the Bay to a salinity of about 25-30‰ at the mouth. The longitudinal distribution in the Bay for a period of high river flow is shown in fig. 13A, and for a period of low to moderate river flow in fig. 13B. During periods of high flow, the "mouth" of the Susquehanna may be extended to a point nearly 45 km into the main body of the Bay. During such periods the transition from river to estuary is marked by a sharp front separating the fresh river water from the salty estuary water. Salinity gradients greater than 5‰ in 5 km are not uncommon in the frontal regions. With subsiding river flow the characteristic 2-layered net circulation regime is reestablished in the upper Bay. Salt is advected into the region by the lower layer and the salinity distribution illustrated in fig. 13A is transformed to resemble that shown in fig. 13B—the distribution characteristic of 2-layered estuarine circulation regimes. The rate of recovery is not well known, but it is almost certainly less than 1 week and may be only a few tidal cycles.

There are, then, marked natural spatial and temporal salinity variations. The changes are greatest in the upper reaches of the estuaries, but relatively large variations occur throughout the Chesapeake Bay estuarine system.

To date, man has had little effect on the salinity distribution in the Bay or its tributaries. Recently, however, there has been concern over the possible effects of the enlargement of the Chesapeake and Delaware Canal on the salinity distribution and on the ecology of the upper Chesapeake Bay. The Canal channel is being widened from 76 m to 137 m, and deepened from 8.2 m to 10.7 m.

Because of differences in the tidal characteristics at the Chesapeake and Delaware ends of the Canal, there is a net non-tidal flow through the Canal from the Chesapeake Bay to the Delaware Bay. Pritchard (1971) estimated that the net non-tidal eastward flow through the 8.2-m-deep Canal is about 28 m^3/sec, and he predicted that the net flow through the enlarged Canal would increase by a factor of 2.7 to about 76 m^3/sec. The tidal velocities and the tidal excursions, which may be of greater ecological significance than changes in the net volume rate of flow, will be increased by a factor of only about 1.2.

Using a 1-dimensional time-dependent numerical model of the salinity distribution in the upper Chesapeake Bay developed by Boicourt (1969), Pritchard (1971) made estimates of the probable effects of the enlargement of the Canal on the Salinity distribution. His analysis showed that the increased diversion of freshwater through the Canal to the Delaware Bay would have very little effect on the salinity distribution during periods of high river flow when salinities are at a minimum. The average minimum salinity would probably increase from 8.60 to 8.79‰ at the Bay Bridge, from 1.14 to 1.19‰ at Pooles Island, and would be unchanged, 0.13‰, at Turkey Point. The greatest effects would, of course, be observed during periods of very low river flow when salinities are a maximum. Pritchard (1971) predicted that the average maximum salinity would probably be increased from about 17.23 to 17.62‰ at the Bay Bridge, from 9.00 to 11.58‰ at Pooles Island, and from 2.14 to 2.94‰ at Turkey Point.

Changes in the salinity distribution in the upper Bay would also result from flow regulation of the Susquehanna River. Flow regulation would reduce the natural variations of the spatial and temporal salinity distributions in the upper Chesapeake Bay, and therefore the variations in the associated circulation patterns in the upper Bay and in a number of the tributary estuaries.

The temporal variations in salinity in the upper Bay provide the basic mechanism for the flushing of tributary estuaries such as the Gunpowder, Bush, Back, Magothy, and Severn (Pritchard, 1968). The small freshwater input to these tributaries is insufficient to maintain a steady circulation pattern, and the water that fills them is derived largely from the adjacent Bay. It is only in the upper reaches of these tributaries that the salinity distribution is significantly affected by the freshwater inflow. The primary factor controlling the exchange of water between these tributaries and the Bay is the temporal variation in the salinity of the upper layer in the adjacent Bay. The salinity of the surface layers of the upper Bay varies seasonally with maximum values in the fall and minimum values in the spring. The salinity changes in the tributaries lag behind those in the adjacent Bay. During winter and early spring when the salinity in the

Bay is decreasing with time, the salinity in the tributaries is, at any given time, higher than in the Bay. As a result water flows into the tributaries at the surface from the Bay, and out of the tributaries in the deeper layers into the Bay. In late spring, summer, and early fall when the salinity of the Bay is increasing, the salinity in the tributaries is less than in the adjacent Bay, and hence the waters of the tributaries flow out at the surface, while Bay waters flow into the tributaries along the bottom. Since these estuaries are shallow—channel depths generally less than 6 m—only the upper layer of the Bay participates in the exchange with the tributaries.

The circulation pattern in these tributaries is thus reversed at least twice each year. Some of the smaller estuaries tributary to the head of the Bay, such as the Gunpowder and the Bush, are renewed more often. These estuaries are subject to rapid renewal rates because of large, short-period fluctuations in the salinity of the adjacent Bay;

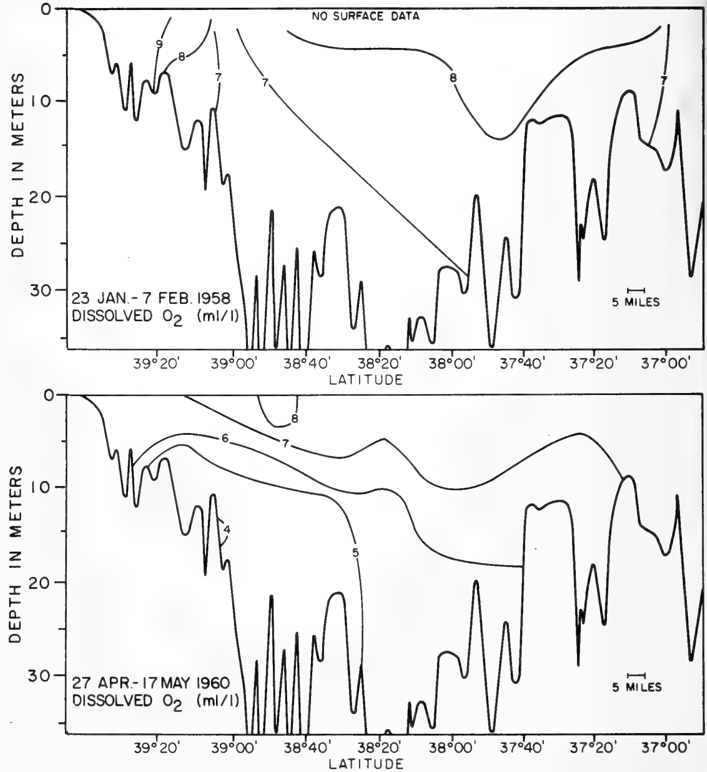


Fig. 14. Longitudinal distribution of dissolved oxygen along axis of Chesapeake Bay during winter (above) and spring (below).

fluctuations produced by sudden, marked changes in the discharge of the Susquehanna River. Pritchard (1968) has pointed out that if the flow of the Susquehanna were controlled to the extent that the seasonal changes in salinity in the upper Bay were to disappear, the primary mechanism for the flushing of a number of the small tributaries would disappear, and pollution problems would be intensified.

In summary, there are marked natural temporal and spatial variations of the salinity particularly in the upper reaches of the Bay and its tributary estuaries. To date, man has had little effect on the distribution of salinity in the Chesapeake Bay estuarine system.

Dissolved Oxygen

Dissolved oxygen is added to the water by exchange across the air-sea interface (naviface) and by photosynthesis. Oxygen is removed from the water by loss across the naviface, by respiration, by oxidation of or-

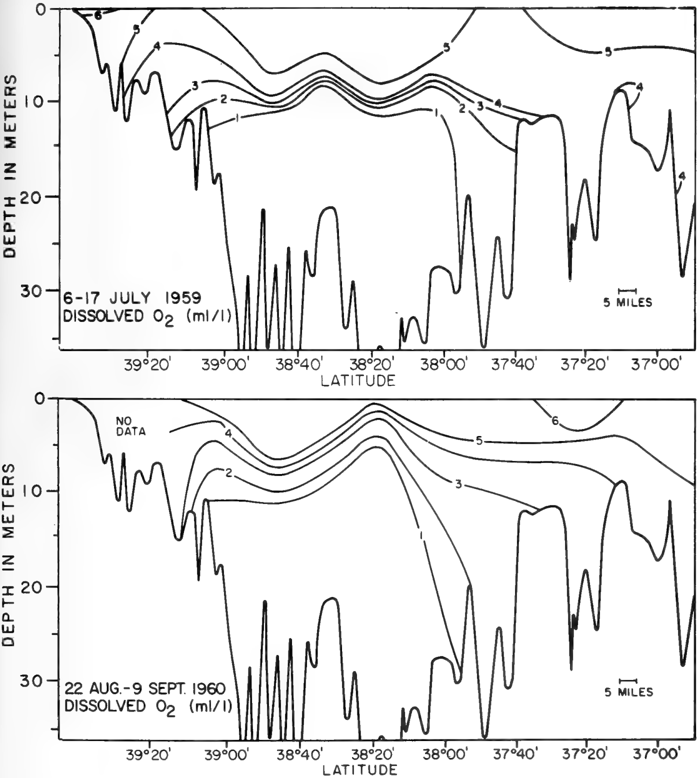


Fig. 15. Longitudinal distribution of dissolved oxygen along axis of Chesapeake Bay during summer.

ganic matter, and by reactions with reduced materials such as sulfides, and iron[I]. Dissolved oxygen is removed from all depths, but it is added only to the upper part of the water column—to the depth of the euphotic zone. There are marked natural variations in the temporal and spatial distributions of dissolved oxygen. Near the surface of most of the estuary, the values stay near saturation throughout the year, but in the lower layer the concentrations of dissolved oxygen may go from near saturation to near 0 over the year. Superimposed upon these natural variations are fluctuations resulting from man's activities.

The natural variations are explainable in terms of the characteristic physical, chemical, and biological processes. We will examine the seasonal variations of dissolved oxygen along an axial section of the Chesapeake Bay, (figs. 14-15). During the winter the water is cold, saturation values are high, and mixing is relatively intense. The estuary is nearly uniformly high in dissolved oxygen content throughout the water column. In the spring, the water temperatures rise in response to increased solar insolation and warm spring rains. Because of the increased water temperatures, saturation values of dissolved oxygen decrease. Near the surface the concentrations of dissolved oxygen stay near saturation, but in the lower layer the values decrease more rapidly than at the surface, and soon become much less than the saturation values. In the early spring the river flow increases because of increased precipitation and melting snow. The additional freshwater inputs increase the stability of the water column, thereby decreasing the vertical mixing. The source of oxygen to the lower layer has thus been greatly diminished. Utilization of oxygen, however, increases with increasing temperature. By mid-June the concentration of dissolved oxygen in the deeper layers of the Bay may be less than 1 ml/l, while the surface values which are near saturation may be greater than 5 ml/l. This condition continues throughout the summer months. By mid-summer the concentration of dissolved oxygen at depths greater than 12 m may be less than 0.1 ml/l. Anaerobic conditions have not been observed in the main body of the Bay, but the deeper areas of a number of the tributaries including the Severn, the Potomac, and Eastern Bay go anaerobic in the summertime.

In late summer, usually near the end of August, rapid changes in the vertical distribution of dissolved oxygen often occur. A few clear, cool nights cool the surface waters sufficiently to increase their density above that of the underlying water. Vertical downward mixing is initiated and the deeper water is thus replenished with dissolved oxygen. Another warm spell may re-establish a strong vertical density gradient, and the oxygen in the deeper layer will again decrease. By the middle of October the concentration of dissolved oxygen has started to increase steadily at all depths, and within a few weeks the Bay becomes nearly uniform in dissolved oxygen.

There are also diurnal variations of the concentration of dissolved oxygen in the euphotic zone. Values are higher during the daylight hours of photosynthetic activity than during the hours of darkness when photosynthetic production of oxygen ceases but respiratory consumption continues. The "natural" diurnal variations are generally small, but in highly productive areas they may be large.

Superimposed upon these natural fluctuations are variations resulting from man's activities. These effects have resulted largely from the introduction of nutrients which stimulate primary productivity and are most readily observable in the upper reaches of some of the tributary estuaries. When nutrients are no longer limiting, solar energy is, and there is frequently a sequence of intense blooms separated by massive die-offs. The die-offs produce large oxygen depletions, sometimes resulting in anaerobic conditions. Low oxygen zones in the tributaries probably began to increase in frequency, duration, and extent as early as the latter part of the 18th century as a result of increased agriculture. The additional nutrients introduced into the triburaries stimulated primary productivity. The organic detritus placed heavy oxygen demands on the estuaries. The nutrients in the sewage and municipal wastes of a burgeoning population have seriously

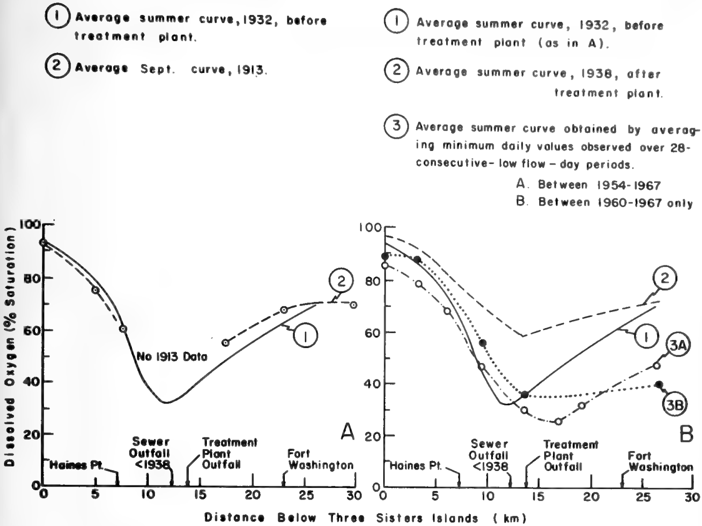


Fig. 16. Longitudinal distributions of dissolved oxygen in tidal reaches of Potomac. Fig. at right after Wolman (1971).

aggravated the problem in a number of the tributaries.

The effects of man on the distribution of dissolved oxygen are readily apparent in the Potomac, particularly in the tidal reaches of the River below Washington, D.C. Large amounts of nutrients added by the metropolitan Washington area sewerage system to an already enriched Potomac result in a high level of primary productivity and large biochemical oxygen demands (BOD).

Recently Wolman (1971) reported some observations of dissolved oxygen made between 1932 and 1967 in the tidal reaches of the Potomac River. He presented a curve depicting an average longitudinal variation of dissolved oxygen minima expressed as % saturation for the summer of 1932 before construction of the Washington treatment plant, and a similar curve for the summer of 1938 following construction of the treatment plant. He also presented a curve of the average longitudinal distribution of dissolved oxygen minima obtained by averaging the lowest daily oxygen values observed over 28-consecutive-day periods of minimum river flow between 1954 and 1967. A similar curve was plotted for 1960-1967 only. These curves are shown in fig. 16. Fig. 16 shows a curve depicting the average distribution of dissolved oxygen in 1913 during the month of September, the month of lowest oxygen levels (Cumming, et al., 1916). All of the curves in fig. 16 show a sag in the oxygen levels below Washington. There were no 1913 data in the region of the sewer outfall. Upstream from the outfall, the 1913 oxygen levels were slightly lower than the 1932 levels while downstream from the outfall they were slightly higher. The differences may not be significant, but the higher levels in 1913 downstream from the sewer outfall might be explained by the dense growth of submerged vegetation that covered nearly all of the bottom outside of the channel in 1913 but which disappeared in the 1920's.

In 1938, following construction of the Blue Plains sewage treatment plant, the oxygen levels rose significantly, but the therapeutic effects of the plant were apparently relatively short-lived. The average oxygen minimum curve for periods of low flow between 1954 and 1967 indicates that not only had the concentrations of dissolved oxygen apparently decreased to levels below those observed before any treatment was provided, but the zone of low oxygen extended farther downstream. For the period 1960-1967 the situation was apparently slightly improved.

The trends indicated by the curves in fig. 16 are very probably real, but one must, for a number of reasons, be prudent in comparing these observations which span 54 years: the accuracy and precision of the measurements are uncertain; the averaging processes used by the investigators are obscure; and the diurnal fluctuations of the concentration of dissolved oxygen which are appreciable in this region were apparently not considered in sampling.

Improvement of the levels of dissolved oxygen in the tidal reaches of the Potomac presents a formidable challenge. As Wolman (1971) pointed out, "Despite expenditures upward of $70 million from 1938 through 1965, in recent years dissolved oxygen during the summer months has retreated to the position occupied by similar curves in 1932 before major treatment works were installed in 1938." The low concentrations of dissolved oxygen result from massive die-offs of intense blooms which are stimulated by the high nutrient levels. Even if all of the nutrients were to be removed from the Washington metropolitan area waste effluent, the nutrient levels in the River would still be at an undesirable level.

In summary, man's activities have certainly increased the frequency, extent, and duration of low oxygen zones in the upper reaches of the Potomac and of a number of other tributaries. Because of the lack of historical data, however, it is not possible to chronicle these changes.

Low levels of dissolved oxygen are a symptom of a much more serious problem, probably the most serious, that threatens the Bay—the influx of nutrients from municipal and agricultural wastes.

Nutrients

The nutrients nitrogen and phosphorous are necessary for primary productivity. They are added to the Chesapeake Bay estuarine system by natural sources and as a result of man's activities. They have not only always been present in the Chesapeake Bay and other estuaries because of their natural sources, but have probably, because of the dynamic processes in the estuary, always been present in relatively high concentrations—high relative to other parts of the marine environment. But large additional inputs of nitrogen and phosphorous have been added to the Chesapeake Bay and other waterways by man's activities. It has been estimated that the total amount of phosphorous discharged into United States waterways probably exceeds that of 50 years ago by a factor of 3 or 4 (Man's Impact on the Global Environment, 1970). Large amounts of nutrients are introduced directly into the Chesapeake Bay estuarine system through the discharges of municipal treatment plants. In addition, rivers convey large quantities of nutrients into the Bay—nutrients which result in large part from man's activities in the drainage basin, perhaps hundreds of kilometers away. Nutrients are added to the rivers in sewage, in runoff from fertilized fields, and from animal feedlots.

Both nature and man concentrate their effects on the tributaries and on the upper reaches of the Bay. These zones have buffered man's impact on the main body of the Bay, but many of them have been degraded by undesirably high levels of productivity stimulated by high nutrient concentrations.

In the Maryland portion of the Bay the effects of nutrient-loading from municipal wastes are most apparent in the upper Potomac and in Back River; the receiving waters for the wastes from the metropolitan Washington, D.C., and Baltimore areas. The dramatic increases in nutrient levels which have recently been reported in the upper Patuxent (Flemmer, 1971) are a result of the wastes from the burgeoning population in the small drainage basin of that river. The effects of local inputs from the septic field drainage of largely unsewered land areas are observable in some of the smaller tributaries including the South, Magothy, Miles, Chester, and Severn estuaries. In the upper reaches of the main body of the Bay, the Susquehanna is the major conveyor of nutrients—nutrients derived from extensive agricultural areas and from a population that exceeds 1 million in the drainage basin.

Assemblages of primary producers are adjusted to certain ranges of the concentrations of the essential nutrients and to certain ranges of their relative abundances. The limits of the ranges characteristic of "unpolluted" and "polluted" waters have not been firmly set. Some guidelines are necessary, however. After examination of the literature and discussion with several of my colleagues, the following conclusions were tentatively determined. In unpolluted, productive waters the ratio of total N to total P probably does not fall below 10:1, and the limit may be 15:1. In addition, concentrations of total P greater than about 3 μg at./l are probably undesirable.

The Potomac River with an average flow of about 310 m^3/sec is the second largest river discharging into the Chesapeake Bay estuarine system. It is a flashy river with no significant flow regulation; the recorded flow range is from about 20 m^3/sec to 1360 m^3/sec. The Potomac drains approximately 28,490 km^2 of forested and agricultural land above Washington and 5,180 km^2 of urban area within the metropolitan Washington area. The transition from the Potomac *estuary* to the Potomac *River*, marked by the upstream limit of sea salt, occurs between 80-100 km above the mouth of the estuary. This is approximately 35-55 km below Washington, D.C. The tidal effects extend farther upstream to the fall line just above Washington. The freshwater region between the upstream limit of sea salt and the head of tide is called the "tidal reaches of the river."

Nutrients are introduced into the upper reaches of the Potomac *River* by drainage of agricultural areas and by additions of sewage. Measurements made in 1965-1966 showed that in the river just above Washington the concentrations of nitrate were 100-150 μg at./l during periods of high river flow, and the concentrations of phosphate about 5 μg at./l (Carpenter, et al., 1969). During periods of low river flow the concentrations of nitrate were about 50-70 μg at./l, and the concentrations of phosphate about 3-4 μg at./l. THe levels of phosphorous in the River are already at undesirable levels, even before the river reaches Washington, D.C.

The sewerage systems of the Washington metropolitan area presently discharge into the Potomac River about 1.1 x 10^6 m^3/day (290 MGD) containing more than 6 metric tons of phosphorous and 10 metric tons of nitrogen, and these values are expected to double within 30 years. Probably more than half of the phosphorous is from phosphate in detergents. These inputs produce very high local concentrations of nutrients, particularly during periods of low river flow. For example, with a river flow of about 85 m^3/sec, the input of sewage would increase the concentrations of phosphorous by about 180 μg at./l (Carpenter, et al., 1969). During 1965 the river flow exceeded 85 m^3/sec less than 1/3 of the time. These high concentrations of nutrients do not extend very far downstream; they are primarily restricted to the tidal reaches of the river.

Carpenter et al., (1969) have described the distributions of nutrients in the Potomac, and this discussion is based in large part on their report. The longitudinal distribution of nutrients in the Potomac varies seasonally, with concentrations of total nitrogen in the *estuary* generally being highest during January, February, and March, (fig. 17).

The monthly longitudinal distributions of total phosphate show increases in the tidal reaches of the river during late fall and winter, displacement of the high values downstream into the estuary with increasing flow in the spring, and then relatively moderate and uniform concentrations in the estuary throughout the summer and most of the fall, (fig. 18). The concentrations of inorganic phosphate are high in the tidal reaches of the river and constitute an appreciable fraction of the total phosphate concentrations. Farther downstream in the estuary, however, inorganic phosphate concentrations exceed 0.5 μg at./l only after high river flow.

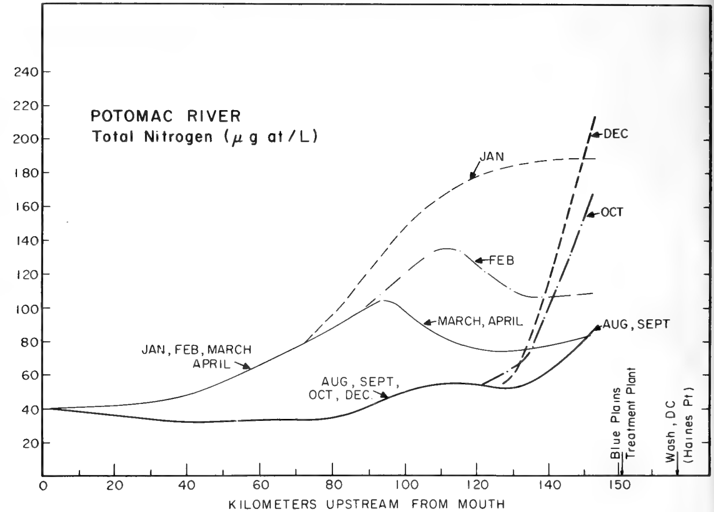


Fig. 17 Longitudinal distribution of total nitrogen in the Potomac (from Carpenter, et al., 1969).

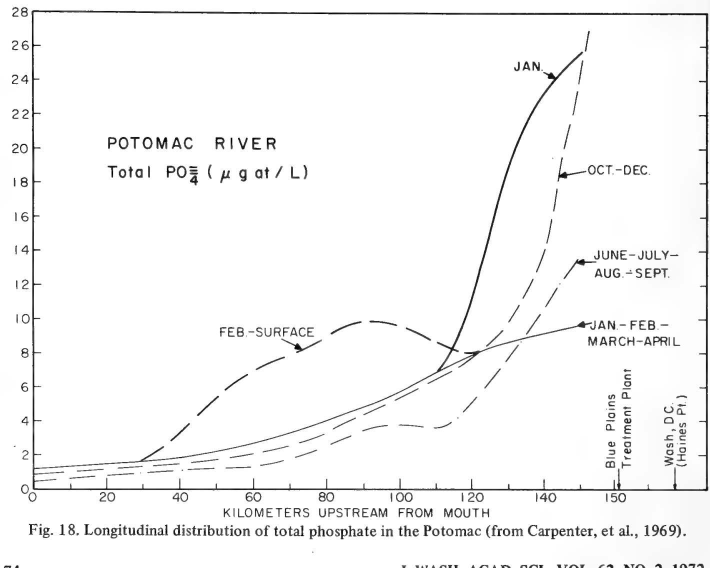


Fig. 18. Longitudinal distribution of total phosphate in the Potomac (from Carpenter, et al., 1969).

In the tidal reaches of the Potomac River the concentrations of total phosphorous are at undesirably high levels, and the ratio of nitrogen to phosphorous is lower than in "healthy" productive waters. Farther seaward, in the estuary, the concentrations of phosphorous fall below 3 μ g at./l, and the ratio of N to P is greater than 10:1. The nutrient patterns are reflected in the longitudinal distributions of chlorophyll, which show very high concentrations in the tidal reaches of the River—concentrations which frequently exceed 70 μ g/l. These high values are produced primarily by *Microcystis aeruginosa*. These organisms collect in mats along the shoreline, producing repugnant conditions. In the estuarine sections of the Potomac chlorophyll levels are appreciably lower and are comparable to those in the upper Chesapeake Bay.

Clearly man has had a major and undesirable effect on the nutrient levels in the upper Potomac. Historical data are not available to chronicle the evolution of this impact, but one can get some idea of the inputs of nutrients from the Washington area by examining the population and waste water records. The Washington metropolitan area treatment plant (Blue Plains) was constructed in 1938. Prior to this, Washington had a sewerage system but did not have a treatment plant. In 1970 the treatment plant served a population of about 1.8 million and discharged approximately 1.1 x 10^6 m^3/day (290 MGD) into the Potomac. This waste water contributed approximately 6 metric tons of phosphorous and 10 metric tons of nitrogen to the Potomac each day. In 1970 Washington, D.C. had a population of 756,510. In 1940 the Blue Plains treatment plant served a population of about 0.8 million and discharged approximately 0.4 x 10^6 m^3/day (100 MGD). At that time Washington, D.C. had a population of 663,091. If the concentrations of phosphorous and nitrogen in the waste water were the same in 1940 as in 1970, this would represent daily inputs of about 2 metric tons of phosphorous and 3 metric tons of nitrogen. The concentrations of nutrients were probably less in 1940 than in 1970, but even if they were only 50% of the 1970 values, these lower inputs would result in undesirably high nutrient levels. The oxygen data, discussed elsewhere in this paper, also suggest that problems of eutrophication in the upper Potomac are of long standing. Following the introduction of soap powders containing phosphorous *circa* 1938, the concentrations of phosphates in the tidal reaches of the Potomac probably rose significantly, but they have probably been at undesirable levels for well over 50 years.

In some other tributaries the increases of nutrient concentrations to undesirable levels have been much more recent. In the upper Patuxent the concentrations of inorganic nitrogen increased by 10-15 times between 1962-64 and 1971, and inorganic phosphorous has also shown substantial increases over this period (Flemmer, 1971). The concentrations of nutrients in the upper Patuxent frequently reach levels comparable to those in the upper Potomac. The standing crop, as measured by chlorophyll, has increased, but not to the point of nuisance blooms such as those occurring in the upper Potomac (Flemmer, 1971).

In the main body of the upper Chesapeake Bay the nutrients are derived primarily from the inflow of the Susquehanna River. The upper Chesapeake Bay is the estuary of the Susquehanna River. The Susquehanna, with a long-term average flow of about 985 m^3/sec, discharges more than 85% of the total freshwater into the Bay above the mouth of the Potomac. The Susquehanna drains about 71,225 km^2 of New York, Pennsylvania, and Maryland. The watershed has extensive agricultural areas and a population of more than 1 million. These sources combine to contribute large quantities of nitrogen and phosphorous to the river (Carpenter, et al., 1969). The inputs are modified along the course of the river by biological removal which occurs in broad, shallow reaches of the river and in the series of reservoirs. When the river reaches the head of the Bay at Havre de Grace, Maryland, the concentrations of total phosphorous range from about 1.5 μ g at./l during winter and spring to about 1.0 μ g at./l during summer and fall. Nitrogen levels range from 80-105 μ g at./l during spring to

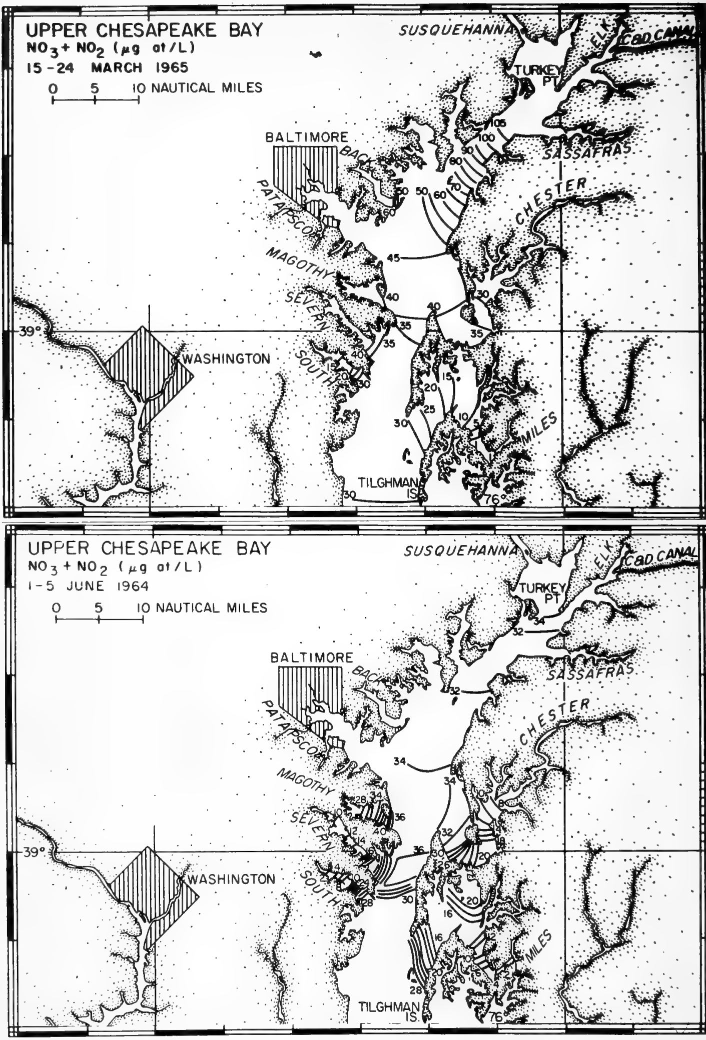


Fig. 19. Surface nitrate distributions ($NO_3 + NO_2$) in upper Chesapeake Bay (J.H. Carpenter, personal communication).

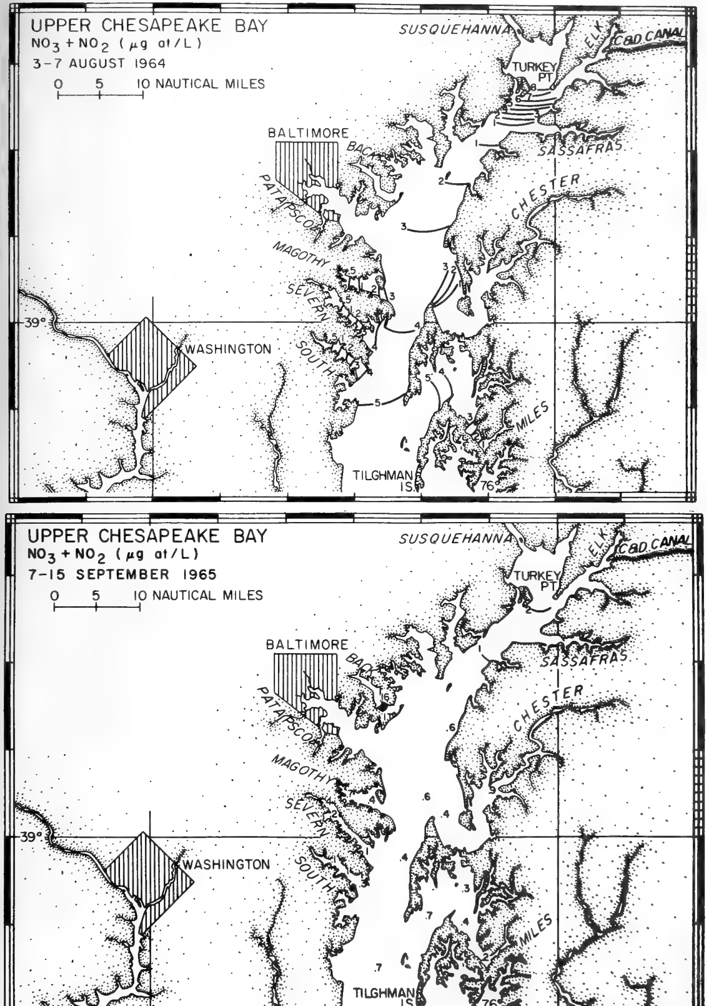


Fig. 20. Surface nitrate distributions ($NO_3 + NO_2$) in upper Chesapeake Bay (J.H. Carpenter, personal communication).

about 50 μg at./l during other seasons. Most of the nitrogen is present as nitrate.

The spatial distribution of nitrate in the upper Bay indicates that the Susquehanna River is the primary source, (figs. 19-20). Nearly half of the total annual flow of the Susquehanna occurs during a 3-month period in late winter and early spring. Since the nitrate concentrations are highest during this period, the Susquehanna discharges more than 60% of its total annual nitrate input during these 3 months. By the middle of April the Bay has a rather uniform nitrate distribution with concentrations of about 45 μg at./l. Throughout the late spring and summer the concentrations generally decrease and by September may be less than 1 μg at./l.

The distributions of phosphorous differ markedly from those of nitrogen. Total phosphate values are relatively uniform and have a range of only about 1-2 μg at./l. Phosphorous is apparently cycled at least twice between May and August, since the disappearance of some 45 μg at./l of nitrogen is not accompanied by changes in phosphate. During the summer more than half of the total phosphorous is present as dissolved organic phosphate.

In the main body of the upper Bay nutrient levels and phytoplankton production are high, but the grazing rate is also high thereby preventing an undesirable buildup of algae such as occurs in the tidal reaches of the Potomac. Nutrient levels are probably near the upper limit for "healthy" conditions. Pritchard (1968) estimated that a doubling of present nutrient levels in the main body of the Bay would produce undesirable conditions. A number of the upper Bay's tributaries are already over-enriched, and any additional inputs will be detrimental.

The municipal wastes from Baltimore are treated at the Back River treatment plant, which discharges about 0.6 x 10^6 m^3 (150 MGD) of treated effluent each day. Of this, approximately 0.4 x 10^6 m^3/day (100 MGD) are utilized by Bethlehem Steel as industrial cooling water and discharged into Baltimore Harbor. The remaining 0.2 x 10^6 m^3/day (50 MGD) is discharged into Back River, a small estuary that is tributary to the Bay and located just north of Baltimore Harbor. Nutrient levels in Back River are very high, and blue green algae thrive. In 1965 chlorophyll concentrations exceeded 60 μg/l from March through November and reached levels of 400 μg /l in October. Eutrophication in Back River is intense, but the effects are restricted to the tributary and are not apparent in the adjacent Bay. There are marked decreases in chlorophyll and total phosphate near the mouth of the tributary—decreases greater than can be accounted for by dilution. Deposition of algal cells in the sediment is the most probable process of removal. The Back River estuary is acting as a type of tertiary treatment pond, and the sacrifice of this tributary has protected the main body of the Bay.

The waste ferrous sulfate added to the part of the effluent used as cooling water by Bethlehem Steel is apparently sufficient to precipitate the phosphate in the Harbor so that little of it reaches the Bay. The nitrate is apparently also being rapidly removed either by a component added to the effluent during its use as a cooling water, or by a constituent in the receiving waters, but the process by which this happens is not clear.

While the effects of the treated sewage discharged into Baltimore Harbor and Back River are readily observable in these tributaries, they are not apparent in the adjacent Bay. Carpenter et al., (1969) pointed out: "During the prolonged drought of 1965, discharge of the Susquehanna River was 4,000 ft^3/sec (113 m^3/sec) during July, August, and September. The admixture of this inflowing freshwater with seawater produced a density-driven circulation in the Bay off Baltimore with a flow in the upper layer of about 3 times the freshwater discharge, or 12,000 ft^3/sec (340 m^3/sec). This flow would provide a dilution for the sewage discharge of 1 to 50, which corresponds to a possible increase of 6 μg at. per liter of phosphorous and 36 μg at per liter of nitrogen in the mixture. Such increases are not observed in the bay."

In summary, man has had an appreciable effect on the distributions of nutrients in the Chesapeake Bay estuarine system, particularly in the upper reaches of the Bay, and of a number of the tributaries. In the Maryland portion of the Bay, nutrients are at undesirable levels in the upper Potomac and in Back River, and are near the upper limit in the upper Bay, the Patuxent and in many of the smaller tributaries. The discharge of improperly treated sewage and municipal wastes constitute the most serious immediate threat to the Chesapeake Bay estuarine system.

Sediments

The general features of the geology of the Chesapeake Bay and the surrounding region have been discussed by Ryan (1953) and more recently by Wolman (1968). The characteristics of the bottom sediments have been described by Ryan (1953) and Biggs (1967). The sediments accumulating in the Bay are predominantly fine-grained silts and clays except in the littoral zone, where sand locally derived from shore erosion predominates (Ryan, 1953; Schubel, 1968a). The sources of sediment have been considered by Schubel (1968a, 1971a) and Biggs (1970), and the relationships between the circulation patterns and the sedimentation patterns have been investigated by Schubel (1971b).

The archenemy and ultimate conqueror of every estuary is the sediment that fills the basin and drives out the intruding sea. Sediments are introduced into the Chesapeake Bay by rivers, by shore erosion, by biological activity, and by the sea. The sources are thus external, marginal, and internal. Most of the inputs are poorly known. The only rivers for which reliable estimates are available are the Susquehanna (Schubel, 1968b; Schubel, 1972) and to a lesser extent the Potomac (Wolman, 1968). The Susquehanna discharges approximately 0.3-0.8 x 10^6 metric tons/yr, while the Potomac probably discharges more than 2.3 x 10^6 metric tons/yr. The sediment discharged by the rivers is fine-grained silt and clay. Most of it is trapped in the upper reaches of the estuaries by the net non-tidal circulation, which creates a very effective sediment trap in the transition zone where the net upstream flow of the lower layer dissipates until the net flow is downstream at all depths (Schubel, 1971b). Fine particles that settle into the lower layer are carried back upstream by its net upstream flow, leading to a rapid accumulation of sediment. The sedimentation rate in the upper Bay is probably at least an order of magnitude greater than in the middle and lower reaches of the Bay. Similar patterns exist in the tributary estuaries. Because of the net non-tidal circulation and the mixing there are also accumulations of *suspended* sediment in the upper reaches of the Bay and larger tributary estuaries. Such features, called "turbidity maxima", are characterized by turbidities and suspended sediment concentrations that are higher than those either farther upstream in the source river or farther seaward in the estuary. The turbidity maximum in the upper reaches of the Bay has been described by Schubel (1968c).

Since the Susquehanna is the only *river* that debouches directly into the main body of the Bay, it is the only major source of *fluvial* sediment to the Bay proper (Schubel, 1971a, b). Most of the sediment discharged by the other rivers is deposited in the upper reaches of their estuaries and does not reach the Bay proper. In the middle and lower reaches of the Bay, shore erosion is not only a major source, but probably the most important source of sediment (Schubel, 1968a, 1971; Biggs, 1970). The margins of the Bay are being digested at an alarming rate (Singewald and Slaughter, 1949; Schubel, 1968a).

The remains of the large populations of plankton, nekton, and benthos contribute little directly to the total accumulation of sediment. Filter-feeding benthos (Haven and Morales, 1966) and zooplankton (Schubel, 1971; Schubel and Kana, 1972), however, play an important role in the Bay's sedimentation. These organisms bind fine suspended particles into larger composite particles which are ultimately deposited. Without agglomeration many of the finer particles would not be deposited in the Bay but would be carried through the estuary and discharged to the ocean. Biological agglomeration is an important geological process.

Because of their circulation patterns, the

Chesapeake Bay and its tributaries are effective sedimentation traps, and sedimentation rates are naturally high. But man has markedly increased the sedimentation rates by increasing the inputs of sediment. With the clearance of forested land for agriculture in colonial days, sediment yields increased from an average of less than 35 metric tons/km^2/yr to 140-280 metric tons/km^2/yr (Wolman, 1967). Hundreds of thousands of acres of forested lands were cleared with axe and fire for tobacco farming. After 2 or 3 crops, the nutrients in the soil were depleted and new lands were needed for growing tobacco. The old fields were frequently abandoned and left bare to be eroded by the wind and rain. Much of the sediment was carried by streams and rivers into the estuaries tributary to the Bay.

Even before 1800, siltation was a serious problem in harbors such as Upper Marlboro on the Patuxent River, Port Tobacco on the Port Tobacco River (a tributary to the Potomac), and Joppa Town at the mouth of the Little Gunpowder. In the early 1700's Joppa Town was the county seat of Baltimore County and Maryland's most prosperous and important seaport. By 1750 the port had declined in importance, primarily because of sedimentation problems, and in 1768 the county seat was moved to Baltimore. Stone mooring posts that once held the hawsers of seagoing vessels are now 2 or more miles from navigable water (Gottschalk, 1945). According to Gottschalk (1945), who summarized observations on the sedimentation of colonial ports, the limit of open tidewater in Baltimore Harbor was 7 miles farther inland in 1608 when John Smith visited the Harbor than it is today.

In more recent years local sediment yields have been dramatically increased by imprudent land clearance for construction–yields sometimes reach 10,000 or even 35,000 metric tons/km^2/yr. It has been estimated that sediment from construction sites in the metropolitan Washington, D.C. area probably accounts for 25-30% of the total sediment load entering the Potomac at Washington (Wolman, 1968). Sediment derived from construction sites in the metropolitan Baltimore area is probably a major source of the sediment being discharged into Baltimore Harbor. After completion of urban construction projects, the new asphalt and concrete "land" may reduce sediment yields to levels well below those characteristic of forested regions.

But man's activities can also decrease the masses of sediment discharged into the Chesapeake Bay estuarine system. The construction of a series of dams along the lower courses of the Susquehanna River has decreased the quantities of sediment discharged into the upper Bay.

The effect of man's activities during the 18th and most of the 19th centuries was to increase sedimentation rates in the main body of the Chesapeake Bay and its tributary estuaries. In the latter part of the 19th century and during the 20th century, with better soil conservation practices, less land under cultivation, and the construction of a series of dams on the lower reaches of the Susquehanna, the overall sedimentation rate was decreased. In some tributaries, however, which drain areas of urban construction, the local sedimentation rates were greatly increased. The net effect of man's activities has been an increase in the overall "natural" sedimentation rate, but we can not say by how much.

In addition to the direct effects of filling the estuarine basin and thereby expelling the intruding sea, the fine-grained sediments have many indirect effects on the estuary. While suspended they limit the penetration of light, and therefore the depth of the euphotic zone and the primary productivity. Because of their high sorptive capacity, clay particles concentrate heavy metals, nutrients, oil, pesticides, biocides, and other "pollutants." Since these pollutants are "attached" to fine particles, they are concentrated in the sediments, both suspended and deposited, in the upper reaches of the Bay and its tributary estuaries. Filter-feeding organisms which ingest these particles concentrate the contaminants. Butler (1966) has pointed out the ability of oysters to concentrate DDT in their pseudo feces, making it available in a more concentrated form to deposit feeders. Increases in the concentration of contaminants at each trophic level are well documented for radioactive elements and pesticides (Woodwell, 1967). This phenomenon has been referred to as "biological magnification."

Although there are few analyses of pesticides, herbicides, and heavy metals in Chesapeake Bay organisms, it might be anticipated that the concentrations of these constituents will be relatively high.

In summary, sediments are the estuary's natural archenemy and ultimate conqueror. As they fill in the basin they expel the intruding sea, converting the estuarine system back into a river valley system. At times, a man's activities have tended to both accelerate and decelerate this process, but their net effect has been to increase the overall sedimentation rate. The indirect effects of the sediments, particularly the fine-grained sediments that are accumulating in the Bay and its tributaries, are of greater significance to man than the long-term direct effects of filling. These indirect effects are poorly understood.

Heavy Metals

The so-called heavy or trace metals (transition metals) are of considerable interest because certain of these metals are highly toxic to plants and animals, including man but are, of course, also essential for life. They are highly persistent and retain their toxicities for prolonged periods of time. Most heavy metals are concentrated in the bodies of organisms where they remain for prolonged periods of time and function as cumulative poisons. There are approximately 2 dozen metals which are highly toxic to plants and animals, but the most toxic, persistent, and abundant heavy metals in the marine environment include mercury (Hg), arsenic (As), cadmium (Cd), lead (Pb), chromium (Cr), and nickel (Ni). Since heavy metals are present in the earth's crust, they are carried both in solution and in suspension by rivers and streams into the Chesapeake Bay estuarine system and the rest of the marine environment. Man also contributes heavy metals to the Bay. Some heavy metals have been used extensively as pesticides and biocides and have been introduced into the environment from these sources.

There are very few data on the temporal and spatial distributions of any of the heavy metals in the Chesapeake Bay estuarine system or its tributary rivers. The most extensive studies have been made by J.H. Carpenter of The Johns Hopkins University's Chesapeake Bay Institute. He has kindly permitted me to summarize some of his unpublished results. Carpenter analyzed samples of Susquehanna River water collected at approximately weekly intervals from April 1965 through August 1966 at Lapidium, Maryland, located about 1 mile downstream from the dam at Conowingo. Using atomic absorption techniques, the samples were analyzed for the concentrations of iron, manganese, zinc, nickel, copper, cobalt, chromium, and cadmium in both the dissolved and suspended states. Carpenter distinguished between the solid material that was deposited by gravity settling after 10-14 days, and the solid material remaining in suspension after this settling period but which could be removed by filtration through membrane filters with an average pore size of 0.2μ. The heavy metals were extracted from the particulate matter in normal HCl at 60°C with constant agitation for 72 hours.

The river flow, the concentration of total suspended solids (suspended sediment) and the total concentrations of the several heavy metals were all highly variable during the period of observation, (figs. 21-23). The pattern of river flow shown in fig. 21 illustrates the characteristic seasonal variation of flow of the Susquehanna and other rivers in this region—high discharge in the spring followed by low to moderate flow throughout the summer and most of the fall. The obvious positive correlation between river flow and the concentration of suspended sediment illustrated in fig. 21 is well documented. The most striking thing about the heavy metal analyses is their marked variability. In general, high concentrations of the heavy metals were associated with high concentrations of suspended sediment, but there were some exceptions notably zinc, nickel, and cobalt during January, 1966.

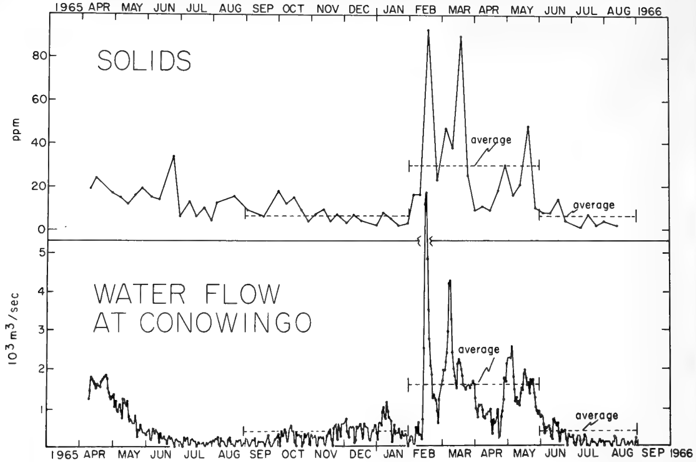


Fig. 21. Flow of the Susquehanna River and concentration of suspended sediment between April 1965 through August 1966 (J.H. Carpenter, personal communication).

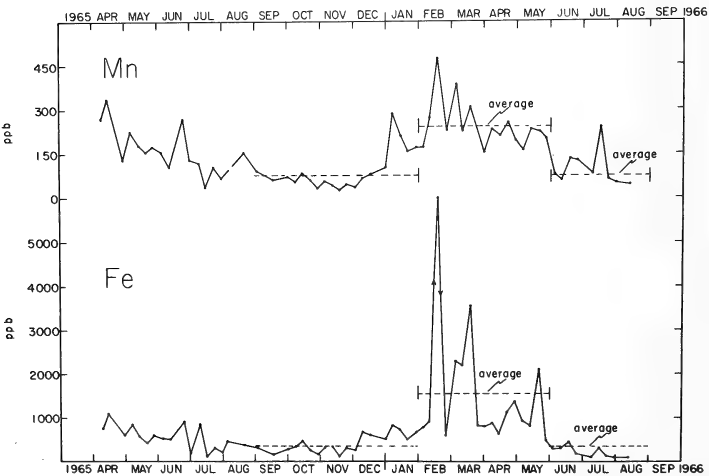


Fig. 22. Concentrations of total iron and manganese in Susquehanna River samples (J.H. Carpenter, personal communication).

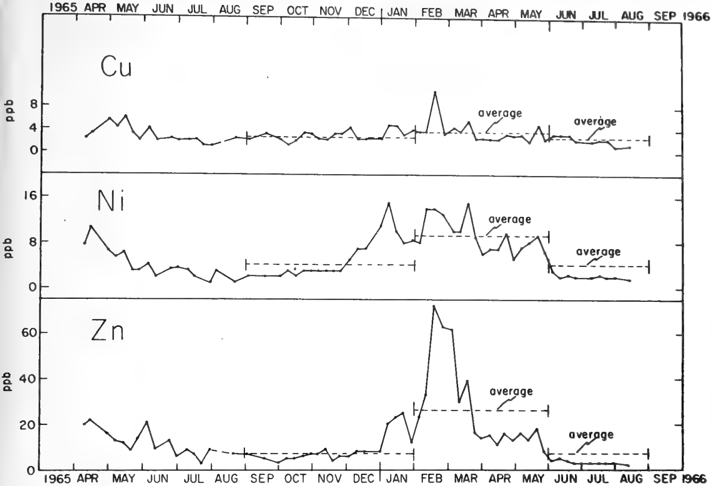


Fig. 23. Concentrations of total Cu, Ni, and Zn in Susquehanna River samples (J.H. Carpenter, personal communication)

The partitioning of iron, manganese, zinc, nickel and copper among the soluble, filtered solids and settled solids fractions showed marked seasonal variations. The occurrence of manganese in a soluble form, for example, appears to be seasonal with the necessary conditions being present during winter and early spring, (fig. 24). the seasonality of both the total concentration and the solubilization of many metals suggests the significance of organic matter and metals derived from decaying vegetation (Carpenter, personal communication). Vegetation in the drainage basin then appears to be a major source of heavy metal "pollution" to the Susquehanna and to the upper Chesapeake Bay.

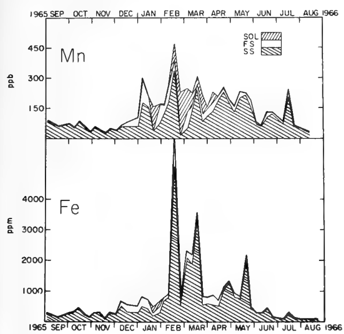


Fig. 24. Concentrations of iron and manganese in the soluble, filtered solids, and settled solids fractions of Susquehanna River samples (J.H. Carpenter, personal communication).

It is obvious from Carpenter's data that estimates of the inputs of the several metals must take into account the variability of the source. Estimates based on one sample (Turekian and Scott, 1967) or even on several samples are naive and are apt to be very misleading. Table 1 provides a comparison of estimates of the annual inputs of several heavy metals based on one sample (Turekian and Scott, 1967) with estimates based on weekly samples (Carpenter, 1971, personal communication).

For each of the 3 heavy metals for which there were common analyses, Turekian and

Table 1.—Heavy Metal Input to Chesapeake Bay From the Susquehanna River

Constituent	Estimate Based on One Sample Collected in June of 1966[1] (tons/year)	Estimate Based on 52 Weekly Samples Collected during 1965-1966[2]
Manganese	120,000	5,300
Nickel	3,000	215
Cobalt	1,500	88

Scott (1967) estimated annual discharges were more than an order of magnitude higher than Carpenter's. (Turekian and Scott 1967) attributed the high concentrations of heavy metals to industrial contamination and suggested that the inputs were sufficiently large to be of possible economic interest.

The Susquehanna River, supplying more than 90% of the total freshwater input to the Bay north of the Potomac, is the major source of freshwater and fluvial sediment to the upper Chesapeake Bay. Tidal currents provide most of the energy for the mixing of the fresh river water with the salty estuary water. There are very few reliable data on the spatial distributions of heavy metals in the waters of the Bay itself, and data on temporal distributions are not available. To assess man's affect on the distributions of heavy metal one must examine the only historical record that exists—the sedimentary record. Unfortunately, that record has received only meager examination.

Sediment samples taken on a cross-section near the Chesapeake Bay Bridge at Annapolis show variations in the concentrations of both iron and zinc of more than an order of magnitude. The variations are associated with changes in the grain size of the sediments; the coarser-grained sediments are impoverished in heavy metals relative to the finer sediments. There are also local spatial variations associated with spoil deposits which are enriched in certain of the heavy metals.

There are a few data that *suggest* there is a longitudinal gradient of heavy metals in the fine sediments of the Bay. Concentrations of heavy metals tend to be higher near the head of the Bay than farther seaward in the estuary. This might have been anticipated, since the fine sediments in the upper Bay are derived primarily from the Piedmont, while the fine sediments in the middle and lower reaches of the Bay are probably derived primarily from the shore erosion of Coastal Plain sediments—sediments originally derived from the Piedmont and now impoverished in heavy metals relative to their source rocks. The differences in the sources of organic matter may also be important in producing this gradient. This is an important problem; one which deserves further study.

Analyses of the longer-term sedimentary record are even more scarce. Recently a 135-cm-long core was taken in the upper Bay off Howell Point. Since the sedimentation rate in the area is probably between 5 and 10 mm/yr, the core represents 135-270 years of sedimentary history. The core was analyzed for extractable[3] iron and zinc at the surface and at 20-cm increments to the bottom of the core. One might have anticipated that the concentrations of iron and zinc would decrease with depth, since man's impact has presumably increased with time. The results showed, however, that below the surficial layer the concentrations were nearly uniform with depth. The concentration of zinc was about 70 ppm (dry weight) and the concentration of iron about 20 ppt. The uniformity may be attributable in part to the homogenization of the sediment by burrowing organisms. The core may not have been long enough to pass through the sedimentary horizon corresponding to the initiation of

---

[1] Data from Turekian & Scott (1967), who filtered their water sample through an 0.45 μ APD Millipore filter, ashed it, and analyzed the residue spectrographically. This procedure results in a determination of something close to the concentrations of the total particulate fraction of the various metals.

[2] Data from J.H. Carpenter, personal communication. Carpenter's methods result in determinations of the dissolved fraction and the "extractable" particulate fraction. The extractable part of the particulate fraction may be less than the total particulate fraction, but it is probably never less than 50% of it.

[3] Using techniques described previously.

mining in the Susquehanna drainage basin about 130 years ago. These scant data do not demonstrate, however, that man's activities have increased the levels of iron and zinc in the upper Bay off Howell Point. Furthermore, they do not violate the hypothesis that the concentrations of these heavy metals have always been *naturally* high at this location, and that man has not has a measurable effect on their concentrations.

It might be anticipated that the industrial enrichment of heavy metals in the sediments of the Maryland portion of the Bay would be most obivous in Baltimore Harbor. Samples of surface sediment from Baltimore Harbor show large variations in their concentrations of heavy metals. Local areas are enriched by more than an order of magnitude in certain of the heavy metals, such as Zn, Cu, and Cd, over contiguous areas where levels are approximately equal to those in the open Bay. Man has almost certainly increased the concentrations of heavy metals in Baltimore Harbor, but the magnitude of his impact is not clear. The pertinent data are being compiled for a report to the Submerged Lands Commission of the State of Maryland (J.H. Carpenter, personal communication).

In summary, because of their presistence, and their toxicity at high concentrations, heavy metals are potentially dangerous pollutants. Heavy metals are introduced into the Bay, in solution and adsorbed on fine particles, as a result of the natural processes of weathering and erosion. They are also introduced into the Bay as a direct and indirect result of man's activities. Man's use of heavy metals in pesticides, biocides, and industrial applications have tended to increase the inputs of heavy metals to the Bay, as have mining and agriculture in the drainage basin. Man's dam building activities have tended to decrease the inputs. Dams on the lower Susquehanna trap large amounts of sediment and heavy metals, thus preventing them from reaching the Bay. The extent of man's impact on the spatial and temporal distributions of heavy metals in the Chesapeake Bay estuarine system is obscure.

The spatial and temporal distributions of heavy metals should be determined in the water, in the bottom sediments, and in selected organisms. Filter-feeding and deposit-feeding organisms which ingest fine sedimentary particles may be exposed to diets with relatively high concentrations of adsorbed heavy metals. Like many other estuarine pollution problems, the problem of heavy metals is not amenable to facile solution. This is an important area of research—one which has received far too little attention. It will require extensive sampling programs to establish the inputs of heavy metals to the Bay and to delimit their routes, rates, and reservoirs within the estuary.

Summary

This paper describes the prevailing physical and chemical conditions of Chesapeake Bay and attempts to assess man's impact on these conditions. The properties which are considered are temperature, salinity, dissolved oxygen, nutrients, sediment, and heavy metals. Other important items are pesticides, herbicides, and oil.

There are marked natural spatial and temporal variations of water temperature throughout the Bay. Superimposed upon these are the "excess" temperatures which result from the discharge of condenser cooling water from power plants. The inputs of heated discharges from present power plants and from those now under construction do not appear to pose a threat to the Bay. Man's power "requirements," however, are increasing at an alarming rate, and the Bay does have a limit on its capacity to receive waste heat.

There are marked natural temporal and spatial variations of salinity in the upper reaches of the Bay and its tributaries. Man has had little effect on the distribution of salinity in the Chesapeake Bay system. Flow regulation of the Susquehanna would decrease the fluctuations of salinity in the upper Bay and would have a serious effect on the flushing of a number of small tributary estuaries.

There are relatively large natural spatial and temporal variations in dissolved oxygen. Low levels of dissolved oxygen have always occurred in the deeper waters of the main body of the Bay during the summer months

as a result of natural processes. But man's activities have certainly increased the frequency, extent, and duration of low oxygen zones in the upper reaches of a number of the tributaries.

Man has dramatically increased the inputs of nutrients to the Chesapeake Bay estuarine system. The effects of the increased nutrients are concentrated in the upper reaches of the tributaries and in the upper Chesapeake Bay. In the Maryland Portion of the Bay, nutrients are at undesirable levels in the upper Potomac, and in Back River, and are near the upper limit in the upper Bay, the Patuxent, and in many of the smaller tributaries. The discharge of improperly treated dewage and municipal wastes constitute the most serious immediate threat to the Chesapeake Bay estuarine system.

Sediments are the estuary's natural archenemy and ultimate conqueror. Man's activities have, at times, tended to both increase and decrease the natural sedimentation rates, but his net effect has been to increase the overall sedimentation rate. The indirect effects of the fine-grained sediments are of more immediate concern than the direct effects of the infilling of the basin. These are poorly understood.

There are marked variations of heavy metals in the water, and in the sediments of Chesapeake Bay. The sources of heavy metals, the routes and rates of transport, and the patterns and rates of accumulation in the sediments are very poorly known. This is an important area of research.

There is very little published data on the occurrence of pesticides and herbicides in the waters, sediments, or organisms of the Chesapeake Bay estuarine system. It might be predicted however, that the concentrations would be relatively high in some of the filter-feeding and deposit-feeding organisms.

There have been a number of oil spills in Chesapeake Bay, but all have been relatively minor. Oil from illegal pumping of bilges, oils and greases in municipal wastes, and oil from filling stations that are washed into storm drains and eventually into the Bay pose an increasing threat.

Most of the serious sources of pollution that threaten the Bay can be reduced to acceptable levels by existing technology if sufficient funding is provided, and if efforts are directed to the "real" problems.

Acknowledgements

I am indebted to my colleagues, H.H. Carter, D.W. Pritchard, and J.H. Carpenter of the Chesapeake Bay Institute, for their advice in the preparation of this report, and for their generosity in allowing me to use their unpublished data. This does not imply that these individuals necessarily agree with the author's interpretations. I also want to thank my wife for editing the manuscript. The figures were prepared by W.L. Wilson and D. Pendleton, and the manuscript was typed by A.W. Sullivan. The preparation of this review was supported by the Fish and Wildlife Administration of the State of Maryland and by the Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife, Department of the Interior through Dingell-Johnson Funds, Project F-21-1. Contribution 170 from the Chesapeake Bay Institute of The Johns Hopkins University.

References Cited

Beaven, G.F., 1946. Effect of Susquehanna River stream flow on Chesapeake Bay salinities and history of past oyster mortalities on upper Bay bars. Maryland Board Nat. Res. Ann. Rep., App. B., P. 4, p 123-133.

________________, 1960. Temperature and salinity of surface waters at Solomons, Maryland. Chesapeake Sci. 1: 2-11.

Biggs, R.B., 1967. The sediments of Chesapeake Bay, p. 239-260, *in* Estuaries, G.H. Lauff (ed.), Amer. Assoc. Adv. Sci., Pub. 83, Washington, D.C., 757 p.

________________, 1970. Sources and distribution of suspended sediment in northern Chesapeake Bay. Marine Geol. 9: 187-201.

Boicourt, W., 1969. A numerical model of the salinity distribution in upper Chesapeake Bay. Tech. Rep. 54, Chesapeake Bay Institute of The Johns Hopkins University, 69 p.

Butler, P.A., 1966. Fixation of DDT in estuaries. 31st N. Amer. Wildlife and Nat. Res. Conf.

Carpenter, J.H., D.W. Pritchard, and R.C. Whaley, 1969. Observations of eutrophication and nutrient cycles in some coastal plain estuaries, *in* Eutrophication: causes, consequences, correctives. National Academy of Sciences, Washington, D.C., 1969, p. 210-221.

Cumming, Hugh S., Purdy, W.C., and Homer P. Ritter, 1916. Investigation of the Pollution and Sanitary Conditions of the Potomac Watershed, Hygienic Laboratory Bulletin 104. Treasury Department, U.S. Pub. Health Serv.

Carter, H.H., 1968. The distribution of excess temperature from a heated discharge in an estuary. Tech. Rep. 44, Chesapeake Bay Institute of The Johns Hopkins University, 39 p.

Flemmer, D.A., 1971. Effects of hot water discharges studied in Patuxent River. Commercial Fisheries News, V.4, N.4, p 1-2, July 1971, Fish and Wildlife Administration of Maryland.

Gottschalk, L.D., 1945. Effects of soil erosion on navigation in upper Chesapeake Bay. Geogr. Rev. 35: 319-338.

Haven, D.S., and R. Morales-Alamo, 1966. Aspects of biodeposition by oysters and other invertebrate filter feeders. Limnol. and Oceanogr. 11: 487-498.

Man's Impact on the Global Environment; Assessments and Recommendations for Action, 1970. Mass. Inst. Tech. Press, Cambridge, Mass., 319 p.

Mihursky, J.A., A.J. McErlean, W.R. Roosenburg, V.S. Kennedy, and C.I. Gibson, 1967. Progress Report Period 1 July 1966 - 31 December 1966 from Univ. of Maryland Natural Resources, entitled: Patuxent Thermal Studies, 26 p.

Pritchard, D.W., 1967. What is an estuary: physical viewpoint, p. 3-5 *in* Estuaries, Lauff, G.H. (ed.), Amer. Assoc. Adv. Sci., Washington, D.C., 757 pp.

Pritchard, D.W., 1968. Modification and management of water flow in estuaries. Paper presented at the National Research Council's Symposium on Beneficial Modifications of the Marine Environment held at Washington, D.C. on March 10-12, 1968.

________________, 1969. A report to the Governor's task force on nuclear power plants. Appendix D in Nuclear Power Plants in Maryland, W.W. Eaton, ed., pages not numbered consecutively.

________________, 1971. Chesapeake and Delaware Canal Affects environment. Amer. Soc. Civil Eng. Nat. Water Res. Eng. Meeting, Phoenix, Arizona, 1971, 26 p.

Ryan, J.D., 1953. The Sediments of Chesapeake Bay. Maryland Dept. Geol., Mines and Water Res. Bull. 12, 120 p.

Schubel, J.R., 1968a. Suspended sediment of the northern Chesapeake Bay. Tech. Rep. 35, Chesapeake Bay Institute of The Johns Hopkins Univeristy, 264 p.

________________, 1968b. Suspended sediment discharge of the Susquehanna River at Havre de Grace, Maryland, during the period 1 April 1966 through 31 March 1967. Chesapeake Sci. 9: 131-135.

________________, 1968c. Turbidity maximum of northern Chesapeake Bay. Science 161: 1013-1015.

________________, 1971a. Sources of Sediments to Estuaries, p V-1 to V-19, *in* The Estuarine Environment, estuaries and estuarine sedimentation. Schubel, J.R., (ed.). Amer. Geol. Inst., Washington, D.C.

________________, 1971b. Sedimentation in the upper reaches of the Chesapeake Bay, p VII-1 to VII-31, *in* The Estuarine Environment, estuaries and estuarine sedimentation, Schubel, J.R., (ed.). Amer. Geol. Inst., Washington, D.C.

________________, 1972. Suspended sediment discharge of the Susquehanna River at Conowingo, Maryland during 1969. Chesapeake Sci. (in press).

________________ and T.W. Kana, 1972. Agglomeration of fine-grained suspended sediment in northern Chesapeake Bay. Powder Techn. (in press).

Seitz, R.C., 1971. Temperature and salinity distributions in vertical sections along the longitudinal axis and across the entrance of the Chesapeake Bay (April 1968 to March 1969). Graphical Summary Rep. No. 5, Reference 71-7, Chesapeake Bay Institute of The Johns Hopkins University, 99 p.

Singewald, J.T., and T.H. Slaughter, 1949. Shore erosion in tidewater Maryland. Maryland Dept. of Geol., Mines, and Water Res., Bull. 6, 140 p.

Stroup, E.D., and R.J. Lynn, 1963. Atlas of salinity distributions in Chesapeake Bay 1952 - 1961, and temperature and seasonal averages 1949 - 1961. Graphical Summary Rep. No. 2, Reference 63-1, Chesapeake Bay Institute of The Johns Hopkins University, 410 p.

Tagatz, M.E., 1969. Some relations of temperature acclimation and salinity to thermal tolerance of the blue crab, *Callinectes sapidus*. Trans. Amer. Fisheries Soc. 98: 713-716.

Turekian, Karl K., and Martha R. Scott, 1967. Concentrations of Cr, Ag, Mo, Ni, Co, and Mn in Suspended Material in Streams. Environ. Sci. Techn. 1: 940-942.

Whaley, H.H., and T.C. Hopkins, 1952. Atlas of the salinity and temperature distribution of Chesapeake Bay 1949 - 1951. Graphical Summary Rep. 1, Reference 52-4, Chesapeake Bay Institute of The Johns Hopkins University, pages not numbered.

Wolman, M.G., 1967. A cycle of sedimentation and erosion in urban river channels. Geograf. Ann. 49: 385-395, Ser. A.

________________, 1968. The Chesapeake Bay: geology and geography, p. II-7 to II-48, *in* Proceedings of the Governor's Conference on Chesapeake Bay, September 12-13, 1968.

________________, 1971. The Nation's Rivers, problems are encountered in appraising trends in water and river quality. Science 174: 905-918.

Woodwell, G.M., 1967: Toxic substances and ecological cycles. Sci. Amer. 216: 24-31.

Biology and the Chesapeake Bay

Francis S. L. Williamson[1]

Chesapeake Bay Center for Environmental Studies, Smithsonian Institution, Route 4, Box 622, Edgewater, Maryland 21037

ABSTRACT

Threats to the biological productivity of the Chesapeake Bay have grown in magnitude and complexity as correlates of diverse social, economic, and engineering developments engendered by an ever increasing bayside human population. There is growing agreement that the biological problems have evolved as a result of failure to (1) recognize the Bay (and its watershed) as a large, complex system, and (2) to deal with its problems as parts of an interrelated whole. Each sector of the public and private interest has used and/or abused this common resource in a manner deficient in concern for the resultant *combined and cumulative* effects of these uses on the physical, chemical, and ultimately the biological, state of the system. Problem areas must be delineated and research priorities established to provide the direction for federal, State, and university laboratories that allows them to be more responsive to the needs of management and regulatory agencies, and the society these agencies serve. The current *modus operandi* of many laboratories is ineffective for ecological problem-solving, and can be corrected only by the development of appropriate methodologies, by more rigid programming and direction of research, and by improved liaison with managers and planners.

The title of this symposium, "The Fate of the Chesapeake Bay", has a gloomy, almost ominous ring that, unfortunately, may be altogether appropriate. The use of the word *fate* (from the Latin *fatum* = oracle, prophetic declaration), and its definition as that principle, or determining cause or will, by which things in general are supposed to come to be as they are, or events to happen as they do, or foreordination by which either the universe as a whole or particular happenings are predetermined, implies to me that we are little more than chroniclers of events over which we exercise surprisingly meager control. This paper is an attempt to examine the extent to which this is true, at least with respect to our present and prospective ability to deal with the biological problems of the Chesapeake Bay in such a way as to insure its continued functioning as a productive biological system.

The present generation of symposia on the Chesapeake Bay began a little over 3 years ago (Sept., 1968) with the Governor's Conference at Wye Institute. That meeting was particularly well attended by a group that included teachers, scientists, industrial executives, businessmen, government officials from many local, State, and federal organizations, and officers and representatives from trade organizations, conservation and voter groups. The conference was conducted in what seemed to be an almost festive manner, perhaps stemming from a more or less general, and a more or less subliminal, belief that so many important people could not possibly assemble to discuss so many matters of concern about a major natural resource without the emergence of definitive solutions to management problems. In fact, virtually every speaker offered recommendations ranging from the need for more re-

[1] Dr. Williamson received his B.S. degree (Zoology) from San Diego State College, his M.A. (Ecology) from The University of California, and his Sc.D. (Ecology, Pathobiology) from The Johns Hopkins University. He serves on the Steering and Advisory Committees of the Chesapeake Bay Study (Corps of Engineers), the Research Planning Committee and Steering Committee of the Chesapeake Research Consortium, Inc., the Board of Directors of the Chesapeake Environmental Protection Association, and the Power Plant Siting and Human Health and Welfare Studies Group (Maryland Department of Natural Resources). He serves as Director of the Chesapeake Bay Center.

search of all kinds on just about everything in, on, or around the Bay, to a review of proposed and potential management schemes by Federal agencies, 6 and 7 specific management goals for State and local governments, respectively, and ending with a grand plan for organizing a coordinated resources management structure (The Chesapeake Bay Conservation Commission) for the Bay (Proc. Gov. Conf. Chesapeake Bay, 1968). During the concluding discussions of that first multi-institutional, interdisciplinary conference, however, the question was raised as to just *what* had been accomplished as a result of the lengthy deliberations, and the remark was made that the conference had supplied a very good platform on which to base another conference. Indeed, the Steering Committee recommended similar meetings, i.e., ones directed toward the orderly development of Chesapeake Bay, at 2-year intervals.

Since that first of the super-conferences, a host of somewhat less impressive symposia and conferences have been sponsored by a variety of agencies, and seemingly endless rhetoric has been dedicated to (1) revealing the status of our knowledge of this vast estuary; (2) delineating the problems that are steadily, almost inexorably, reducing its value for diverse and often conflicting uses; and (3) issuing endless recommendations for solutions of these problems. Perhaps this kind of interplay is necessary for the development of solutions to the many problems confronting the Bay, and we have not substituted rhetoric and verbiage for more substantive progress. We must all hope so because conferences, symposia, workshops and so on, are expensive and time-consuming enterprises, and we are in real need of time and money for the solution of clearly identified existing problems, as well as those we know are surely to come.

The Chesapeake Bay, like so many other large natural systems, has demonstrated a remarkable degree of resiliency in its capacity to withstand, and/or to recover from, literally hosts of deleterious, man-induced perturbations. Not only is this capacity likely enhanced as a result of a biota adapted to the naturally unstable conditions that characterize any estuary (Caspers, 1967), but it is made the more striking because of the vastness of this particular system. The widely varying temperature, salinity, and turbidity that are associated with tidal cycles and the mixing of fresh and ocean waters in the Bay tend to mask and to ameliorate changes due to man's activities, especially those that are simply the acceleration of otherwise natural processes. Unfortunately, the exponential increase in such accelerations, combined with a seemingly endless variety of novel abuses, is now reflected by adverse and grossly manifest changes in the system. Seasonal fish kills are relatively commonplace, large algal blooms are phenomena so conspicuous as to be observed by laymen, municipal beaches have been closed for swimming, oil spills are not uncommon, approximately 70,000 acres of shellfish beds are closed, and the annual harvest of oysters has dropped from 8-10 million bushels to 2-3 million. There is general recognition, even among observers of modest sophistication, that there exist serious threats to the continued maintenance of a high level of biological productivity of the Chesapeake Bay, and that these problems are growing in magnitude and complexity as correlates of diverse social, economic, and engineering developments engendered and demanded by a bayside human population that is increasing at an annual rate of about 1.7%. The human population within the drainage area of the Chesapeake Bay, estimated to be 11 million persons in 1960, is projected to increase to 30 million persons within the next 40-50 years. For this population the Chesapeake Bay is a natural resource available for a multiplicity of uses, many of which conflict. It is not realistic to expect, after a review of the decisions that have been made, that are currently being made, and the ones that will need to be made in the immediate future, that this estuary can possibly have other than steadily increasing use as a channel for commerce, and as a sink for disposal of industrial and domestic wastes. It is difficult, if not impossible, to predict whether the Bay can continue to be used for these purposes to a greater extent each day, month, and year and still function productively as a biological system. If not, it will almost certainly cease to function as a recreational and esthetic resource. Already, several of the major tributaries have ceased to have biological, and thus recreational and esthetic, value, signs of similar changes are apparent in others, and disturbing changes are seen in the main stem of the Bay.

I believe that this introduction serves to outline a disturbing trend, i.e., the inability of our scientific and political systems to cope with the problems evolving from the staggering multiplicity of conflicting uses of a large, complex natural system.

The Biological Significance of the Chesapeake Bay

Like other estuaries, the Chesapeake Bay is a remarkably productive biological system. An excellent recent review of the role of the Bay has been provided by Masmann (1971). The shallow, warm waters of the myriad subestuarial systems, such as the lower reaches of the Patuxent River, possess phytoplankton communities that fix 1-3 g carbon/cm^2/day, or the equivalent of 2-3 tons of plant production/acre annually (Stross and Strottlemeyer, 1965). Even more important as units for primary production are the 400,000 acres of wetlands that border much of the Bay; an area equivalent in size to 28% of the surface area of the Bay's tributary system (main stem to head of tide). Production of vegetation on marshes in Virginia, principally grasses in the genus *Spartina*, has been shown to average 5.1 tons/acre annually, and to be as great as 10 tons (Wass and Wright, 1969). The diverse functions of wetlands, and their major role in the functioning of the estuarine ecosystem, has been characterized by Cronin and Mansueti (1971) as follows: ". . . they are organic factories, traps for sediments, reservoirs for nutrients and other chemicals, and the productive and essential habitat for a large number of invertebrates, fish, reptiles, birds and mammals. Annual plant growth and decay, providing continuing large quantities of organic detritus, is one of the major components of the cycling of nutrients in estuaries." Secondary productivity is equally impressive. The annual harvest of fish, including both sport and commercial catches, is about 125 lb/acre, with a potential for harvesting 600 lb./acre (McHugh, 1967). In 1966, the commercial harvest of finfish (303.6 million lb.), oysters and clams (27.8 million lb.), and blue crabs (95.1 million lb.) totalled 426.5 million lb. Adding the annual sport catch of 22 million lb. (Stroud, 1965) brings the total harvest of recent years to nearly one-half billion pounds. Nearly two-thirds (63%) of the commercial catch of fish on the Atlantic coast are species believed to be estuarine-dependent (McHugh, 1966). At present levels of development of the fisheries, this is equivalent to about 535 lb./acre of estuaries; i.e., for each acre of estuary destroyed there could be a loss in yield of 535 lb. of fisheries products on the continental shelf (Stroud, 1971). Many birds, including approximately 350,000 Canada geese, 550,000 ducks, 50,000 whistling swans, and hosts of shorebirds are dependent on the Chesapeake Bay as a wintering area (Masmann, 1971). Eagles, ospreys, herons, gulls, and terns are important nesting species. Important mammals associated with the Bay include the muskrat, raccoon, land otter, and mink.

The biological significance of the Bay is manifest in another extremely important way; its use as a recreational resource. Swimming, boating, fishing, hunting, and other recreational activities have become increasingly important as the human population has grown. As pointed out in *The Chesapeake Bay Plan of Study* (1970), accelerating urban development, an abundance of leisure time, and a generally expanding level of personal income have created in the Bay area a great demand for water-based recreation. The industrial and economic base of the prosperity that generated the demand also threatens to destroy the existing recreation potential by its deleterious effect on the water quality that maintains the integrity of the aquatic environment upon which water-based recreation depends. As demands intensify in the future, recreational activities may conflict not only with other beneficial water uses, but among themselves.

Lastly, the Bay is a truly unique esthetic resource that will lose all value and importance without the continued maintenance of the system as a biologically productive one. In a decision-making process, economic values such as labor, capital, energy, material, products, and consumers are commodities and easily quantifiable values. Because we are not yet confident of our human judgment we tend to ignore those values which are not so readily quantifiable. The real result has often been that the quantitative factors are evaluated against nonquantitative factors on a quantified scale. Since nonquantifiable factors such as the future quality of life, natural and cultural diversity, and esthetics cannot be plugged into this system, the quantifiable factors become, in fact, the end or the goal of the decision-making process.

Biological Problems of the Chesapeake Bay

The biological problems of estuaries generally, and the Chesapeake Bay specifically, have been very well outlined in a host of publications including: *The Chesapeake Bay Plan of Study* (1970); Lauff (1967) (*Estuaries*); *A Symposium on the Biological Significance of Estuaries*, 1971; *Proceedings of the Governor's Conference on Chesapeake Bay*, 1968; *Eutrophication: Causes, Consequences, Correctives*, 1969; *A Research Program for Protection and Enhancement of the Biological Resources of the Chesapeake Bay*, 1971; *A Report of the Review Panel of the Smithsonian Institution*, 1971; *The Chesapeake Bay, Report of a Research Planning Study*, 1971; Schubel, (1972) (*The Physical and Chemical Conditions of the Chesapeake Bay: An Evaluation*); and Cronin, (1967) (*The Condition of the Chesapeake Bay*). Consideration of the data in these and hosts of other technical publications, combined with the knowledge of many of those persons who have had the greatest first-hand experience in dealing with the physical, chemical, and biological systems of the Chesapeake Bay, resulted in the rostering of causes of biological problems shown in Table 1. This listing, together with that of the geographical areas of greatest concern (Table 2), was prepared by The Research Planning Committee of the newly-formed Chesapeake Research Consortium, Inc. and resulted in the establishment of priorities for those critical problems of the Bay most in need of research emphasis.

Table 1.–Causes of biological problems in the Chesapeake Bay.

Material	Primary Sources/Causes	
Emissions and Additions to the Bay		
Nutrients	Municipal and domestic wastes, agriculture	
Sediments	Agriculture, urbanization, road building	
Biocides	Agriculture, pest control	
Metals	Industry, biocides, mining	
Petroleum	Boats, municipal and suburban runoff	
Radionuclides	Nuclear power plants	
Leachates	Land fills	
Other Chemicals	Industry, power plants	
Heat	Thermal discharges	
Exotic species	Introductions, deliberate or accidental	
Deletions from the Bay		
Process or product		
Fresh water diversion	Dams, consumptive use, Chesapeake & Delaware Canal	
Fishery products	Exploitation, poor fishing techniques	
Alterations of Wetlands, Shorelines and Shallows		
Process		
Shoreline erosion	Natural processes, wetlands destruction	
Habitat destruction	Dredging, dumping, filling	
Loss of productivity	Dredging, dumping, filling	
Flooding, sedimentation	Dredging, dumping, filling	
Cumulative Effects of Multiple Engineering Changes		
Process		
Erosion	Filling	Bulkheading
Sedimentation	Dredging	Piling placement
Habitat destruction	Groin construction	Construction
Loss of productivity	Spoil deposition	

These are (1) nutrient loading, (2) addition of hazardous substances, (3) sedimentation, (4) effects of engineering activities, (5) extraction of living resources, (6) problems resulting from alterations and destruction of wetlands, and (7) the impact of regional population growth and distribution. The following remarks relating to these priorities arose from the deliberations of the Chesapeake Research Consortium.

Dissolved nutrients play a fundamental role in the general food chain in large estuaries such as Chesapeake Bay. However, an excessive nutrient supply can, and often does, create undesirable effects by causing certain species to flourish at the expense of others. These perturbations, resulting in blooms and their associated by-products, are responsible for water-quality deterioration in many regions of the world. The best known and documented cases of the effects of excessive nutrient loading are found in fresh water streams and lakes and in low salinity parts of estuaries. Saline waters, however, are not exempt from blooms, though the biological participants are often quite different from the typical blue-green algae which causes problems in fresh water.

In Chesapeake Bay, the effects of nutrient loading from municipal and industrial wastes are most apparent in the upper Potomac and in Back River, the receiving waters for the wastes from the metropolitan Washington and Baltimore areas, and in the upper and lower James River, from the Richmond and Hampton Roads-Newport News regions. In the upper Potomac, levels of phosphorous are at disruptive levels even before the river reaches Washington, D.C., while in the tidal reaches the concentrations of total phosphorous and the ratio of nitrogen to phosphorous are considered to be characteristic of less productive, "unhealthy" waters. These high nutrient levels result intermittently in low concentrations of dissolved oxygen, and it has been estimated that in recent years dissolved oxygen levels during the summer months have retreated to the levels occurring in the early 1930's, prior to the installation of major treatment works for the Washington area (Wolman, 1971). Nutrient levels in Back River are very high, and the results of over-enrichment are intense. This estuary acts as a type of tertiary treatment pond and in this sense protects the main body of the Bay from the nutrient loading associated with municipal wastes from Baltimore (Schubel, 1972).

Dramatic rises in nutrient levels have recently been reported in the upper Patuxent (Flemer et al., 1970) where concentrations of nutrients now frequently reach levels comparable to those in the upper Potomac. This is mainly the result of a rapidly increasing population in the small drainage basin of the river. Local inputs from septic field drainage of largely unsewered land areas are observable in the smaller tributaries of the western shore. Nutrient inputs from agricultural areas are most noticeable from the Susquehanna, Northeast, and Bohemia Rivers.

In summary, the effects of the increased nutrients are concentrated in the upper reaches of the tributaries, and in the upper portions of the Bay. Nutrients are at undesirable levels in the upper Potomac and in Back River, and are near undesirable levels in the upper Bay, the Patuxent, the James, and in many smaller tributaries. Although most of the open Bay is currently in good condition, it is generally believed that the discharge of improperly treated sewage and municipal wastes constitute the most serious immediate threat to the Chesapeake Bay estuarine system (Cronin, 1967).

The problem of nutrient loading in Chesapeake Bay, particularly its tributary estuaries, is not new and is not likely to decline in the near future for several reasons. The population in the Bay region is growing and is predicted to continue to increase in the foreseeable future. Hence, additional waste loading from domestic and municipal treatment plants is a certainty. The nutrients provided from these sources, particularly phosphorus and nitrogen, not to mention a host of lesser items, will most likely increase faster than new, expanded, or upgraded treatment plants can be provided for removing them. Actually, significant removal of phosphorus and nitrogen from effluent requires tertiary treatment which is expensive and certainly not commonplace in future planning for the area—the Blue Plains Plant in Washington representing the exception. Simultaneously, increased attention is being given to the Bay and its tributaries for recreation, housing, and industrial activities by the nearby populace. This redistribution or crowding by the presently growing population will cause, and is causing, an intensification of the loading in close proximity to the Bay. In one form or another, population pressure is the major causal factor in the nutrient loading problem.

Concern about hazardous additions that are wasted to the Bay, and which might have lethal effects on the biota, has developed as the result of such observations as fish kills near Sparrows Point and other areas, oil spills at a number of locations around the Bay, and heavy metals found in shellfish. However, considerable uncertainty exists about the magnitude and effects of certain additions, since measurements of many of these materials have not been made until recently, and then only at a few locations. For example, the sources of heavy metals, the routes and rates of transport, the patterns and rates of accumulation in the sediments and the biota, and the biological effects are poorly known. There is very little published data on the occurrence of pesticides in the waters, sediments, or organisms of the Chesapeake Bay estuarine system, despite their wide-spread use and the tendency of some of the filter-feeding and deposit-feeding organisms to concentrate such materials. A number of oil spills have occurred in Chesapeake Bay but all have been minor. Oil from illegal pumping of bilges, oils, and greases in municipal wastes, and oil from filling stations that is washed into storm drains and eventually into the Bay, pose an increasing threat (Schubel, 1972). Evidence available from other areas suggests that significant effects on the exceptionally important biota of the Chesapeake Bay, and possible hazards to man, can be expected from the above materials under appropriate conditions, and that intensive evaluation of these inputs should be undertaken. In addition, preparations should be made to deal with new exotic additions as the need arises.

Pesticides have caused local mortalities of crabs in Virginia, and the capacity of oysters, clams, and other molluscs to extract some pesticides and concentrate them to 50-70,000 times above ambient concentration has caused continuing concern. A recent preliminary report from the Department of Natural Resources suggests that pesticides, especially chlordane, may be present in softshell clams at levels sufficient to injure the organisms and also make them totally unacceptable in interstate commerce as food. Longer-term observations on fish in the Potomac and Susquehanna Rivers do not disclose any dangerous pesticides at levels which threaten either the fish or human consumers. Pesticides do not now present a major problem in the Bay, but they merit thorough understanding because of the exceptional value and pesticide vulnerability of shellfish.

As indicated above, there is relatively little quantitative information available on the extent or effects of the addition of hazardous materials into Chesapeake Bay. The status of heavy metals is of particular concern because certain of these metals are highly toxic to plants and animals, including man, and they are highly persistent, retain their toxicities for prolonged periods of time, and generally function as cumulative poisons. The most toxic, persistent, and abundant heavy metals in the marine environment include mercury, arsenic, cadmium, lead, chromium, and nickel (Schubel, 1972).

There are very few data on the temporal and spatial distributions of any of the heavy metals in the Chesapeake Bay estuarine system or its tributary rivers. The unpublished work of Carpenter at the Chesapeake Bay Institute (discussed in Schubel, 1972) indicates that concentrations of heavy metals in the Susquehanna River are generally associated with concentrations of suspended sediments. The seasonality of both the total concentration and the solubilization of many metals suggests the significance of organic matter and metals derived from decaying vegetation. Vegetation in the drainage basin, then, may be a major source of heavy metal pollution to the Susquehanna and the upper Bay.

Relatively few measurements have been made of heavy metal discharges and of historical and geographical deposition in sediments. In the matter of discharges it is known that input estimates must take into account the variability of the source, and that small samples may be extremely misleading. In 2 studies of heavy metals in the Susquehanna, the estimated annual discharges of 3 common metals differed by more than an order of magnitude. Regarding spatial distribution, there are a few data that suggest there is a longitudinal gradient of heavy metals in the fine sediments of the Bay. Concentrations of heavy metals tend to be higher near the head of the Bay than further seaward in the estuary, apparently reflecting the different source materials from the Piedmont and Coastal Plain sediments and the removal of metals into sinks. The differences in the sources of organic matter may also be important in producing this gradient.

Temporal sedimentary records of heavy metal deposition are also scarce, but analyses to date do not demonstrate that man's activities have increased the levels of at least iron and zinc in portions of the upper Bay. Even the magnitude of man's activities relative to heavy metals in Baltimore Harbor is not clear in view of the wide variation (an order of magnitude in certain cases) in concentrations in contiguous areas.

In summary, because of their persistence and their toxicity at high concentrations, heavy metals are potentially dangerous pollutants. Heavy metals are introduced into the Bay in solution and adsorbed on fine particles, as a result of the natural processes of weathering and erosion. They are also introduced into the Bay as a direct and indirect result of man's activities. Man's use of heavy metals in pesticides, biocides, and industrial applications have tended to increase the inputs of heavy metals to the Bay, as have mining and agriculture in the drainage basin. Man's dam-building activities have tended to decrease the inputs. Dams on the lower Susquehanna trap large amounts of sediment and heavy metals, thus preventing them from reaching the Bay. The extent of man's impact on the spatial and temporal distributions of heavy metals in the Chesapeake Bay estuarine system is obscure.

Natural processes deliver millions of tons of sediment to Chesapeake Bay every year with water runoff from the entire watershed. These processes are being accelerated by earth-moving and construction, so that an estimated 8,000,000 tons/year enters the tributaries (Wolman, 1968). Dredging and spoil disposal practices contribute additional millions of tons to the problem, with further contributions coming from shore erosion from natural action and engineering activity.

Such sediments can have devastating effects on the uses of the Bay. Navigational channels are so filled as to require expensive dredging, recreational waters are made too shoal for use, and biological populations can be smothered or impaired.

Therefore, reasonable decisions must be made by management agencies about regulations on land use, on construction practices, on shore erosion control, and on the spoil disposal which is to be permitted. Each of these may involve large costs for landowners, construction firms, municipal, State and federal governments; and for many of those who use the Bay for related purposes. Management decisions must, therefore, be based on realistic understanding of the estuarine effects involved.

Very gross estimates have been made of the total input of sediment to the Bay from upland runoff and from marginal erosion. Schubel and Biggs (1969) estimated for the upper Bay that river-sourced sediment input is $0.6\text{-}1.0 \times 10^9$ kg/year, and Singewald and Slaughter (1949) showed that shore erosion contributes about 0.3×10^9 kg/year in the same area. Gaging stations and other local observations provide additional data, but the full annual budget for input distribution, deposition, resuspension in part, and other sedimentary patterns has not been determined.

Sherk and Cronin (1970) and Sherk (1971a, 1971b) have summarized available data on the effects of suspended and deposited sediments on estuarine organisms. Both field observations and laboratory experiments have been conducted on these effects, and there is strong evidence that sediments can reduce photosynthetic activity, kill benthic organisms, and seriously impair the welfare of eggs, larvae, and adults by sublethal damage. The review also demonstrated, however, that adequate prediction of sediment effects is rarely possible and that properly designed research is of exceptional urgency.

The fine sediments which are abundant in the Bay present enormous total surface area for sorption, and they have important roles in the removal and storage or later release of nutrients, toxic chemicals, and other materials.

Important engineering changes that have cumulative effects include filling principally around major cities, for parks, industry, housing, and airports; and the dredging that is associated with filling because of the necessity for deposition of spoil. These activities contribute to the problems of sedimentation and to the losses of productive wetlands and shallows.

The linkage of all of these problems to human population growth is obvious. It is also obvious, from perusal of Table II, that we have made the decision to eliminate several sub-estuaries as productive and esthetically pleasing parts of the Chesapeake Bay system. How many more we are prepared to sacrifice is an important and unanswered question.

As discussed above, there is a general understanding of the biological value of wetlands and their role as one of the 3 distinct production units involved in primary fixation of energy in estuaries (Odum and Smalley, 1957). An up-to-date, comprehensive review of marsh production, including a literature summary, has been presented by Keefe (in Flemer et al., 1970). It is apparent from this review that little work has been done on the biology of wetlands bordering the Chesapeake Bay, where situations vary widely in salinity regimes.

Turning to the significance of wetland sediment interactions, we know that marshes act as sources and sinks for sediments. The marsh surface itself is built by deposition of organic and inorganic sediments. Much of the inorganic sediment trapped in the marsh has its origin from the rivers tributary to the Bay. The marsh-derived organic sediment is largely the detrital vegetation which is transported via the marsh drainage system to the estuary (Odum and de la Cruz, 1967). The channels flooding and draining the marsh are thus the critical transport link in delivering detritus to the estuarine food chain. It may be anticipated that the drainage desnity (area/enclosed stream length) of a marsh determines, to some extent, the level of decomposition of detritus prior to its introduction to the system. At present we have a relatively poor understanding of the sediment transport processes within marsh channels and of the deposition or erosional characteristics of marsh surfaces. It is imperative that we understand more of the details of these transport processes if we are to specify the transport rates of detritus and nutrients.

Another major consideration is that of shoreline utilization. Although the possible management of marshes has received special attention, it is important to keep in mind that the marshlands are but one component of the broader question of shore line utilization and management. Since management agencies have (perhaps only temporarily) adopted a more conservative posture regarding alternate usage of marshes, the less biologically productive shoreline reaches are, and will continue to be, subject to additional stresses for development. The increasing concentration of the population near shorelines which generally have a high recreational appeal has made shorelines the most expensive property in the Bay region. This enhanced value has lead to a deeper awareness of the significance of shoreline erosion.

As in any resource problem, that of shoreline use is dynamic, since it is the result of many interacting factors that vary through time. However, a rather detailed understanding of the physical and biological processes and current land use is a prerequisite to the formulation of a shore utilization policy which will accomplish the desired objective. Specific actions are needed in the acquisition of baseline erosion data leading to recommendations for correction. Furthermore the research activities focused on understanding tidal river-bank erosion processes is needed for the improved design of river bank erosion control structures (Commonwealth of Virginia, 1971). Finally, it is very important to assemble for the land planners and managers the relevant data needed in shoreline planning. These data should include physical characteristics of the shoreline, the erosion rates, the key biological characteristics, current land use, and

Table 2.–Geographical areas of the Chesapeake Bay of particular concern for solution of biological problems

Area	Reason for concern	Immediacy of problems (if this is reason for concern)
	Maryland– Western Shore	
Susquehanna River	Nutrients, modification of fresh water flow, sediments, energy, fisheries	Freshwater flow–immediate: others–chronic
Bush River	Proposed thermal addition	Near term
Back River	Municipal waste, nutrients	Immediate
Patapsco River	Municipal and industrial wastes, dredging, spoil disposal, all hazardous materials	Chronic
Magothy, Severn and South Rivers	Residential wastes, agricultural runoff (nutrients), recreation	Chronic
West and Rhode Rivers	Protected area of low stress for baseline data and experimental study	
Calvert Cliffs	Thermal addition, radionuclides, political problems	Immediate
Cove Point	Proposed liquid natural gas terminal, dredging, spoil disposal	Immediate
Patuxent River	Thermal addition, nutrients, area of immediate stress	Immediate
	Maryland–Eastern Shore	
Chesapeake & Delaware Canal	Modification of freshwater flow, dredging and spoil disposal, shipping, oil spills	Immediate
Chester River	Heavy metals, biocides	Long range
Choptank River	Nutrients, sedimentation	Near term
Dorchester County	Shoreline erosion	Chronic
Maryland & Virginia		
Upper Tidal Potomac River	Urbanization, municipal wastes (nutrients), sediments, legal and institutional problems	Chronic
Lower Tidal Potomac River	Oil spills, dredging, fisheries	Near term
Lower eastern shore	Economy, agricultural wastes, wetlands, fisheries, erosion, access to water, industrial development	Immediate
	Virginia	
Rappahannock River	Freshwater flow modification, industrial wastes, area of relatively low stress, nutrients	Freshwater flow–immediate: others–chronic
Upper York River	Industrial wastes, freshwater flow modification wetlands, fisheries	Freshwater flow–immediate: others–chronic
Lower York River	Thermal addition, oil transport, dredging, spoil disposal, wetland alteration, fisheries, residential wastes, VIMS	Immediate
Upper Tidal James River (above Jamestown)	Industrial and municipal wastes, dredging, heavy metals, human health (bacterial counts)	Immediate
Lower Tidal James River (below Jamestown)	Industrial and municipal wastes, transportation (water & vehicular), spoil disposal, dredging, thermal addition, fisheries, heavy metals	Immediate and chronic
Hampton Roads	Transportation (water & vehicular), ship waste, spoil disposal, recreation	Immediate and chronic
Nansemond, Elizabeth and LaFayette Rivers	Heavy metals, municipal wastes, fisheries, urbanization, oil handling and transport, shipping, shoreline modifications	Immediate
Lynhaven system	Residential development, nutrients, shoreline modifications	Chronic
Bay-mouth area	Only exit from system to sea, sedimentation, fisheries (crab spawning area)	Near term

recommendations for siting specific activities which are based on the physical and biological characteristics.

The preceding comments on the biological problems of the Chesapeake Bay emphasize, I believe, that nutrient loading is the matter of primary concern and that this problem, like so many others, has resulted from a series of more or less unconscious decisions that continue to the present day. There are about 25 major subestuaries ringing the Bay. To reach this high count, I have included areas as small as the Middle River, north of Baltimore, with ones as large as the Potomac. Ten of these are presently affected by overenrichment to one degree or another. Four of them, the (upper) Potomac, the (upper) Patuxent, the Back, and the Patapsco Rivers, as well as the "Upper Bay", are so severely affected by nutrient loading that their productivity and esthetic qualities are impaired. Nonetheless, there has been no public outcry, and no formation of state-supported advisory committees like those relating to the siting of power plants in Maryland. This is of special interest in light of the *concensus opinion* that nutrient loading is *the major problem* affecting the Bay, and that sewage treatment plants are proliferating at a rapid rate. I have even heard complaints from a county official that a particular sewer main was carrying well below capacity volume; a matter that should be corrected forthwith by the adjustment in zoning that would permit new home construction.

Who is going to make the decision(s) concerning the number of subestuaries we should preserve? These are vital parts of the Bay, remarks concerning the usefulness of the Back River as a nutrient trap that protects "the Bay" notwithstanding. Who is going to make the decision about the upper level of nutrients that the entire system can tolerate? Perhaps we can only wait and see; it should not take very long.

Biological Research on the Chesapeake Bay

As a result of extensive research on this estuary, there has been accumulated a great deal of knowledge concerning the more than 2,000 species of plants and animals that we know to be important members of the Chesapeake Bay biological community and, concerning these, there has been developed in excess of 1,000 publications. Thus, we do know a great deal at the present time about the biology of the Chesapeake Bay. This knowledge has been obtained by investigators in a host of State and federal laboratories as well as those of a number of universities. In many instances, it has been research of an opportunistic nature evolving from the curiosity and interests of particular investigators concerning particular species or problems of biological interest. Much of it has also necessarily been research on economically important species. In regard to the latter, there have been certain constraints on the scope of the work in that it evolved around existing economic values; that is, economically important species concerned with the fishery resource. Thus, to a large extent, this research can be defined as autecology concerned with single taxa or groups of taxa. However, much of it has involved research more germane to an understanding of the Bay as a biological system and has resulted in some understanding of the interrelationships between many of the important biological species and the physical and chemical parameters that control their distribution and abundance. Consequently, enough has been learned about some natural and social systems for realistic selection and assignment of priorities. And, we have been able to supply to management and regulatory agencies much of the information they need regarding the sustained harvesting of economically important species, or the use of these in other ways. However, there has emerged from this background the unfortunate recognition that most of these studies have not been of the in-depth character needed for the solution of major environmental problems. This is not a phenomenon peculiar to the Bay; it is one that relates equally to other large scale biological-physical systems. Even if we had long ago comprehended the Bay as a large, intricately interrelated system of physical, chemical, and biological units, we would not have studied it as such because the demand for such elaborate consideration was not necessary, and the funds, personnel and expertise were not available. The Bay, like other large systems, had in the past the resiliency to withstand the environmental insults to which it was being subjected without a significant or appreciable loss in (1) its biological productivity, (2) its use as a recreational resource, or (3) in loss of its esthetic value. Now, however, in many of the subestuarial systems which form the bulk of the biologically productive parts of the Bay, we are alarmed by gradual changes related to social development and economic growth which may or may not be irreversible, which have reduced biological productivity, and which have reduced the use of these systems for recreational purposes, and have made them esthetically displeasing. We are alarmed because we know that we do not have the data necessary for the solution of large scale environmental problems. We recognize that there are a very large number of known and unknown independent variables which must be uncovered and, although we already possess some of the legal machinery necessary to regulate the quantities of nutrients, industrial wastes, sediments, toxic chemicals, heat, and so on that may be delivered to the Bay, we do not know all the organisms involved in the food webs, their responses to natural and man-induced pertubations and their short and long term interactions. Further, we know very little about the cumulative and synergistic effects of diverse uses. Unless we decide what changes may be acceptable, it will be impossible to say "how much" or "how long". In such an atmosphere of ignorance of quantitative limits public support can be dissipated into rather non-essential, but highly visible directions while basic but more complex problems progress unchecked to crisis proportions. We recognize that the Chesapeake Bay is a vastly complex system and that its tributaries and watersheds, its terrestrial and aquatic populations, including human populations, collectively present a formidable open-ended study that could quite literally involve thousands of investigators and tens of millions of dollars for an indefinite time. Unless some priorities are established in the direction of our research efforts, it is quite conceivable that many of the irreversible and sometimes catastrophic consequences of man's intrusion on the ecosystem will come about long before the system can be described, much less understood.

An Approach to the Solutions of Biological Problems in the Chesapeake Bay

The States of Maryland (Department of Natural Resources, Department of Planning) and Virginia (Marine Resources Commission, Virginia Institute of Marine Science) have the *major* management responsibilities for the Chesapeake Bay. The basic objectives of State management of the Bay are difficult to make explicit, but they can be expressed in the most general terms as the maintenance or increase of the following overlapping Bay attributes: health, productivity, safety, cleanliness, and esthetic quality. The translation of these generalities into operationally useful objectives moves on to categories such as: maintenance of biological stability and protection of the capacity of the system to recover from perturbations (health), maintenance or increase in the yields of desired species (productivity), removal of hazards to human health and well being (safety), achievement and maintenance of politically determined water quality standards (cleanliness), and maintenance of indirectly expressed standards of sensible parameters (esthetic qualities). All of these categories admit to measurement, and become operationally useful to the extent that they are measured and measurable. The question becomes one of how do we make the critical measurements, and how do we make them operationally useful?

Estuarial managers frequently lament that they lack sufficient biological information for solving key resource management problems. The obvious solution to this deficiency is to identify problems in advance, determine the kinds of information necessary to solve those problems, and launch data collection and research necessary to produce this information, to be available when needed (Jenkins, D.W., personal communication).

This exercise is as difficult as it is obvious. Problem identification involves making predictions about the future that are necessarily tenuous, considering the pace of technological change. Once problems are identified, the kinds of information necessary for their solution are by no means self-evident. Identification of information useful to making a decision implies the existence of an explicit decision-making process which can seldom be found, let alone described, outside a resource allocation textbook. Finally, there is the difficulty of linking specific research to specific management-information needs. The complexity and interrelatedness of the biological system suggests the necessity of having a total systems predictive capability before important decisions can be based on firm biological evidence.

Notwithstanding these difficulties, the exercise is presumed to be a useful one. It would require management to state as explicitly as possible its anticipated information needs, with the scientific community responding as to how this information could be produced. The cycle would be completed if management then solicited and received public funds for the generation of this information, and called upon scientists for the conduct of the necessary research.

How has this approach actually worked in practice? There is presently minimal coordination between the hosts of federal, State, university, and private laboratories conducting research on the Chesapeake Bay, and the bulk of these are not responsive to the urgent needs of the regulatory and management agencies of Maryland and Virginia. Further, it is not always clear just which federal or State management agency has primary responsibility or authority for a particular area of concern. Thus, it becomes apparent that a central research organization, with a program designed to meet the needs of management, be clearly identified, and that this research group be responsive to at least the State agencies with primary management and regulatory responsibility. Such a step has been taken in the formation of the Chesapeake Research Consortium, Inc., with support from the National Science Foundation. The member institutions of this consortium include The Johns Hopkins University, The University of Maryland, The Virginia Institute of Marine Science, and the Smithsonian Institution. Thus, not only is the bulk of Chesapeake Bay expertise made available from a host of institutional departments, but the central bayside laboratories are also included. This consortium is open-ended, it will enlarge, and it has the promise of providing the properly coordinated scientific program so vital to the future of the Bay.

Solution of the complex problems of the Bay requires an approach that is novel to most investigators. Interdisciplinary teams, including economists, sociologists, attorneys, land-planners, representatives of industry, and biological and physical scientists, must be assembled for work on well-defined problem areas. The planning of the program must include representatives of regulatory and management agencies, and their participation should result in the collection and availability of that data most needed for immediate decisions concerning immediate problems. The highest priority must be for directed research designed specifically for problem solving, and this research must be rigidly programmed and directed. Basic research is needed for the identification of problems not yet identified, but limitations of personnel, time, facilities, and money demand that priority be given to directed research on already well-identified or anticipated problems whose solution is mandatory. Only in this way will we ever achieve any success in the balancing of the conflicting uses of the Bay, and the establishment of those policies that will protect the Bay as a multiple use resource. Information presented earlier clearly indicates that present legal authority, e.g., the Wetlands Acts of Maryland and Virginia, the Power Plant Siting Act of Maryland, the Federal Water Pollution Control Act, the proposed Federal Toxic Substances Control Act, and many others, is insufficient to cope with management problems, particularly at the local level.

Finally, there is a distinct need for the development of a methodology that produces data sufficiently adequate to cope realistically with the problems of such a vast natural system. Since we obviously cannot study all areas and all problems with equal intensity, a bonafide case must be made for the validity of extrapolating from locally derived results to arrive at some understanding of effects on the Bay as a whole. If a small change or a multiplicity of small changes in one locale has a given effect, what is the cumulative effect of a host of such changes in comparable communities within the entire system? Secondly, we must use the available knowledge and supplement it with that which is lacking (i.e., largely the separation of effects deriving from natural as distinct from unnatural perturbations, and the rather different information derived from interdisciplinary research that is temporally and spatially coincident) to establish clearly what sorts of change(s) result from what type(s) of alteration(s) to carefully selected areas. Empirical data gathered in these areas, *combined* with results from experimental manipulations, will enhance the possibility of success.

Man-induced, deleterious changes in major natural systems are traditionally subtle, difficult to detect and measure, and they often confound us in our efforts to establish definitive cause and effect relationships. This is true because measurable changes usually result from the cumulative effects of small perturbations seemingly insignificant as isolated events, occurring over long periods of time. When the major natural system is a land-water complex as vast as the Chesapeake Bay and its drainage basin, the detection and solution of environmental problems becomes especially difficult. This methodology should be of major assistance in overcoming these problems.

None of these proposals has referred to the role of the political process in making decisions concerning the use of natural resources. We can reasonably assume that all decisions result from assessments of conflicting benefits and costs, and that those which approach cost-benefit equality and involve conflicting values and non-quantified elements become extremely difficult and contentious. Unfortunately, decisions based on the benefits to be derived from a particular use of any component of the Bay, or a component of any other large and complex natural system, are often or usually removed in time from an assessment of the costs. Immediate economic gain (benefits) is understood by everyone, but cumulative harmful effects (costs) are not nearly so easy to elucidate. Compounding this problem is the role of political expediency in decision making, and the fact that this often renders the best efforts of everyone to absolute zero. Since this is the case, our best efforts must be made even better.

Summary

What we term the Chesapeake Bay is actually a vast natural system that has, because of size and peculiar biological and phyiscal attributes, been able to withstand and/or recover from, a large number of deleterious, man-induced perturbations. These changes have been difficult to separate from natural processes that also change the character of the Bay, many of which have been accelerated by man's activities. It is now possible to detect gross changes in the Bay that include the virtual extinction of several subestuaries as biologically and esteticly useful resources. These events are foreboding in that we can foresee the possibility of their continuing unchecked until the entire Bay is similarly affected.

The Chesapeake Bay has enormous biological, and thus economical, significance in terms of the large commercial fishery, and its use as an esthetic and recreational resource. The longevity of all of these things depends upon the continued maintenance of the physical and chemical integrity of the Bay, i.e., maintenance in a state that supports all of the trophic levels and relationships.

The principal biological problems of the Bay result from excessive nutrient loading, the addition of hazardous materials, erosion and sedimentation, the cumulative effects of engineering activities, the exploitation of living resources, and the alteration and destruction of the wetlands. All of these things are related to the impact of human population growth in the Chesapeake Bay Region, and the conflicting demands placed by these people on a multiple-use resource.

Previous biological research on the Chesapeake Bay has been inadequate in failing to

provide much of the information needed by management and regulatory agencies. This has resulted primarily from failure of the approach used to deal effectively with the Bay as a large interrelated system, and thus to identify all of the key organisms in food webs, their responses to natural and man-induced perturbations, and their short and long term interactions. Little is known about cumulative and synergistic effects of diverse uses of the Bay, what changes are acceptable, and the establishment of quantitative limits.

There is a distinct need for the management agencies of Virginia and Maryland, as well as those of the Federal government, to join with the academic community in an effort to obtain the information needed for decision-making, and to do this in as expeditious a manner as possible. This effort will require a major interdisciplinary approach based on a sound methodology that can deal constructively with the complex problems of the Chesapeake Bay.

References Cited

Beers, R.F., Jr., et al. 1971. The Chesapeake Bay: A research program to assist in better management of complex environmental systems. Johns Hopkins University, University of Maryland, VIMS. xiii + 211 pp.

Berger, B.B., et al. 1971. Report of the review panel of the Smithsonian Institution on a research program for protection and enhancement of the biological resources of Chesapeake Bay. 19 pp.

Caspers, H. 1967. Estuaries: Analysis of definitions and biological considerations. p. 6-9 *In* Lauff, G.M., (Ed.) Estuaries. Amer. Assn. Adv. Sci. Pub. 83, Washington, D.C. 757 pp.

Cronin, L.E. 1967. The condition of the Chesapeake Bay. Trans. 32nd N.A. Wildlife and Natural Resources Conf., Wash. D.C., pp. 138-150.

Cronin, L.E., and J.J. Mansueti. 1971. The biology of the estuary, pp. 14-39. *In* A Symposium on the Biological Significance of Estuaries. Sponsored by the Sport Fishing Inst. in cooperation with Sportsmen's Clubs of Texas, Inc. and Nat. Wildlife Fed. xi + 111 pp.

Douglas, P.A., and R.H. Stroud. 1971. A symposium on the biological significance of estuaries. *Ibid*., xi + 111 pp.

Flemer, D.A., D.M. Hamilton, C.W. Keefe, and J.A. Mihursky. 1970. The effects of thermal loading and water quality on estuarine primary production, NRI, Ref. 71-6.

Hargis, W.J., Jr., and B.L. Laird. 1971. The environmental resource-use and management needs of the Coastal Zone. Spec. Sci. Rep. No. 57, Virginia Inst. of Marine Science.

Lauff, G.M. (Ed.). 1967. Estuaries. Amer. Assn. Adv. Sci. Pub. 83. Washington, D.C. 757 pp.

Masmann, W.H. 1971. The significance of an estuary on the biology of aquatic organisms of the Middle Atlantic Region. pp. 96-109. *In* A Symposium on the Biological Significance of Estuaries, sponsored by the Sport Fishing Inst. in cooperation with the Sportsmen's Clubs of Texas, Inc., and the Nat. Wildlife Fed. xi + 111 pp.

McHugh, J.L. 1966. Management of estuarine fisheries, pp. 133-154. *In* A Symposium on Estuarine Fisheries. Spec. Pub. No. 3. Amer. Fisheries Soc. Washington, D.C.

_______________. 1967. Estuarine nekton, pp. 581-620. *In* Lauff, G.M. (ed.). Estuaries. Amer. Assn. Adv. Sci. Pub. 83. Washington, D.C. 757 pp.

National Academy of Sciences. 1969. Eutrophication: causes, consequences, correctives. (Symposium proc.). Nat. Acad. Sci., Washington, D.C. 659 pp.

Odum, E.P., and A.A. de la Cruz. 1967. Particulate organic detritus in a Georgia saltmarsh estuarine ecosystem, pp. 383-388. *In* Lauff, G.M. (ed.). Estuaries. Amer. Assn. Adv. Sci. Pub. 83. Washington, D.C. 757 pp.

Odum, E.P., and A.E. Smalley. 1957. Trophic structure and productivity of a salt marsh ecosystem. Progress Report, N.S.F.

Proceedings of the Governor's Conference on Chesapeake Bay, 1968. 218 pp.

Schubel, J.R. 1972. The physical and chemical conditions of Chesapeake Bay: an evaluation. Spec. Report, 21. Chesapeake Bay Inst., 73 pp.

Schubel, J.R., and R.B. Biggs. 1969. Distribution of Seston in Upper Chesapeake Bay. Chesapeake Science 10: 18-23.

Sherk, J.A., Jr. 1971a. The effects of suspended and deposited sediments on estuarine organisms—Literature summary and research needs, Ches. Biol. Lab. Contributions, 443. 73 pp.

_______________. 1971b. The effects of sediments in the marine environment including estuaries. Report to Panel on Water Quality Criteria for Marine Aquatic Life and Wildlife, Nat. Acad. Sci. CBL Ref. 71-93. 37 pp.

Sherk, J.A., Jr., and L.E. Cronin. 1970. The effects of suspended and deposited sediments on estuarine organisms—an annotated bibliography of selected references. CBL Ref. No. 70-19. 61 pp.

Singewald, J.T., and T.H. Slaughter. 1949. Shore erosion in tidewater Maryland. Md. Dept. Geol., Mines, and Water Res. Bull. 6. 141 pp.

Stross, R.G., and J.R. Strottlemeyer. 1965. Primary production in the Patuxent River. Chesapeake Sci. 6: 125-140.

Stroud, R.H. 1965. Chesapeake Bay Fishing. SFI Bull. 164: 6.

_______________. 1971. Introduction. *In* Douglas, P.A., and R.H. Stroud. Symposium on the Biological Significance of Estuaries. Sponsored by the Sport Fishing Inst. in cooperation with Sportsmen's Clubs of Texas, Inc. and Nat. Wildlife Fed. xi + 111 pp.

The Chesapeake Bay Plan of Study. 1970. Corps of Engineers and Advisory Group to the Chesapeake Bay Study. iv + 95 pp.

Wass, M.L., and T.D. Wright. 1969. Coastal Wetlands of Virginia. Interim Report to the Governor and General Assembly; VIMS. No. 10. x + 154 pp.

Wolman, M.G. 1968. The Chesapeake Bay: Geology and Geography, Proc. Gov. Conf. on Chesapeake Bay. pp. 11-48.

_______________. 1971. The nation's rivers. Science 174: 905-918.

The Fate of the Chesapeake Bay: Socio-Economic Aspects

John J. Boland[1]

Department of Geography and Environmental Engineering, The Johns Hopkins University, Baltimore, Md. 21218

ABSTRACT

Much of the attention directed to the Chesapeake Bay is quite properly concerned with the response of the Bay's natural systems to the industrial, recreational, and other uses which are made of its waters and shorelands. Another aspect of the problem lies in the nature of the social and economic systems whose functioning is known to affect the Bay. This paper describes a study of the electric generating industry in the Chesapeake Bay region, now underway. The purpose of the study is to learn how that industry can be expected to respond to policies regarding the use of the Bay as a heat sink. Specific investigations include analyses of future electric energy demands, future demands for generating sites, and the role of public policy in siting new generating facilities.

The Chesapeake Bay as a Resource

It must strike the participants in this Symposium as self-evident that the Chesapeake Bay is a natural resource of inestimable value. This follows, not from any mind-boggling list of numbers and varieties of species of life found in its waters, but from its enormous capacity for making this part of the world a better place to live, now and in the future.

We have grown accustomed to using the Bay for many things. It supports a wide variety of recreational and leisure-time activities—those of us fortunate enough to live near its shores are constantly aware of even the visual pleasures it affords. The Bay provides some of the more delectable items in our diet from its range of harvestable finfish and shellfish. It is an important water transportation route. Its abundant waters have supported the growth of a large and diversified industrial community in Maryland and Virginia, in part by offering a sink for the

[1]Mr. Boland is an environmental engineer with a background in economics and public administration. His professional career includes local government service in the municipal public works field. He was Chief of Utility Operations for Anne Arundel County, Maryland. More recently, he served as Chief, Water Resources Section, Hittman Associates, Inc., offering consulting services to various levels of government in the water resource management field. Mr. Boland received his B.E.E. (Electrical Engineering) from Gannon College, Erie, Pa., and his M.S. (Government Administration) from George Washington University, Washington, D.C. He is presently a Ph.D. candidate at the Johns Hopkins University, where he serves as a research associate on the study entitled "Economic Considerations in Power Plant Siting in the Chesapeake Bay Region." This research is supported by the State of Maryland and the U.S. Atomic Energy Commission.

chemical and thermal wastes which result from many kinds of human activity.

This last use of the Chesapeake Bay is now the source of much concern. It becomes more and more evident that we cannot continue to treat the Bay as a waste sink and expect to maintain some of the other uses, uses which make important contributions to the quality of our life. Even if the trade-off between uses were to appear attractive now, the slow or doubtful reversibility of many of the predicted effects suggests that much of the burden of our decision will fall on future generations.

Much of the interest and study devoted to this problem has quite properly been focused on physical, chemical and biological phenomena. It is essential that we understand as completely as possible the exact response of the natural system to various man-made perturbations. That the discharge of a specified quantity of a certain waste at a particular place will have an effect on the Bay is usually clear, but we should not rest until we can predict with some accuracy the exact nature and magnitude of that effect. It may appear that when this level of understanding is reached, the proper management of the Bay will be assured. For all we need do is determine which discharges are acceptable and which inacceptable, and create laws or regulations to prohibit the latter.

Such a simplistic approach ignores a major part of the subject area—the man-made system which generates the discharges. This man-made system is fully as complex as the natural system, and our ability to predict its behavior is no further advanced. It is comprised of that group of firms, utilities, governments, institutions public and private, which provide goods and services to the public, and in turn, dispose of its wastes. The nature, quantity, and location of waste discharges depend on numerous factors, including economic growth, technological advances, changing tastes, and the various laws and regulations affecting discharge. If our goal is the development of public policy which will insure the best use of the Chesapeake Bay, now and in the future, it is necessary to understand the operation of the man-made system as thoroughly as that of the natural system. Anything less carries the risk of creating larger problems than those solved.

At the present time, at The Johns Hopkins University, we are conducting a study of one portion of the man-made system—specifically, the electric power generating industry. As the principal discharger of waste heat, the electric power industry is and will continue to be a major feature of the Chesapeake Bay scene. At the same time, electric energy has become indispensable to civilization as we know it today. We demand increasing quantities of electricity not only to provide conveniences and comforts to a growing population, but to power many of the processes designed to control waste discharges from other industries and activities.

This is the dilemma—too-strenuous efforts to reduce heat discharges from electric generation may cause a shortage of energy more harmful to our society that the heat discharge avoided, yet even when the regulations appear to strike the right balance, growth or technological change in other sectors of the economy may wipe out any gains.

With these possibilities in mind, the Chesapeake Bay Cooling Water Studies Group, with the support of the U.S. Atomic Energy Commission and the State of Maryland, Department of Economic and Community Development, inaugurated almost one year ago a major socio-economic study of the electric generating industry in the Chesapeake Bay region. I will attempt to describe some features of that study, and to indicate the type of results that might be expected from it.

The Electric Power Generating Industry

The region contiguous to the Chesapeake Bay is served by five major electric utilities, plus a number of smaller cooperatives, municipal utilities, and private generating facilities. Four of the 5 utilities and 4 industrial facilities are currently operating a total of 20 fossil-fueled steam-electric generating stations, which together discharge about 225×10^{12} BTU's of waste heat each year, almost all of it directly into the Bay or its tidal tributaries.

Still, the Bay has escaped bearing what might be considered its fair share of the thermal load. Only about 2/3 of the generating capacity required to serve the electric demand in the area is actually located on the shores of the Bay. Much of the remainder is composed of large, coal-burning plants located in the Appalachian coal fields, their energy transmitted long distances over shared transmission lines.

The Keystone and Conemaugh minemouth plants in western Pennsylvania, which are owned and operated by utility joint ventures including several of the Chesapeake Bay area utilities, are examples of this practice. The considerable savings in fuel transportation costs outweighed, in these instances, the additional costs of waste heat disposal through cooling towers and transmission losses. This pattern of power plant location cannot be expected to continue into the future, however. Even before the finite nature of the Appalachian coal resource becomes a problem, the existence of air quality standards limiting sulfur emissions from such plants may place a heavy burden on their operation.

Another well-known trend in the utility industry figures in these calculations. There seems little doubt but that a very large share of new generating capacity will be nuclear-fueled. In the case of the Chesapeake region, 48% of all new capacity planned for operation before 1980 will consist of nuclear units. Two facts stand out: currently available nuclear plants have substantially lower thermal efficiency than the best contemporary fossil plants, discharging up to 50% more waste heat for each unit of electrical output; and nuclear technology creates unusually strong incentives for very large plant sizes.

Thus we find that the 225×10^{12} BTU's of waste heat discharged annually by the Chesapeake Bay electric generating industry will most probably swell to 680×10^{12} BTU's by 1980, tripling itself in less than 10 years. Furthermore, the heat will be produced by a relatively few, very large plants, greatly aggravating the problems of dispersal and assimilation. This forecast rests on currently accepted projections of electric demand and actual plans regarding new capacity and technology. It is presented here to underline the importance of learning something of the process which is capable of producing such profound changes.

Socio-Economic Studies

Our studies are presently directed to 3 major subjects:

- The future demand for electric energy;
- The future demand for electric generating sites; and
- The relationship between public policy and generating plant siting.

As these investigations are completed, we expect to examine more closely the linkages between the electric utility industry and the rest of the region's economy, as well as initiating a comprehensive study of the internal and external costs associated with the disposal of various residuals from electric generation. Near the end of the study, about 3 years from now, these various lines of inquiry should converge as a reasonably complete model of the electric generating industry in the Chesapeake Bay region.

The Demand for Electric Energy.—A basic ingredient in any study, prediction, or speculation about the industry is a forecast of future demand for electric energy. Forecasts are prepared by the utilities themselves, as an indispensable element in their planning; by regional groups such as the utility interconnections, or the regional reliability councils; and by national groups including the Federal Power Commission (FPC) and the Edison Electric Institute (EEI). Most regional forecasts tend to be simple aggregations of utility forecasts, but national forecasts are sometimes performed independently.

The central theme of recent forecasts is familiar to everyone—the demand for electricity is rising exponentially, doubling every 8-10 years. Clearly, in a resource-limited world, no demand can grow exponentially without sooner or later encountering certain checks and balances which modify the rate of growth. This will happen in the utility industry, but no one knows when. An important fact to remember is that, so long as existing forecasting techniques are retained, there will be no advance notice of any change in the rate of growth.

Forecasting methods in use by Chesapeake Bay region utilities, and in general, by utilities elsewhere, rely heavily on extrapolation of past trends. If demand doubled in the last 9 years, the tendency to make the same prediction for the next 9 is very strong. These extrapolations are not always performed uncritically, and several utilities study the expansion plans of their larger users, compute the impact of specific commercial developments, etc., modifying the exponential growth assumption accordingly. Still, such adjustments merely reflect an awareness of short-term fluctuations in the growth rate and do not represent a critical examination of long-term trends.

A need exists for an econometric model of electric demand, relating its growth to changes in residential, commercial, and industrial activity, to relative prices of electric energy and related goods, and to other factors which pertain to the actual workings of the energy market. We have initiated the development of such a model for the region, although it is too early to offer any more specific description of its nature. With the aid of this econometric description of electric demand, changes in the structure of the economy, to the extent that they are predictable, can be linked with changes in the level and structure of demand for electric energy.

This approach has many advantages over methods now available. Should the measures necessary to protect resources such as the Chesapeake Bay result in a substantial increase in the cost of electric power, as some suggest, the demand for energy will be affected. Not only will the average level of demand be reduced, but the pattern of peak demands will be altered in a way which cannot now be predicted. These changes, in turn, affect the design and operation of generating facilities, and their impact on the environment. The environmental protection measures appropriate to the original problem may no longer be so, after some period of adjustment. The purpose of an econometric demand model is to provide visibility of this chain of causes and effects which weave through the entire economy.

The Demand for Generating Sites.—One product of improved methods for forecasting energy demand is a fresh perspective on the problem of forecasting the demand for generating sites. Electric utilities possess a number of options with respect to satisfying energy demands. They can build and operate generating facilities sufficient to meet all anticipated demands from their own capacity. They might enter into cooperative agreements with neighboring utilities, pooling certain facilities for operating purposes, and capturing the advantages of their collective diversity. This arrangement is usually highly advantageous, and is typified by the successful PJM Interconnection of utilities in 4 states, including all but one of the utilities in this region. Another alternative is to purchase all or a portion of the required power from other utilities on a wholesale basis.

With respect to the generating capacity provided by a utility in this region, it may or may not be located on the Chesapeake Bay, or any of its tidal tributaries. It is quite feasible to locate a large plant inland, and this is done when other incentives are great enough. Through the medium of joint ventures and other arrangements, utilities sometimes invest in plants considerable distances outside of their service areas. Even without leaving the service areas, 2 of the region's utilities have the ability to site plants on the Atlantic Ocean, and one of them operates plants on the Delaware Bay.

A study of the electric generating industry of the Chesapeake Bay requires some knowledge of the electric generation to be expected on the Bay. It should be clear that a projection of energy demand in the region is not sufficient information. Before a forecast of Bay-sited generation can be made, a thorough understanding of the factors which influence utility decisions in these matters must be available. The function of the interconnections, and the economic incentives provided by them to the individual utilities must be studied. The relative cost of inland siting, remote siting, and ocean siting must be taken into account. The policies of the utilities with respect to reserve capacity must be known. These and other factors must be understood as they are today, and as they are likely to be tomorrow.

Ultimately, we expect to be able to make reliable forecasts of the demand for generating sites on the Bay, their number and the probable size of units to be erected on them. Furthermore, we hope to predict the utilization of these plants, including seasonal patterns of generation, and peak levels. Studies of this type form an important link in the overall model of the industry.

Public Policy and Power Plant Siting. One of the most widely publicized aspects of the electric generating industry is the problem of siting new facilities. The process of selecting and evaluating sites and of obtaining the necessary permits and licenses has been transformed almost overnight from a relatively invisible, routine function of utilities and regulatory agencies to a *cause celebre*. Decisions once scarcely questioned outside the offices of the affected utility are now reviewed in detail by numerous government agencies, by public interest groups, by enviornmental interests, and in the press. The public policies which have evolved to deal with such matters are not only under attack but, not surprisingly, are undergoing active change.

Public policy with respect to power plants and the environment is formulated in 2 areas. The first is related to existing facilities and is concerned with permissible modes of operation and waste discharge practices. In the present example, this type of policy takes the form of water quality standards regulating the conditions of waste heat discharge into the Chesapeake Bay, and of various other permits, regulations, and stipulations intended to prevent existing plants from causing undue damage to the environment.

The second area of public policy applies to the siting of new generating facilities. Depending on the type of plant contemplated, and the nature of the site, a variety of permits, approvals, and licenses are required by state, local and federal agencies prior to construction. These are intended to protect the public interest in areas such as air and water emissions, safety, land use, utility rates, etc. Even in cases where adequate laws exist to regulate discharges after construction, every effort is made by public agencies to verify that the contemplated facility is capable of complying with those laws.

Examples of specific agency interests are the Atomic Energy Commission's regulations of nuclear reactor construction and operation, the Corps of Engineer's control of structures and construction operations in navigable waterways, the state regulatory agencies' interest in the economic justification for the facility and in its ability to comply with environmental standards, as well as local governments' concern with land-use questions. The result, in many areas, is a lengthy, complex process of public review, in which the utility is repeatedly called upon to defend its siting decisions.

Many critics of this type of policy feel that it does not lead to a balanced, comprehensive review of decisions to build generating facilities at specific sites. The utilities argue, with some justification, that the lengthy, disorganized review process imposes substantial costs on them, and, in turn, on the consumer. On either count, there is reason to examine the existing public policy with respect to power plant siting. The examination should determine, first of all, whether public policy is effective in insuring the proper level of resource utilization, and whether the implementation of that policy creates unnecessary costs.

An excellent opportunity exists in this region for review of policy as it was in the immediate past. Within a period of 2 years (March 1967 to March 1969), applications were filed with the U.S. Atomic Energy Commission for permission to construct 3 nuclear-fueled generating stations in the Chesapeake Bay region. The Virginia Electric and Power Company (VEPCO) were the first to announce their plans, proposing the Surry project to be located on the James River about 25 miles northwest of Norfolk, Virginia. The Surry plant will initially consist of 2 units of 800 megawatts capacity each. The Baltimore Gas and Electric Company (BG&E) requested a construction permit for its Calvert Cliffs plant, located on the Chesapeake Bay in Calvert County, Maryland, and similar in size to the Surry plant. VEPCO followed with the announcement of the North Anna facility to be located on the North Anna River about 24 miles from Fredericksburg, Virginia. At 875 megawatts capacity per unit, this installation is also similar in size to Surry and Calvert Cliffs.

We are now conducting a detailed review of the public review of these 3 installations, covering the period from first announcements to Fall, 1971. The purpose of this review is to document the public policy with respect to power plant siting as it existed in Maryland and Virginia during that period; to expose such deficiencies in the policy as may be evident; and to obtain insights into why the policy and regulatory process is as it is. Although this is obviously a complex subject, and our review is not complete, I can report a few general observations.

One interesting comparison pertains to the level of public interest and controversy surrounding the various approval processes. VEPCO escaped almost completely on both the Surry and North Anna sites, the public outcry that has accompanied many nuclear power plant proposals. BG & E, on the other hand, encountered virtually every type of objection, every class of intervenor, every form of legal and procedural challenge conceivable under existing regulatory practice. The Calvert Cliffs plant became a household word even before it was the subject of a landmark decision by Judge Skelly Wright of the D. C. Court of Appeals; a decision which precipitated a major revision of the AEC's procedures for handling such matters.

While it might be interesting to discover the reasons for the apparent contrast between the experience of BG & E and VEPCO, it is more to the point to inquire whether or not the difficulties of BG & E served some constructive purpose. In all 3 cases, the public review process resulted in minor changes in the original plans of the utilities. If the plant designs, as they now exist, show any marked differences in terms of potential environmental impact, it is not evident. In no case was public pressure successful in producing significant departures from the originally announced design concepts. A major result of the Calvert Cliffs experience, however, pertained not to the plant design but to the public review process itself.

It is fair to say that the review and regulatory processes encountered by these 2 utilities proved satisfactory to neither the utilities, the public agencies, nor the opponents of the proposed facilities. The histories of all 3 cases abound in confusion and frustrations for all concerned. In both states there were instances of public agencies incorrectly defining their jurisdictions, only to be subsequently reversed by court action. Each such event was time consuming, expensive, and embarrassing. In Maryland, these uncertainties and inadequacies achieved a high level of visibility, due to the prominence of the Calvert Cliffs controversy in the press.

As a direct consequence of these events, the State of Maryland initiated a thorough review of its policies with respect to power plant siting. Early in 1971, legislation was enacted in the General Assembly of Maryland, creating a state power plant siting program, including the following features:

- "One-stop" site evaluation and review procedure, coordinating all regulatory and review functions of state agencies through a single agency;
- A state-operated advance site selection and acquisition program; and
- A supporting environmental research and monitoring program.

These activities are funded through a surcharge on electric generation within the state, initially set at 0.1 mill/KWH.

While we have yet to observe Maryland's new program in action, it does represent one of the most comprehensive and innovative approaches to this problem adopted by any state. To the extent that this program resulted form the Calvert Cliffs siting process, the difficulties experienced by all concerned may be said to have had a constructive result.

Conclusion

These individual studies have been described in an attempt to convey some flavor of the range of investigations which fall under the heading "socio-economic research." While they do not yet form an integrated exploration of the subject matter, it should be obvious that as additional studies are launched, and existing ones broadened, a broad and useful knowledge of the electric generating industry in the Chesapeake Bay region will emerge.

The major point which I would like to make today is that studies of this type represent neither a luxury, nor the eccentricity of certain social scientists. They are an absolute necessity if the knowledge gained by physical and biological scientists is to be converted to effective action.

We have all been impressed by the complexity and subtlety of natural systems, and by the range of physical, chemical and biological effects which man is capable of making on a system such as the Chesapeake Bay. It is too easy to forget that the social and economic apparatus which man has erected around himself is no less intricate and fragile.

If we are to protect the usefulness of our natural resources, it appears certain that we will have to intervene in the normal functioning of our society to accomplish this. We can propose various laws, regulations, taxes, etc., but unless we understand how they will affect the man-made system, we cannot pretend to understand the resultant impact of the man-made system on the natural system.

Chesapeake Research Consortium, Inc.

Robert H. Roy[1]

Dean, Engineering Science, The Johns Hopkins University, Baltimore, Md. 21218

ABSTRACT

This paper describes a planning study for research on the Chesapeake Bay, to be carried on by a newly formed organization, Chesapeake Research Consortium, Inc., whose member institutions are Johns Hopkins, University of Maryland, Smithsonian Institution, and Virginia Institute of Marine Science. Prediction also is made that environmental management increasingly will encounter problems of regulating human behavior, in addition to reliance upon technology and economic rewards and sanctions.

As the morning has passed, I have become increasingly aware that my speech has been made for me, partly by Dr. Williamson and partly by Dr. Boland. I will be very brief not only because of this but also because Dr. Pelczar feels that the meeting will be more rewarding if there is opportunity for dialogue. I will try to allow time for that exchange to take place.

What I had planned to say and what Dr. Williamson has already said bears considerable resemblance because he and I have been part of a group that has engaged in preparation of a research proposal which will be filed with the National Science Foundation in the name of the Chesapeake Research Consortium, Inc. The charter and bylaws of this proposed organization have been agreed to by counsel of the 4 institutions that are to be represented–Johns Hopkins, University of Maryland, Smithsonian Institution, and the Virginia Institute of Marine Science–and will be considered and hopefully approved during the month of January by the respective regents, directors and trustees. The signed and notarized charter is ready for submission to the State of Maryland now. (Note: The Corporation was chartered on January 28, 1972.)

This represents a kind of culmination of work which began in the Spring of 1970, when a group from these institutions began to conduct a planning study for the Chesapeake Bay, and one of the recommendations of the *Report* submitted in March 1971 was that a consortium be formed. You have already heard from Dr. Williamson about 2 facets of that program–first, that it will be problem-oriented; second, that it will be a more directed and better integrated research effort than has characterized the research carried on independently by these institutions. I will not dwell upon the problems to be studied because Dr. Williamson already has done so, but I would like to say a little bit about the framework for the research that we intend to carry on. Fig. 1 shows the region of the Bay as a system in which are depicted two boxes, "Natural Systems" and "Man Systems," arbitrarily labeled but reasonably self-explanatory. Between each of these and the larger box for the region are light lines and arrows, each bearing a symbol and subscript to indicate the nature of the baseline interactions between and within each of the several parts of the system.

For each of the boxes and for each kind of interconnecting arrow there are also bold

[1]Robert H. Roy is Professor and Chairman of Operations Research and Industrial Engineering, and Dean of Engineering Science at the Johns Hopkins University. During the past two years he has served as Chairman of a Steering Committee whose members have conducted a planning study for research on the Chesapeake Bay. The most significant outcome of these deliberations has been the formation of Chesapeake Research Consortium, a corporation whose institutional members are the University of Maryland, Virginia Institute of Marine Science, Smithsonian Institution, and Johns Hopkins University.

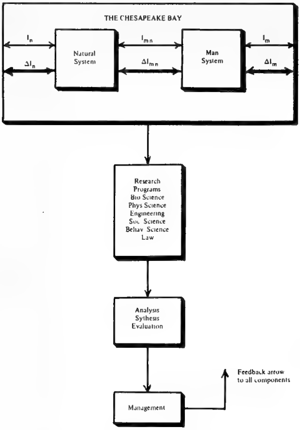


Fig 1. Framework for the research program. Light lines indicate existing "baseline" conditions and interactions at present time t. Bold lines indicate past or future conditions and interactions at past time $t-\Delta t$ or future time $t+\Delta t$, $t+2\Delta t$, etc.

lines. These are intended to delineate interactions at past and, more importantly, future periods of time: $t-\Delta t, t+\Delta t, t+2\Delta t$, etc. Among the several class of interactions, those symbolized by ΔIm are most important to those charged with environmental management, for these depict the changes, or threatened changes which arise, or threaten to arise, from the multitudinous activities of human organizations.

Preservation of environmental quality requires that decisions be made about these man-related stresses and impacts, to grant or deny permission or to modify or ameliorate the stress to be imposed. Despite the frequency and urgency and importance of these decisions, it is unfortunately true that presently more depends upon wisdom and sagacity than upon knowledge. Now and in the foreseeable future political processes rather than science will lead to the decisions which must be made.

Because of this important fact, the box in the diagram for research (Fig. 1) contains a series of classifications by way of indicating that basic knowledge must be acquired in a number of disciplines if tomorrows' decisions are to have the assistance which science can provide. We hope to engage in this research, to synthesize and evaluate it, and to make it available to any and all who need this kind of information.

Finally, the feedback arrow, which remains unconnected, is intended to indicate that management needs will influence all parts of the research program as well as the region of the Bay itself.

Important parts of research strategy include plans for inventorying the entities which lie within the region and, over time, the interactions between them. Dr. John Cumberland, Professor of Economics at the University of Maryland, is working toward development of a predictive environmental input-output model derived from the economic method of Leontief, a task of great difficulty but of comparable promise. To provide information of the kinds which will be needed for this effort we have some hopes for student, citizen, and voluntary participation in extending the inventory of entrepreneurial entities. Our ideas about this approach are presently structured but as yet untested.

For extension of the inventory of biological entities, we have been fortunate enough to receive a grant through National Science Foundation by inter-agency exchange from the Corps of Engineers for inventorying the biota of the Bay. The lead institution in this work is the University of Maryland and the lead investigator is Dr. Andrew McErlean. Investigators from the Smithsonian Institution and the Virginia Institute of Marine Science also are participating.

I would like to reinforce and amplify what Dr. Boland has said about the relationship of this research and management. We do not ourselves wish to become—and indeed will make strong efforts not to become—managers, but we have every wish and every intention of becoming useful to management agencies. Within the Consortium, investigators at Virginia Institute, at the Chesapeake Biological Laboratory, at the Chesapeake Bay Institute at Johns Hopkins, and at the

Smithsonian have had many connections with Maryland, Virginia, and Federal regulatory agencies, and we hope that these may be enhanced and strengthened. The Consortium itself does not intend to become a major research laboratory facility in the manner of Woods Hole, because at VIMS, at CBI, at CBL, at CBCES, and the prospective Horn Point Laboratory of the University of Maryland, there are and will be extensive laboratory facilities.

As the regulatory agencies confront needs for decisions, it is my opinion that they will confront increasingly difficult decisions. Here I venture into the domain of social philosophy for which I am not well qualified. But I think it can be shown that historical technological progression has been characterized by two things: (1) capital investment requirements have increased at exponential rates; and (2) technological life expectancies have diminished, also exponentially. It would be quite fanciful to say that we have as yet reached threshholds of infinite first cost and infinitesimal life expectancy but, if you are willing to let your fancy roam, the thermonuclear warhead is not too far from these ultimate threshholds.

In any event, society beyond doubt has become increasingly interdependent, and the kind of interdependence that has been so eloquently demonstrated by Dr. Boland is, I think, going to require increasing regulation. In the American ethic certain things have been deeply ingrained. The independence of the frontiersman is still a part of the American ethic, despite the fact that this kind of independence has given way to the interdependencies of our larger, much more specialized population. Additionally, we revere continued growth and accept the technological and economic regulation of that growth. My surmise is that we are going to have to look ahead to regulation of conduct in ways which hitherto has not been a part of our ethic. The ethic of growth will give way to a quest for stability. In addition to considering how we can best increase available electric power, it will be necessary to consider how we may utilize less of it. Thus, regulation will encounter—collide with—the vagaries of behavior. Reference to such regulatory efforts as prohibition, to current efforts toward civil rights, and to our inability to control crime suggests that we are much less successful in this behavioral domain. It will be acceptable if someone discovers a fuel that produces less harmful emissions, but it will be much less acceptable when government decrees reduced car mileage. I am therefore very much inclined to agree with Dr. Boland that research effort must be directed toward the total environment, not just the Bay. We must discover how to govern ourselves. This will be the most difficult, the most protracted, and certainly the most controversial of all the research that will be necessary.

The Fate of the Chesapeake Bay: Current Status Questions and Answers

Moderator: **Dr. Michael Pelczar**, *University of Maryland*

Panelists: **Dr. J.R. Schubel**, *The Johns Hopkins University*
Dr. Francis S.L. Williamson, *Smithsonian Institution*
Mr. John J. Boland, *The Johns Hopkins University*
Dr. Robert H. Roy, *The Johns Hopkins University*

Q–The Maryland Department of Planning predicts that Maryland industry will grow only 0.4% per year in the next decade. Why does the power industry expect a doubling of power needs? Isn't the power industry using Madison Avenue techniques on the public?

MR. BOLAND–It's factually correct that the demand for electric energy is growing at a rate substantially faster than the economy. One way of looking at this is to look at the use of electric energy in industry. The productivity of electric energy in industry over the past 20 years is the value added to final products per kilowatt hour. It has been falling steadily for the past 20 years. I think it was about half the level in 1966 as it was in 1946. At the same time, however, the productivity of labor–the value added per manhour–has been rising at about the same rate. We're learning to substitute electrical energy for other things, in this case for manpower. This is what we call progress. The thrust of most of technological change and development effort is do exactly this–substitute energy for people, and improving the productivity of our own labor. This is how we improve our standard of living. Now, perhaps we could stop doing that and lead a different life within our technological society, or devise some other kind of society, but I don't hear a great public outcry for doing it. The power industry has been accused of using Madison Avenue techniques on the public–they are often criticized for the promotion of electric heat. Electric heat, as you may know, is grossly inefficient from an energy utilization or cost point of view. Dean Abrahamson has suggested the only less efficient way to heat a home would be to burn it down. But at the same time most of the utilities in this area experience their peak load in summer. To promote the use of electric heat adds load in the winter when plants are partially idle, permitting an increase in operating efficiency. There are great advantages to industry in doing that, and the advantage to you is the lower unit-cost of power. The effect on the environment of the generation of power for electric heat is probably very minimal. Industry might be critized for promoting electric heat, but it isn't quite as serious as it looks on first examination.

Q–Your final and strongest point incriminated the military as the major single source of ecological impact on the Bay. Other than restricting areas to boat traffic because of bombing targets, etc., what does the military do to the portion of the Bay (17%) which it has restricted?

DR. SCHUBEL–That was not the point I wanted to make. I did not mean to imply that the military activity has done anything to damage the ecology of the Bay or the waters of the Bay, although I'm sure there have been fish killed by bombing and shells. Let me say that, in terms of any sort of persistent damage to the ecology of the waters of the Bay from military activities, I don't think it has amounted to anything significant. The point I wanted to make is that people seem to like to measure man's impingement on the estuary by looking at areas where his activities have been either restricted or prohibited. We see figures that 30,000 acres of oyster bars are closed because of pollution; man's harvesting activities there have been prohibited. Because of military activities the use of about 1/5 of the Bay is restricted or prohibited in some way. If I am part of the ecology, then my relationship to the Bay has been affected in a greater percentage of it by military activities than by any other single factor.

Q–When do you think thermal pollution would become a problem in the Bay?

DR. SCHUBEL–We don't have the data to answer that question, and the kinds of studies that are now being done will not provide the information that is necessary to answer it.

Q–What are the options for siting locations for the generating plants? As an example, what about the ocean as a potential site?

MR. BOLAND–The ocean is an option of course. In fact, 2 of the utilities in this area serve communities on the ocean front, have the ready option of siting plants there. The difficulty is that the greatest concentration of electric demand and population is on the Western shore of the Chesapeake Bay, and there are some major costs involved in getting power from the ocean across or around the Bay to the Western shore. Before the utilities can be expected to move all their plants to the ocean there will have to be some major costs associated with locating the plants on the Chesapeake Bay to provide the incentive–it will no doubt happen if thermal pollution turns out to be a problem in the Bay.

Q–Would you care to comment on the history of sedimentation in the Chesapeake Bay with a view to the possible forecast of its effect?

DR. WILLIAMSON–The most definitive data that we have shows that natural erosion from the Applachian plateau across the Piedmont into the Bay in undisturbed conditions (that is, presettlement forest) was something on the order of 100 tons of sediment/mi^2/year. I think this is the basis for Dr. Schubel's earlier remarks that the Bay is, by natural processes, receiving large amounts of sediment and has a predicted lifespan now of some 50,000 years. The increase in sedimentation as a result of human activities has of course been very great. The cause for most of it can be attributed to subdivision development, highway building, and early agricultural clearing of land. More recently, human population and activities have increased, and most of the political subdivisions have failed to enact proper grading and erosion control ordnances, or if they have been enacted, they are not properly enforced. At the level of Washington, D.C., in the Potomac system, there are currently some 1 million tons of sediment (180 tons/mi^2/yr.) reaching the estuary per year, and about 30% of this is from the metropolitan area. This is the order of magnitude of change that we are talking about. Prompting my statement is the fact that in both Virginia and Maryland there were enacted ordnances to control grading, erosion and sedimentation of stream's in the early 1700's. If I remember correctly, the first Maryland ordnance was passed in 1735. It has a rather interesting wording that I can't repeat at this time from memory, but it said something about the undue silting up of our streams. I guess that ordnance is still in effect. The effects of sedimentation have been very great, of course. I think Dr. Cronin could bear me out on it. One of the major reasons we have lost some 40-50 thousand acres of shellfish beds in the upper Bay is due to sedimentation. We can look forward to further changes of this magnitude in the future. A final comment. In our little estuary, the Rhode River, we are doing an up-to-date bathymmetry, and we have a little bit of history. In the last 100 years at one point in the estuary, water that was previously only about 7 ft. deep is now only 3 ft. due to sedimentation. This is a change in only one small system.

Q–How or when will education of the general public be initiated so that it will accept the regulations coming into the picture?

DR. ROY–I can't give a simple answer like Dr. Williamson–I don't know. I have engaged in some dialogue with Secretary Coulter both orally and in writing on the general hypothesis that some of the necessary regulation for environmental preservation will tend to be counter-cultural. He rebuts that, and I think properly so, by saying that culture is not a static but a dynamic quality. He thinks that our cultural values will change sufficiently rapidly to make this possible. I suspect he is right, and I think there are some signs one can perceive. As you walk out on the campus of the University of Maryland or on the campus where I work, and draw a mind's eye contrast between the students that you see—the way they look and behave—with those who were in universities and colleges when we were younger, you might be able to conclude that today's youth have much more kinship with Thoreau than with Horatio Alger and are much less interested in the progression of gross national product than we have been throughout our lives. I can't profess to know or to say whether this has anything to do with education or how these social changes came about. It may be combinations of perceived threats; it may be subtle changes in the social climate that I am unable to identify. I might be able to give a little more direct answer to this question, however, by concentrating upon the field of engineering education, about which I do know a little more. Up to World War II, engineering education was intensely pragmatic and technological and to a very considerable extend dedicated to the teaching of the art of engineering. As a consequence of World War II and the formidable problems that were attacked and resolved, not by engineers but by those trained in the physical sciences, engineering awakened to the realization that if it was to become and remain a viable profession, it had to embrace the physical sciences. Engineering programs changed radically to include two things—additional physical science and graduate study. In engineering education today there is recognition of the need to add a third dimension—the social sciences. Engineers can no longer promulgate public works of the kinds to which they have become accustomed in the past without becoming aware of the social consequences. I am inclined to think, therefore, that professional education, not just in engineering but in medicine and public health and other fields as well, will have to take on additional social dimensions if it is to meet the kinds of needs that are inferred by the question. That's not a very succinct answer but it is the best I can contrive.

Q—Has the possibility been considered that stabilizing or reducing fluctuating natural temperature cycles by thermal loading of power plants could be the danger point for thermal alterations?

DR. SCHUBEL—The temperatures that we are talking about are excess temperatures—temperature elevations superimposed upon the natural fluctuations. The fluctuations will still be present unless the generation of electricity is seasonally controlled so that more electricity is generated in the winter than in the summer. Since I have the microphone I want to make a couple of comments about sedimentation. Man's initial impact on Chesapeake Bay was to increase the sedimentation rate by probably at least an order of magnitude because of his agricultural activities, which started early in the 17th century. This impact was particularly acute because man was growing tobacco on land that was once forested. Since there was an abundance of land, he would raise 2 or 3 tobacco crops and then just move onto different land after the nutrients had been depleted, leaving the barren land behind. So we had very early sedimentation problems. Later in the 1800's, sedimentation rates went down because of better agricultural practices and because less land was being cultivated. When we started to build dams on the Susquehanna River, the major effect was to decrease the amount of sediment being brought into the main body of the Bay. Thus sedimentation was increased and then decreased. The net effect, I'm sure, has been to increase the sedimentation rate over what it would have been had man not been in the area at all. The clearing of land for construction is certainly a serious problem. Most of this is relatively local, but whereas agricultural losses may represent 3 or 4 hundred tons/mi^2/year, clearing an equal area to build shopping centers could increase losses to several thousand tons/mi^2/year.

Q–[Regarding erosion of Poplar Island.]

DR. WILLIAMSON–I have a special interest in this particular locality because it is part of the property in my charge, at least for the present. Many of you who boat on the Bay are familiar with Poplar Island. Actually, it is a cluster of islands. What previously was Poplar Island comprises 4 small islets with a total of about 50 acres. There are 2 adjacent islands, Jefferson and Coaches; Coaches Island on the south side was formerly a part of Poplar Island as recently as less than 50 years ago. The original acreage of Poplar Island, first surveyed in 1634, exceeded 1,000. As late as 1915, if I remember correctly, people lived and farmed on the island; I think the Post Office and school were finally closed about 15 years later. It's interesting because it's an example of the very rapid rate of shoreline erosion on the eastern shore of the Chesapeake Bay in Talbot and Dorchester counties. We are interested in it because we have an idea for shoreline stabilization that could have broader applicability to other areas along the eastern shore and that perhaps could pay for itself. Specifically, we would build a revetment which we would backfill with debris from construction and demolition, cover the fill with soil, thus extend the acreage of the island and stabilize it. Fill material would be barged in from the large metropolitan centers on the west side of the Bay. We think the plan is feasible, and we are in the process now of completing our own evaluation. We might be able to demonstrate that shoreline can be stabilized on that side of the Bay while utilizing the debris from adjacent urban centers at the same time. But in the meantime, we are losing 2-3 ft. of shoreline a year.

Q–Is it enough to show that natural variations in the Bay exceed expected manmade variations when even natural events create unacceptable conditions? Should we consider man's effect in terms of added potential for the creation of unacceptable conditions?

DR. SCHUBEL–I'm showing natural variations to get some idea of whether these things would be harmful. For example, if the temperature is increased by x degrees, would you expect a current to result? Then you can examine a place where the temperature is x degrees higher, and so on. This is why I say long-term studies will be required to establish any data base. We certainly must consider man's effect in terms of added potential for the creation of unacceptable conditions.

MODERATOR–I might ask Dr. Williamson if he would comment in response to this question in terms of nutrients that might be added to increase productivity rather than as pollutants?

DR. WILLIAMSON–The best predictions indicate that, by embarking upon a very serious program of aquaculture, we could vastly increase the productivity of the Bay. Of course one of the key nutrients is phosphorous, which is also one of the principal nutrients in domestic waste. Now, I almost have to hear you rephrase the question to go on.

MODERATOR–By way both of temperature variation and/or chemical variations, in many instances the first response is to view adding nutrients as being an undesirable event. Is there a possibility that some of these nutrients might be used for desirable transformations?

DR. WILLIAMSON–I know very little about aquaculture and its use of nutrients, but I know that the normal flux of nutrients in the upper regions of any tidal tributary are very great simply due to the productivity of the wetlands adjacent to these waters. Production is such that dissolved oxygen swings are very great in the productive part of the year. I don't know that I can comment on the ways these nutrients can be made more productive. We are presently searching for ways to augment productivity on wetlands and in shallows by adding nutrients.

DR. SCHUBEL–You also have to keep in mind that you can't begin to talk about man's effects unless you know what the natural spacial and temporal variations of some of these properties are. I tried to point out how someone was very badly misled calculating the flux of heavy metals in the Chesapeake Bay from 1 sample. You have to know the natural variations in order to assess man's impact. But can we stop everything until all the answers are known? Either you do that, or you make the best estimates with the information you have.

Q—Do you anticipate a shoreline land-use policy for the Bay and a one-agency, one-stop application permit for any development on the Bay such as the San Francisco Conservation and Development Commission?

MR. BOLAND—Let me say first that I'm not advocating the one-agency, one-stop policy process particularly. I think the Maryland action to coordinate all of the State functions is a worthwhile move, but to carry that to its logical conclusion—walking into one agency and getting one permit for everything—is running the risk of submerging some of the decisions so that no one knows what is going on; the opportunity for any kind of public interest or intervention is reduced. Somewhere between that situation and the existing one there must be the right balance. I anticipate a better policy of shoreline land use. The only thing we have in Maryland now is the land-use zoning laws enacted by the various local subdivisions. One result is that we have a very serious problem in Maryland with public access to the Bay. At the maximum there are only 60 miles of some 3000 miles of Bay shoreline in Maryland that are actually available to the public. A proper land-use policy might have avoided that.

MODERATOR—Along that same line, Mr. Boland, there is a question: "Is not private exploitation of the Bay shoreline easily the most serious impact of man upon his ecology"?

MR. BOLAND—I don't think I'm qualified to say what is the most severe impact on the ecology on the Bay. A completely unplanned private exploitation of the Bay is a serious problem.

MODERATOR—Dr. Williamson, again along those same lines in connection with wetlands and wetlands legislation?

DR. WILLIAMSON—The question is "What is the quality of wetlands legislation in East coast States, and do all States have such legislation?" I can't really address myself to all the States. Of course Maryland has wetlands legislation now in House Bill 285, which was passed year before last. My impression is that it is a good bill and would do a very great deal to protect the wetlands in the state of Maryland if it is properly enforced. As far as I have been able to determine, Virginia does not yet have the same high quality of legislation with which to back up enforcements regarding wetlands, but such a bill is now pending in the Virginia legislature. It almost goes without saying that this is a very essential kind of legislation. The number of acres of wetlands around this Bay is very great. To give you some idea—the 400,000 acres of wetlands are the equivalent of about 28% of the total surface area of all the sub-tributary systems of the Bay (main stem to head of tide) and are those tributary systems I mentioned earlier as being the highly biologically productive parts of the system. Production on these lands can be as great as 3-10 tons of plant material/acre/year (average 5.1 tons). These plants multiply proteins during the decomposition and, through the detritus food chain, supply nutrients to the adjacent estuary. The wetlands in the past have been very rapidly filled or reclaimed for various uses. I will make one comment here that we've been batting around for the last couple of days about wetlands—we need to be able to assign a dollars-and-cents value to any given unit of a particular type of wetland, some being more productive and more valuable than others. If we can't do that, then we suffer on the witness stand when the other guy puts the dollar-and-cents value on a house or a road or some other sort of development which might really be a very poor swap for the particular piece of wetland. In other words, we need a sound basis for decision-making.

MODERATOR—Here is a $64 question. We will be accused of being responsible for your getting cold mashed potatoes for lunch, but I will read this question and ask each member of the panel to give a 60-second response. We will begin with Dr. Schubel. The question reads as follows, "What is the greatest technology need to adequately handle the Chesapeake Bay environment problem; i.e., to preserve the ecology?"

DR. SCHUBEL—First of all, I think most of the technology now exists to handle most of the problems that threaten the Bay. It is a question of identifying the real problems and being willing to spend the money to attack them.

DR. ROY—I am inclined to say that the greatest need—I don't know whether technological or intellectual—is the development of a successful dynamic system model capable of providing quantitative answers with reasonable accuracy and capable of taking into account the value differences which exist in our assessment of variables. Such a model would provide better and more definite means for making wise decisions concerning the environment. I don't think I will live to see that.

DR. WILLIAMSON—I agree with Dr. Roy. Further, I don't know if my answer concerns technological need, but I think it is the construct of adequately informed and highly benevolent dictator.

MR. BOLAND—Perhaps my response is related to that. A technological need is not the greatest need—it is the change in our social philosophy and our system of values to which Dr. Roy alluded earlier. We must place sufficiently high value on the Chesapeake Bay so that our lifestyle will reflect that value. At that point the survival of the Bay as we now know it will be assured. I don't think I will live to see that either.

The Major Threats to the Chesapeake Bay Opening Remarks

Ruth Patrick[1]

Limnology Department, Academy of Natural Sciences of Philadelphia, 19th and the Parkway, Philadelphia, Pennsylvania 19103

Thank you and good afternoon. I'm sure that all of us here are very thankful for the Chesapeake Bay and realize it is not only one of the largest but one of the most beautiful estuaries or bays in the world. Today, though locally you see many of the impacts of man's activities upon the Bay, these are more or less restricted to local areas and as a result much of the Bay retains its natural beauty. However, our challenge is to see to it that the Bay remains beautiful and in a condition many can enjoy. Today we can enjoy many kinds of sports such as sailing, fishing, and swimming in the Bay. It is important in the Bay's symposium that we consider some of the major threats to the Bay and initiate plans so they will never materialize.

The first speaker this afternoon is Col. William J. Love, who is general manager and chief engineer of Hampton Roads Sanitary District, Norfolk, Va. He is going to speak about threats to the hydrodynamics of the Bay or hydrodynamic changes.

[1]A short biographical sketch will be found elsewhere in this issue.—Ed.

Hydrodynamic Changes in the Chesapeake Bay

William J. Love[1]

General Manager and Chief Engineer, Hampton Roads Sanitation District, Box 1741, Norfolk, Va. 23501

ABSTRACT

Past and present physical changes in the configuration of Chesapeake Bay, and their impact upon the hydrodynamics of the Bay, are discussed. Included are natural and manmade influences which have altered the Bay, and a projection of what may be expected in the future. The need for technical knowledge on which political, economic, and environmental decisions can be reached is stressed. The tools available to assist the decision maker are discussed, and future advances in technology are considered.

This symposium is rightly entitled the "Fate of the Chesapeake Bay." This title neither prejudges nor presupposes an outcome, good or bad. It simply poses the question, and to a degree lays down the challenge. Because we are all interested in the future of this invaluable asset, it expresses our concern, and I suppose our hope, that the fate of the Bay within our lifetime and for many years to come will be "good." The

[1]Col. William J. Love retired from the U.S. Army Corps of Engineers on 1 July 1971. His last assignment was as District Engineer of the Baltimore District, where he supervised the Corps of Engineers' comprehensive water resource management study of the Chesapeake Bay.

"good" is a general characterization from which we assume that we will be able to not only continue to reap the many benefits now available from the use of the Bay and its tidal waters, but that we will also be able to enhance them and to make them available to our successors for many generations to come.

Our symposium is considering the many pressures which are exerted upon the Bay by forces of man and nature. We are interested in its past, as the happenings of history can give us greater wisdom to evaluate the present pressures upon the Bay and to provide an insight into its future management. Although it is interesting to read the recorded annals of the history of the Bay, beginning possibly with the diaries of John Smith and extending through more recent times, what we are really trying to do is to picture the time change chart of the Bay to use as a barometer in measuring the present health and future prognosis of the Bay. I hesitate to refer to the Bay as our patient, because that indicates a degree of illness or possibly a diseased condition which I personally do not believe to be the case. However, like a good patient visiting the doctor for a checkup, we are interested in examining local irritations, in looking at rashes causing specific discomfort, and are most interested in taking the temperature of the entire body. We are certainly interested if the entire body shows an elevated temperature indicating either temporary or long term malaise.

There is general agreement that the Bay is a sunken river caused by natural phenomena involving probably the simultaneous depression of the old Susquehanna river bed, possibly inter-related with some upheaval of the surrounding land. Certainly the Eastern Shore areas of Maryland and Virginia, as we see them today, exhibit little of the upheaval phenomena which is seen to a marked degree on the western shore, for instance, in the Scientist-Calvert Cliff areas. Being a river, though submerged, it has followed for possibly the last 10,000 years the characteristics of other rivers with which we are familiar. It has continued to receive natural loadings of upstream material which have both flowed in the depths and shoaled the shoulders. Although it is easy enough to say that the average depth of the Chesapeake Bay on a geometric basis is some 28 feet, it is more significant for our interests to note that there have been large shoal areas established with average depths on the order of 2, 5, and 6 feet. These areas have tremendous significance today when studying either Benthic populations or fin-fish habitats. Some shoal areas, due to the action of wind and water over the years, have partially surfaced and have added to the marsh land census of the Chesapeake Bay. Similarly, natural erosion of the shore line by wind and wave in turn have reduced prior highlands, especially on the Eastern Shore, to marsh land. The shoaling or rising of the shallows and the lowering of the highlands have for our purposes resulted in the same phenomena. These natural processes, contributed to for many years by the suspended and bedload carrying abilities of all the streams tributary to the Chesapeake, have established what is within a time scale of interest to us, an equilibrium which we now call the hydrodynamic environment of the Chesapeake. Continuation of these natural forces will of course on a long range time scale affect the future of the Bay. However, it is where these longterm or very slow acting processes of nature are overridden and supplemented by the works of man that we may find indications of trouble. Hydrodynamic changes brought on by silt loadings, aggravated by urban development, by sanitary waste disposals in a not necessarily sanitary fashion, by urban community development surrounding the Bay, and by haphazard, if not reckless dredging and filling operations for private, municipal or corporate interests, have provided a period of change in a handful of years that nature could not have duplicated in many centuries. I emphasize that in my opinion at this time, these hot spots of stress are local in nature, are far from uncontrollable, and may be satisfactorily brought into rational balance if intelligent decisions can be made in the future.

Over the years in an effort to utilize the water resources of the Bay, we have over emphasized some particular use, possibly at the degradation of the capabilities of the Bay to fill other uses. Some channel dredging and land filling must fall in this category. Much of the channel development has not been haphazard in nature and has been proven to be extremely compatible—in fact even beneficial—to the current health of the Bay. By establishing and maintaining a main channel in sections of the Bay where one did not exist, the Corp of Engineers principal ship channel developments have over the years provided a counter effect to the filling process which nature itself has been carrying out. A positive benefit also has been the many well planned and executed spoil disposal areas of many projects, both by the Corp's and by other municipal and private developers which today are prized as highly valuable wetland areas. This has occurred where the spoil materials, either by design or circumstances of nature, have been contained and in many cases added to by wind and tide action. In those cases where nature took over and provided the vegetative cover which led to a re-establishment, or a new establishment in many cases, food chains, nesting habitats, and hatchery areas now of great value were established. Havre de Grace Island and the unnamed island off the mouth of Skiffes Creek in the lower James River are excellent examples. I hope my meaning here is quite clear. Dredging *per se* is not bad; improperly planned and executed dredging is. To allow spoil material to haphazardly enter a waterway is just as serious an offense against the environment of the Bay as to allow sediments of urban development to enter haphazardly. The creation of artificial wetlands has been successfully accomplished in the past, possibly as an accidental corrollary of other projects, but nonetheless has been done. I see no reason why future efforts to maintain our waterways, be they for navigation or recreation, cannot in most cases have exactly the same beneficial effect to even a more marked degree. As an objective this is certainly desirable because it makes entirely viable, then, a very serious conflict in conjunctive uses of the Bay. Certainly as an asset the waterways which presently provide recreational boating to over 70,000 licensed recreation vessels in Maryland alone must be considered. It will not do to merely state as an objective the use of the Bay as some sort of gigantic fishery and bird haven at the expense of all other uses.

Although not necessarily directly related to hydrodynamic considerations, this rationale must hold true for certain other conjunctive uses of the Bay. Cooling water uses, for instance, which are frequently associated with hydrodynamic changes because of inlet and outlet works, must be considered as an asset of the Bay. The use of the Bay to receive properly treated effluents of the waste water treatment plants of the communities surrounding the Bay is a perfectly legitimate use. Further, without the return of properly treated waste waters to the Bay the entire system would actually suffer losses from the upstream use of waters which should be returned to the system.

The high rate of erosion of many of the areas surrounding the Bay, particularly those of the Eastern Shore of Maryland and Virginia, poses some very serious problems. It has been estimated that the approximate 2,000 miles of tidal shoreline in Maryland is being eroded at the rate of nearly 300 acres/yr. A guess for the entire Bay is on the order of 700 acres/yr. It may be that the forces of nature and the balances of our economy may give us little voice, at least at the present time, in the retardation or slowing of this erosion. However, to the property owners affected, or to the marsh lands which may well be eliminated as a result of these forces, this is a very serious problem indeed. Many of us who have worked with the problem are staggered by the costs involved in the present state-of-the-art techniques to eliminate or even to slow these processes of erosion. However, most of us who have worked in this area are even more frustrated by our imperfect engineering and scientific ability to make reasonable predictions of the effect upon erosion, or shore control as I prefer to call it, when engineering proposals are put forward. Various proposals, be they small or large, which have been made over the years have been reacted to by the regulatory or jurisdictional bodies having responsibility on a one-at-a-time and a seat-of-thepants type decision making process. We know, for instance, that if a 300-ft groin is suddenly interspersed with a number of 50- or 75-ft groins, there is going to be an impact. We can guess only imperfectly at the present at the nature of this impact. We know that the deepening and precise alignment of a channel, be it a shallow recreation type channel or a much more significant navigational channel, will have an impact. We can only guess at that impact based on developed empirical experience. Mathematical modeling thus far has not enabled us to make a more reasonable and accurate prediction. The hydraulic modeling which has been done in the past on various relatively small sections of the Bay has provided certain answers for those specific locations. We desperately need the proposed Corp hydraulic model of the entire Bay to enable us to develop similar insights for the management of the entire region. The time has long since passed when "guesstimates," be they municipal or by a regulatory agency, can be accepted. I am strongly convinced that the construction and operation of the Corp model as now proposed and planned at Matopeak on Kent Island in Maryland will not only give us the immediate answers to a number of problems but may well have a far greater benefit in the future. It can supply the answers to some of the basic relationships involved in the hydrodynamics of the Bay and give us a more accurate understanding of the co-efficients which must be applied to those relationships.

Thanks to the work of Pritchard and others, we now have a gross understanding of the major currents at work in the Bay. We know that there is a net flow of fresh water to the sea, concentrated in the upper stratum of the waters during the periods of high fresh-water inflows which is somewhat reversed during the winter months. We know something of the flushing characteristics of individual bays, inlets, and tributary tidal waters. Thanks to the work led by Cronyn and Hargis, we are beginning to get an understanding of the ecological relationships of the biota of the Bay. The missing link at the present time is a reasonable understanding of the impact of the many works and activities of man on the Bay. How much use may be made of Bay waters at what locations and for what purposes by man without straining or destroying present living relationships within the Bay? What are the alternatives to man? At what cost? The answers to these questions involve study in many disciplines. Without exception the geometry and the derived hydrodynamics of the Bay must be considered in every case. What is needed is a quantum jump in our technology—in our capability to derive a rational understanding and predictive capability for the impact of man and of nature for that matter—on the environment of the Chesapeake. What greater need can be stated for the rapid completion and early operation of the Corps hydraulic model!

I hope my thoughts and observations about what we can and must do to insure the future health of the Bay are clear. Management techniques must be found to enable decision makers at the Federal, State, local, and regional level to make rational decisions—to enable us to have beneficial use of the Bay in the future involving all of the conjunctive uses to which it is and should be put. Wetlands are an extremely valuable resource. This has now been officially recognized by Maryland and Virginia, and the efforts of the States to survey, catalog, and assign priorities of use should proceed. The construction of artificial wetlands in areas determined by model and analytical study to be suitable should be encouraged. Random changes in the geometry of the Bay, be they large or small, cannot be permitted. All proposed changes must be subject to analysis after adequate hydraulic model testing. Finally, and most importantly, we must insist as a citizenry that all decisions affecting our Bay by our decision makers be based on fact—not speculation—and be in the best interests of present and future generations.

Insecticides, Herbicides, and Polychlorinated Biphenyls in Estuaries

Gerald E. Walsh[1]

Environmental Protection Agency–National Environmental Research Center, Corvallis, Oregon; Gulf Breeze Laboratory, Sabine Island, Gulf Breeze, Florida 32561

ABSTRACT

Pesticides are present in estuaries throughout the world, and it is probable that they will remain there for an indefinite period of time. Production rate of chemical pesticides has increased by about 16% each year since 1964. About 390 chemicals are used in pest control, and some of them reach estuaries through runoff from land, discharge of municipal and industrial wastes, direct application to marshes, aerial drift, and accidental discharge. Residues of pesticides are found in water, sediment, and at all levels of estuarine trophic pyramids, but there is still uncertainty as to what these residues mean in terms of toxicity, reproduction, and other factors which relate to estuarine organisms in the field. Data from both laboratory and field studies suggest a few beneficial and many harmful effects of pesticides in estuaries. In this presentation, insecticides, herbicides, and polychlorinated biphenyl compounds are discussed in relation to survival, photosynthesis, behavior, metamorphosis, resistance, and chemical changes in tissues, in estuarine organisms.

Pesticides are ubiquitous in estuaries throughout the world (Dustman and Stickel, 1966; Butler, 1967; Moden, 1969) and pollution by these chemicals will probably continue in the foreseeable future. Production of chemical pesticides has increased approximately 16% per year since 1964 (Neumeyer *et al.*, 1969). Herbicides are the sales leaders among pesticides, increasing at the rate of 20% per year. In 1955, purchases of pesticides by farmers were valued at 184 million dollars. By 1968, value was slightly more than 1 billion dollars, and it is estimated that this will be greater than 2.3 billion dollars by 1975. The reasons for such growth in use of chemical pesticides are mainly economic. Crop losses due to pests in the United States in 1968 were estimated at approximately 11.2 billion dollars, with an additional 2 billion dollar loss during crop storage (Neumeyer *et al.*, 1969).

About 390 chemicals are used to control unwanted species, and some of the chemicals reach estuaries as the result of rainout from the atmosphere, runoff into rivers, and other means. Approximately 4,000 tons of pesticides are applied annually to land, including wetlands, in the United States. Types used include insecticides, herbicides, algacides, defoliants, molluscicides, fungicides, amebicides, rodenticides, miticides, virucides, fumigants, and soil sterilants. In addition to largescale application to agricultural land, approximately two million acres of estuarine marsh and tidelands are treated annually with insecticides to control noxious insects.

Pesticides and related compounds such as the industrial pollutants polychlorinated biphenyls (PCB's) concentrate in estuaries. They originate from several sources: (1) runoff from the land after agricultural application (Goodman, 1965; Weibel *et al.*, 1966; Haderlie, 1970; Frere, 1971), (2) discharge

---

[1]Dr. Walsh received his B.S. in Zoology from Loyola University, his M.S. in Biology from De Paul University, and his Ph.D. in Zoology with specialization in Marine Ecology from the University of Hawaii. He served on the staff of the Department of Biochemistry of the University of Illinois College of Medicine; was a post-doctoral fellow in the Systematics-Ecology Program, Marine Biological Laboratory, Woods Hole, Massachusetts; and was Assistant Professor in the Zoology Department, University of Hawaii. He presently is Project Coordinator, Environmental Protection Agency Laboratory, Gulf Breeze, Florida.

of industrial and municipal wastes (Butler, 1967), (3) direct application to estuaries (Coppage and Duke, in press), (4) aerial drift and rainout (Cohen and Pinkerton, 1966; Abbott *et al.*, 1966; Tarrant and Tatton, 1969; Foy and Bingham, 1969), and (5) accidental discharge and careless use (Duke *et al.*, 1970). Also, migrating animals probably transport pesticides along their migratory routes. High concentrations have been found in migrating porpoises (Butler, 1967), whales (Wolman and Wilson, 1970), fishes (Hansen and Wilson, 1970), and ducks (Heath and Prouty, 1967; Reichel and Addy, 1968).

Pesticides that are ordinarily insoluble in water are made soluble by humic acids, which reduce the surface tension of water (Wershaw *et al.*, 1969).

Transport of pesticides that are adsorbed on particulate matter suspended in river water is well known (Duke, 1969; Pfister *et al.*, 1969). Deposition of silt and ionic flocculation of dissolved materials from freshwater as it enters the estuary add to the concentrations of pesticides in sediments. Differential solubilities of pesticides and PCB in fresh and salt water probably result in precipitation and deposition in sediments in areas where the 2 types of water mix (Walsh, in press, a). Also, pesticides are present on detritus in estuaries (Odum *et al.*, 1969) and compounds such as 2,4-D may be sorbed to organic compounds in solution (Wershaw *et al.*, 1969). Pesticides in solution and sorbed on organic and inorganic particles in the water and substratum are available for introduction into food chains in estuaries. There is ample evidence of uptake of pesticides from solution and particles by animals and plants, so that pesticides in estuaries are partitioned between living and nonliving portions.

Chlorinated hydrocarbon insecticides are persistent and are concentrated within the bodies of marine organisms. Related compounds such as PCB's are also persistent and are accumulated by marine forms (Nimmo *et al.*, 1971a, b). Even though usage of herbicides is growing more rapidly than all other classes of pesticides, it is not generally known that the urea, triazine, and picloram herbicides are almost as persistent as chlorinated hydrocarbon insecticides (Kearney *et al.*, 1969). Except for unicellular algae (Ukeles, 1962; Walsh and Grow, 1971; Walsh, in press, b), little is known about effects of these herbicides in estuaries.

In the following review, effects of insecticides, herbicides, and PCB's on estuarine organisms are discussed. It is not an exhaustive summary nor a popular review. It is, rather, a review of the scientific literature from papers readily available to the author and may be of use to researchers and others interested in the field of pesticide pollution.

Insecticides

Algae

Most literature reports on pesticides in estuaries concern chlorinated hydrocarbons such as DDT, endrin, dieldrin, and aldrin. In freshwater, adsorption of these compounds to particles is related to composition of the particles. Thus, lindane was found in greatest concentration on inorganic particulate matter, endrin and aldrin with organic detritus and unicellular organisms, and DDT with all fractions (Pfister *et al.*, 1969).

Three species of unicellular algae and two species of ciliates were exposed to 1 ppm (part per million) of DDT and the organophosphate parathion for 7 days (Gregory *et al.*, 1969). The organisms concentrated DDT 99 to 964 times and parathion 50 to 116 times the concentration in the medium. Studies on the distribution of DDT between particulate and liquid phases of seawater have shown that approximately 90% of the chemical is associated with particles of algal size (Cox, 1971a). The same studies showed a saturation value for uptake by *Dunaliella salina* independent of the ambient concentration of DDT. Cox hypothesized that adsorption of DDT to cell surfaces of algae is a more likely explanation for uptake than phase-partitioning of the toxicant in lipid, as he had previously suggested (Cox, 1970b). Whatever the method of uptake, Cox (1970b) did show that *Syracosphaera carterae* (a coccolithophorid), *Amphidinium carteri* (a dinoflagellate), and *Thalassiosira fluviatilis* (a centric diatom) removed from 16 to 54% of radioactive DDT added to cultures.

Phytoplankton probably act as primary concentrators of pesticides in water. There is evidence that these toxicants reduce photosynthesis, but bioconcentration by algae may be more important ecologically because they transfer many materials to higher trophic levels.

Residues of DDT, DDD, and DDE in the wet weight of marine phytoplankton in Monterey Bay, California, increased from about 0.2 ppm to approximately 0.6 ppm in 1969, and the data suggest that the partition coefficient of DDT in phytoplankton diminishes as the density of phytoplankton increases (Cox, 1970a). The significance of DDT residues to phytoplankton is suggested by the fact that DDT reduced the rate of photosynthesis in 4 genera of marine algae (Wurster, 1968).

Genera of algae differ in their response to chlorinated hydrocarbon insecticides (Menzel *et al*., 1970). *Dunaliella tertiolecta* was insensitive to treatment with DDT, dieldrin, and endrin, whereas *Cyclotella nana* was slightly affected at concentrations of dieldrin and aldrin between 0.1 and 1.0 ppb (parts per billion). Ukeles (1962) tested effects of DDT and toxaphene on 5 species of unicellular marine algae and found that concentrations of DDT to 1.0 ppm did not affect growth of *Protococcus* sp., *Chlorella* sp., *Dunaliella euchlora, Phaeodactylum tricornutum,* and *Monochrysis lutheri*. Toxaphene, however, was toxic to all species at 0.15 ppm. More recently, Derby and Ruber (1971) reported that DDT inhibited oxygen evolution by *D. euchlora, P. tricornutum, Skeletonema costatum,* and *C. nana*. Concentrations of 10 ppb inhibited oxygen evolution by 30% in *D. euchlora* and 36% in *S. costatum*; 1 ppm reduced evolution of oxygen by *P. tricornutum* 35% and by *C. nana* 33%. The marine diatom *P. tricornutum* was more susceptible to DDT than was the freshwater species *Chlorella pyrenoidosa* (Hannan and Patouillet, 1971).

DDT was found to be concentrated in an oil slick in Biscayne Bay, Florida (Seba and Corcoran, 1969), and it is possible that such a film promotes absorption of the chemical by phytoplankton.

Uptake and metabolism of DDT were studied in seven species of marine phytoplankton by Bowes *et al*. (1971). Rates of cell division by *T. fluviatilus, C. nana, A. carteri, D. tertiolecta*, and *Porphyridium* sp. were unaffected by 80 ppm DDT. *Coccolithus huxleyi* and *S. costatum* exhibited lag phases at that concentration: thereafter, rates of cell division in treated and untreated cultures were the same. These authors also studied effects of DDT and DDE on photosynthetic and mitochondrial electron transport. They suggested that the site of action of the toxicants is in either the electron transport chain between photosystems I and II or the water-splitting mechanisms. One wonders, however, what relationship such high laboratory concentrations (e.g. 80 ppm) have to algae living in the estuary or ocean because such high concentrations are not found in nature, except for occasional accidental spills.

Organochlorine compounds are not the only insecticides which inhibit primary producers. Ukeles (1962) demonstrated toxicity of 15 other pesticidal compounds to 6 marine unicellular algae. The most toxic compound was Lignasan, an organomercurial bactericide-fungicide that affected all species at concentrations above 0.6 ppb. Organomercurial compounds are very toxic to marine algae; 1 ppb of the fungicides PMA (Phix), Panogen, and MEMMI caused significant reduction of photosynthesis and growth by the diatom *Nitzschia delicatissima* (Harriss *et al*., 1970). Baytex and Abate (organophosphates) and Baygon (a carbamate) were toxic to marine algae (Derby and Ruber, 1971). At 0.01 or 0.1 ppm, all caused reduction of oxygen evolution, and the order from least sensitive to most sensitive was *C. nana, P. tricornutum, S. costatum* and *D. euchlora*. Interestingly, Derby and Ruber reported *D. euchlora* to be the least resistant species, whereas Menzel *et al*. (1970) found it to be the most resistant to organochlorines.

Vascular Plants

Organochlorine insecticides have been detected in marine macrophytes also, though their effects are not understood. Croker and Wilson (1965) applied technical grade DDT to a tidal marsh ditch at the rate of 0.2 lb/acre, a recommended rate for mosquito control. Uptake of DDT by *Ruppia maritima* and *Cladophora* sp. was measured for 7 weeks after application. Residues in plants increased rapidly until the 4th week, when the average was 75 ppm, but fell rapidly thereafter, reaching 9.1 ppm 7 weeks after treatment. *Fucus serratus* from the Northumberland coast contained 2 ppb p,p'-DDT and 1 ppb HEOD (the major constituent of technical dieldrin) and *Laminaria digitata* contained 3 ppb p,p'-DDT and 0.1 ppb HEOD (Robinson *et al.*, 1967). Woodwell *et al.* (1967) reported that the shoots of *Spartina patens* contained 0.33 ppm and the root 2.80 ppm DDT. It is conceiveable that when the macrophytes died, the toxicants entered the detritus-based food web.

Invertebrates

Increasing concentrations of pesticides in ascending levels of food chains is well known. Examples of bioaccumulation in estuarine trophic pyramids were reported by Woodwell *et al.* (1967) and Robinson *et al.* (1967).

Effects of pesticides occur at all trophic levels. In laboratory populations of the ciliated protozoan *Tetrahymena pyriformis* strain W, growth rate and maximal population density attained were reduced significantly by 1.0 ppb mirex, a chlorinated hydrocarbon insecticide (N.R. Cooley, personal communication).

Chronic exposure to sublethal concentrations of pesticides can reduce productivity of estuarine fish and shellfish (Butler, 1969; Miller and Berg, 1969). The insecticides DDT, toxaphene, and parathion are toxic to oysters at concentrations of approximately 1 ppm in water (Butler, 1963). When exposed to only 1.0 ppb of each of these insecticides separately, no effects were noted in young oysters (Lowe *et al.*, 1971a). However, growth was slowed and pathological changes occurred when young oysters were reared in seawater which contained a mixture of 1.0 ppb each of DDT, toxaphene, and parathion. Lowe *et al.* did not speculate as to whether the effects were due to the greater total amount of insecticide, to synergism of the 3 pesticides, or to both. Engle *et al.* (1971) exposed quahogs, *Mercenaria mercenaria*, to sublethal concentrations of DDT and lindane for 30 weeks, and found that activity of the enzyme glucose-6-phosphate dehydrogenase was stimulated, while phosphofructokinase, fructose diphosphate, and pyruvate kinase were inhibited. They suggested that the chlorinated hydrocarbons interfere with gluconeogenesis.

DDT prevented metamorphosis of barnacle larve in oyster beds (Loosanoff, 1947), and also inhibited the setting of oyster larvae (Waugh *et al.*, 1952; Waugh and Ansell, 1956; Loosanoff, 1960). Lindane and Guthion are toxic to the eggs of oysters, *Crassostrea virginica*, and clams, *Venus (Mercenaria) mercenaria* (Davis, 1961).

Quahog clams, *M. mercenaria*, were subjected to graded concentrations of methoxychlor (an organochlorine insecticide) and malathion (an organophosphorous insecticide) by Eisler and Weinstein (1967). All clams survived exposure to 37 ppm malathion and 1.1 ppm methoxychlor for 96 hours, and there was no difference in appearance or behavior between exposed and unexposed animals. However, large differences between the groups were found in concentrations of Ca, Zn, Na, Mg, and Fe in the whole clam, mantle, gills, and muscles. The authors suggested that such changes in metal ion concentration could result in abnormal metabolism of clams.

Ernst (1969, 1971) exposed the polychaetes *Nereis diversicolor* and *Lanice conchilego* to DDT dissolved in seawater. After 5 days of daily treatment with 0.3 ppb, *N. diversicolor* contained 4.2 ppm of the chemical in or on its body. Three days after a single dose of 0.009 ppb, *L. conchilego* contained 2.1 ppb DDT. Metabolites of DDT were not found in either species, but this is a good example of bioaccumulation of a pesticide by lower organisms.

As insecticides were developed for the specific purpose of killing arthropods, it is not surprising that they affect estuarine forms such as zooplankton, shrimp, and crabs. According to Butler (1966a), marine crustaceans generally appear to be affected more by organophosphorous than by organochlorine compounds. However, there is extensive literature on effects of organochlorine insecticides on estuarine forms. Grosch (1967) showed that the proportion of resting eggs to non-resting eggs of the brine shrimp, *Artemia salina*, was increased by treatment with DDT, and concluded that decreased fecundity was due to maternal debility. Conversely, Bookout *et al.* (in press) found direct effects of mirex on larval development of the stone crab, *Menippe mercenaria*, and the mud crab, *Rhithropanopeus harrisii*. They reported that the duration of developmental stages, and the total time of development of *R. harrisii* were lengthened as concentration of the toxicant increased between 0.01 and 10.0 ppb. No such effect was found with *M. mercenaria*. Survival of larvae was reduced by treatment of both species, but *M. mercenaria* was more sensitive to mirex than was *R. harrisii*. *M. mercenaira* crab stages reared in a solution of 0.01 ppb mirex contained 0.13 ppm, whereas *R. harrisii* reared in the same medium contained no detectable residue. When reared in 0.1 ppb mirex, *M. mercenaria* contained 0.24 ppm and *R. harrisii* contained 0.13 ppm.

In a field study, DDT, endrin, and Baytex (Bayer 29493), formulated on granules, significantly reduced numbers of the salt-marsh copepod *Microcyclops bicolor* (Ruber, 1963). In laboratory studies, exposure to 0.008 ppm Baytex, 0.06 ppm endrin, or 0.25 ppm DDT caused total mortality of *M. bicolor*. For the ostracod, *Ostracoda vidua*, 24-hour LC-100 values were: endrin, 2.6 ppb; DDT, 1 ppm; Baytex, 2 ppm; and for the cladoceran, *Ceriodaphnia quadrangula*, they were: Baytex, 1.3 ppb; endrin, 0.026 ppm; DDT, 0.12 ppb.

Eisler (1969) reported acute toxicities of 7 organochlorine (heptachlor, aldrin, dieldrin, lindane, methoxychlor, endrin, p,p'-DDT) and five organophosphorous (Delnav, malathion, Phosdrin, DDVP, and methyl parathion) insecticides to sand shrimp (*Crangon septemspinosa*), grass shrimp (*Palaemonetes vulgarus*), and a hermit crab (*Pagurus longicarpus*). At 20C and 24 ppt (parts per thousand) salinity, the organochlorine compounds DDT (96-hr LC-50 range=0.6-6.0 ppb) and endrin (96-hr LC-50 range=1.7-12 ppb) were most toxic, and heptachlor (96-hr LC-5 range=8-440 ppb) was least toxic. Among the organophosphorous insecticides, methyl parathion was most toxic (96-hr LC-50 range=2-7 ppb) and Delnav or malathion the least toxic (96-hr LC-50 range=33-285 ppb). Eisler showed that slainity and temperature were important to toxicity. Shrimp were more resistant to Phosdrin and DDVP at salinities of 18 ppt and lower than at 24 ppt and higher. Conversely, when exposed to DDT, endrin, or heptachlor, they were most susceptible at 12 ppt salinity and most resistant at 36 ppt. Toxicity of both classes of insecticide was related directly to temperature, mortality being least at the lowest temperature (10C) and greatest at the highest temperature (30C). Eisler stated that the 96-hour LC-50 values for crustaceans fell within the range for various freshwater groups and, in contrast to Butler (1966a), concluded that the organochlorine insecticides are more toxic to marine fauna than most other agricultural, industrial, and domestic pollutants.

Using laboratory populations of the brine shrimp, *Artemia salina*, Grosch (1967) obtained total mortality of adults within 5 days of treatment at a DDT concentration of 1 ppb. This concentration was also toxic to larvae, which died within 3 weeks after exposure before reaching maturity.

The euphausiid shrimp, *Euphausia pacifica*, obtained DDT directly from water and by assimilation from food. Changes in the lipid content of the animal which accompany reproductive cycles and seasonal changes in feeding have impact on DDT residue, and DDT is transported directly in the lipid of food organisms to the lipid reservoir of the consumer (Cox, 1971c).

Penaeid shrimp are among the most sensitive crustaceans to organochlorine insecticides. Butler and Springer (1966) reported 48-hour LC-50 values for pink shrimp, *Penaeus duorarum*, and brown shrimp, *P. aztecus*, were 0.03 - 0.4 ppb when exposed to heptachlor, endrin, and lindane. The values were 1-6 ppb for DDT, chlordane, toxaphene, and dieldrin. Baytex, an organophosphorous insecticide used in mosquito control, was the most toxic compound (48-hr LC-50=0.03 ppb). Nimmo *et al.* (1970) reported DDT residues in various organs of *P. duorarum*, and the white shrimp, *P. setiferus*, exposed in the laboratory. Residues were always greatest in the hepatopancreas, least in the exoskeleton and tail muscle. When exposed to 0.05 ppb DDT for 56 days, the hepatopancreas of *P. duorarum* contained 0.7 ppm, the ventral nerve 0.4 ppm. In all shrimp, the ventral nerve contained relatively high concentrations of DDT. Possible effects on nerve tissue were shown by Narahashi and Haas (1968) who found that DDT forms charge transfer complexes with nerve components of lobsters. When exposed to a lethal concentration of 0.2 ppb, the hepatopancreas contained 40.4 ppm DDT. The authors concluded that concentrations of DDT in some estuaries may be high enough to kill shrimp (Nimmo *et al.*, 1970).

Burnett (1971) used the sand crab, *Emerita analoga*, as an indicator of pollution along the coast of California. After exposure for 24 hours to 7.8 ppt DDT dissolved in seawater, crabs contained an average of 1 ppb of the chemical. It appeared that the DDT was actively taken up because the major surfaces for passive absorption contained very little insecticides. In the field, crabs contained between 2.9 and 6,900 ppb DDT, with highest concentrations at the Los Angeles County sewer outfall. Much of this DDT appeared to have come from a pesticide manufacturing plant. Also *E. analoga* obtained DDT from particulate matter that had rested among bottom sediments until resuspended by rough winter seas.

Lowe (1965a) exposed juvenile blue crabs, *Callinectes sapidus*, to several concentrations of DDT in water. He found that 0.5 ppb was the approximate highest concentration tolerated and suggested that a sudden slight increase above this concentration could be disastrous to blue crabs. Below this concentration, however, growth and molting proceeded normally. Lowe (unpublished data) also exposed blue crabs to the chlorinated hydrocarbon insecticide mirex, in the laboratory. After exposure to 0.84 and 8.7 ppb mirex in water for 72 hours, separate populations contained 0.093 and 0.21 ppm mirex respectively as whole body residues. No mortality occurred. When fed fish flesh containing 5.0 ppm mirex, crabs accumulated 1.4 ppm as whole body residue. No deaths occurred in the feeding tests.

After treatment of a marsh ditch with DDT, Croker and Wilson (1965) detected up to 4.97 ppm of the chemical in the whole body of the fiddler crab, *Uca minax*. Another species, *Uca pugnax*, was fed detritus which contained 10 ppm DDT for 11 days by Odum *et al.* (1969). During that time, no crabs died, but 5 days after exposure, all had lost muscular coordination. Concentrations of DDT in the muscles of the large claw increased from 0.235 ppm before exposure to 0.885 ppm after 11 days. There was no change in concentration in untreated crabs. In the field, DDT residues appeared to be associated with particulates in the size range of 250 to 1,000 microns. Because crabs and other detritus-feeding animals consume particulate matter of that size range, the authors concluded that organic detritus particles constitute a reservoir from which pesticides enter food chains.

Vertebrates

It is well known that marine fishes contain insecticides and, in general, are less susceptible to poisoning than some other aquatic forms (Table 1). Organophosphorous compounds tend to be more acutely toxic than the organochlorines, and herbicides are less toxic than insecticides (Butler, 1971). Effects of organophosphates may last for only hours or days, however, whereas the organochlorines are more persistent and exert their effects following bioaccumulation and magnification in trophic pyramids.

Residue values of DDT and its metabolites ranged from 15 ppb in ocean perch (*Sebastodes alutus*) to 220 ppb in hake (*Merluccius productus*) from the northeastern Pacific Ocean (Stout, 1968). Duke and Wilson (1971) pointed out that in fish from that same area, highest concentrations of pesticides were found in prespawning go-

Table 1.–Acute toxicity (24 hours) of 240 pesticides to estuarine fauna (from Butler, 1971).

	No effect	Toxic to 20% of test population		
Pesticide (ppm)	1.0 %	0.1-1.0 %	0.01-0.1 %	0.001-0.01 %
Fish	46	16	28	10
Shrimp	33	14	33	20
Oysters	41	21	33	5

nads and liver. Duke and Wilson (1971) reported DDT, DDD, DDE, PCB, and dieldrin in livers, but did not find BHC, heptachlor, heptachlor epoxide, aldrin, toxaphene, chlordane, methoxychlor, or endrin.

The amount of pesticide in a field population may vary over the seasonal cycle in different species and Cox (1970c) showed that concentrations of DDT in *Triphoturus mexicanus* increased with size of the fish. Hansen and Wilson (1970) reported annual variation in the content of DDT and its metabolites in 5 species of fish from the estuary near Pensacola, Florida. Concentrations ranged from undectable in spot (*Leiostomus xanthurus*) and croaker (*Micropogon undulatus*) in June, to an average of 1.11 ppm (whole body, wet weight) in pinfish (*Lagodon rhomboides*) in July. For fish in general, DDT residues were highest in summer and fall. When spot and croaker were exposed to 0.1 ppb DDT in the laboratory, whole body concentrations ranged from 10,000 to 38,000 times that in the water. After 4 weeks in pesticide-free water, pinfish which had been exposed to 1.0 ppb DDT for 2 weeks lost 41% of the accumulated chemical. After 8 weeks in pesticide-free water, loss of DDT from pinfish and croaker exposed to 0.1 ppb for 5 weeks was 87 and 78%, respectively. Hansen and Wilson also pointed out that when exposed to 0.1 ppb DDT, pinfish stored 2.4 times as much DDT as did croakers, so differences in rates of storage must be considered when comparing pesticide contamination in different areas which contain different fish species. They stated that pesticide residues in benthic fishes which remain in 1 location are better indicators of pollution than residues in pelagic fishes.

Croker and Wilson (1965) applied technical grade DDT to a tidal ditch in a marsh. Within 1 week after application of 0.2 lb/acre, mortality of fishes was 90%. Young mullet (*Mugil cephalus*) died first, followed by several cyprinodont species, silversides (*Menidia beryllina*), spot, and gobies (*Gobinoellus boleosoma*). Several months after application of DDT, the fish population was as large or larger than before spraying and there seemed to be no permanent effects (Butler, 1966a). A similar response was observed by Harrington and Bidlingmayer (1958) after application of dieldrin at the rate of 1 lb/acre to a marsh.

Bearden (1967) treated a marsh with Dibrom, and organophosphorous insecticide, at rates as high as 72 ppb/acre foot of water without apparent effect on brown shrimp, white shrimp, blue crabs, killifish, or spot. He ascribed the lack of effect to adsorption

Table 2.–Acute toxicity of endrin to 5 species of marine fish (from Lowe, 1965).

Species	24-hr LC-50, ppb	Temp., °C	Salinity, ppt
Mullet (*Mugil cephalus*)	2.6	29	21
Menhadden (*Brevoortia patronus*)	0.80	27	29
Spot (*L. xanthurus*)	0.45	17	23
Sheepshead (*C. variegatus*)	0.32	28	29
Killifish (*Fundulus similis*)	0.23	25	19

of Dibrom to particulates in water, adherence of the spray to the stems and leaves of emergent vegetation, and tidal flushing.

Uptake of DDT by the flatfishes *Platyichthys flesus* and *Solea solea* was measured by Ernst (1970a, b). DDT administered orally in 1-2ug doses for 1-2 weeks was absorbed by the gastrointestinal tract and was detected in the brain, kidney, muscle and gastrointestinal tract. In *S. solea*, 10% of the total dose was degraded to DDD 9 days after treatment. Small amounts of DDE were found in both species.

O'Brien (1967) stated that fishes are generally more resistant to pesticides than shrimp and oysters but are the most sensitive of all vertebrates to organochlorine pesticides. Fishes do, however, vary in their responses to these toxicants.

DDT is thought to exert its toxic effects upon the nervous system by inhibition of adenosine triphosphatase (Matsumura and Patil, 1969). Janicki and Kinter (1971) showed that DDT impaired fluid absorption in the intestinal sacs of the eel, *Anguilla rostrata*, by inhibiting the Na^+- and K^+ -activated, Mg^+ -dependent adenosine triphosphatase system of the intentinal mucosa. They suggested that effects of organochlorine pollutants on marine teleosts may be related to disruption of osmoregulatory transport mechanisms.

Northern puffer fish, *Sphoeroides maculatus*, were exposed for 96 hours to methoxychlor (organochlorine) and methyl parathion (organophosphorous) singly and in combination by Eisler (1967). Those exposed to 30 ppb methoxychlor were unaffected, whereas those exposed to 20.2 ppm methyl parathion or to a mixture of 10.1 ppm methyl parathion and 15 ppb methoxychlor refused to eat, were sluggish, and mortality increased rapidly at 96 hours. Survivors had total inhibition of serum esterase and less hemoglobin and fewer erythrocytes, less magnesium in the liver, and less zinc in the liver and gill filaments than did untreated fish. In a similar study on effects of endrin on puffers, Eisler and Edmunds (1963) showed that concentrations of sodium, potassium, calcium, and cholesterol in blood serum were higher in exposed than in unexposed fish. Concentrations of sodium, potassium, calcium, magnesium, and zinc were higher in the livers of treated animals. Exposure to sublethal concentrations of endrin (0.05-1.0 ppb) caused impaired liver function.

Organophosphate insecticides inhibit activity of brain acetylcholinesterase in estuarine fishes. Enzyme activities of spot (*L. xanthurus*) and sheepshead minnows (*Cyprinodon variegatus*), from waters polluted with organophosphorous compounds were 73 to 88% of normal (Holland *et al.*, 1967). Coppage (1971) developed an accurate method for measurement of acetylcholinesterase activity in fish brain, and applied the method in a study of the effects of Guthion, phorate, and parathion on sheepshead minnows (Coppage, in press). He demonstrated that inhibition to less than 87% of normal activity is necessary to indicate exposure. Death occurred when enzyme activity fell below 17.7% of normal. Coppage concluded that brain acetylcholinesterase activity, when properly assayed, is a dependable indicator of exposure and impending death of fish. In a field study, Coppage and Duke (in press) demonstrated that brain acetylcholinesterase activities of spot, croaker, and mullet, *Mugil cephalus*, were depressed after application of malathion to a salt marsh in Louisiana.

Chronic exposure of spot to 0.1 ppm of the carbamate insecticide, Sevin, for 5 months had no effect upon growth, survival, histology, activity of cholinesterase, and salinity tolerance (Lowe, 1967). In earlier studies with Sevin, Butler (1963) reported 24-hour TLM values of 1.75 ppm for longnose killifish (*Fundulus similis*), and 4.25 ppm for the white mullet (*Mugil curema*). A detailed report on effects of Sevin on marine organisms is given by Milleman (1966).

Because of their effects on the nervous system, it would be expected that pesticides cause behavioral pathology in fishes. Warner *et al.* (1966) and Anderson and Peterson (1969) showed that pesticides affect conditioned responses of freshwater fishes. Anderson (1968) reported that 24-hour exposure to sublethal concentrations of DDT caused impairment of the neurophysiological function of the trunk lateral line nerve of the brook trout, *Salvelinus fontinalis*. It was shown that, after exposure of trout to 0.1, 0.2, or 0.3 ppm DDT, stimulation of the lateral line nerve caused a marked prolongation of the multifiber response. The prolongation was most pronounced at low temperatures, which correlates well Cope's (1965) evidence that DDT is more toxic to freshwater fish at lower than at higher temperatures. In contrast, Ogilvie and Anderson (1965) showed that the effect of DDT on temperature selection by young Atlantic salmon, *Salmo salar*, was greater for fish acclimated to warm water (17C) than to cold water (8C). Also, fish exposed to a low concentration of DDT (5 ppb) selected lower temperatures than did fish exposed to high concentrations (up to 50 ppb). Hansen (in press) exposed mosquitofish to 5, 10, and 20 ppb DDT at a salinity of 15 ppt then tested their salinity preference. These fish selected significantly higher salinities than did unexposed fish, and Hansen suggested that the pesticide changed the fish's preference capacity to discriminate between salinities. No effect on salinity preference was found with malathion. Hansen (1969) also found that sheepshead minnows avoided water which contained DDT (0.01 or 0.05 ppm), endrin (0.1 or 1.0 ppb), the organophosphorous insecticide Dursban (0.1, 0.25, or 10.0 ppm), and the herbicide 2,4-D (0.1, 1.0, or 10.0 ppm). When fish were given a choice of 2 concentrations of the pesticides, the highest concentration of 2,4-D was avoided, but the highest concentration of DDT was preferred. Fish did not discriminate between concentrations of endrin or Dursban and did not avoid Sevin or malathion.

In the work cited above, Hansen suggested that if the capacity to avoid a pesticide is controlled genetically, fish which survive pollution by this means would produce more offspring with the capacity to avoid the chemical. Thus, genetic ability to avoid pesticides would have survival value for the species.

Another mechanism for resistance has been suggested by Fabacher and Chambers (1971). They found that mosquitofish from a heavily insecticide-contaminated site in Mississippi were resistant to organochlorine pesticides. The total-body lipid content of resistant mosquitofish was 1.8 times greater than that of susceptible fish. Organochlorine pesticides tend to accumulate in the liver, and the livers of resistant fish contained 1.7 times more lipid than did non-resistant fish. Ludke (1970, cited by Fabacher and Chambers, 1971) found that the livers of resistant mosquitofish were approximately twice as large as those of susceptible fish. Increased size of the liver is due, at least in part, to high lipid content.

Resistance of estuarine fishes to pesticides was demonstrated by Vinson *et al*. (1963) and described in further detail by Boyd and Ferguson (1964a, b) and Ferguson and Boyd (1964). Ferguson *et al*. (1966) showed that mosquitofish from areas heavily contaminated with insecticides had a 36-hour TL_m value of 1,000 ppb. For mosquitofish from uncontaminated areas, the value was 1 ppb. A combination of 2 insecticides (e.g. endrin-DDT, endrin-toxaphene, endrin-methyl parathion, DDT-toxaphene, DDT-methyl parathion, and toxaphene-methyl parathion) produced higher mortality in resistant mosquitofish than did either insecticide alone (Ferguson and Bingham, 1966). However, the sum of mortalities caused by individual insecticides exceeded that for the same insecticides in combination, indicating that there were no additive effects.

The potential hazard of endrin-resistnat mosquitofish was demonstrated by Rosato and Ferguson (1968). They fed an endrin-exposed mosquitofish each day to fish, frogs, turtles, snakes, and birds. All, except red-eared turtles (*Pseudemys scripta elegans*) and the cottonmouth moccasin (*Ancistrodon piscivorus*), experienced 100% mortality after 2 weeks. Mortality of turtles was 72%, and cottonmouths 91%.

Sensitivity to organochlorine compounds may be passed from parent fish to offspring. Sheepshead minnows whose parents had been exposed to 20-40 ppb DDT were more sensitive to DDT and endrin than were offspring of fish which were not exposed (Holland *et al.*, 1966). Holland and Coppage (1970) later suggested that lipid metabolism and maturation of ova were greatest when the parent fish were exposed. Incorporation of DDT via lipids into the ova may have been the factor that caused increased sensitivity when the lipids were utilized by the larvae.

Extensive literature exists on effects of pesticides on estuarine birds (see especially the papers of Moore and Tatton, 1965; Risebrough *et al.*, 1967; Hickey and Anderson, 1968; Porter and Wiemeyer, 1969; Heath *et al.*, 1969; Anderson *et al.*, 1969; Lamont *et al.*, 1970; and Lamont and Reichel, 1970).

Little is known, however, about pesticides in marine mammals. DDT was found in seals from Antarctica (Sladen *et al.*, 1966) and in grey seals (*Halichoerus grypus*), common seals (*Phoca vitulina*), and harbor porpoises (*Phocoena phocoena*), in England (Holden and Marsden, 1967). Koeman and Genderen (1966) found 9.6 to 27.4 ppm of DDT and 0.07 to 2.3 ppm of dieldrin in harbor seals in the Netherlands. Anas and Wilson (1970a) examined livers and brains of 30 fur seals, *Callorhinus ursinus*, from the Pribilof Islands and the Washington State coast. All samples contained DDE, 21 contained DDD, 24 contained DDT, and 3 contained dieldrin. Concentrations in the liver were always higher than in the brain. DDE was present in livers from 3 of 7 fetuses and in brain tissue from two. DDD, DDT, and dieldrin were not found in fetal liver and brain. The same authors (1970b) examined muscle, brain, liver, blubber, and ingested milk from nursing fur seal pups. Pesticides were found in every sample of tissue and ingested milk. Of 20 pups, all contained DDD, 17 contained DDT, and 5 contained dieldrin. The highest concentration of any pesticide was 45 ppm of DDE in the blubber of one pup.

Pesticides have also been found in whales (Wolman and Wilson, 1970). Blubber of grey whales (*Eschirichtius robustus*) and sperm whales (*Physeter catodon*) from waters near San Francisco, California, contained up to 6.0 ppm DDT. Highest dieldrin concentration in grey whales was 0.075 ppm, and in sperm whales 0.019 ppm.

Herbicides

Very little is known about effects of herbicides in estuaries. Herbicides are currently being used in protected coastal marine areas (Thomas, 1968; Haven, 1969) and are used in bays for control of Eurasian watermilfoil, *Myriophyllum spicatum*, (Rawls, 1965). Use of herbicides in estuaries will probably increase due to expanding use of these natural resources for recreation and for industrial development.

A great amount of research has been done on herbicides in freshwater ecosystems (see reviews of Klingman, 1963; House *et al.*, 1967; Fryer and Evans, 1968; Mullison, 1970; and the book published by the National Academy of Sciences-National Research Council, 1966).

Ukeles (1962) was the first to report effects of herbicides on marine unicellular algae. She found that the substituted urea herbicides diuron, monuron, neburon, and fenuron were among the most toxic compounds tested against *Protococcus* sp., *Chlorella* sp., *Dunaliella euchlora, Phaeodactylum tricornutum*, and *Monochrysis lutheri*. Diuron, at a concentration of only 0.02 ppb, inhibited growth of all genera except *Chlorella*. Walsh (in press, b), in a study of effects of 30 herbicidal formulations, confirmed that low concentrations of urea herbicides inhibit both gorwth and photosynthesis by marine unicellular algae (*Chlorococcum* sp, *D. tertiolecta, I. galbana*, and *P. tricornutum*). He also showed that the triazine herbicides (e.g. ametryne, atrazine, simazine) are as toxic, or more so, than the ureas. In a study on effects of urea herbicides on marine algae in relation to salinity, Walsh and Grow (1971) found a decrease in the amount of carbohydrate in cells after treatment of 6 species that was related directly to salinity. *Chlorococcum*, the most susceptable alga, lost 65.6% of its total carbohydrate when treated with concentrations that inhibited growth by 50 to 75% at 30 ppt salinity.

Rawls (1965) tested Silvex and 3 formulations of 2,4-D on blue crabs, eastern oysters, softshell clams (*Mya arenaria*), and pumpkinseed sunfish (*Lepomis gibbosus*).

Only 2,4-D acetamide powder applied at 20 lb active ingredient/acre was toxic to these animals. An undesired side-effect however, was caused by death of Eurasian watermilfoil brought about by treatment in the field. Anaerobic conditions created by decomposition of dead plants caused severe losses of estuarine fauna. Thomas (1968) and Thomas and Duffy (1968) tested effects of the butoxyethanol ester of 2,4-D on eelgrass, *Zostera marina*. They suggested use of this formulation to eliminate weeds in oyster-growing areas for increase of shellfish production.

Softshell clams and oysters did not acquire residues of Diquat when exposed in the field (Haven, 1969). Kobayashi *et al.* (1970) demonstrated that the herbicide pentachlorophenate was detoxified by the shellfish *Tapes philippinarum*.

On the other hand, Butler (1965) found that 1 ppm of 2,4-D reduced uptake of radioactive carbon by 16% in a natural population of plankton composed mainly of dinoflagellates and diatoms. He (1963, 1964) also reported that continuous exposure of oysters to 3.75 ppm 2,4-D reduced oyster shell growth 50%. No effects of 1 ppm of a combination of 2,4-D and picloram were found on phytoplankton, oysters, shrimp, and fish (Butler, 1965).

An estimate of possible effects of herbicides on estuarine crustaceans may be obtained from the freshwater work of Sanders (1970). He tested 37 herbicidal formulations on 6 species of crustaceans: *Daphnia magna, Cypridopsis vidua, Gammarus fasciatus, Asellus brevicaudus, Palaemonetes kadiakensis,* and *Orconectes nais*. Dichlone, a naphthoquinone, was the most toxic chemical to all species (48-hr TL-50=0.025-3.2 ppm). The propylene glycol butyl ether ester of 2,4-D was almost as toxic (48-hr TL-50=0.10-2.7 ppm except for *O. nais*). The propylene glycol butyl ether ester of Silvex and technical formulations of trifluralin and molinate were toxic at concentrations of less than 1 ppm.

In a study of effects of 2,4-D on behavior of fish, Hansen (private communication) found that mosquitofish sought water free of 1.0 or 10.0 ppm of the butoxyethanol ester, but not free of 0.1 ppm.

Polychlorinated biphenyls

Polychlorinated biphenyls (PCB's) are aromatic organochlorine compounds that are similar in structure to chlorinated hydrocarbon insecticides such as DDT and methoxychlor. The sole manufacturer of these chemicals in the United States is the Monsanto Chemical Co., Saint Louis, which markets them under the trade name "Aroclor." The same compounds are also marketed in the United States as Chlorextol, Dykanol, Inerteen, Noflamol, Pyramol, and Therminol. They are also manufactured abroad under the trade names Phenochlor and Pyralene (France), Clophen (Germany), Fenclor (Italy), Kannechlor (Japan), and Soval (Russia). PCB's are made by substitution of chlorine atoms for 1 or more hydrogen atoms on the biphenyl structure. When biphenyl hydrocarbons are chlorinated, the result is a mixture of compounds. The degree of chlorination is used to identify the commercial product. For example, Monsanto markets 8 formulations of Aroclor, designated 1221, 1232, 1242, 1248, 1254, 1260, 1262, and 1268. The last 2 digits indicate the percentage by weight of chlorine.

PCB's have low vapor pressures, low water solubility, and high dielectric constants. They also are inert, stable at high temperatures, resistant to acids and bases, soluble in fat, and resistant to microbial breakdown. These properties make them very persistent in the natural environment.

Recently, Safe and Hutzinger (1971) reported that 2,4,6,2',4',6'-hexachlorobiphenyl was degraded to di-, tri-, tetra-, and pentachlorobiphenyls when irradiated for 100 min at λ_{max} 3100Å in hexane.

As early as 1944, Miller noted that there were hazards to humans associated with the use of PCB's. He showed that guinea pigs, rats, and rabbits, when exposed to PCB with an approximate chlorine content of 42% over a period of 6 days, developed liver and skin pathologies. Similar results were reported by Oettingen (1955). Recent studies have shown that chronic toxicity to animals is a significant factor in survival (Gustafson, 1970).

PCB's tend to be less toxic than DDT and dieldrin. Lichtenstein *et al.* (1969) compared toxicity of 11 polychlorinated bi- and triphenyls with dieldrin and DDT to houseflies (*Musca domestica*) and fruit flies (*Drosophila melanogaster*). Dieldrin was the most toxic compound, PCB's the least toxic. Toxicity of PCB's was related inversely to chlorine content. More important, however, is that sublethal dosages of PCB increased the toxicity of dieldrin and DDT.

Ubiquity of PCB's was brought to notice in 1966 (Anon.) when concern over the findings of Jensen was expressed. The anonymous author stated that increased amounts of PCB were entering the air from industrial and rubbish-dump smoke and were absorbed by water, from which they were taken up by fishes and humans. Since then, Holden (1970) reported crude sewage sludge as a source of PCB's in Scotland, and Schmidt *et al.* (1971) found PCB's in sewage outfalls in California. In Escambia Bay, Florida, Duke *et al.* (1970) found that a PCB originated from leakage of a heat-exchange fluid from an industrial plant.

PCB's are present in all components of estuarine ecosystems. Duke *et al* (1970) found Aroclor 1254 in water, sediment, and biota of Escambia Bay. Sediment contained up to 486 ppm. Flounder, croaker, menhaden, pinfish, speckled trout, shrimp, and blue crabs contained from 1.0 to 184 ppm. In the Netherlands, the presence of PCB's was reported in mussels, fish, and birds (Koeman *et al.*, 1969). In Sweden, Jensen *et al.* (1969) found residues in the fat of mussels, *Mytilus edulus*, (1.9-8.6 ppm), herring, *Clupea harengus*, (0.5-23.0 ppm), and seals, *H. grypus*, (16-56 ppm), and in the eggs of guillemot, *Uria aalge* (140-360 ppm), muscle of eagle, *Haliaeetus albicilla*, (8,400-17,000 ppm), and muscle of heron, *Ardea cinerea*, (9,400 ppm).

Dr. Nelson Cooley, of the Environmental Protection Agency Laboratory at Gulf Breeze, Florida, has found that *Tetrahymena pyriformis* W, a euryhaline ciliated protozoan, accumulated 167.9 ppb of Aroclor 1254 (dry weight) when exposed to 10.0 ppb for 7 days.

These data suggest strongly that biological concentration of PCB's occurs in food chains.

Invertebrates

Effects of Aroclor 1254 on oysers (*C. virginica*) during 96-hour exposures were reported by Duke *et al.* (1970). The rate of shell growth was reduced 19% by only 1.0 ppb and completely inhibited by 100 ppb. Oysters exposed to 1.0 ppb PCB contained 8.1 ppm and those exposed to 10.0 ppb contained 33.0 ppm of the toxicant in soft tissues. Aroclor 1254 killed *Gammarus oceanicus* at concentrations between 1 and 10 ppm (Wildish, 1970) and uptake occurred across the general integument (Wildish and Zitko, 1971). The mean rate of uptake by living animals exposed to 1.0 ppm PCB was 0.057 $mg/hr/mm^2$. Wildish suggested that crustaceans were most susceptible to PCB poisoning during molting, and additional evidence for this was given by Duke *et al.* (1970) and Nimmo *et al.* (1971a).

Acute toxicity of Aroclor 1254 to juvenile pink shrimp, *P. duorarum*, was reported by Duke *et al.* (1970) and Nimmo *et al.* (1971a). No mortality occurred among shrimp exposed to 1.0 or 10.0 ppb for 48 hours. When exposed to 100 ppb, mortality was 80% after 48 hours and 100% after 96 hours. After 48 hours, shrimp exposed to 1.0 ppb contained 0.14 ppm PCB (whole body residue), those exposed to 10.0 ppb contained 1.3 ppm, and those (dead and moribund) exposed to 100 ppb had 3.9 ppm. In chronic studies, Nimmo *et al.* (1971a) showed that Aroclor 1254 was more toxic to juvenile pink shrimp than to adults. For shrimp 2.5 to 3.8 cm long, 0.94 ppb killed 51% of the animals after 15 days. For shrimp 9.5 to 12.5 cm long exposed to 3.5 ppb, 50% mortality was not attained until 35 days. PCB was incorporated into the body organs through the water and through the food. Most of the toxicant was found in the hepatopancreas, least in the exoskeleton and abdominal muscle. When shrimp were placed in uncontaminated water, PCB was transferred from the hepatopancreas to other organs. Whole-body loss in uncontaminated water was about 60% in 5 weeks.

Crustaceans may also obtain PCB adsorbed on particles of sediment. Nimmo *et al.* (1971b) exposed pink shrimp and fiddler crabs, *Uca pugilator*, to various concentrations of Aroclor 1254 on silt. Uptake by the animals was related directly to amount in the sediment. The hepatopancreas of shrimp exposed to sediment containing 61.0 ppm PCB for 30 days had an average of 240 ppm. Hepatopancreas of fiddler crabs in the same experiment contained an average of 80 ppm.

Vertebrates

PCB does not seem to be acutely toxic to some estuarine fishes. It was present in the livers and fat of fishes from the northeastern Pacific Ocean (Duke and Wilson, 1971) but Duke *et al.* (1970) obtained no mortality of juvenile pinfish after exposure to 100 ppb Aroclor 1254 for 48 hours, although the fish did absorb the chemical. Those exposed to 1 ppb had 0.98 ppm in whole body residues. At an exposure of 100 ppb whole body residue was 17.0 ppm. Later, Hansen *et al.* (1971) reported that pinfish and spot died when exposed to 5 ppb Aroclor 1254 for 14 to 45 days. Delayed toxicity was demonstrated when 48% of fish exposed to 5 ppb for 26 days died within 1 week after being placed in PCB-free water. Most PCB was stored in the liver, but residues were also found in the brain, gills, heart, muscle, gall bladder, gonad, gut, and skin.

A possible mechanism for effect of PCB's in fish was suggested by Yap *et al.* (in press). They found that Aroclor 1221, 1254, and 1268 inhibited the ATPase enzyme system of the blue-gill sunfish, *Lepomis macrochirus*, at concentrations less than 1 ppm.

Residues of PCB's have been reported in many birds (see Risebrough *et al.*, 1968; Koeman *et al.*, 1969; Jensen *et al.*, 1969; Bagley *et al.*, 1970; Prestt *et al.*, 1970; Heath *et al.*, 1970; Vos and Koeman, 1970). Stickel *et al.* (1970) found 230 ppm of PCB, 385 ppm DDE, 6 ppm DDD, 2.2 ppm dieldrin, and 0.4 ppm heptachlor epoxide in the brain of a bald eagle found sick in the field. Low dietary levels (25 and 50 ppm) of Aroclor 1254 had no measureable reproductive effects on mallard ducks, *Anas platyrhyncos*, and bobwhite quail, *Colinus virginianus*. PCB was less toxic to birds than DDT, but the joint toxicity of Aroclor 1254 and DDE was additive and not synergistic.

Mussels and fish contained more PCB's of lower percentage chlorine than birds (Jensen *et al.*, 1969; Koeman *et al.*, 1969). These authors suggested that PCB's with lower chlorine values were metabolized or excreted faster than those with more chlorine and are thus lost at a greater rate from the food chain. The gas chromatographic pattern of ingested PCB's changes as they are stored in bird tissues, a phenomenon also reported by Nimmo *et al.* (1971a) for shrimp.

PCB's affect reproductive physiology of birds. Reproductive failure of pheasants, *Phasianus colchicus*, occurred after ingestion of PCB (Dahlgren and Linder, 1971). In the American kestrel, *Falco sparverius*, microsomal breakdown of oestradiol after ingestion of bird flesh which contained Aroclor 1254 or 1262 was reported by Lincer and Peakall (1970). Studies on effects of Aroclor 1254 on secondary sexual characteristics of White Leghorn cockerels by Platonow and Funnell (1971) suggest that the toxicant exerts an anti-androgenic affect. The authors described a delayed reaction in which testicular weights of treated animals were lower than those of untreated birds. The difference was not noted until 6 weeks after the experiment began. It is possible that similar effects occur in estuarine birds. The data of Platonow and Funnell (1971), Dahlgren and Linder (1971) and Lincer and Peakall (1970) suggest that reproduction by both male and female birds is affected by PCB's.

It is also possible that PCB's reduce resistance to disease in birds. Mallard ducklings were fed Aroclor 1254 for 10 days, and showed no apparent clinical effects. Given PCB-free food and challenged 5 days later with duck hepatitis virus, they suffered significantly higher mortality than did birds which were not fed PCB (Friend and Trainer, 1970).

Trace amounts of PCB were found in muscle, liver, blubber, and ingested milk of nursing fur seal pups (Anas and Wilson 1970b).

Acknowledgments

I thank P.A. Butler, N.R. Cooley, D.L. Coppage, T.W. Duke, D.J. Hansen, J.I. Lowe, and D.R. Nimmo, all of the Environmental Protection Agency laboratory at Gulf Breeze, Florida, for making their files of literature on pesticides available to me.

References Cited

Abbott, D.C., R.B. Harrison, J.O'G. Tatton, and J. Thompson. 1966. Organochlorine pesticides in the atmosphere. Nature 211: 259-261.

Anas, R.E., and A.J. Wilson, Jr. 1970a. Organochlorine pesticides in fur seals. Pestic. Monit. J. 3: 198-200.

________________. 1970b. Organochlorine pesticides in nursing fur seal pups. Pestic. Monit. J. 4: 114-116.

Anderson, D.W., J.J. Hickey, R.W. Risebrough, D.F. Hughes, and R.E. Christensen. 1969. Significance of chlorinated hydrocarbon residues to breeding pelicans and cormorants. Can. Field Nat. 83: 91-112.

Anderson, J.M. 1968. Effect of sublethal DDT on the lateral line of brook trout, *Salvelinus fontinalis*. J. Fish. Res. Board Canada 25: 2677-2682.

Anderson, J.M., and M.R. Peterson. 1969. DDT: Sublethal effects on brook trout nervous system. Science 164: 440-441.

Anonymous. 1966. Report of a new chemical hazard. New Scient. 32: 612.

Bagley, G.E., W.L. Reichel, and E. Cromartie. 1970. Identification of polychlorinated biphyenyls in two bald eagles by combined gas-liquid chromatography-mass spectrometry. J. Assoc. Off. Anal. Chem. 53: 251-261.

Bearden, C.M. 1967. Field tests concerning the effects of "Dibrom 14 Concentrate" (Naled) on estuarine animals. Contrib. No. 45 from the Bears Bluff Labs., Wadmalaw Island, S. C. 14 pp.

Bookhout, C.G., A.J. Wilson, Jr., T.W. Duke, and J.I. Lowe. Effects of mirex on the larval development of two crabs. Water, Air, Soil Pollut. In press.

Bowes, G.W., R.W. Gee, and A.F. Carlucci. 1971. Biochemical studies of marine phytoplankton in the presence of DDT. FAO Fish. Rep. 99 (abstracts). Report of the FAO Technical Conference on Marine Pollution and its Effects on Living Resources and Fishing. Rome, 9-18 December 1970. p. 162.

Boyd, C.E., and D.E. Ferguson. 1964a. Spectrum of cross-resistance to insecticides in the mosquitofish, *Gambusia affinis*. Mosquito News 24: 19-21.

________________. 1964b. Susceptibility and resistance of mosquitofish to several insecticides. J. Econ. Entomol. 57: 430-431.

Burnett, R. 1971. DDT residues: Distribution of concentrations in *Emerita analoga* (Stimpson) along coastal California. Science 174: 606-608.

Butler, P.A. 1963. Commercial fisheries investigations. Pesticide-Wildlife Studies: A Review of Fish and Wildlife Service Investigations during 1961 and 1962. U.S. Fish. Wildl. Serv. Circ. 167: 11-25.

________________. 1964. Commercial fisheries investigations. U.S. Fish. Wildl. Serv. Circ. 199: 5-28.

________________. 1965. Effects of herbicides on estuarine fauna. Proc. South. Weed Conf. 18: 576-580.

________________. 1966a. The problem of pesticides in estuaries. Trans. Am. Fish. Soc. 95(Suppl.): 110-115.

________________. 1966b. Pesticides in the marine environment. J. Appl. Ecol. 3(Suppl.): 253-259.

________________. 1967. Pesticides in the estuary. *In* J.D. Newsom (ed.). Proc. Marsh Estuary Manage. Symp., Baton Rouge, Louisiana, T.J. Moran's Sons, Inc., Baton Rouge, pp. 120-124.

________________. 1969. The significance of DDT residues in estuarine fauna. *In* M.W. Miller and G.G. Berg (eds.). Chemical Fallout. C.C. Thomas, Springfield, Illinois. pp. 205-220.

________________. 1971. Influence of pesticides on marine ecosystems. Proc. R. Soc. Lond., Ser. B. 177: 321-329.

Butler, P.A., and P.F. Springer. 1966. Pesticides–A new factor in coastal environments. Trans. 28th. N. Am. Wildl. Nat. Resour. Conf. 4-6 March 1963, pp. 378-390.

Cohen, J.M., and C. Pinkerton. 1966. Widespread translocation of pesticides by air transport and rainout. Adv. Chem. Ser. No. 60: 163-176.

Cope, O.B. 1965. Agricultural chemicals and freshwater ecological systems. *In* C.O. Chichester (ed.), Research in Pesticides. Academic Press, Inc. New York., pp. 115-127.

Coppage, D.L. 1971. Characterization of fish brain acetylcholinesterase with an automated pH stat for inhibition studies. Bull. Environ. Contam. Toxicol. 6: 304-310.

________________. Organophosphate pesticides: Specific level of brain AChE inhibition related to death in sheepshead minnows. Trans. Am. Fish. Soc. In press.

Coppage, D.L., and T.W. Duke. Effects of pesticides in estuaries along the Gulf and southeast Atlantic coasts. Proc. Nat. Conf. Mosq. Control. In press.

Cox, J.L. 1970a. DDT residues in marine phytoplankton: Increase from 1955 to 1969. Science 170: 71-73.

_______________. 1970b. Low ambient level uptake of ^{14}C-DDT by three species of marine phytoplankton. Bull. Environ. Contam. Toxicol. 5: 218-221.

_______________. 1970c. Accumulation of DDT residues in *Triphoturus mexicanus* from the Gulf of California. Nature 227: 192-193.

_______________. 1971a. DDT residues in seawater and particulate matter in the California Current system. Fish. Bull. 69: 443-449.

_______________. 1971b. DDT increasing in the marine environment. Biol. Conserv. 3: 272-277.

_______________. 1971c. Uptake, assimilation, and loss of DDT residues by *Euphausia pacifica*, a euphausiid shrimp. Fish. Bull. 69: 627-633.

Croker, R.A., and A.J. Wilson, Jr. 1965. Kinetics and effects of DDT in a tidal marsh ditch. Trans. Am. Fish. Soc. 94: 152-159.

Dahlgren, R.B., and R.L. Linder. 1971. Effects of polychlorinated biphenyls on pheasant reproduction, behavior, and survival. J. Wildl. Manag. 35: 315-319.

Davis, H.C. 1961. Effects of some pesticides on eggs and larvae of oysters (*Crassostrea virginica*) and clams (*Venus mercenaria*). Commer. Fish. Rev. 28: 8-23.

Derby, S.B. (Sleeper), and E. Ruber. 1971. Primary production: Depression of oxygen evolution in algal cultures by organophosphorus insecticides. Bull. Environ. Contam. Toxicol. 5: 553-557.

Duke, T.W. 1969. Estuarine pesticide research–Bureau of Commercial Fisheries. Proc. Gulf Caribb. Fish. Inst., 22nd. Annu. Sess., pp. 146-153.

Duke, T.W., J.I. Lowe, and A.J. Wilson, Jr. 1970. A polychlorinated biphenyl (Aroclor® 1254) in the water, sediment, and biota of Escambia Bay, Florida. Bull. Environ. Contam. Toxicol. 5: 171-180.

Duke, T.W., and A.J. Wilson, Jr. 1971. Chlorinated hydrocarbons in livers of fishes from the northeastern Pacific Ocean. Pestic. Monit. J. 5: 228-232.

Dustman, E.H., and L.F. Stickel. 1966. Pesticide residues in the ecosystem. *In* Pesticides and Their Effects on Soils and Water. Am. Soc. of Agron. Spec. Pub. No. 8, pp. 109-121.

Eisler, R. 1967. Tissue changes in puffers exposed to methoxychlor and methyl parathion. U.S. Bur. Sport Fish. Wildl., Tech. Pap. No. 17, 15 pp.

_______________. 1969. Acute toxicity of insecticides to marine decapod crustaceans. Crustaceana 16: 302-310.

Eisler, R., and P.H. Edmunds. 1963. Effects of endrin on blood and tissue chemistry of a marine fish. Trans. Am. Fish. Soc. 95: 153-159.

Eisler, R., and M.P. Weinstein. 1967. Changes in metal composition of the quahaug clam, *Mercenaira mercenaria*, after exposure to insecticides. Chesapeake Sci. 8: 253-258.

Engel, R.H., M.J. Neat, and R.E. Hillman. 1971. Sublethal chronic effects of DDT and lindane on glycolytic and gluconeogenic enzymes of the quahaug, *Mercenaria mercenaria*. FAO Fish. Rep. 99. Report of the FAO Technical Conference on Marine Pollution and its Effects on Living Resources and Fishing. Rome, 9-18 December 1970, 7 pp.

Ernst, W. 1969. Stoffwechsel von Pesticiden in marinen Organismen. I. Vorlaufife Untersuchungen uber die Umwandlung und Akkumulation von DDT-^{14}C durch den Polychaeten, *Nereis diversicolor*. Veroff. Inst. Meeresforsh. Bremerh. 11: 327-332.

_______________. 1970a. Stoffwechsel von Pesticiden in marinen Organismen. II. Biotransformation und Akkumulation von DDT-^{14}C in Plattfischen, *Platichthys flesus*. Veroff. Inst. Meeresforsch. Bremerh. 12: 353-360.

_______________. 1970b. Stoffwechsel von Pesticiden in marinen Organismen. III. Abbau und Speicherung von DDT-^{14}C in Plattfischen, *Solea solea*. Veroff. Inst. Meeresforsch, Bremerh. 12: 361-364.

_______________. 1971. Accumulation and metabolism of DDT-^{14}C (Dichloro-diphenyltrichloro-ethane) in marine organisms. FAO Fish. Rep. 99. Report of the FAO Technical Conference on Marine Pollution and its Effects on Living Resources and Fishing. Rome, 9-18 December 1970, 3 pp.

Fabacher, D.L., and H. Chambers. 1971. A possible mechanism of insecticide resistance in mosquitofish. Bull. Environ. Contam. Toxicol. 6: 372-376.

Ferguson, D.E., and C.E. Boyd. 1964. Apparent resistance to methyl parathion in mosquitofish, *Gambusia affinis*. Copeia 1964: 706.

Ferguson, D.E., and C.R. Bingham. 1966. The effects of combinations of insecticides on susceptible and resistant mosquitofish. Bull. Environ. Contam. Toxicol. 1: 97-103.

Ferguson, D.E., J.L. Lundke, and G.G. Murphy. 1966. Dynamics of endrin uptake and release by resistant and susceptible strains of mosquitofish. Trans. Amer. Fish. Soc. 95: 335-344.

Foy, C.L., and S.W. Bingham. 1969. Some research approaches toward minimizing herbicidal residues in the environment. Residue Rev. 29: 105-135.

Frere, M.H. 1971. Requisite sampling frequency for measuring nutrient and pesticide movement with runoff waters. J. Agric. Food Chem. 19: 837-839.

Friend, M., and D.O. Trainer. 1970. Polychlorinated biphenyls: Interaction with duck hepatitus virus. Science 170: 1314-1316.

Fryer, J.D., and S.A. Evans. 1968. Weed Control Handbook, Vol. 1, Principles. Blackwell Scientific Publications, Oxford and Edinburgh. 494 pp.

Goodman, R.N. 1965. Effect of pesticides from land drainage in farm pond waters. *In* C.O. Chichester (ed.). Research in Pesticides. Academic Press, Inc. New York, pp. 129-133.

Gregory, W.W. Jr., J.K. Reed, and L.E. Priester, Jr. 1969. Accumulation of parathion and DDT by some algae and protozoa. J. Protozool. 16: 69-71.

Grosch, D.S. 1967. Poisoning with DDT: Effect on reproductive performance of *Artemia*. Science 155: 592-593.

Gustafson, G.C. 1970. PCB's—prevalent and persistent. Environ. Sci. Technol. 4: 814-819.

Haderlie, E.C. 1970. Influence of pesticide run-off in Monterey Bay. Mar. Pollut. Bull. 1: 42-43.

Hannan, P.J., and C. Patouillet. 1971. Nutrient and pollutant concentrations as determinants in algal growth rates. FAO Fish. Rep. 99. Report of the FAO Technical Conference on Marine Pollution and its Effects on Living Resources and Fishing. Rome, 9-18 December 1970. 7 pp.

Hansen, D.J. 1969. Avoidance of pesticides by untrained sheepshead minnows. Trans. Am. Fish. Soc. 98: 427-429.

____________. DDT and malathion: Effect on salinity selection by mosquitofish. Trans. Am. Fish. Soc. In press.

Hansen, D.J., P.R. Parrish, J.I. Lowe, A.J. Wilson, Jr., and P.D. Wilson. 1971. Chronic toxicity, uptake, and retention of Aroclor® 1254 in two estuarine fishes. Bull. Environ. Contam. Toxicol. 6: 113-119.

Hansen, D.J., and A.J. Wilson, Jr. 1970. Significance of DDT residues from the estuary near Pensacola, Florida. Pestic. Monit. J. 4: 51-56.

Harrington, R.W., and W.L. Bidlingmayer. 1958. Effects of dieldrin on fishes and invertebrates of a salt marsh. J. Wildl. Manag. 22: 76-82.

Harriss, R.C., D.B. White, and R.B. Macfarlane. 1970. Mercury compounds reduce photosynthesis by plankton. Science 170: 736-737.

Haven, D.S. 1969. Levels of the herbicide Diquat in two estuarine molluscs and in the water and mud. Va. J. Sci. 20: 51-53.

Heath, R.G., and R.M. Prouty. 1967. Trial monitoring of pesticides in wings of mallards and black ducks. Bull. Environ. Contam. Toxicol. 2: 101-110.

Heath, R.G., J.W. Spann, and J.F. Kreitzer. 1969. Marked DDE impairment of mallard reproduction in controlled studies. Nature 224: 47-48.

Heath, R.G., J.W. Spann, J.F. Kreitzer, and C. Vance. 1970. Effects of polychlorinated biphenyls on birds. Proc. XV Int. Ornithol. Congr. 20 pp.

Hickey, J.J., and D.W. Anderson. 1968. Chlorinated hydrocarbons and eggshell changes in raptorial and fish-eating birds. Science 162: 271-273.

Holden, A.V. 1970. Source of polychlorinated biphenyl contamination in the marine environment. Nature 228: 1220-1221.

Holden, A.V., and K. Marsden. 1967. Organochlorine pesticides in seals and porpoises. Nature 216: 1274-1276.

Holland, H.T., D.L. Coppage, and P.A. Butler. 1966. Increased sensitivity to pesticides in sheepshead minnows. Trans. Am. Fish. Soc. 95: 110-112.

____________. 1967. Use of fish brain acetylcholinesterase to monitor pollution by organophosphorus pesticides. Bull. Environ. Contam. Toxicol. 2: 156-162.

Holland, H.T., and D.L. Coppage. 1970. Sensitivity to pesticides in three generations of sheepshead minnows. Bull. Environ. Contam. Toxicol. 5: 362-367.

House, W.B., L.H. Goodson, H.M. Gadberry, and K.W. Dockter. 1967. Assessment of ecological effects of extensive or repeated use of herbicides: Final report. Midwest Res. Inst., Kansas City, Missouri. 369 pp.

Janicki, R.H., and W.B. Kinter. 1971. DDT: Disrupted osmoregulatory events in the intestine of the eel *Anguilla rostrata* adapted to seawater. Science 173: 1146-1148.

Jensen, S., A.G. Johnels, S. Olsson, and G. Otterlind. 1969. DDT and PCB in marine animals from Swedish waters. Nature 224: 247-250.

Karinen, J.F., J.G. Lamberton, N.E. Stewart, and L.C. Terriere. 1967. Persistence of carbaryl in the marine environment. J. Agric. Food Chem. 15: 148-156.

Kearney, P.C., E.A. Woolson, J.R., Plimmer, and A.R. Isensee 1969. Decontamination of Pesticides in Soils. Residue Rev. 29: 137-149.

Klingman, G.C. 1963. Weed Control: As a Science. John Wiley and Sons, Inc. New York. 421 pp.

Kobayashi, K., H. Akitake, and T. Tomiyama. 1970. Studies on the metabolism of pentachlorophenate, a herbicide in aquatic organisms III. Isolation and identification of a conjugated PCP yielded by a shell-fish, *Tapes philippinarum.* Jap. Soc. Sci. Fish. Bull. 36: 103-108.

Koeman, J.H., and H. van Genderen. 1966. Some preliminary notes on residues of chlorinated hydrocarbon insecticides in birds and mammals in the Netherlands. J. Appl. Ecol. 3(Suppl.): 99.

Koeman, J.H., M.C. Ten Noever de Brauw, and R.H. de Vos. 1969. Chlorinated biphenyls in fish, mussels, and birds from the River Rhine and the Netherlands coastal area. Nature 221: 1126-1128.

Lamont, T.G., G.E. Bagley, and W.L. Reichel. 1970. Residues of o,p'-DDT in brown pelican eggs and mallard ducks. Bull. Environ. Contam. Toxicol. 5: 231-236.

Lamont, T., and W. Reichel. 1970. Organochlorine pesticide residues in whooping cranes and Everglade kites. Auk 87: 158-159.

Lichtenstein, E.P., K.R. Schulz, T.W. Fuhremann, and T.T. Liang. 1969. Biological interaction between plasticizers and insecticides. J. Econ. Entomol. 62: 761-765.

Lincer, J.L., and D.B. Peakall. 1970. Metabolic effects of polychlorinated biphenyls in the American kestrel. Nature 228:783.

Loosanoff, V.L. 1947. Effects of DDT upon setting, growth, and survival of oysters. Fish. Gaz., New York 64: 94-96.

________________. 1960. Some effects of pesticides on marine arthropods and molluscs. *In* Trans. 1959 Seminar, Public Health Serv. (U.S.), Tech. Rept. W60-3, pp. 89-93.

Lowe, J.I. 1964. Chronic exposure of spot, *Leiostomus xanthurus*, to sublethal concentrations of toxaphene in seawater. Trans. Am. Fish. Soc. 93: 396-399.

________________. 1965a. Chronic exposure of blue crabs, *Callinectes sapidus*, to sublethal concentrations of DDT. Ecology 46: 899-900.

________________. 1965b. Some effects of endrin on estuarine fishes. Proc. 19th Ann. Conf. Southeast. Assoc. Game Fish. Comm., Tulsa, Okla. 10-13 October 1965, pp. 271-276.

________________. 1967. Effects of prolonged exposure to Sevin® on an estuarine fish, *Leiostomus xanthurus* Lacepede. Bull. Environ. Contam. Toxicol. 2: 147-155.

Lowe, J.I., P.D. Wilson, A.J. Rick, and A.J.Wilson, Jr. 1971a. Chronic exposure of oysters to DDT, toxaphene, and parathion. Proc. Natl. Shellfish. Assoc. 61: 71-79.

Lowe, J.I., P.R. Parrish, A.J. Wilson, Jr., P.D. Wilson, and T.W. Duke. 1971b. Effects of mirex on selected estuarine organisms. Trans. 36th North Am. Wildl. Nat. Resour. Conf. Portland, Oregon, 7-10 March 1971, pp. 171-186.

Ludke, J.L. 1970. Unpublished Ph.D. thesis, Mississippi State University, 19 pp. (cited by Fabacher and Chambers, 1971).

Matsumura, F., and K.C. Patil. 1969. Adenosine triphosphatase sensitive to DDT in synapses of rat brain. Science 166: 121-122.

Menzel, D.W., J. Anderson, and A. Randtke. 1970. Marine phytoplankton vary in their response to chlorinated hydrocarbons. Science 167: 1724-1726.

Milleman, R.E. 1966. Effects of pesticides on estuarine organisms. Progress Report from Oregon St. Univ., U.S. Public Health Serv., Grant 5 RO1 EF-00628. 44 pp.

Miller, J.W. 1944. Pathologic changes in animals exposed to commercial chlorinated biphenyl. Publ. Health Rep. 59: 1085-1093.

Miller, M.W., and G.G. Berg. 1969. Chemical Fallout. Charles C. Thomas, Springfield, Illinois. 531 pp.

Moden, J.C. 1969. Residues in fish, wildlife, and estuaries. Pestic. Monit. J. 3: 1-7.

Moore, N.W., and J. O'G. Tatton. 1965. Organochlorine insecticide residues in the eggs of sea birds. Nature 267: 42-43.

Mullison, W.R. 1970. Effects of herbicides on water and its inhabitants. Weed Sci. 18: 738-750.

Narahashi, T., and H.G. Haas. 1968. Interaction of DDT with the components of lobster nerve conductance. J. Gen. Physiol. 51: 177-198.

National Academy of Sciences–National Research Council. 1966. Principles of Plant and Animal Pest Control. Vol. 2, Weed Control. Natl. Acad. Sci. Wash., D.C. 471 pp.

Neumeyer, J., O.D. Gibbons, and H. Trask. 1969. CW report: Pesticides, Part I. Chem. Week 104: 37-68.

Nimmo, D.R., A.J. Wilson, Jr., and R.R. Blackman. 1970. Localization of DDT in the body organs of pink and white shrimp. Bull. Environ. Contam. Toxicol. 5: 333-341.

Nimmo, D.R., R.R. Blackman, A.J. Wilson, Jr., and J. Forester. 1971a. Toxicity and distribution of Aroclor® 1254 in the pink shrimp *Penaeus duorarum*. Mar. Biol. 11: 191-197.

Nimmo, D.R., P.D. Wilson, R.R. Blackman, and A.J. Wilson, Jr. 1971b. Polychlorinated biphenyl absorbed from sediments by fiddler crabs and pink shrimp. Nature 231: 50-52.

O'Brien, R.D. 1967. Insecticides: Action and Metabolism. Academic Press, New York. 332 pp.

Odum, W.E., G.M. Woodwell, and C.F. Wurster. 1969. DDT residues absorbed from organic detritus by fiddler crabs. Science 164: 576-577.

Oettingen, W.F. von. 1955. The halogenated hydrocarbons - toxicity and potential dangers. U.S. Public Health Serv. Publ. No. 414, p. 306.

Ogilvie, D.M., and J.M. Anderson. 1965. Effect of DDT on temperature selection by young Atlantic Salmon, *Salmo salar*. J. Fish. Res. Board Canada 22: 503-512.

Pfister, R.M., P.R. Dugan, and J.I. Frea. 1969. Microparticulates: Isolation from water and identification of associated chlorinated pesticides. Science 166: 878-879.

Porter, R.D., and S.N. Wiemeyer. 1969. Dieldrin and DDT: Effects on sparrow hawk eggshells and reproduction. Sicence 165: 199-200.

Platonow, N.S., and H.S. Funnell. 1971. Antiandrogenic-like effect of polychlorinated biphenyls in cockerels. Vet. Rec. 88: 109-110.

Prestt, I., D.J. Jefferies, and N.W. Moore. 1970. Polychlorinated biphenyls in wild birds in Britain and their avian toxicity. Environ. Pollut. 1: 3-26.

Rawls, C.K., 1965. Field tests of herbicide toxicity to certain estuarine animals. Chesapeake Sci. 6: 150-161.

Reichel, W.L., and C.E. Addy. 1968. A survey of chlorinated pesticide residues in black duck eggs. Bull. Environ. Contam. Toxicol. 3: 174-179.

Risebrough, R.W., D.B. Menzel, D.G. Martin, Jr., and H.S. Olcott. 1967. DDT residues in Pacific seabirds: A persistent insecticide in marine food chains. Nature 216: 589-591.

Risebrough, R.W., D.B. Peakall, S.G. Herman, M.N. Kirven, and P. Rieche. 1968. Polychlorinated biphenyls in the global ecosystem. Nature 220: 1098-1102.

Robinson, J., A. Richardson, A.N. Crabtree, J.C. Coulson, and G.R. Potts. 1967. Organochlorine residues in marine organisms. Nature 214: 1307-1311.

Rosato, P., and D.E. Ferguson. 1968. The toxicity of endrin-resistant mosquitofish to eleven species of vertebrates. BioScience 18: 783-784.

Ruber, E. 1963, The effects of certain mosquito larvacides on microcrustacean populations. Proc. 50th Annu. Meet. N.J. Mosq. Exterm. Assoc., 12-15 March 1963, pp. 256-261.

Safe, S., and O. Hutzinger. 1971. Polychlorinated biphenyls: Photolysis of 2,4,6,2',4',6'-hexachlorobiphenyl. Nature 232: 641-642.

Sanders, H.O. 1970. Toxicities of some herbicides to six species of freshwater crustaceans. J. Water Pollut. Control Fed. 42: 1544-1550.

Schmidt, T.T., R.W. Risebrough, and F. Gress. 1971. Input of polychlorinated biphenyls into California coastal waters from urban sewage outfalls. Bull. Environ. Contam. Toxicol. 6: 235-243.

Seba, D.B., and E.F. Corcoran. 1969. Surface slicks as concentrators of pesticides in the marine environment. Pestic. Monit. J. 3: 190-193.

Sladen, W.J.L., C.M. Menzie, and W.L. Reichel. 1966. DDT residues in adelie penquins and a crab-eater seal from Antarctica: Ecological implications. Nature 210: 670-673.

Stickel, W.H., L.F. Stickel, and F.B. Coon. 1970. DDE and DDD residues correlated with mortality of experimental birds. *In* W.B. Deichmann (ed.). Pesticides Symposia. Helios and Associates, Miami, Florida, pp. 287-294.

Stout, V.F. 1968. Pesticide levels in fish of the northeast Pacific. Bull. Environ. Contam. Toxicol. 3: 240-246.

Tarrant, K.R., and J.O'G. Tatton. 1968. Organochlorine pesticides in rainwater in the British Isles. Nature 219: 725-727.

Thomas, M.L.H. 1968. Control of eelgrass using 2,4-D in oyster-growing areas. Fish. Res. Board Canada, Mar. Ecol. Lab., Gen. Ser. Circ. No. 1, pp. 13-16.

Thomas, M.L.H., and J.R. Duffy. 1968. Butoxyethanol ester of 2,4-D in the control of eelgrass (*Zostera marina* L.) and its effects on oysters (*Crassostrea virginica* Gmelin) and other benthos. Proc. Northeast Weed Control Conf. 22: 186-193.

Ukeles, R. 1962. Growth of pure cultures of marine phytoplankton in the presence of toxicants. Appl. Microb. 10: 532-537.

Vinson, S.B., C.E. Boyd, and D.E. Ferguson. 1963. Resistance to DDT in the mosquitofish, *Gambusia affinis*. Science 139: 217-218.

Vos, J.G., and J.H. Koeman. 1970. Comparative toxicologic study with polychlorinated biphenyls in chickens with special reference to porphyria, edema formation, liver necrosis, and tissue residues. Toxicol. Appl. Pharmacol. 17: 656-668.

Walsh, G.E. a. Lack of effect of mirex and PCB (Aroclor® 1254) upon evolution of oxygen by unicellular algae. *In* Progress Report of the Bureau of Commercial Fisheries Center for Estuarine and Menhaden Research, Pesticide Field Station, Gulf Breeze, Florida, Fiscal Year 1970. U.S. Dept. Interior Circ. In press.

_______________. b. Effects of herbicides on photosysnthesis and growth of marine unicellular algae. Hyacinth Control J. In press.

Walsh, G.E., and T.E. Grow. 1971. Depression of carbohydrate in marine algae by urea herbicides. Weed Sci. 19: 568-570.

Warner, R.E., K.K. Peterson, and L. Borgman. 1966. Behavioural pathology in fish: A quantitative study of sublethal pesticide toxication. J. Appl. Ecol. 3(Suppl.): 223-247.

Waugh, G.D., and A. Ansell. 1956. The effect on oyster spatfall of controlling barnacle settlement with DDT. Ann. Appl. Biol. 44: 619-625.

Waugh, G.D., F.B. Hawes, and F. Williams. 1952. Insecticides for preventing barnacle settlement. Ann. Appl. Biol. 39: 407-415.

Weibel, S.R., R.B. Weidner, J.M. Cohen, and A.G. Christianson. 1966. Pesticides and other contaminants in rainfall and runoff. J. Am. Water Works. Assoc. 58: 1075-1084.

Wershaw, R.L., P.J. Burcar, and M.C. Goldberg. 1969. Interaction of pesticides with natural organic material. Environ. Sci. Technol. 3: 271-273.

Wildish, D.J. 1970. The toxicity of polychlorinated biphenyls (PCB) in sea water to *Gammarus oceanicus*. Bull. Environ. Contam. Toxicol. 5: 202-204.

Wildish, D.J., and V. Zitko. 1971. Uptake of polychlorinated biphenyls from sea water by *Gammarus oceanicus*. Mar. Biol. 9: 213-218.

Wolman, A.A., and A.J. Wilson, Jr. 1970. Occurrence of pesticides in whales. Pestic. Monit. J. 4: 8-10.

Woodwell, G.M., C.F. Wurster, Jr., and P.A. Isaacson. 1967. DDT residues in an east coast estuary: A case of biological concentration of a persistent pesticide. Science 156: 821-823.

Wurster, C.F., Jr. 1968. DDT reduces photosysnthesis by marine phytoplankton. Science 159: 1474-1475.

Yap, H.H., D. Desaiah, R.B. Koch, and L.K. Kutkomp. The sensitivity of fish ATPases to polychlorinated biphenyl compounds. Nature. In press.

The Potential of Various Types of Thermal Effects on Chesapeake Bay

Ruth Patrick[1]

Limnology Department, Academy of Natural Sciences of Philadelphia, 19th and the Parkway, Philadelphia, Pa. 19103

ABSTRACT

Shifts in natural temperatures have physical, chemical, and biological effects upon the receiving body of water. They may affect the viscosity of water and thus the ability of plankton to float. They may affect the circulation pattern of water and hence the current pattern in the Bay. Raising or lowering the temperatures decreases or increases the oxygen-carrying capacity of the water. Shifts in temperature also have considerable effect upon the organisms living in the Chesapeake Bay—for example, their physiological activities. Shifting the natural rhythms of temperature may affect the reproduction of organisms. The effects of sudden changes of temperature are closely related to time of exposure. Organisms can withstand higher shifts in temperature for short exposures than if the temperatures are of longer duration. Much more research needs to be done as to the beneficial effects of temperature. In conclusion, important biological, chemical and physical conditions for power plant siting are set forth.

The Chesapeake Bay is one of the largest estuaries in the world. It is approximately 180 miles long and has a mean width of about 15 miles (Wolman, 1968). However, it is a relatively shallow estuary, as the mean depth of the Bay proper is 25-30 ft. Because it is so large and shallow, the waters are turbulent and during most of the year well mixed, although stratification does occur during the summer months. The shallow water margins of the Bay where most of the aquatic life lives is subject to strong wave action during most of the year and also to the deposition of sediments due to bank erosion.

The Chesapeake estuary is a drowned portion of the Susquehanna River system and is estimated to be about 10,000 years old. The greatest inflow of water is from the Susquehanna, which has a mean annual flow of 40,000 cfs. The Potomac, Rappahannock, and James Rivers also have significant flows of fresh water, but it is the flow of the Susquehanna which has the greatest influence on water quality, particularly on the west side of the Bay.

The increase in population in the drainage area of the watershed and the Bay proper has brought about a fairly high amount of pollution in certain areas. I refer particularly to suspended solids and nutrients.

The suspended solids are brought in by various tributaries and by the erosion and deposition of sediments forming the coastline of the Bay. Prior to the clearing of the portions of the watershed forests for agriculture, the sediment contribution to the system was probably in the order of 100 tons/mi^2/year. However, with the clearing of the land for agriculture and urbanization these values rose to 400 to 800 tons/mi^2/year. The Potomac and the Patuxent, although having much less flow than the Susquehanna, are the largest contributors of sediments. The dams on the Susquehanna greatly reduce the suspended solids contribution of this river.

[1]Dr. Patrick, a member of 14 scientific societies, received an honorary Sc.D. degree from PMC Colleges and an honorary L.LD. degree from Coker College. She was elected to the National Academy of Sciences in 1970, and has received the Pennsylvania Award for Excellence in Science and Technology for 1970 and a Merit Award from the Botanical Society of America. She is a member of Pennsylvania's Environmental Control Board and a member of Governor Shapp's Science Advisory Committee. She has been Curator and Chairman of the Limnology Department of the Academy since 1947.

With the increase in population has come increases in nutrients entering the basin. This is particularly evident in Baltimore Harbor and in many of the small embayments where towns and industrial development have taken place. Indeed, in some of these areas pollution is heavy, and bluegreen algal blooms in the summer months are extensive. However, the contribution of nutrients to the Bay are negligible because of the size and degree of mixing of the Bay water. The Susquehanna River contributes a large portion of the nutrients in the form of NO_3 to the Bay, particularly during the spring of the year when the concentration in the flow is 80-105 μg atm/1 and concentrations in the upper Bay may reach 45 μg atm/1.

The importance in considering these 2 types of pollution in relation to temperature is that the deposition of sediments together with increased nutrients and small increases in temperature often bring about increased growth in benthic algae and rooted aquatics, which may or may not be beneficial depending on the species that develop. If they are effective food sources, productivity of fish and other organisms increase, whereas if they are species of little value as food and predator pressure is low, nuisance growths may develop.

Temperature, unlike some pollutants such as some heavy metals and pesticides, is part of the natural environment. All organisms have a range of temperature in which they live and a smaller range in which optimum living and growth conditions occur. This range of tolerance and optimum activity varies with the species and with the life stage of the organisms. Typically, as shown by diatom experiments which I have conducted, if one raises temperatures a few degrees toward the optimum, the number of species in the community and the sizes of their populations increase, and as a result diversity increases. The biomass also may increase. For example, small increases from 2.8 to 10°C and from 5.7 to 10.4°C. Since diatoms are a nutritive food source, the productivity of the whole system may be increased. However, if one moves away from the optimum range, either up or down, species reduction and/or reduction in sizes of populations of most species and of biomass occurs. It is true that a few species which are tolerant to the new condition may develop large populations which result in lower diversity. Increases in temperature often bring about changes in the species composing communities. For example (Patrick *et al.*, 1969), if one maintains the temperature above 33°C in White Clay Creek in Pennsylvania, one can bring about a change from a diatom-dominated to a blue-green dominated flora at any season of the year. Since blue-greens are not as desirable a food source, predator pressure goes down and the efficiency of energy transfer in the system and the production of fish is reduced.

Temperature affects the chemical and physical characteristics of the aquatic environment as well as the organisms themselves. The viscosity of water is greatly affected by temperature, and plankton which can float in cold or cool water will sink in warm water to that depth at which the viscosity of the water will support them. Likewise, suspended solids will sink more quickly in warm than in cold water. Typically the deeper waters of the Chesapeake Bay are cooler than the surface waters and lower in oxygen in the summer. The introduction of warm water into these cooler layers might locally produce considerable change in the circulation pattern of water with accompanying alteration in the oxygen and salinity and perhaps nutrient patterns natural to the bay. Most chemicals are more soluble in warm water. The oxygen-carrying capacity of water is reduced with increases of temperature, and as a result fish and other gill-breathing organisms have to dilate their gills much more rapidly in warm than in cold water to obtain enough oxygen for life. Indeed the respiration rate of many organisms increases with increases in temperature, but in some organisms after acclimation the respiration rate returns to its former level.

Examples of alteration in the natural functioning of other physiological processes are changes in the lipid content in the brain and spinal cord of fish (*Aequidens portalegrensis*); and in acetyl cholinesterase in bluegill (*Lepomis macrochirus*) brains, both of which have been correlated with changes in temperature (Schneider, 1969; Hogan, 1970). Acclimation to low temperatures for 8 days produced in crayfish an increase in hepatopancreas weight, lipid unsaturated lipids, ribonucleic acid, and free amino acid. Suppression of defecation rates in the tubificid worms (*Peloscolex multisetosus*) has been shown to occur when the temperature is raised from 14 to 18°C.

Many organisms cease to feed, or feed at a slower rate at low temperatures. Examples are the oyster drill (*Urosalpinx cinerea*) and the flatworm (*Stylochus ellipticus*), which feed at a much slower rate at 10°C or less (Manzi, 1969, 1970; Landers and Rhodes, 1970).

Temperature rhythms are important in the natural functioning of many organisms. For example, in Maryland the reproduction of bass seems to be triggered by the temperature of the water increasing from the low sixties (°F) to the high sixties in the Spring of the year. In the Missouri River the spawning of the freshwater drum (*Aplodinotus grunniens*) occurred when the river water reached 18°C. Oysters in the Chesapeake spawn when the temperature of the water passes from the high sixties to the low seventies in the Spring. The emergence of insects in the Spring may be advanced by raising the temperature 10°F (experiments at Stroud Water Research Center).

Sudden changes of temperature may have a profound effect on aquatic life. The sudden increase in temperature of water may bring about the release of gas bubbles in the blood of fish (embolism) which causes death. This phenomenon may occur when the flow of cold water from a dam is suddenly stopped and the pool of water at the base of the dam warms quickly. Sudden rise in temperature such as occurs when organisms are entrained through a power plant may have adverse effects. The severity of the effect seems to be determined by the degree of temperature to which organisms are exposed and the length of time they are exposed to the higher temperatures. Many organisms can withstand for a very short period of time (a few minutes) temperatures which would be lethal under longer exposures. The length of exposure to high temperature seems to be very important in determining the severity of the effect. The effect on entrained organisms in coolant water seems to be related to the size and characteristics of the species, the degree to which the temperature rises, and the time of exposure.

In general, acclimation of organisms to a new temperature regime is a slow process and if carried out too quickly will result in deleterious effects and even death. Therefore, very short sudden rises of temperature and subsequent quick return to ambient not involving acclimation has less deleterious effect than sudden rises of temperature with prolonged exposure to the higher temperature, which necessitates acclimation, particularly if the organism has not been correctly acclimated.

Abnormal temperature regimes have also been shown to affect the susceptibility of organisms to disease and predation. For example, oysters seem to be more susceptible to *Dermocystidium* when exposed to temperatures of 75°F and over lor long periods of time. Parasitized snails (McDaniel, 1969) are less tolerant to high temperature than non-parasitized snails. Furthermore, predator pressure from oyster drills and flatworms (cited above) seem to be less at temperatures of 10°C or less.

From this discussion it is evident that all species of organisms have a range of temperature tolerance and within this range a shorter range of optimum temperature. This range varies from species to species and between races of the same species. It also may be different for different stages in the life history of an organism. There is evidence that moderate raising or lowering of temperatures toward the optimum is favorable for species.

The precise temperature, high or low, which is deleterious or kills a species is closely related to the time of exposure. Shifts in natural temperature regimes may indirectly affect organisms in various ways. It may increase the susceptibility of the species to disease and predator pressure, it may change other chemical and physical characteristics of the environment in which the aquatic community lives and thus indirectly alter competition and predator pressure.

Most of the experimentation to date has been directed toward deleterious effects of temperature. However, there are a number of experiments now in progress directed toward showing beneficial uses of warm water in oyster, shrimp, and fish culture; in treatment of sewage; in treatment of water for industrial use; and in beneficial effects in irrigation. Many of these show considerable promise for the use of this low-heat resource.

To date the impact of altered temperature regimes in the Chesapeake Bay are local. Although there are many plants on the tributaries, there are very few fossil fuel plants (2 in Baltimore Harbor and 4 close to the mouth of the Bay) located on the Bay proper, and 1 nuclear plant in the process of construction. By the year 2000 it is expected that 10 plants about the size of the Calvert Cliffs plant will be erected. It is important that the various States bounded by the Bay develop uniform plans for the development of all industries and population centers on the Bay so that the least impact which might be deleterious to its natural functioning will occur. It is as important to plan for the preservation of natural areas as for development.

In developing plans for siting power plants and other industries with thermal discharges, one must consider biological, chemical, and physical aspects of the Bay. Some of the more important biological considerations are:

1. What are the kinds of aquatic life living in the vicinity of the proposed plant site and what are the temperature optimums and tolerance for these organisms?

2. Are there nursery and spawning areas?

3. Is the plant site in the area of an important migratory path of fish and crabs?

4. Do fish form large schools in deep water in the winter time in the vicinity of the site?

5. Do large populations of crabs hibernate in the bottom sediments in the area?

6. What are the characteristics of the plankton in the area and does the plankton at certain seasons of the year contain the young of many species?

Some of the more important chemical aspects to consider are:

1. What is the nutrient level of the water and are these nutrients biodegradable?

2. What are the oxygen and salinity regimes of the water, and will the intake and heating of water at that particular site produce more than a local effect on these regimes which might be deleterious to aquatic life?

Some of the physical considerations are:

1. Is the flow sufficient so that the volume of water passing through the plant will be only a small portion of the total flow?

2. How will the introduction of the projected volume of coolant water affect the current pattern of water in the area?

3. What will be the isotherms of increased temperature produced by plant operation, and how much of the bay will be affected by a significant rise of temperature?

4. Will the removal of water from the deep layers be sufficient to alter the general pattern of stratification, particularly in the summer?

5. Will reverse flow cause accumulation of heated water in marsh areas which are often important breeding and spawning grounds? At some seasons of the year and under some conditions this effect might be beneficial, and others detrimental.

The design ot the plant may also greatly minimize thermal effects—for example, the location of the discharge away from the shallow water areas where most organisms live and reproduce; the use of low intake speeds to minimize the entrainment of fish and macro-invertebrates; the placement of the intakes so that cool water with low plankton content is taken in; the minimization of time of exposure and degree of heat to which organisms in entrained water are exposed; the use of substances similar to Amertap for slime removal; and the use of chlorine in such a way that there is no or very little free chlorine residual entering the receiving body of water.

I have for the most part mentioned some of the more important ways to minimize deleterious effects of thermal changes in Chesapeake Bay. I believe that much more emphasis than in the past must be placed in the future in optimizing the use of warm water, which should have an ultimate beneficial effect on the Bay.

References Cited

Hogan, J.W. 1970. Water temperature a source of variation in specific activity of brain acetylcholinesterase of bluegills. Bull. Environ. Contam. Toxicol. 5: 347.

Landers, W.S., and E.W. Rhodes. 1970. Some factors influencing predation by the flatworm, *Stylochus ellipticus* (Girard), on oysters. Chesapeake Sci. 11: 55.

Manzi, J.J. 1969. The effect of temperature on the feeding rate of the rough oyster drill, *Eupleura caudata* (Say). Proc. Nat. Shellfish Ass. 60: 54.

———————. 1970. Combined effects of salinity and temperature on the feeding, reproductive, and survival rates of *Eupleura candata* (Say) and *Urosalpinx cinerea* (Say) (Prosobranchia: Muricidae). Biol. Bull. 138: 35.

McDaniel, S.J. 1969. *Littorina littorea*: lowered heat tolerance due to *Cryplocotyle lingua*. Exper. Parasitol. 25: 13.

Patrick, R., B. Crum, and J. Coles. 1969. Temperature and manganese as determining factors in the presence of diatom or blue-green algal floras in streams. Proc. Nat. Acad. Sci. 65: 472-478.

Schneider, M.J. 1969. Effects of the size and thermal history on central nervous system lipids in the fish, *Aequidens portalegrensis*. Ph.D. thesis, University of Oregon, Eugene.

Wolman, M.G. 1968. The Chesapeake Bay: Geology and Geography. *In*: Proceedings of Governor's Conference on Chesapeake Bay, pp. II-7 to II-49.

Heavy Metals—an Inventory of Existing Conditions[1]

M.E. Bender[2], R.J. Huggett, and H.D. Slone

Virginia Institute of Marine Science, Gloucester Point, Virginia 23062

ABSTRACT

In this paper we report on studies undertaken to: (1) establish mercury levels in biota and sediments from the lower portion of Chesapeake Bay; (2) describe the pattern of metal distribution in oysters from 3 Virginia estuaries; and (3) determine if estuarine sediments can be used to detect the effects of man's activities on the environment. To date, mercury analyses of biota from the Bay area have shown no levels in excess of FDA guidelines, nor have they indicated any influence of man's activities in the areas studies. Oysters have been shown to vary naturally in their body burdens of the heavy metals—copper, cadmium, and zinc—and techniques are suggested whereby unnatural heavy metal inputs can be identified. Sediments from an industrialized river system have been shown to reflect the inputs from human activities.

An attempt is made in this report to inventory the status of knowledge on certain metallic elements in the lower portion of Chesapeake Bay. Some of the data presented have been published or submitted for publication elsewhere, and in all cases the sources of information are identified. Much can be learned from what we have called the inventory approach, as one in an attempt to explain what has been observed is usually forced to consider many variables which *a priori* were not thought to be significant. During this process, interpretations are frequently made which suggest avenues for future research. Initially, however, the objective of any inventory is to establish the existing conditions—in this case, the distribution of certain heavy metals in sediments and biota from the Bay region. Studies of the

[1] VIMS Contribution No. 435.

[2] Dr. Bender received his B.S., M.S., and Ph.D. degrees in zoology, fisheries, and environmental sciences, respectively. He is a member of 9 professional societies, is currently the principal investigator or co-investigator of 6 research grants, and has co-authored 13 scientific papers. He is the Assistant Director, Virginia Institute of Marine Science.

inventory nature are generally begun for a variety of reasons. Among these are:

1. Do the residue levels in certain commercial species exceed health standards or guidelines?

2. How is the distribution of certain elements influenced by natural phenomena?

3. Can one discern the influences of man upon natural systems?

In this paper we report on studies undertaken to: 1) establish mercury levels in biota and sediments from the lower portion of Chesapeake Bay; 2) describe the pattern of metal distribution in oysters from 3 Virginia estuaries; and 3) determine if estuarine sediments can be used to detect the effects of man's activities on the environment.

Mercury in Sediments and Biota

All analyses for mercury were conducted by flameless atomic absorption spectrophotometry. Sediment samples from the James, York, and Rappahannock were collected during the fall of 1970 from the channel at each station with a Petersen grab. Three grabs were taken from each location and the upper 3 cm of sediment from each was removed for individual analysis. Dried samples were screened through a 63-micron sieve, and only that portion of sediment passing through the screen was retained for analysis. The core sample was obtained from the Rappahannock River and subsamples from it were not screened. Approximate age of the oldest, i.e. lowest, portion of the core is 300 years (Nichols, personal communication). Digestion of the sediment samples was accomplished by oxidizing a 0.25-g sample with 5 ml of concentrated H_2SO_4 and 7.5 ml of a 6% aqueous potassium permanganate solution.

Mercury determinations in animal tissues were conducted on edible muscle only, with the exception of oysters which were completely digested. Duplicate samples from fish and crustacenas were taken. Collections were made during the fall of 1970 and the spring and summer of 1971.

Results obtained from the survey of 3 Virginia rivers are shown in Fig. 1. Statistical analyses showed no differences (5% signifi-

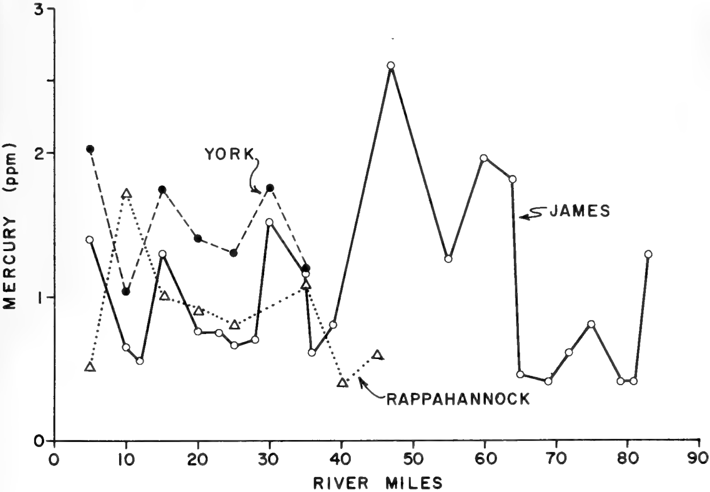


Fig. 1.–Distribution of mercury in sediments from three Virginia rivers.

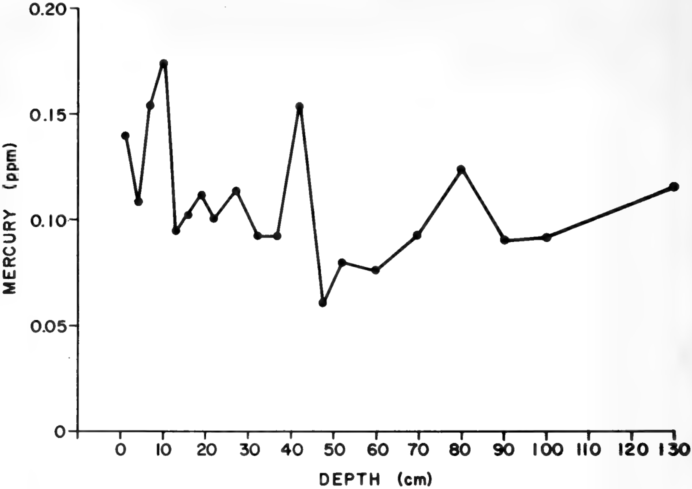


Fig. 2.—Mercury vs. depth in a core sample from Rappahannock.

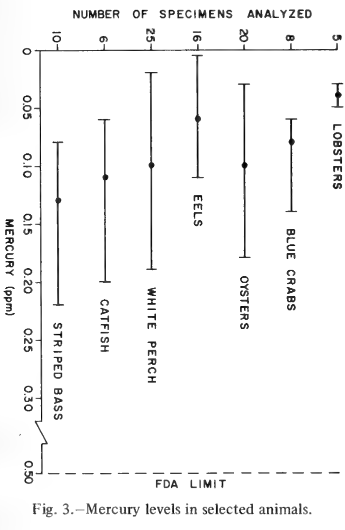


Fig. 3.—Mercury levels in selected animals.

cance level) within rivers with respect to distance from the mouth, or between rivers (Huggett *et al.*, 1971a).

Mercury concentrations found in the core sample as a function of depth are shown in Fig. 2. No indication of man's influence is evident from this core sample, as has been recently shown by Kennedy *et al.* (1971) from sediment cores taken in Lake Michigan.

Fig. 3 shows the mean and range of mercury levels found in various specimens collected from the Bay and Continental Shelf regions. Lowest levels were found in lobsters collected from Norfolk Canyon, while the highest were found in striped bass collected in the York River. The highest mean value, i.e. for striped bass, of 0.13 µg/g was well below the FDA limit of 0.50 µg/g.

Patterns of Metal Distribution in Oysters

The study described in this section is based on an investigation conducted during a period from February to May 1971 in which a total of 495 oysters were collected from

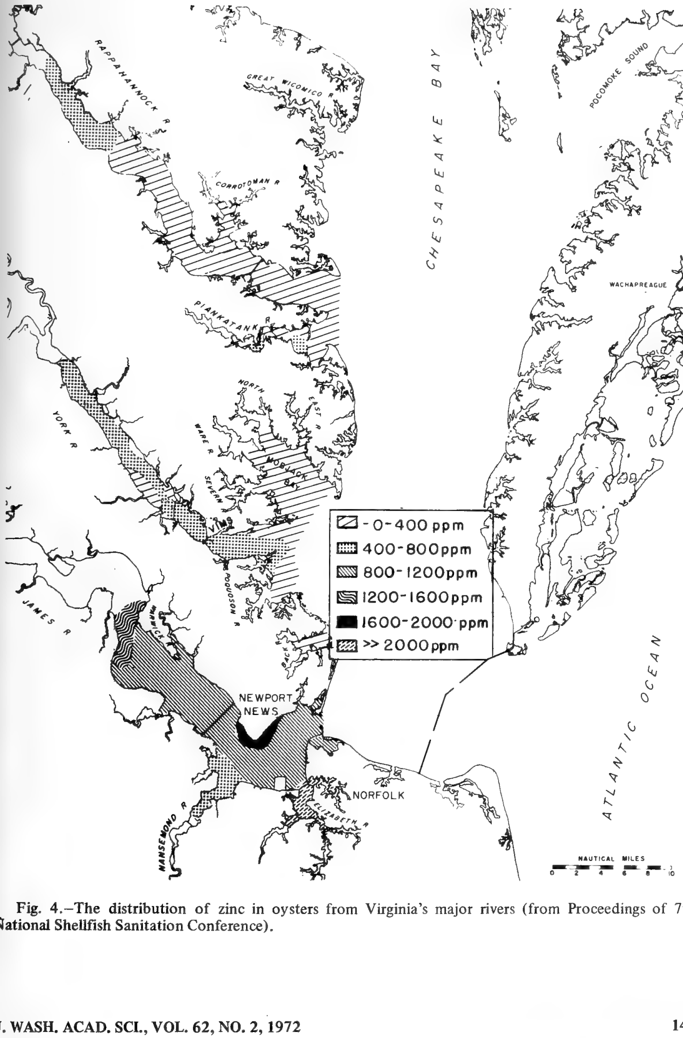


Fig. 4.–The distribution of zinc in oysters from Virginia's major rivers (from Proceedings of 7th National Shellfish Sanitation Conference).

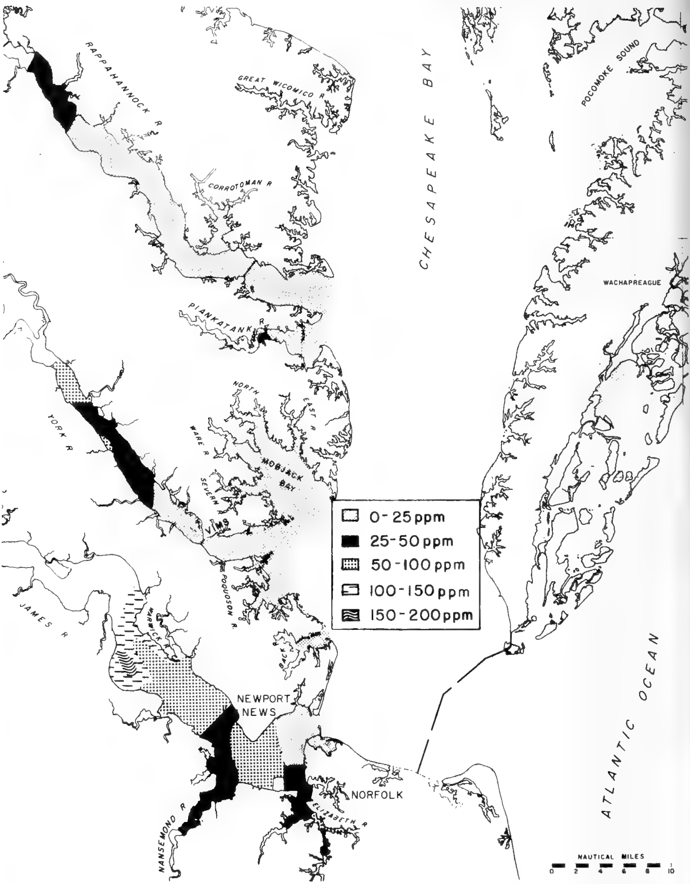


Fig. 5.–The distribution of copper in oysters from Virginia's major rivers (from Proceedings of 7th National Shellfish Sanitation Conference).

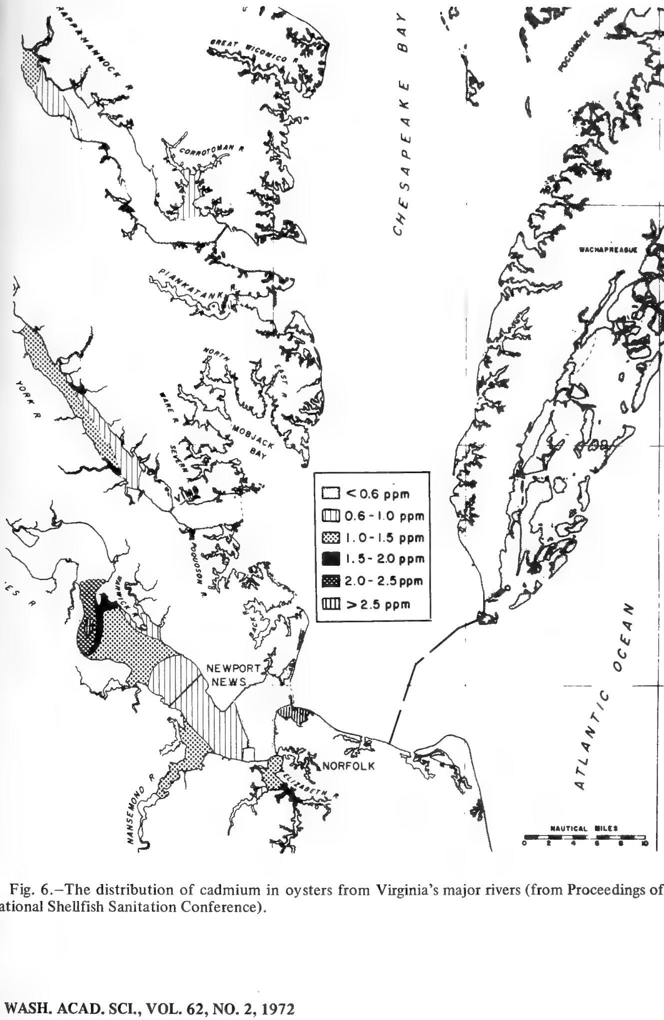


Fig. 6.–The distribution of cadmium in oysters from Virginia's major rivers (from Proceedings of 7th National Shellfish Sanitation Conference).

99 stations in the lower Bay (Huggett *et al.*, 1971b). Salinities at these stations ranged from 32‰ for the ocean side Eastern Shore to 7‰ in the upper reaches of the rivers. Five specimens from each site ranging in weight from 2 to 35 g were digested in concentrated nitric acid. The dissolved samples were analyzed for cadium, copper and zinc by atomic absorption.

Examination of the data showed that although oysters from the same location often varied in concentration by 100‰, there was no relationship between age of the oyster as indicated by weight and the metal concentration.

Average metal concentrations were used in this study only to establish the areal distribution of metals in the various river systems. The means showed that a concentration gradient existed in all systems, and that each metal increased in concentration as fresh water was approached (Figs. 4, 5, 6).

To account for these observations, the following assumptions are proposed:

1) The metals (Cd, Cu, and Zn) available to oysters in non-industrialized areas are from the natural weathering of rocks.

2) The ratio of copper to zinc in the weathering rocks is relatively constant within a drainage basin.

3) Oysters accumulate a constant percentage of each element available to them.

4) Some factor, e.g. salinity or humic acid concentration, varies predictively with distance, causing the amount of metal available for uptake to vary.

If these assumptions are valid, one should be able to establish a relationship between various metals in oysters taken from areas which have similar drainage basins. Furthermore, if such relationships for naturally occurring phenomena can be established, perhaps a method can be developed to identify unnatural inputs.

To establish whether there was a relationship between one metal and another, the zinc and copper concentrations from all samples taken from rivers which extend above the fall line and in which there is no known unnatural zinc or copper source are plotted in Fig. 7.

The placement of confidence bands around this line, which is intended to represent background conditions, would allow for a simple and direct method to detect outliers or "unnatural" inputs. However, the use of normal confidence intervals requires that there be an independent and a dependent variable. If the assumptions previously outlined are correct, then both variables are independent, i.e., the zinc concentration does not control the copper concentration. Hence, the authors have placed a band, consisting of 2 straight lines, around the least squares line. The band encompasses 95% of the points and can be thought of as an approximate confidence band. The equations for the 2 lines are:

$$Y = -33 + 0.07X$$
$$Y = -30 + 0.11X$$

Oysters collected from areas of suspected unnatural inputs, as well as those falling outside the limits established from Fig. 7, are plotted along with the confidence band in Fig. 8. It appears that the Elizabeth River and Hampton Roads, both highly industrialized, are contaminating the oysters in their immediate areas as well as the lower reaches of the James River with zinc. In the upper James, an unnatural source of copper is indicated by points falling on the copper side of the band in Fig. 8.

Metal Sediment Relationships

In the late summer of 1971 a survey of the pollutants present in sediments of the James River system was initiated. The objective of the study was primarily to establish whether the existing levels of certain materials in these sediments would prohibit the disposal of dredgings into open waters, as based on guidelines established by the Environmental Protection Agency. The results reported here were obtained from the Southern Branch of the Elizabeth River, where at present all spoil materials from dredging operations are disposed of in a specially constructed site (Craney Island). Three samples collected across the channel were obtained at 0.25-mi intervals with a 3-ft gravity corer. Sediment from each core was completely

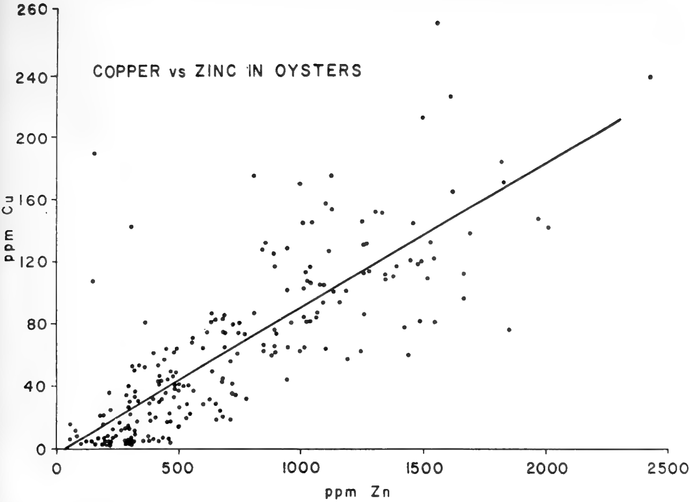


Fig. 7.–Relationship between zinc and copper in oysters from Virginia's major rivers (from Proceedings of the 7th National Shellfish Sanitation Conference).

homogenized before subsamples were taken for analysis.

Concentrations of the metals copper, lead, mercury, and zinc found in Elizabeth River sediments are shown in Fig. 9. Several significant observations can be made from this figure: 1) there appears to be an input of all metals at miles 9.5 and 8.5; 2) an input of just zinc at about mile 7; and 3) inputs of both zinc and copper at mile 5. From these data it is apparent that the levels of metals in these sediments reflect inputs from man's activities and that the sediment levels are sufficiently distinct to allow for the recognition of specific metal inputs.

Discussion

Mercury levels reported for sediments from 3 Virginia rivers–the James, York and Rappahannock–did not show evidence of man's influence. However, sediments from the Southern Branch of the Elizabeth River, a much smaller river, did indicate inputs from man. The only other analyses for mercury in sediments from the Bay have been reported by Pheiffer (1972) for the Potomac–the levels found there were extremely low, highest value reported 26.20 ppb, compared with our results.

The concentration banding of heavy metals by oysters has been shown to follow a predictable pattern and allows for the use of the oyster to identify unnatural metal inputs. The cause of this banding pehnomenon is, however, unknown. Drobeck and Carpenter (1970) reported variations in metal uptake with salinity and attempted to discern the role of sediments in the uptake of metals by the oyster. They concluded that metal uptake was highest in low salinities and was not related to natural sediment loads. A recent laboratory study completed by Lunz (1972) confirmed their results, demonstrating that dissolved copper was taken up much more readily than copper adsorbed to clay particles. The authors believe that the form of the metal in solution is responsible for the banding phenomenon and that the inter-

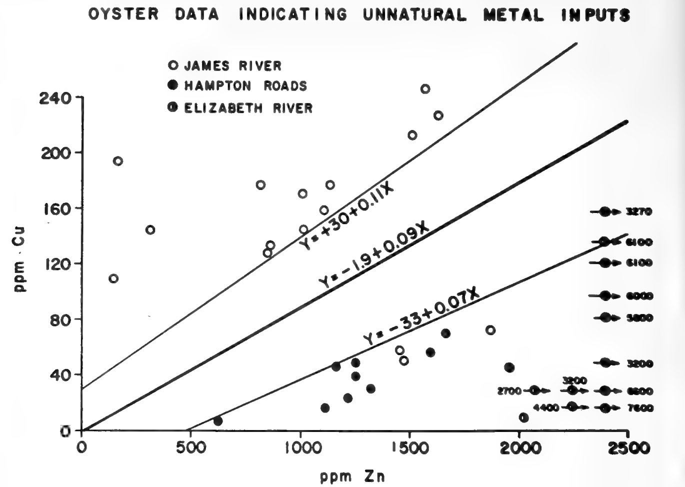


Fig. 8.–Oyster data indicating unnatural metal inputs (from Proceedings of 7th National Shellfish Sanitation Conference).

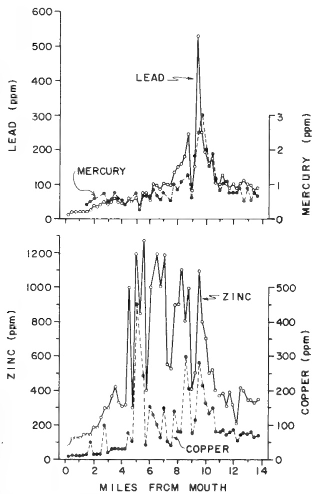


Fig. 9.–Metals in sediments from the Southern Branch of the Elizabeth River.

action of the sediments, which serve as sumps for metals, with the overlying waters, plays an important role in the overall process.

A study is underway to determine whether metal concentration ratios, determined on certain size fractions of sediments, can be used to detect unnatural metal inputs. This study is an extension of our oyster work and if successful should allow investigators to survey entire river systems, where oysters limit the investigators to particular salinity regimes.

Sediments from the Southern Branch of the Elizabeth have been shown to reflect inputs from man's activities. Similar results have been reported by Pheiffer (1972) in a study of the Potomac, where sediment analysis showed increases of lead, cobalt, chromium, cadmium, copper, nickel, zinc, silver, barium, aluminum, iron, and lithium in a critical area of the upper estuary. Inputs were attributed to both wastewater treatment facilities in the upper river and steam generating electric plants further downstream.

References Cited

Drobeck, K.G., and J. Carpenter. 1970. Shellfish accumulation of heavy metals in Chesapeake Bay. Progress Report to: Maryland Departments of Health and Public Works. Nat. Res. Inst., Univ. of Maryland.

Huggett, R.J., M.E. Bender, and H.D. Slone. 1971a. Mercury in sediments from three Virginia estuaries. Chesapeake Sci. 12: 280-282.

——— 1971b. Utilizing metal concentration relationships in the eastern oyster (*Crassostrea virginica*) to detect heavy metal pollution. Proceedings: 7th National Shellfish Sanitation Workshop. Wash. D.C. Oct. 1971.

Kennedy, E.J., R.R. Ruch, and N.F. Shrimp. 1971. Distribution of mercury in unconsolidated sediments from Southern Lake Michigan: Ill. State Geol. Surv., Environm. Geol. Note No. 44, 18 p.

Lunz, J.D. 1971. The importance of particulate clay in the uptake and accumulation of copper by the American oyster, *Crassostrea virginica* (Gmelin). M.S. Thesis, Long Island University.

Pheiffer, T.H. 1972. Existing conditions report: metals. Unpublished manuscript.

Trace Element Analysis by Proton-Induced X-ray Excitation

F. C. Young[1]

Department of Physics and Astronomy, University of Maryland, College Park, Maryland 20742. Present address: Naval Research Laboratory, Washington, D.C. 20390

ABSTRACT

A new technique for detecting trace elements by exciting characteristic X-rays through proton bombardment is described. Typical results from analyses of algae, perch blood serum, perch liver, and sediment samples are presented.

Today I want to bring to your attention a new technique for trace element analysis that should be useful in evaluating many pollution problems of the Chesapeake Bay. The technique involves the excitation of atomic X-rays by bombardment with energetic protons. The X-ray production probabilities for such bombardments are sufficiently large that only small sample size is required. For example, one drop of blood is sufficient to detect trace elements in blood.

The technique is described schematically in Fig. 1. A beam of protons from the University of Maryland 3 MV Van de Graaff accelerator is incident upon a target sample. The incident protons pass through the thin target and lose a small fraction of their energy in the target by interaction with electrons in the target. Some protons remove electrons from the K-shell of atoms in the target with subsequent characteristic X-ray emission. The X-rays leave the target and pass through a 1-mil Be window on the target chamber and into a Si(Li) X-ray detector. It is the development of this high resolution detector that makes this technique so feasible and attractive. An X-ray from the target is completely absorbed in the active volume of the detector, producing an electronic signal of amplitude proportional to the incident X-ray energy. These signals are amplified and stored in a multichannel pulse-height analyzer. A measurement of the energy of the characteristic X-ray identifies the element in the target from which the X-ray originated. Knowledge of the number

[1]The author is an experimental nuclear physicist by training and has carried out numerous investigations into the structure of the light nuclei using nuclear reactions induced by ions from Van de Graaff accelerators. His recent interests have extended to using positive ions in studies of radiation effects, atomic physics, and trace element detection.

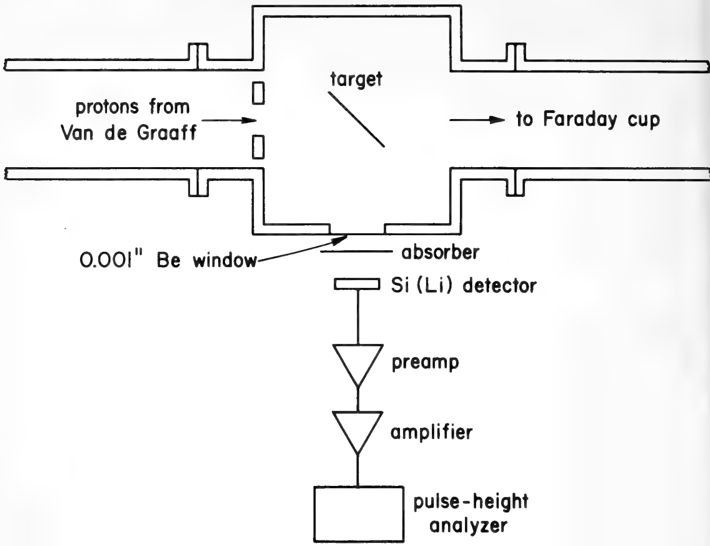


Fig. 1.—Experimental layout of the apparatus used for proton-induced X-ray excitation measurements.

of X-rays of a given energy indicates the quantity of the element in the target.

Several attractive features of this technique should be noted. Only a small quantity of a sample is required. In a given measurement all elements from silicon to uranium can be detected. A single measurement takes only 5-10 minutes, and samples can be remeasured with various absorbers between the target and detector to accentuate the detection of some elements relative to others.

This technique is currently being developed to detect the presence of trace elements in a variety of materials, including samples relevant to the Chesapeake Bay. The spectrum obtained from an algae sample is shown in Fig. 2. The X-ray energy is scaled along the horizontal axis, and peaks in the spectrum are labeled by the element corresponding to the characteristic X-ray energy. For elements lighter than the rare earths, K_α X-rays are strongly excited. Weaker K_β X-rays are observed for K, Fe, and Zn. For elements heavier than the rare earths, L-shell X-rays are strongly excited. The L_α and L_β X-rays for Pb are observed in this algae spectrum.

Pulse-height spectra measured for perch liver and perch blood samples are shown in Fig. 3. In addition to the many lighter elements identified in these spectra, there is positive evidence for the presence of Br in the perch blood serum and Se in the perch liver. The quantity of these elements present is of the order of ppm, and procedures are being developed to quantify such measurements.

For the measurements the samples were mounted on filter paper backings. This backing contributes very little to the trace elements observed but is responsible for a significant bremstrallung continuum which limits the detection of very small quantities. For comparison a pulse-height spectrum obtained from a sediment sample deposited on a thin carbon foil ($\sim$100 times thinner than the filter paper) is shown in Fig. 4. Nineteen

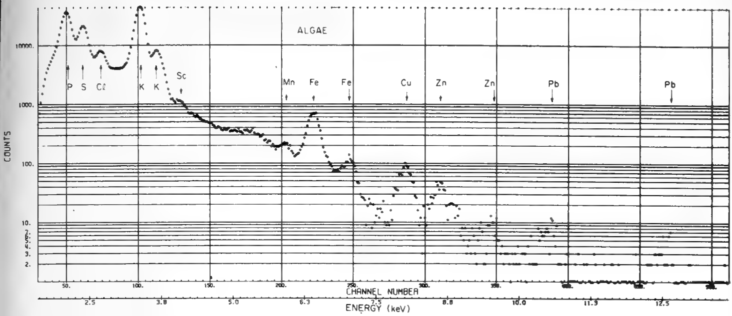


Fig. 2.–Pulse-height spectrum of X-rays from an algae on filter paper sample excited by 2.5 MeV protons.

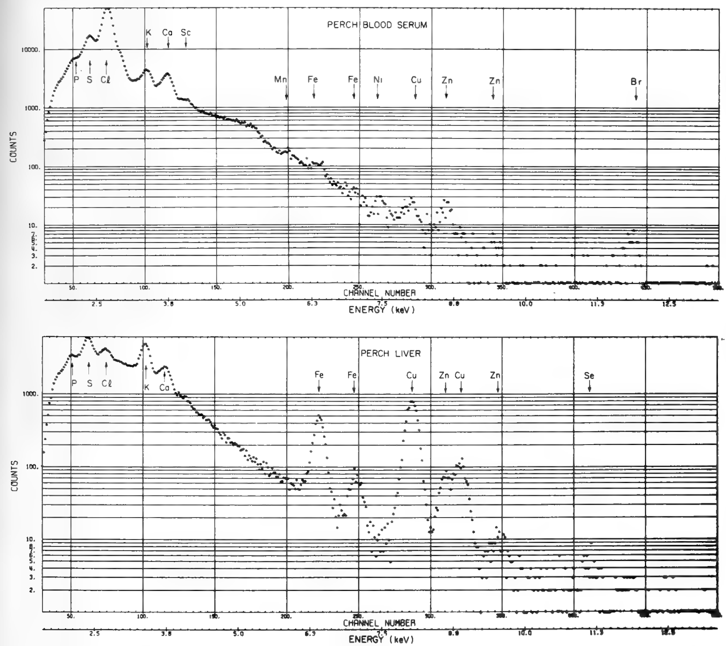


Fig. 3.–Pulse-height spectra of X-rays from perch liver (top) and perch blood serum (bottom) samples on filter paper excited by 2.5 MeV protons.

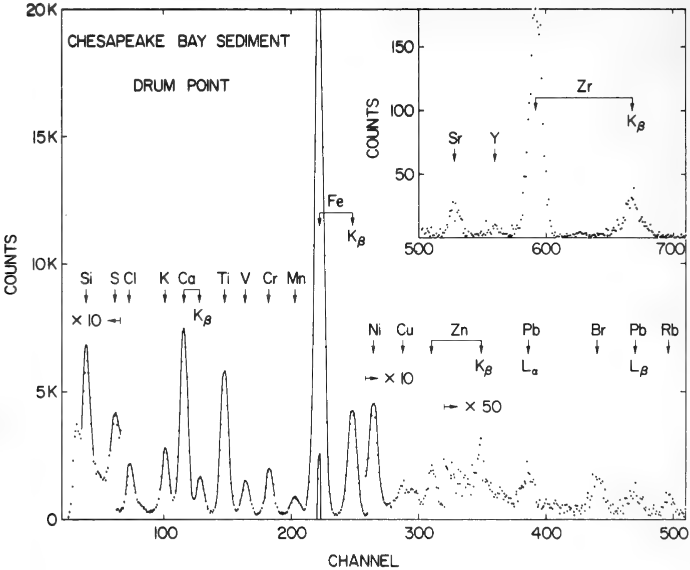


Fig. 4.—Pulse-height spectrum of a sediment sample taken from the Drum Point region of the Chesapeake Bay excited by 2.5 MeV protons.

different elements are positively identified in this spectrum, and the continuum in the lower portion of the spectrum is greatly reduced compared to the previous spectra.

Acknowledgments

The collaboration of M. L. Roush and P. Berman in this research is gratefully acknowledged. Appreciation is expressed to University of Maryland staff P. Orris (Botany Department) for the algae samples, R. Morgan (Chesapeake Biological Laboratory) for the perch samples, and R. Belcher (Chemical Engineering Department) for the sediment samples.

Human Wastes and the Chesapeake Bay

Thomas D. McKewen[1]

Director, Maryland Environmental Service, State Office Building, Annapolis, Md. 21401

ABSTRACT

The Chesapeake Bay is generally considered to be a healthy body of water, but its future quality is in jeopardy so long as major tributaries remain polluted. Past pollution abatement actions, and most current ones, were directed toward removing oxygen-consuming substances, solids, and microorganisms. New plant designs provide greatly increased removal efficiencies. Such increased efficiency is essential if present pollution levels are to be reduced as projected population growth takes place. In addition, nutrient reductions will become increasingly important. With improved treatment of sewage and industrial wastes, the effects of urban and rural runoff and sedimentation will become more important. Already silt is the most important pollutant in some streams and urban and rural runoff will become the limiting factors in water quality when adequate control of point sources has been achieved.

In geologic terms, the Chesapeake Bay is young. Early man may have witnessed the formation of at least parts of it. Some fear has been expressed that contemporary man may witness its destruction. And, of course, the same geologic and climatic forces that created the Bay a few thousand years ago will ultimately submerge the Bay under the ocean or convert it to dry land. Our narrow perception of time permits us to view such a future catastrophe with equanimity. The "Save the Bay" bumper stickers that were popular at one time were not a plea to prevent further fluctuations of the ocean level or to legislate against orogeny. They reflected a much more practical concern that *man's uses* of the Bay are being threatened.

What we are concerned about, then, is not the threat to the Bay, but the threat to the Bay's utility. What profits it a man to save the Bay if he cannot swim, sail, or fish it? This egocentric view, while it may not sound noble, is appropriate since the principal threat to man's use of the Bay is man's use of the Bay. To be more accurate, the principal threat is man's unwise use of the Bay.

It is important but not always easy to distinguish between wise and unwise uses, and between beneficial and harmful uses. In fact, the same use can be both wise and unwise, both beneficial and harmful depending upon such variables as time, location, and one's attitude. Some uses of the Bay are not even recognized as such by the user. The contractor or farmer who does not guard against erosion is using the Bay as a sediment trap. The community or industry which discharges liquid wastes is using the Bay as a waste transportation and treatment device.

Such uses are, in one sense, extensions of natural processes which occurred before man arrived on the scene. Erosion and subsequent sedimentation predates and likely will postdate man. Similarly, addition of organic materials to the Bay is a natural process that is in part responsible for the rich population of beneficial organisms in the Bay.

There is a vast difference, however, between natural rates of sedimentation and those existing today; and between natural runoff that bears life-giving levels of nutri-

[1]Mr. McKewen received his Bachelor of Engineering degree and his Master of Science in Engineering from The Johns Hopkins University. He has served successively in the Maryland Department of Health as Field Engineer, Division of Sanitary Engineering; Head, Public Water Supply Program; Head, Planning Section, Division of Water and Sewerage; Director, Bureau of Resources Protection; and Director, Environmental Health Services. He has held his present position since 1970.

ents and massive discharges that suffocate or expel higher forms of aquatic life.

The title assigned to this discussion implies that emphasis is to be given to problems rather than solutions. For this I am grateful, since it makes for an easier and safer task. However, it is not possible to separate the two cleanly, particularly since some of today's problems were yesterday's solutions.

To complete this prologue, I will make one more general remark. Attitudes toward wastes handling can be put in three general categories, labeled: discard, control, and manage. There has been an uneven but rapid evolution from the first to the last in recent years. As we go through a discussion of the unpleasant assortment of pollutants that comprise my topic, some examples will be given of this evolution and an attempt will be made to assess its significance.

Liquid Wastes

Sanitary sewage and industrial liquid wastes are the classic villains. Recently, they have been upstaged at times by such Johnny-come-latelies as heavy metals and thermal effects, but as sustained, publicly accepted threats, they have no equal.

The Chesapeake Bay drainage area is populated by about 10 million people, and this figure may double by the turn of the century. It would seem, therefore, that in order to hold the line at present water quality levels, we will in the future need to do twice as effective a job of liquid waste treatment as we are presently doing. Doubling the effectiveness of any kind of process is usually considered a substantial accomplishment. In this instance, such an approach would be naive. For one thing, doing no better than simply maintaining present water quality levels would hardly be a worthwhile accomplishment. For another, treatment processes commonly employed today are rather selective. For example, the performance of sewage treatment plants is usually stated as the percentage removal of oxygen demanding substances or BOD. By this measure, performance could be improved without reducing levels of phosphates and nitrogen–nutrients whose pollution potential is causing increasing concern.

Another complication is the changing value of liquid wastes. Today, with few exceptions, they are considered to have a negative economic value. However, as effluents of higher and higher quality are produced, coupled with increasing demands for water for potable, industrial, agricultural, and recreational purposes, it will become increasingly desirable and ultimately essential to reuse rather than discharge. Some types of reuse–drinking water is an obvious example–will require extremely high, and therefore expensive, levels of pollution reduction and reliability. Agricultural use, on the other hand, may require less expensive treatment than would direct discharge to a stream.

The handling of liquid wastes offers a good example of the previously mentioned evolution from discard through control to management. The time has long passed when the simple discharge of raw wastes to the nearest stream was considered acceptable. Such discharges from municipalities and industries were once the most serious pollutant in many tributaries of the Bay. The great acceleration in sewage treatment plant construction that took place during the past decade eliminated most of these. The major problems that remain are in the metropolitan areas of Washington and Baltimore. Barring an inconceivable backing-off from present projects and commitments, these problems will be eliminated and point source raw waste discharges need not be considered a long-range threat to the Bay or its tributaries.

Of more concern is the impact of controlled discharges–controlled both in the sense of receiving treatment before discharge and in the sense of being regulated by government. Although sewage treatment is not a new art, and some communities to their credit, built plants back in the days when polluted water and smoking stacks were viewed as symbols of economic progress, it is only recently that pollution control measures have kept pace with the growth of pollution generation. In Maryland, for example, it was not until 1968 that a chronological plot of sewage treatment plant capacity began to parallel and then approach a similar plot of sewage generated.

The effort to provide adequate treatment capacity is obviously not over. It will never be over so long as population and per capita waste generation continue to grow. But, at least, the trend is in the right direction and the quantitative battle appears to be in good shape. The effort to provide adequate quality of treatment is less clear. It is rather unsettling to look at the history of sewage treatment. At one time, simply achieving an adequate volumetric ratio between receiving water and raw sewage discharged was considered adequate, leading to the old adage, "Dilution is the solution to pollution." Then, plain sedimentation, or primary treatment, became the accepted minimum. More recently so-called secondary treatment, using biological processes to remove additional fractions of the pollutants, was set as the goal.

Now there is much discussion of further steps, usually, if vaguely, referred to as tertiary or advanced waste treatment. These terms are sometimes employed to refer to processes which are meant to improve the BOD or solids removal performance of a standard secondary plant, but they are more specifically used to designate nutrient removal facilities.

Few matters are more important to future protection of Bay quality than resolution of the questions concerning critical levels of nutrients in the Bay. The Chesapeake Bay is already rich biologically. Although over-enrichment does not appear to be an immediate problem in the Bay proper, it has occurred in tributaries such as the Potomac Estuary and Back River. Both of these bodies of water are in effect helping to protect the Bay, but at severe cost to their own quality.

The decision has already been made to include nitrogen and phosphate reduction at the Blue Plains Sewage Treatment Plant serving the District of Columbia and areas of suburban Maryland and Virginia. The extent to which such action will be required elsewhere has not yet been determined. The Maryland Department of Natural Resources has appointed a committee to review existing water quality standards and recommend changes in them where needed. A special subcommittee has been charged with examining the issue of nutrients.

Another important issue is reliability. As the performance of treatment plants improve, there is a commensurate need for consistency in that performance. High performance means high water quality that will support the more demanding and valuable forms of aquatic life and permit recreational uses. Even a fairly short period of bypassing, or discharge of poorly treated wastes, will have serious consequences in such waters.

Reliability will impose additional costs in construction, monitoring, and operation. This, coupled with increased costs brought about by the need for more effective treatment plants, will give increased emphasis to cost-effectiveness considerations. This is already becoming evident in the administration of the Federal and State grant programs. Although this is hardly the time to cut back on expenditures for pollution abatement, it is the time to make certain that the maximum water quality is purchased with the money available.

Surface Runoff

Similar in pollutional effects to domestic sewage and industrial wastes, but far different in its susceptability to control land runoff, urban runoff is a serious problem now and is likely to remain one for some time to come. The first increment of rain that flushes city streets, alleys, and yards has chemical and bacteriological characteristics not too different from those of raw sewage. Unlike raw sewage, however, it is not conveyed to a treatment plant prior to discharge but piped to a nearby stream along with the cleaner runoff that follows the initial flush.

Whether urban runoff can be considered a long-range threat to the Bay is problematical, but it clearly contributes to local water quality degradation. As cleaner water results from improved handling and treatment of sewage and industrial wastes, urban runoff will become proportionately more important. It may well become the limiting factor in attaining water quality.

The major problem with urban runoff is, of course, its volume. A system of pipes and other structures adequate to convey the runoff from a good-sized rainfall in a large city to one or even several treatment plants would be of staggering proportions. The plants, too, would be huge even though they would stand idle most of the time.

Several possible approaches are being explored, including storage followed by controlled release and treatment, treatment of the first flush only, and filtration at each storm water outlet. Near-future prospects for effective solutions are not bright.

Agricultural runoff poses many of the same problems, with the additional one that it is even less controlled; reaching watercourses through a diffuse array of trickles, rivulets, and ditches.

Fortunately, this area has not had to contend with the proliferation of huge feed lots that have seriously polluted streams in some other parts of the country. However, we have problems enough. On some streams agricultural runoff is an important source of bacteriological pollution and may be a significant source of nutrients. Like its city sister, agricultural runoff will increase in importance as the treatment of municipal and industrial wastes improves. Again, near future prospects for adequate control are not bright.

Urban and agricultural runoff have one other commonality. The best place to control pollution is at the source. In the city, this means improved solid wastes storage and collection. On the farm, it means improved methods of applying agricultural chemicals and managing livestock.

Sediment

To those who like to measure, photograph, and otherwise record pollutional effects, few pollutants are as obliging as sediment. Although, as mentioned earlier, sedimentation is a natural process, that process has been accelerated greatly by man and his activities. Forested land that may have lost 100 tons/mi^2/yr or less will lose several times as much when cleared for farming, and even more, though for a briefer period of time, when cleared for a construction project.

Some colonial ports in the Bay area can be reached now only by a flat bottom skiff or, in some aggravated instances, by a pedestrian. Other ports have not suffered this indignity because of frequent dredging. The Bay and most of its tidal estuaries are already quite shallow. They can ill afford rapid siltation.

Sedimentation is one pollutant which can be adequately controlled only at its source. Effective measures have barely begun, but new legislation such as that enacted recently in Maryland should permit substantial progress for the first time.

Some forms of pollution are of such magnitude and complexity that the individual citizen may feel he is powerless to make any significant contribution to their solution. This is not true of sediment. Anyone who owns or controls a piece of land can make a contribution. In fact, that is just about the only way the job can be done. Sediment control does not lend itself to radical technological breakthroughs or heroic single-shot solutions. Willing and knowledgable cooperation of many people will be required.

This leads to my final thought. Only in recent years has the magnitude of the pollution control effort begun to approach the magnitude of the pollution problem. It is hardly a coincidence that also only in recent years has there been a widespread expression of public concern over environmental control.

It was not until a few years ago that man discovered that he was not only surrounded by but was in fact part of the environment. The courtship between man and his newly found enviornment saw the strengthening of pollution control laws and budgets. The further discovery of ecology convinced man that he had better marry the environment before she gave her favors to a more prudent species.

Today, it seems, the excitement of the honeymoon is nearing an end, but the prospects for a stable and mutually rewarding marriage appear good. If so, the prospects for the Chesapeake Bay are also good; but should man become again inattentive and apathetic, the prospects for the Bay will be very dim. That may not make much difference to man though, for if impregnable apathy is to be his way of life, his prospects are also dim.

Questions and Answers

The Fate of the Chesapeake Bay: Major Threats

Moderator: **Dr. Ruth Patrick,** *Academy of Natural Sciences of Philadelphia*

Panelists: **Col. W.J. Love,** *Retired*
Dr. Gerald Walsh, *Environmental Protection Agency*
Dr. Michael Bender, *Virginia Institute of Marine Science*
Mr. Thomas McKewen, *Maryland Environmental Service*

Q—In the rivers oyster-metals study, was anything else analyzed—for example, hydrocarbon residues or herbicide residues?

DR. BENDER—No, just those elements we particularly mentioned. We did analyze for mercury but did not find those kinds of relationships. We have, however, a contract with Gulf-Breeze Labs for monitoring pesticides in 10 locations, and we have monitored for polychlorinated biphenyls and DDT since 1968. In the southern branch of the Elizabeth we find the highest levels of polychlorinated biphenyls reaching a peak at about 2½ parts/million in the oysters. The DDT levels are quite low in at least the lower portion of the Bay that we are monitoring. I don't believe we ever found a total residue higher than 0.2 part/million in the past. In localized instances on the Eastern Shore, when spraying operations occur, higher levels occur in crabs and in oysters.

Q—In your talk you made no mention of the hydrodynamic effects of the enlarging of the Chesapeake Bay-Delaware Canal. Can you say something about that?

COL. LOVE—Not too much. There will be effects of net transfers between the Chesapeake Bay and the Delaware Bay. These are under study now and have been under study for some time, but I don't know if reports have been made on them.

Q—Do you feel the Corps of Engineers should change the percentage of various land forms in Chesapeake Bay? If so, which type should be increased and which decreased?

COL. LOVE—I don't think the Corps of Engineers should change too many land forms. If the question were, "Should land forms be changed in the Chesapeake?" I would say as little as possible.

Q—Do the figures, amounts, and dollars on herbicides include employment by military in Viet Nam?

DR. WALSH—The amount used in Viet Nam is a drop in the bucket. With cessation of the use of herbicides in Viet Nam there is no change expected in the economy of pesticides in this country.

Q—Has there been any case of contamination of drinking water with pesticides in which standard water treatment practice has failed to remove them?

DR. WALSH—In 1964 the U.S. Public Health Service reported the presence of dieldrin and endrin in the municipal water of

Vicksburg and New Orleans. The report stated this was cause for concern, but clinical symptoms of pesticide poisoning were never observed.

Q—Any oyster with 10,000 parts/million of zinc is 1% metal. Have you tried to see how large an accumulation of zinc an oyster can contain without physiological complications?

DR. BENDER—No we haven't. It seems pretty evident from looking at their general condition that oysters don't seem to be particularly harmed by zinc. There have been several studies in South Carolina indicating about the same thing. I'm sure that at some high concentration some effect would be evident. With some metals like cadium and mercury I would be more certain. Some of the ores mined in various parts of the country are quite a bit lower than 1%. We are working on a wet-weight basis, but if you base figures on a dry-weight basis, that's a lot of zinc. It might be a good extraction technique.

Q—Drinking water standard for zinc is 5 mg/l. A man who eats lots of your metallic oysters would certainly get more zinc than his share. When do you expect the FDA to take action? What is the FDA's zinc recommendation?

DR. BENDER—To my knowledge there are no specific levels for metals other than mercury set for oysters or other seafoods. This becomes a big problem in deciding how many oysters or how much seafood at a particular level a person is going to consume. If studies are based on methods similar to those used to establish radioactivity standards, I think you would find that a person would have to eat a lot of oysters to be harmed. In many of these cases the oysters that are high in zinc are also high in copper, and people just don't like to eat green oysters. Greening has been found to occur much before any harm is done to the oyster itself. These oysters are not marketable for either soups or other types of use—they are just objectionable and, as you know, people aren't apt to eat a green one. I should clarify—zinc doesn't turn green, but in most cases when oysters contain that much zinc they are also green from copper.

Q—Apparently the 3 spoil areas you alluded to were the overboard disposal type. Were these areas vegetated by natural or man-made means?

COL. LOVE—I know of no attempts by man to vegetate in those cases I mentioned. Vegetation was extended or implanted in completely natural forms. I think the point is obvious. We can assist that process by implanting the grasses and the flora matching that of the wetlands, rather than waiting for several hundred or thousand years. We can assist nature in that respect.

Q—Are the plants that exist marsh plants or upland plants?

COL. LOVE—Marsh plants in all cases, because in all cases they show at least some chloride content. Although at Susquehanna and Havre-de-Grace, concentrations are very low.

Q—I think it should be pointed out that many spoil-disposal projects have resulted in either marsh destruction or in the replacement of good marsh with relatively unpredictable reed grass.

COL. LOVE—No question about it. Our management practices in the future can and should alleviate that to a good degree. However, we must recognize that if we are going to have places to take all these pleasure boats that we all seem to want to have in greater and greater numbers, some priority must be given to spoil areas where we cannot either effectively create good marsh lands or where we may have to dedicate to the use of spoil the existing possibly higher grade bottom or marsh land. This goes back to a system of priorities which Maryland, particularly, is assessing against their marsh lands—not necessarily for spoil purposes or for any other specific purposes, but for some priority or ranking. If we must have the boats, we need the channels. If we need the channels, we must maintain them. If we maintain them, then let's do the most productive thing with the spoil material from them.

Q–To what extent are ecological and atmospheric effects being factored into the hydrodynamic model of the Bay?

COL. LOVE–The Corps is trying to cipher out the atmospheric effects as much as they can. This is quite a problem because it works with a scale model as opposed to a full-scale normal situation. The effect of a falling leaf on a 1:1000 horizontal scale is a lot more than it is out in the Bay itself. The simple way, of course, is to enclose this structure to avoid the effects of dust, wind, and rain. Obviously rain would put you out of action. A hydraulic model is not a direct demonstrator of biological modeling by any matter of means; it is only indirectly by a study and prediction of current changes, for instance, that there can be some interrelationships drawn on the biological scale.

Q–Do you foresee any hydrodynamic changes associated with the Hart-Miller Island diked disposal complex?

COL. LOVE–Undoubtedly. Just as the emplacement of Crany Island, some 2 miles on each side, in the lower James had a gross effect, so will the emplacement of any contained spoil area have an effect any place in the Bay. The Hart-Miller proposal, being the size that it is, will have an effect. That effect must be studied, possibly modeled, and certainly analyzed. The detrimental effects must be minimized and very possibly the beneficial effects maximized. This can be done.

Q–What explanation can you give for urea-type and triazine compounds being more toxic to marine biota than fresh-water organisms?

DR. WALSH–I said that the urea and triazine herbicides were the most toxic compounds we have tested on marine algae. The urea herbicides caused a decrease in the amount of carbohydrate in algae. The decrease was greatest at 30 parts per thousand salinity and least at 5 parts per thousand. Perhaps there is a greater demand on carbohydrate reserves in relation to osmoregulation at the higher salinity.

Q–If $11.2 billion loss to insects in farm products occurred, what effect would this have on farm economics and soil-bank payments?

DR. WALSH–I see a conflict of interest.

Q–Perhaps what we need is more land in use but operating less efficiently without any pesticides.

DR. WALSH–There's no doubt we would like to use fewer pesticides if possible, and there is a great movement in favor of "organic" farming. With increase in numbers of the population, most people that I've talked to say it is impossible to continue to feed our people without pesticides.

Q–You have given very good data on DDT in seafoods. How does this compare with other foods, vegetables, and meats?

DR. WALSH–If you wash vegetables enough you won't have any problems because most of the pesticides are on the outside. The intake of insecticides by farm animals is quite well known. Their feeds are monitored for insecticide contamination, and in most cases if there is any contamination of animals it is lost rather quickly. I'm thinking of things like picloram and trifluralin, which are lost in a matter of hours after ingestion. You may find insecticides in the milk of cows, but after they are removed from the feed the levels in milk go down and are lost within a matter of days.

Q–As a result of rising concentrations of pesticides in the marine environment, it would seem we may already have caused major changes in the natural populations of lower trophic levels. Are there any data that have indicated such changes?

DR. WALSH–I'm not familiar with it. Cox has shown that the DDT concentration in algae in Monterey Bay has increased since 1964. Whether this has caused any changes in productivity I'm not sure. People often say that productivity is going down, yet it's hard to tell the cause. In some areas productivity is rising. Certainly there has been a decrease in productivity in many Florida bays; a lot of people would like to blame pesticides, but most of the people I have talked to feel that it results from a degradation of nursery grounds or a combination of things like industrial and municipal affluents rather than insecticides.

Q–From the shrimp studies, you have found high levels of DDT in the liver and pancreas. In man, there has been an increase in the incidence of cancer of the liver and pancreas, especially in the black male, and studies have shown higher residues of DDT in black males than in white males or females. Do you think there is a correlation between DDT in the environment and the increased incidence of cancer?

DR. WALSH–I don't know.

Q–EPA currently is conducting hearings on cancellation of all uses of DDT. Do you have an opinion on whether DDT should be banned? If so, why? If not, why not? If you feel it should, what do you feel might be the impact of a United States ban on developing countries that must use DDT for public health purposes?

DR. WALSH–I think DDT has done a good job for what it was made for. But a good example of banning DDT occurred in Mayala, where DDT was completely banned. Before that ban, malaria was virtually wiped out. Since that ban in the last few years, malaria has come back and has become a problem again. Now the Malayan government is starting to use DDT again. I believe that if DDT will do the job on a limited basis it should be used. However, I would like to see something less persistent used whenever possible.

Q–[Question not heard.]

DR. WALSH–My point was: There are cases when DDT has more goods than bads. If a situation arose in the United States in which the only solution was DDT, and either people were going to die of a disease or the pelicans were going to go, I would opt for the people every time.

Q–Because shrimp flushed out quickly, would other organisms?

DR. WALSH–Rapid flushing has been shown in oysters. Oysters are excellent in this regard, and they can be used for monitoring. According to Butler they reflect the level of DDT in water very accurately.

Q–You stressed the complexity of pesticide work because of numbers of organisms and numbers of pesticides. Then you generalized from 2 specific observations: 1) that because shrimp flushed out quickly, other organisms would; 2) that because toxic effects of DDT compared to PCBs on shrimp were higher, this relation would hold for other organisms. Please comment on this discrepancy.

DR. WALSH–I don't recall making such generalizations. I wish I could.

Q–Is total recycling of wastes the ultimate, hence preferred, mechanism of handling sewage and waste waters?

MR. MCKEWEN–Whether it is the ultimate, I don't know. You get kind of cynical about ultimates, especially after they have failed. There's no question that recycling, which really means reducing the residual you discharge to the environment to the minimum, will be a very major part of any kind of ultimate solution to the problem. At the moment a great deal of work is being done in solid waste recycling, and some recycling processes are now available for certain fractions of solid waste. There are some installations–not many and not very large–where sewage is being treated and is being sprayed back onto the surface of the ground. This may be one way to utilize the nutrient value of sewage rather than to discharge it to an environment perhaps not prepared to accept it. This method will require a much lower investment in capital operating costs in sewage treatment plants because it eliminates the step for advanced waste treatment. Chances are, present State and federal policies will lead to much wider use of spray irrigation in the future than we've seen today. Whether it is feasible to spray-irrigate sewage from a city the size of Baltimore or Washington is problematical. It might make more sense to recycle by providing very high degrees of treatment and then pumping the effluent upstream of the water intake. The step beyond that, which we are not prepared technologically to take, would simply be to make the outlet of the sewage plant the inlet of the water treatment plant. That step will undoubtedly come, but not in the immediate future. One kind of reclamation, hopefully to be practiced to a much larger extent in the near future, is the re-use of the solids removed from sewage during the treatment process. Instead of adding organics to the load that the water body is asked to take, put them back on the land where they can do some positive good. This process may require more money than to incinerate the sludge. Without going into economics and environmental control deeply, I would like to make the point that a number of things appear to be advantageous—filling in strip mines with fly ash or utilizing sewage sludge to reclaim barren soils. Many, perhaps most, of these will require a greater dollar outlay than some other lower-cost solution. The difference between the lowest cost and what is conceived to be the project of greatest social value will determine where those dollars will come from. Undoubtedly they will have to come from a form of public subsidy.

Q—You say sewage treatment will improve over the next 10 years—a very short time. Is there in fact a statewide plan in being for improving sewage treatment facilities?

MR. MCKEWEN—Obviously we have a plan for everything. Offhand I don't know how many primary plans are left. There were only a handful and they are programmed for early conversion to secondary. Beyond that I'm not certain at this point whether we go to advanced waste treatments at all plants or at most plants.

Q—Would you care to comment on the pollution caused by the marine toilets on pleasure boats? There are only 400,000 such toilets in the United States, and they are much used only on weekends and holidays. A navy vessel in the Bay would contribute much more, but both forces would appear insignificant. Why has the federal government banned marine toilets as a way to reduce pollution?

MR. MCKEWEN—It is rarely that I have a chance to speak for the federal government, so I welcome this opportunity. There are 2 kinds of effects of disposal from waste from boats. Neither of them have anything to do with either the overall or the long-range quality of a body of water such as the Chesapeake Bay, because the total amount of waste is quite small. However, in 2 situations it can be significant. One is at a marina or any other harborage where a large number of vessels are occupied over a long period of time. This local pollution has been measured a number of times—it obviously happens. In the case of the marina, the problem could be solved by the enforcement of regulations requiring the head and using shore facilities. The second instance in which it has significance, particularly in the case of the Bay, is where you have craft passing directly over shellfish beds and where fecal matter is being deposited directly on the shellfish. I don't know a way to quantify that hazard. I think we are safe in assuming that it exists. What is it worth to remove the hazard? Frankly I don't know, and I wouldn't want to guess. There is a third point: If we were really serious about the integrity of the environment, we would utilize any reasonable tactic we could to improve the quality of the environment. I think that part of the reason EPA has imposed restrictions on marine toilets is that this is simply another way to improve environmental quality. It is, if you will, part of an environmental ethic.

Q—Is there a possibility for making use of the wetlands' ability to convert nutrients to production in reducing expense of sewage treatments?

MR. MCKEWEN—Three years ago I made that suggestion in a letter and received about 50 letters in response, pointing out that I was trying to pollute wetlands, so I hesitate to say it again. I am not a biologist. A few biologists have told me they think there is some merit to this idea. Based on my past experience, I will let it drop at that and suggest you ask Dr. Williamson or someone else more qualified.

Q—Do you have data which correlates with incidence of hepatitis from eating raw oysters? If so, in this problem area, how do

Chesapeake oysters compare with those from Long Island Sound?

MR. MCKEWEN—Choosing Long Island Sound as a base for comparison makes the answer fairly simple. We are in far better shape. I'm sure there is some general data relating the incidence of hepatitis to eating raw oysters; people have contracted the disease when they have eaten contaminated raw oysters. To the best of my knowledge no incidents have been reported in Maryland from Chesapeake Bay oysters. I do have a recollection of 1 instance last year—the source proved not to be shellfish. I'm not aware of any hepatitis from this source in the Chesapeake Bay area. A public health person might provide a better answer.

Q—The pressures for residential development on DelMarVa and the western side of the Bay can be expected to become even greater in the future. The possible effects on the Bay would appear to be critical for discussion here. Could someone describe briefly the potential types of pollution, their various effects on the biota, in a cycle eventually impinging back upon man? Where do you see the trade-off between stopping pollution and continued economic development and new industrial processes?

MR. MCKEWEN—They are 2 interesting questions. I'm not sure anybody can do full justice to both. There is obviously mounting pressure to develop the DelMarVa peninsula. One response to that development pressure, for example, is in Queen Anne's County. With the new parallel Bay Bridge, greater growth can be anticipated in the area. They have learned from mistakes made on the Western Shore years ago. They are at the moment cooperating with our agency in conducting a study to bring about an adequate sewage system, to make it available just before the development explodes, if in fact that occurs, and to make certain that the growth of the sewage system parallels and anticipates the population growth. The tools are available for handling additional waste generated by a larger population. The big question is whether or not anyone desires a complete change in the character of the DelMarVa peninsula due to increased development—that is an environmental question rather than a waste management question *per se*. There is a trade-off between stopping pollution and continued economic development. No matter to what low level you drive residuals, no matter how small a percentage of polluting ability is left, something will always be discharged to the environment. And whatever that something is, one can postulate a population and accompanying industrial development that will cause even that low percentage of pollution to exert a very large effect on the environment. I don't think that you can take the extreme. I can't postulate any control measure that is going to be completely satisfactory if population and industrialization continue indefinitely. We have to assume that somewhere a plateau is reached. There is a trade-off that is taking effect right now at present levels. More and more of the gross national product, even though the amount may be small, is being put into pollution control measures. Not only does this have the effect of reducing the amount of waste being discharged to the environment—it also has the effect of reducing the gross national product, because any dollar put into sewage treatment is not a dollar that is turning out automobiles or electrical power, etc. As the percentage of the gross national product invested in environment control increases, as apparently it will for at least some time to come, some day an optimum balance between environmental pollution and economic sacrifices will be achieved. The greater the public insistence upon clean environment, the higher that balance point will be in favor of environmental quality, and conversely, the lower the pressure exerted for it, the lower will be the final point of environmental quality. The last part of the question had to do with new industrial processes. There is a point at which the industrial manager can achieve a certain quality of effluent by changing his process rather than by putting more money into treatment. As the standards for effluent quality become more stringent, I'm sure we can anticipate still more changes in industrial processes to reduce the investment in treatment facilities. Someone made the point this morning that perhaps power plants would be built on the ocean, but only if it could be demonstrated that the cost of building them on the periphery of the Bay had become unacceptable. This notion is the same one governing the paper mill that converts to a new papermaking process to reduce cost of waste treatment.

Q–Please estimate the fraction of sanitary sewage entering the Bay without treatment. Is it changing fast enough?

MR. MCKEWEN–I don't know if I can give you a precise fraction. The 2 major sources of raw sewage in the Bay today are Washington and Baltimore. In Baltimore several million gallons per day are lost by leakage from the many old sewers that aren't able to convey all the collected sewage down to the plant. In Washington, D.C., combined sewers discharge raw sewage into storm drains, and there are inadequate sewers and, at the moment, an inadequate sewage treatment plant. In both cities construction is underway now to eliminate the problem. It will take longer in Washington because doing something about some of the combined sewers is an extremely difficult and costly engineering problem. But the bulk of raw sewage now reaching the Bay should be reduced to a very low level in the very next few years by virtue of construction work either actually underway at the moment, or in the case of Baltimore City, about to get underway this current year. I would guess the fraction is presently somewhere under 4 or 5%. Within a few years it would be down well under 1%, and this value occurring only during rainfalls when combined sewers are surcharged by the combination of sanitary sewage and runoff.

Q–If you burn the sewage sludge at Blue Plains, what level of air pollution will be reached?

MODERATOR–I was going to answer in a sort of general way by saying that the incineration of sludge is a part of research to reduce the bulk of sludge without air pollution.

Q–What would be done with the burned sludge?

MODERATOR–This again is part of a research effort to find ways to incorporate this inert oxide product into cement or mortar, or to find some kind of beneficial use for it.

Q–Will oysters expel metals if they are placed in beds where metal concentrations in water and sediments are low? If so, what percent?

DR. BENDER–Oysters will lose metals. There is not a great wealth of data that can be relied upon concerning the exact rate of loss. Of course the loss depends upon the concentration you put them in. Pringel, in laboratory studies in which he raised the oysters to high metal levels fairly rapidly, showed a loss of 1mg/kg/day, with a suggestion that different metals vary slightly. Now that's not a very high loss rate in an oyster with 2000 parts/million zinc (or milligrams per kilogram, micrograms per gram, etc.). Obviously, it would take a long time for him to drop back down to a low level. All of the problems aren't answered, but there is no doubt that oysters lose metals this way.

Q–Many speakers have mentioned the dangers of persistent materials. The point has not been made clear how fortuitous it is that the flushing rate of Chesapeake Bay is as great as it is. Your problems would be compounded many fold if the flushing rate were cut in half and the load remained the same. Consider the problems in Lakes Michigan and Superior with persistent materials. The flushing times are 100 and 500 years respectively. Count your blessings. What is the flushing rate for Chesapeake Bay?

COL. LOVE–I don't know. The flushing rate of the Patapsco River, Baltimore Harbor, is about 15 days. This is indeed fortunate because a strictly freshwater transfer series of coefficient would give you on the order of 200 days. We get a lot of help from other currents related to salinity differences found in the tidal estuaries. Yes, indeed, we can count our blessings. We get a lot of help from Mother Nature!

Q–Is the Bay sick? Five characteristics: 1) very high plate counts of 2000; 2) poor land-use planning (i.e., Calvert Cliffs and Columbia LNG in pristine areas); 3) high pollution in Baltimore Harbor and the Potomac; 4) low water clarity; and 5) shores of the bay littered with junk.

COL. LOVE–I've already answered that. I don't think it is sick. It has a few rashes here and there that we have to treat before they grow together.

DR. BENDER–I don't know if I want to answer that either. However, recent studies conducted by the Virginia State Health Department and reviewed by the FDA have resulted in the closure of relatively large areas previously open to the direct marketing of shellfish. Unless appropriate measures are taken to treat sewage adequately, these types of actions will continue as the population grows.

DR. WALSH–Coming from Florida, I'm afraid I don't know enough about conditions in the Bay, so I'll pass.

MR. MCKEWEN–The questioner has obviously reached his own conclusions. I don't think the Bay is sick. I think the tributaries of the Bay are sick, and that sickness can spread and in fact was spreading until recently. It has been checked but by no means has been pushed back. That is still going to take some effort and time. The evidence seems to indicate that improved land-use planning could turn out to be one of the most important actions needed to protect Bay quality. I don't know whether this group ever plans to conduct future seminars of this type, but if so, one might well be held on the question of land-use policy as it relates to environmental quality.

Q–What funds are available and projected in Maryland for pollution abatement: air, water, solid waste, Chesapeake Bay?

MR. MCKEWEN–I don't have all those figures in mind, but I can give you some. For water pollution the State has provided about $175 million during the past 10 years, $150 million of that over 3 years for grants to counties and municipalities for sewage treatment plant construction. The budgets for the 2 regulatory agencies–the Division of Water and Sewage in the Health Department and Department of Water Resources–during the past few years have at least doubled. The Air Quality Division in 1968 comprised 4 or 5 people who were really equipped to measure air pollution rather than to reduce it. That Division now has about 75 people, a commensurate increase in equipment, and a much stronger law. About 5 years ago 1 man was devoting somewhat less than half his time to solid waste. There is now a division in the Health Department for solid waste control which employs about 20, and additional people are employed by county health departments in control of solid wastes. Trying to be as objective as I can, I have to add that the State put in a new liquid-waste and solid-waste management agency, the Maryland Environmental Service, just last year. So the State has greatly increased both regulation and direct financial assistance as well as making management assistance available to local government and to industry. I think the effects are showing.

Research to Counter the Threats to Chesapeake Bay Opening Remarks

Rita R. Colwell, Moderator[1]

At this juncture we might pause to consider what has been covered in the talks comprising the first 2 of the 3 sessions of this Symposium. The physical, chemical, biological, socio-economic, and industrial aspects of the Chesapeake Bay, in terms of the current situation and present needs and demands on this resource, have been touched upon in the first session. The current status of the Bay—its "vital signs," as it were—have been described. The threats arising from the alterations and impositions of man upon the Bay have been cited, in part, by the speakers of the second session. We now reach the most important considerations: What future uses and needs can be predicted for Chesapeake Bay and what are the research activities that should be carried on to permit informed decision-making in meeting these future uses and needs. It is in the socio-economic and political arena that the judgements most seriously affecting the survival of a viable, healthy, and aesthetically pleasing natural resource as the Chesapeake Bay are made. The Chesapeake Bay, as any living entity, can be depleted, rendered nonviable, and destroyed. It can, on the other hand, be used wisely and resourcefully. Wisdom, in this instance, must come from knowledge and the knowledge from research. The last session, thus, is devoted to exploring the research that is needed to know Chesapeake Bay and to use it wisely.

[1]For Dr. Colwell's affiliation and biographical sketch, see "Introduction to the Symposium."—Ed.

Research and Decisions

James B. Coulter[1]

Secretary, Department of Natural Resources, State of Maryland, State Office Building, Annapolis, Md. 21401

ABSTRACT

Although man can create changes in the Bay, very few of the changes he makes are irreversable; man's concern to save the Bay may be based primarily on a false sence of his own importance. Many large-scale phenomena such as siltation will continue despite man's attempts to create change. Therefore, he must set goals that do not conflict with the overpowering natural forces that continue to operate. Likewise, he must not over-anxiously apply controls to apparent pollution that, in effect, is natural to the Bay and its life. Man requires 6 capabilities for the effective handling of the Bay's problems: a) to measure phenomena accurately, b) to analyze the data, c) to predict the effects of man-made changes, d) to test action decisions, e) to command action, and f) to follow up action with further changes.

Researchers are motivated for any number of reasons. Some search for truth out of curiosity alone. Others diligently investigate simply because they are driven by a restive mind that won't stop until its thirst for understanding of some phenomenom is quenched. Some seek the fame, others seek the fortune that new discoveries can bring.

Without passing any form of judgment on the potential contributions of the curious, or the restless, or those that seek fame or fortune, my comments, for what they are worth, are directed to a different group. Hopefully, these remarks will be helpful to a handful of dedicated scientists who choose to do research that will improve decisions which could affect the fate of the Chesapeake Bay.

Admittedly, the goal is narrow in scope and pragmatic in nature. But the scientific complexities of the Bay form a worthy challenge for the best of mortal minds, and while the potential for world-wide fame is rather low, few goals are more important to the future of Maryland's natural resources.

While I do not pretend to have the intelligence or scientific skills needed to direct researchers, I do have some knowledge of the Chesapeake Bay and in relation to the decisions that will affect its fate. It is convenient to think of those decisions in 2 categories, short-term and long-term.

The short and the long have very little to do with time as it relates to the Bay itself. I count myself among those who would "Save the Chesapeake Bay". But sometimes I wonder, save it from what? What is the evil that threatens to destroy the Bay? Is it municipal and industrial pollution with

[1]Mr. Coulter received a Master of Science Degree from Harvard University in 1954 after completing graduate study in Sanitary Engineering. His undergraduate degree, in civil engineering, was obtained in 1950 at the University of Kansas. His association with the State of Maryland began in 1966 when he joined the Department of Health as Assistant Commissioner for Environmental Health Services, providing direction for department programs embracing air quality control, solid waste disposal, water supply, sewerage, food and milk, shellfish sanitation, radiological health, drug control and sanitation.

Mr. Coulter is Chairman of the Council on Environment of the American Public Health Association. He is a Diplomate of the American Academy of Environmental Engineers, and a member of Harvard University's Visiting Committee to the Department of Engineering and Applied Physics. He is the Commissioner for Maryland on the Ohio River Basin Commission and serves as Governor Mandel's alternate on the Susquehanna River Basin Commission. He is also active in a number of other regional and national environmental councils and commissions. He was appointed Secretary of the Department by Governor Marvin Mandel on September 22, 1971.

over-abundance of algae and sporadic major fishkills? Is it commerce with boats and bridges and shellfish farms that would take precedence over pleasure craft, sportfishing, hunting, and uncluttered scenery? Is it the pesticides, PCB's, heavy metals and other poisonous compounds? Is it the proliferation of power plants, the consumptive loss of water in the Susquehanna, or the destruction of wetlands?

Some say it is all of those coupled with the many careless acts of man. But I wonder. With a few all-important exceptions, what man has done, he can undo. If man picked up all of his visual works and left the scene, the Bay would forget him in a hurry. I have heard it said that the upper Bay has a memory of about 2 years. Which means that after as little as 2 years—or more conservatively if you like, by the end of a decade at most—man's former influence on water quality and aquatic life of the Bay would be undetectable.

Man's residues might be found in inert deposits by some later-day intelligence. Otherwise, the Bay could and would forget him, provided that man had not committed one or more of a few unforgettable acts. If he changed the composition of gasses in the atmosphere permanently, if he fouled the natural water cycle with indestructible substances that evaporated and condensed exactly like water, if he altered the terrain in a way that created a new hydrodynamic regime, if his wastes induced lasting mutations, or if he wiped an entire species from the face of the earth, the Bay would not forget.

Where there is any reasonable chance of producing an irreversible change, control agencies should be ultraconservative. On the other hand, in most matters, I wonder if our concern to save the Bay isn't somehow rooted in a false and exaggerated sense of our own importance. Compared with the natural forces at work, man's efforts are puny indeed.

The Bay was created by a slight adjustment in the earth's surface. Our geologists tell us that in terms of the earth's history, evidence shows that such adjustments are frequent. Any one of a number of events that have a definable possibility might occur that could greatly alter or completely eliminate the Bay as we know it.

In fact, one such event is occurring even now. The Bay is very young. The soil that makes up much of the eastern shore is not stable when wetted. As a result, shore erosion is progressing at an alarming rate. To put it another way, the eastern shore is washing away. Do we let it go, hoping that erosion will stop before Bay meets ocean, or do we save the Bay. If so, where do we get the money and how do we overcome the argument that the land saved isn't worth the expenditure required for erosion protection?

A fool might claim that God is dead (and thereby open himself to a request for proof that God was alive as a condition to proving that he is now dead), but it would take a super fool to claim that natural forces shaping the face of the earth have ceased to act. Nowhere is this more evident than in the control of sediment. Sediment is a major source of pollution, and Maryland is having measurable success in controlling it. However, success is not measured against a goal of preventing silt from entering the Chesapeake Bay. During intense storms last summer, more silt was carried into the Bay within a few hours than had been retained on the land by all of the control works in operation throughout the year.

Do we save the Bay from all silt pollution or even a major part of it? If you feel we should, visualize the Potomac Valley and estimate how many millions of tons of silt were transported downstream while it was forming. Now, concede that the forces that formed the valley will go right on working until the last hill is leveled, and the fall line at Great Falls recedes to meet the Ohio divide.

With a series of high and low dams in conjunction with other works, energy could be absorbed and much of the silt could be controlled. Those measures would depart from the concept of a free-flowing river, inundate the C & O Canal, and in other ways cause changes that many people would dislike. In fact, so strong is the resistance that there is little likelihood in the near future of a major dam being built on the mainstream anywhere near the head of the estuary.

In the meantime, 2.5 million tons of silt pour into the Potomac every year. Experts have estimated that at this rate the Washington shoreline will silt in within the next 50 years.

In the face of nature's mighty forces, misconceived and misdirected efforts to control the environment are simply pathetic. They might be compared with the well-organized efforts of an industrious colony of ants building an ant hill in the path of a bulldozer.

I am not saying that man should abandon his new-found ecological conscience. I am not saying that man should quit trying to improve the quality of his environment. I am saying that he would be wise to set goals that will satisfy him for some reasonable period of time after they are reached, goals that are not in conflict with the overpowering natural forces of the system, and goals that have a reasonable expectation of accomplishment within the time horizon and within the cost burden that man is willing to tolerate. Otherwise, we are not too different from the ants doing their tribal thing in the shadow of the bulldozer.

In this setting, the 2 categories of decisions, long-term and short-term, are related to man's time opportunities as opposed to the natural time-related changes affecting the Chesapeake Bay. Short-term decisions could relate to the operation of works that are in place and functioning. For instance, the operation of a sewage treatment plant, or the release of water from Conowingo Dam, or the shifting of the load from one generator to another in the power grid. Short-term actions could include the measures taken to avert disaster or minimize damage during an emergency such as a major oil spill. Another example is the choice of strategies to minimize losses or to give the best chance of avoiding some catastrophe during adverse weather periods.

Long-range decisions are made with greater deliberation because of their long-range commitments and consequences. One set of these decisions concerns new investments for environmental control. Typical would be the location, size, capability, and date of construction for a sewage treatment plant. Another example that illustrates a common situation is the choice between once-through cooling or a recirculating cooling tower for a thermal process. If no tower is provided, the heat-induced damage to the Bay might be greater than expected and too great to tolerate. In that event, a cooling tower would have to be built. On the other hand, if the cooling tower were built and it was found that the losses created by salt drift were greater than expected and too great to tolerate, the tower might have to be taken out of use. However, in that event, the cost of the tower would be a complete loss.

Another type of long-range decision is found in environmental laws. It might be argued that laws can be changed as fast as law makers change their minds. In fact, that is the case in the water pollution control field. Nevertheless, the law in effect at any one time is enforced. Those complying take the law into consideration, and it weighs heavily on their selection of water pollution control measures. A subsequent change in the law might render their earlier decisions obsolete and set off another round of long-range decisions. However, the control works that result from the first decisions are still in place. They must be paid for, and even though their usefulness might be diminished or eliminated entirely, their presence becomes a condition on the next set of decisions.

Other long range decisions include the location and controls placed on major industries, environmental inputs for land use planning, and the choices that must be made from the ever-present array of conflicting goals. The adoption of water quality standards for the Chesapeake Bay represents a very special case of long-range decision making. The clean-water crusader, acting on good intentions and misinformation, often ignores an inescapable fact. Impurities contained in the waters of the Chesapeake Bay promote its productivity and make it the treasured natural resource that it is. If it

To my knowledge, no one has made an accurate inventory of the tons of phosphorous that leave the Bay with the harvest of sport and commercial fishes, including the crabs, oysters, and clams. The little knowwere not for organics, nitrogen, phosphorous, traces of heavy metals, and all of the other vital impurities, the waters of the Bay would be clean, clear, and unproductive.

There seems to be a natural tendency to pass laws and adopt regulations that in spite of any good intentions would result in harm to the Bay if enforced. For instance, under the recent amendments to the Water Pollution Control Act as passed by the Senate, the intrusion of salt water into estuaries would be prohibited. Federal guidelines have been developed, and while their legal status is unclear, they are in fact being used to regulate the disposal of dredged materials. The guidelines list permissible concentrations of heavy metals that in some cases are far below the concentrations found in natural deposits in the Bay. For instance, the zinc concentration is one order of magnitude greater than that permissible under the federal guidelines in the pleistocene deposits laid down about 10 thousand years ago.

Contrary to the flurry of concern over phosphorous—the laws that would ban the use of phosphate detergents and the frantic search of scientists for the mythical phosphorous concentration below which blue-green algae could not bloom—literally nothing is known about the daily replenishment of phosphorous needed to keep the Chesapeake Bay healthy and productive.

ledge that is available concerning the fraction of phosphorous released by decaying plants and organisms that becomes locked up in the bottom layers and deposits seems to be ignored. There must be a net transfer of phosphorous between that carried in by the bottom currents of ocean waters entering the Bay and that which empties out into the sea. If in the long run, it is shown that the sea water, including the living things in the water, brings more phosphorous into the Bay than the Bay discharges into the ocean, our expenditures to control phosphorous from sewage discharges might seem futile if not absurd.

Let me close with a description of 6 basic capabilities required by the decision-maker in arriving at the greatest return for his efforts in doing something about the Bay:

- The ability to measure events accurately.
- The ability to bring all of the measurements together and analyze and display them in a meaningful way.
- The ability to predict the effect of man-made changes based on such measurements.
- The ability to test action decisions based on economics and the social sciences in combination with the physical sciences.
- The ability to command action.
- The ability to follow up our actions by creating further changes that may result from our previous activity.

Then, the cycle begins anew by undertaking the task of measuring events in the light of our actions.

Physical-Chemical Crisis Indicators—Are There Any?

Jerome Williams[1]

Associate Chairman, Department of Environmental Sciences, United States Naval Academy, Annapolis, Md. 21402

ABSTRACT

The variation of pH, salinity, oxygen, and temperature is examined at 3 different locations in Chesapeake Bay. It is shown that the natural variation is so great that any attempt at delineating a dangerous environmental situation by the simple monitoring of any single parameter would probably not be successful. The concept of a station signature is introduced, where the ratio of extreme value to average value is plotted for a number of selected parameters. Since these ratios are non-dimensional, the relative variation of different parameters may be directly compared. Even though these signatures vary from station to station, the treatment of a series of different parameters together seems to hold more promise than that of one parameter by itself.

At this time there appears to be no magic black box which may be implemented to signal a crisis. Future work seems to be required in the areas of background determination for desired parameters, investigation of wide extreme persistence, effects of the same magnitude change in a particular water property at different levels of the same property, and the effect of a particular variation of one parameter at different levels of another seemingly independent parameter. It is suggested that the choice of crisis indicators should be determined by the particular ecological problem involved and will probably be different for different types of problems. Not only is it necessary to measure a series of parameters rather than 1 to indicate a crisis, but it also appears that data must be taken over a long enough period of time so that an average value for this period may be determined with which to compare the extreme values encountered.

In the previous papers in this symposium Chesapeake Bay has been described as a long, thin estuary with an average depth somewhat less than 10 m. This estuary is a very dynamic one, with "new" water being added from the ocean in addition to the fresh water input from the rivers. The river flow and the tidal forces drive the circulation of the Chesapeake Bay and produce the flow patterns that are found to exist. Contrary to some other types of arms of the sea, the physical processes of evaporation and wind seem to have a very small effect on the average flow conditions of the Bay, although they may have a strong short term effect.

In order to examine such a system and delineate any crisis indicators which may be utilized in environmental management, it appears necessary to determine first exactly what is meant by a crisis. Ostensibly a crisis is a situation wherein one or more water properties have reached such a value that the Bay is lessened in its usefulness for beneficial purposes or has reached a point where there is a public outcry. These 2 events may or may not be causally related. Generally speaking, there is an implication of some large variation from normal value of a particular parameter or group of parameters. However the definition is a rather subjective

[1]Mr. Williams received his undergraduate training in physics at the University of Maryland and his graduate training in physical oceanography at The Johns Hopkins University. He has been employed in various research and teaching positions by the Chesapeake Bay Institute and the United States Naval Academy, where he is presently Associate Chairman of the Environmental Sciences Department.

The author of many technical and scientific papers, Professor Williams has also written 3 books and has 2 more scheduled for publication in the near future. He has recently finished the design and development of a series of estuarine instruments suitable for high school use which is being marketed by a major instrument manufacturer. He is a member of a number of professional societies and is Vice President of the Estuarine Research Federation. His major research interests lie in the fields of underwater optics, instrumentation, and estuarine physics.

one because the words "large" and "normal" are somewhat difficult to characterize quantitatively. It is supposed that the term "large" will be defined in laboratory and field studies by the biologist who will determine the limits to which organisms may be stressed. The term "normal" will be discussed in this paper.

Stream Flow and Tidal Variations

The natural variation of most measureable parameters in Chesapeake Bay is very large. An excellent example of this is involved with the 2 driving forces mentioned previously as being responsible for the flow patterns found in Chesapeake Bay. Fig. 1 shows a plot of monthly maximum and minimum values for the stream discharge of fresh water into Chesapeake Bay during the period 1951-1971. The numbers appearing at the ends of the vertical lines indicate the year in which these extreme values occured. It may be seen that the monthly maximum amount of fresh water discharged into Chesapeake Bay in 1958 is 30 times as great as the monthly minimum discharge in 1964. Even when comparing the maximum and minimum values experienced in 2 record years during the same month, a wide extreme is found. For example, in the month of April the maximum value is about 4 times as great as the minimum value, going from about 65,000 to about 240,000 ft^3/sec.

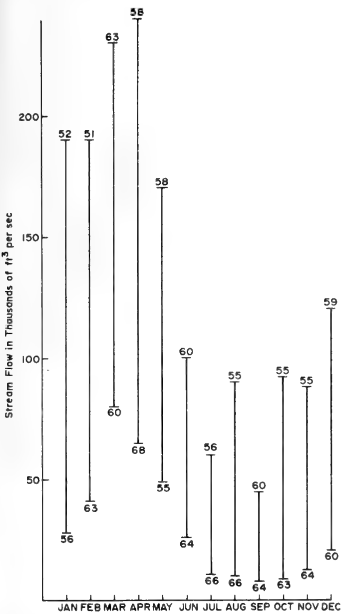


Fig. 1.–Stream discharge into Chesapeake Bay, 1951-71. Monthly ranges.

Tidal currents also vary rather markedly and within a relatively short period of time. This is demonstrated by the difference between the spring and neap situation. In Fig. 2 is shown a typical tidal current record for a point near the Chesapeake Bay Bridge in January, 1970. During the neap tide period the maximum tidal current range is about 1.5 knots (0.9 flood to 0.6 ebb). During the spring tide, following about 7 days later, the maximum range is about 2½ knots (1.3 knots maximum flood to 1.2 knots maximum ebb). Comparing these 2 extremes shows a ratio of 1.67, indicating that within a period of a week the tidal currents changed by almost 70%.

In addition to the extremes in water velocity due to the effect of the tide, the tide also moves a large volume of water past any given location. During 1 tidal cycle (about 12 hours, 25 minutes) of this spring tide, for example, a water mass almost 6 nautical mi long will have passed over an oyster on the bottom in this area. It is not surprising, then, that when various chemical and physical water properties are observed, they are found to vary a great deal.

Choice of Parameters and Stations

Four parameters are examined in this paper, but there are very many others that could have been included. A partial list of physical-chemical properties of interest in pollution studies might include the following: salinity, temperature, nitrate, hydrogen-sulphide, phosphate, pH, oxygen, turbidity, currents, water color, smell, taste, fluorescence, and radioactivity, in addition to fresh water inflow and the magnitude of

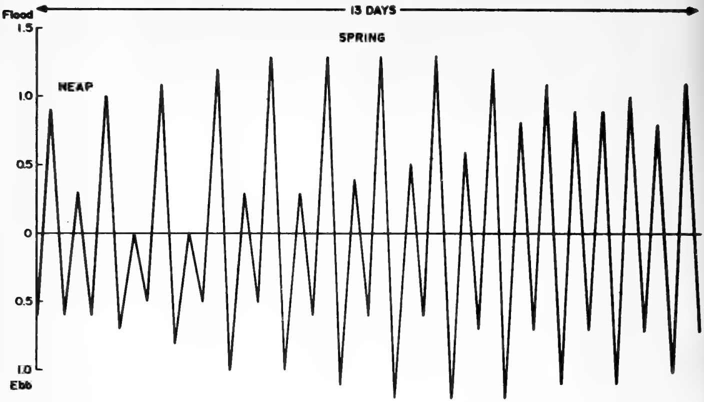


Fig. 2.–Typical tidal currents off Sandy Point over period of 13 days.

tidal currents. Many of these, such as color, smell, and taste, are difficult to measure quantitatively, and there is very little data available for others. For these 2 reasons only pH, salinity, dissolved oxygen, and temperature where chosen for this study. It was also felt that these 4 parameters are probably as characteristic of unspoiled environments as any others.

Most of the data used covered a period of about 10 years and were obtained from a total of 31 cruises occuring at more or less random intervals. Although these cruises were scattered throughout the 4 seasons (since the summer is more amenable to work at sea), somewhat more summertime data is available than for any of the other seasons.

Fig. 3 shows the location of 3 stations that were chosen to examine these data. One is located in the upper portion of the Bay about 4 mi north of the Chesapeake Bay bridge, 1 in the middle of the Bay very close to the mouth of the Patuxent River, and 1 in the lower portion of the Bay just opposite the entrance of the York River. Station 707ϕ and 904N both have a depth of about 12 m, while station 818N has a depth of about 14 m.

pH

The variation of pH at the 3 stations is shown in fig. 4. As before, the numbers appearing at the top of the vertical lines indicate the time at which the extreme value occurred, in this case the month, while the lines span the maximum and minimum values. For each station there is a surface (S) and bottom (B) data series that encompasses a 10-yr period, and for 1 of the stations there is another data series taken on cruises made about every 4-6 weeks for a period of 2 years. These latter data were obtained at the surface and at a depth of 10 M. Note that the pH varies markedly at all levels, but that the greatest range appears to be in the freshest water (Station 904N).

Salinity

A similar type of plot for salinity at these 3 stations is shown in fig. 5. As would be expected, stations closer to the ocean have higher average salinities, but note that the maximum surface salinity recorded at Station 904N is greater than the minimum surface salinity recorded at Station 707ϕ, about 120 mi south. An additional set of data is shown in this figure in that a 12-hr tidal cycle was examined with hourly read-

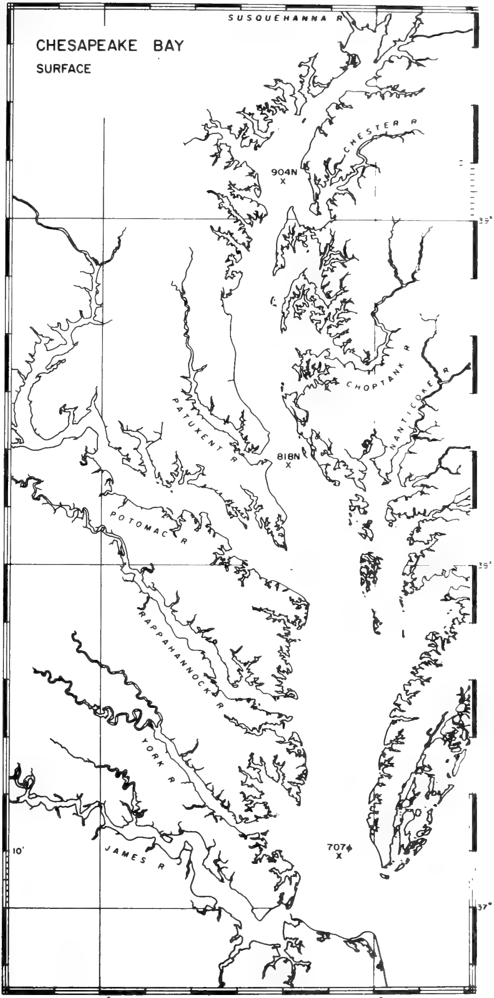


Fig. 3.—Location of Chesapeake Bay stations.

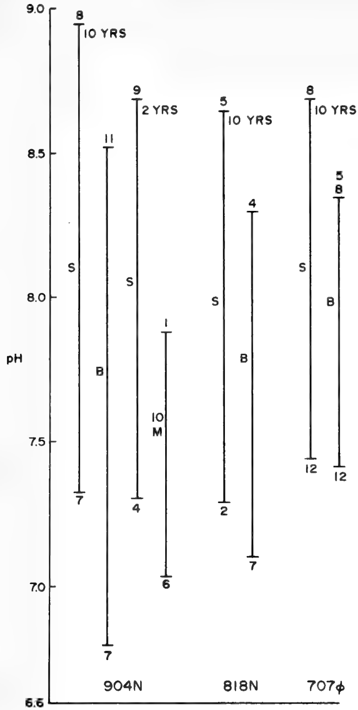


Fig. 4.–pH range of 3 stations in Chesapeake Bay.

ings taken at stations 818N and 707ϕ in the month of May. Even over a time period as small as 12 hours there is a salinity variation of as much as 2°/oo.

Dissolved Oxygen and Temperature

In fig. 6 is shown a similar type of variation for dissolved oxygen. Note that during the summer months the oxygen level on the bottom and even at a depth of 10 m is extremely low. There have been occasions where zero oxygen has been reported, although they did not appear in these sets of data.

Fig. 7 shows similar variations for temperature data including tidal cycle data taken at the same time as the salinity observations shown in fig. 5. Note that within a 12-hr period the surface temperature variation at station 707ϕ was about 3°C.

Not only does the local temperature vary markedly both seasonally and daily, but the variation in temperature throughout the Bay may also be very great. Fig. 8 shows the surface temperature taken during a cruise in August, 1961 over a distance of about 150 mi from the head of the Bay down to the ocean. The 3 stations considered in this study are pinpointed on the abscissa of the graph. There is a total range of temperature shown here of 8°, and even though these data were not taken simultaneously, they were obtained within a period of about 3 days. The anomalous blob of warm water appearing in the southern section of the Bay during this period is unexplained at this time, nor is it known how long this condition persisted.

The Station Signature

It appears from these data that any attempt to pinpoint a crisis on the basis of extreme values, of at least these 4 para-

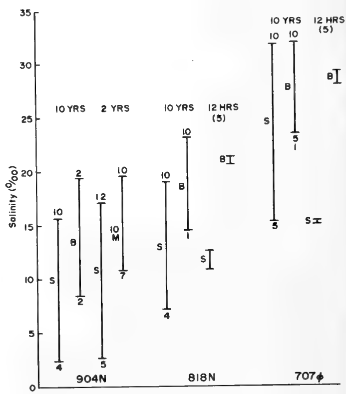


Fig. 5.–Salinity range at 3 stations in Chesapeake Bay.

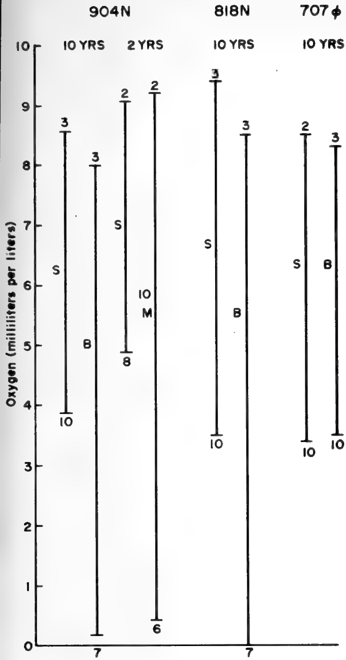


Fig. 6.–Dissolved oxygen range at 3 stations in Chesapeake Bay.

meters, would be somewhat useless since extreme values are not that uncommon under natural conditions. In order to classify more accurately the nature of unusual values it would seem somewhat more meaningful if the variations were compared to some measure of central tendency (an average of sorts) rather than examined as large or small independently. One possible method of doing this is to develop an extreme-to-average ratio for each parameter using all of the data at hand. This ratio seems highly useful if the assumption that something akin to the Weber-Fechner Law holds for the response of organisms to extreme changes in the environment. This law, although designed for the description of threshold values in perception, seems as though it might be applicable here.

The Weber-Fechner law states very simply that the minimum stimulus an organism can detect is related not only to the magnitude of the stimulus but also to the ambient level above which a response must be elicited. Thus, sounds very small in magnitude may be heard if the surroundings are very quiet, but in order to hear sounds in a very noisy atmosphere these minimum perceptible sounds must be quite large. It is suggested that this relationship be extended to the critical extremes of the environment. Thus we shall assume that small changes in the environment occurring at low ambient levels are just as dangerous as large changes imposed on high ambient levels. A salinity change of 1°/oo in an area where the average salinity is 3°/oo may very well be just as damaging to certain organisms, for example, as a salinity change of 10°/oo in an area where the salinity averages 30°/oo. It thus appears that the ratio of the extreme value to an average might be somewhat more meaningful than the extreme value by itself.

An average for some time period of the available data was calculated for each of the parameters, and the extreme values for these periods were then divided by the aver-

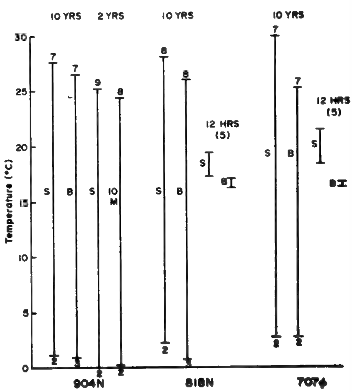


Fig. 7.–Temperature range at 3 stations in Chesapeake Bay.

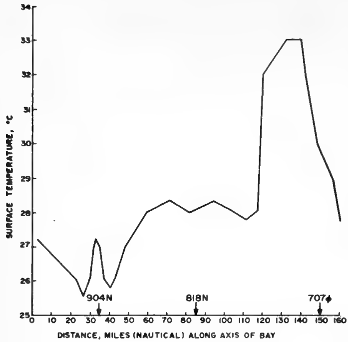


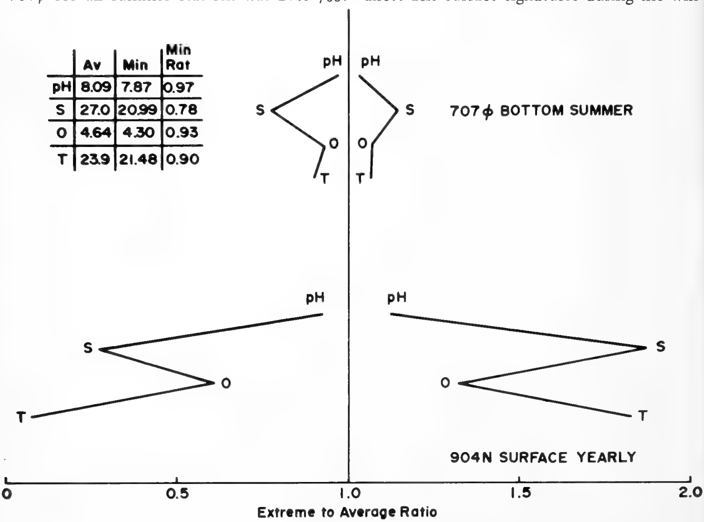
Fig. 8.—Surface temperatures along axis of Chesapeake Bay, August 1961.

ages. Fig. 9 shows the results for 2 particular locations. In the upper left corner a little table of the raw data is indicated to show the mechanism involved. For example, the average of salinity at the bottom of station 707ϕ for all summer stations was 27.0°/₀₀. The minimum value measured during the summer was 20.99, therefore the minimum ratio was 0.78. This is plotted at the top of fig. 9. The same type of calculation was made for both maximum and minimum values for all 4 parameters for Station 707ϕ on the bottom during the summer and Station 904N at the surface for all data available covering all 4 seasons. Since the ratios obtained in this manner are all nondimensional, it is now possible to compare variations in 1 water property with those of another, instead of considering a single property individually. These plots will be called station signatures; a few other examples are shown in the following figures.

Selected Station Signatures

In fig. 10 the surface signatures of Station 904N are shown for summer, winter, and yearly data. Seasonal changes in the total environment are quite evident.

The total environment of different stations during the same season is also at variance. The surface signatures during the win-



	Av	Min	Min Rat
pH	8.09	7.87	0.97
S	27.0	20.99	0.78
O	4.64	4.30	0.93
T	23.9	21.48	0.90

Fig. 9.—Two contrasting signatures, Chesapeake Bay.

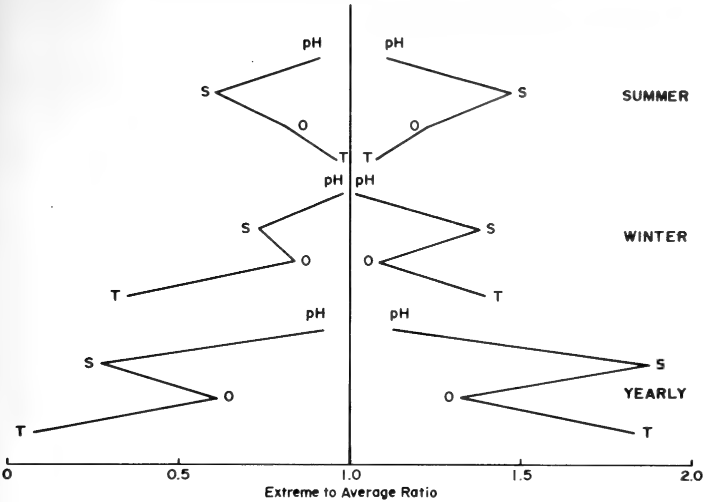


Fig. 10.–904N surface signatures.

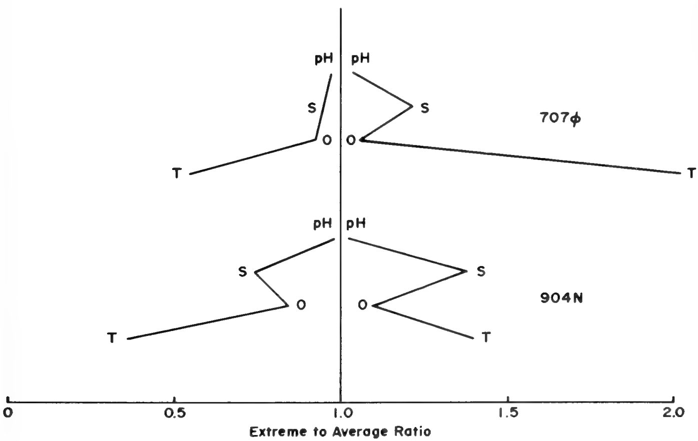


Fig. 11.–Surface winter signatures, Chesapeake Bay.

ter at 2 stations widely separated in Chesapeake Bay are shown in fig. 11, and although they are unique, similarities may be identified. In fig. 12 are shown 2 signatures for bottom conditions during the summer at Stations 707ϕ and 904N, and it may be seen that again there is a marked contrast. At Station 904N the oxygen protion of the signature is markedly different than it is at 707ϕ, although the other 3 parameters seem to have about the same general coordinates.

Fig. 13 shows both surface and bottom conditions at Station 904N during the summer. Even here it may be seen that the oxygen situation at the bottom of the station outweighs all other characteristics and lends the characteristic shape to the signature. One advantage of this presentation seems to be that a particular parameter is highlighted when it has a large effect on the environment, as oxygen does in this case.

From these data it seems that at this time it is not possible to implant a magic box in Chesapeake Bay that will automatically signal an alarm whenever a crisis appears. Part of the problem is involved with the previous discussion indicating that parameters are very variable, but another portion of the problem is involved with the fact that for each particular environmental situation there are different physical-chemical parameters to be considered. Just which of the various water properties are of major import is a management decision that is hopefully based on both laboratory and field data.

Since each parameter varies in a different manner at each location, the signature concept appears very desirable. However there is a major disadvantage in that for each signature large amounts of data are required for each depth, each season, and each stage of the tide. There seems to be no easy out.

Future Research

The suggestion for employing station signatures is one based on very preliminary data and will certainly require a great deal of exploration to validate not only the concept of the signature but also the concept of the greater validity of the extreme to average ratio as compared with the absolute value. It is suggested then that future research should fall into 4 general areas:

- The first of these would be determination of background information for the desired parameters in much greater detail than is presently available.
- The second area is the investigation of the persistence of wide extremes of particular parameters and their effects on various organisms.

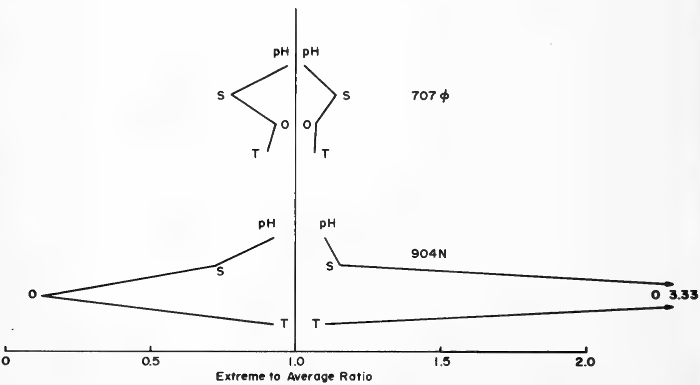


Fig. 12.—Bottom summer signatures, Chesapeake Bay.

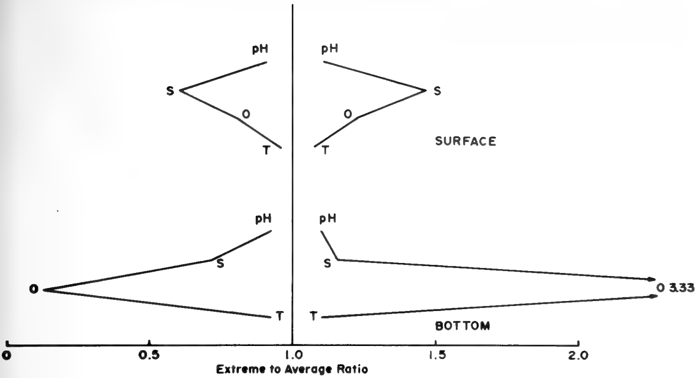


Fig. 13.—904N summer signatures.

• Third, it is suggested that investigation be made of the effects of the variation of 1 parameter on an organism when the ambient level of that parameter is changed. It would be expected, for example, that a rapid change of 5°C would be somewhat more noticable to an organism if this occurred at an average temperature of 1° as compared to this change occuring at a temperature of 20°. Investigations of this nature would determine the validity of the utilization of the extreme-to-average ratio.

• Lastly, it is suggested that research is required into the effects of variation of 1 parameter at different levels of another. This, of course, is an extremely complex procedure requiring a great deal of experiment, and it is an area in which very little work has been done. Since the natural environment exhibits such marked changes in so many parameters, a knowledge of the response of organisms to variations of 1 water property at different levels of another should be of extreme importance.

Some Biological Indicators of Marine Environmental Degredation

Carl J. Sindermann[1]

Middle Atlantic Coastal Fisheries Center, National Marine Fisheries Service, NOAA, U.S. Department of Commerce, Highlands, New Jersey 07732

ABSTRACT

Evidence is accumulating that marine organisms can provide clues to the extent of degradation of inshore waters resulting from human activity. The warning signs include mass mortalities, changes in species composition, and increasing occurrences of diseases and abnormalities in fish and shellfish. A critical present need exists for more information which will enable us to distinguish man-induced phenomena from natural phenomena.

As the human species, in the midst of a global population explosion of unprecedented proportions, begins to make harmful impact on the shallow edges of the seas, the marine organisms whose immediate surroundings are being degraded attempt to communicate their displeasure and discomfiture. The methods of communication, if we are perceptive enough to be aware of them and to interpret them, can provide us with an early warning system about increasing levels of environmental contamination. Some elements of the system are undoubtedly subtle and may well escape observation; others are relatively overt and obvious.

I hope, in this paper, to identify some of the more obvious biological warning signs of environmental damage in inshore marine areas—itemizing some of the forms in which the protests manifest themselves and indicating the kinds of research we should do to best interpret the signals we are receiving. Some of the following material is frankly speculative; the rest is based firmly on the very thin layer of specific information now available to us. The thesis to be defended is that damage is being done to inshore marine environments and populations, and that responses of marine organisms can give us clues to the nature and extent of that damage.

[1] Dr. Sindermann is presently Director of the Middle Atlantic Coastal Fisheries Center, and Adjunct Professor, Division of Fisheries Sciences, Rosenstiel School of Marine and Atmospheric Sciences, University of Miami. He is a native of North Adams, Massachusetts and received his advanced degrees at Harvard University. He has published 2 books and over 70 scientific articles concerned with ocean resources.

Mass Mortality

Probably the best, and certainly one of the most apparent, indications of environmental degradation, whether by toxic or infective material, or chemical or thermal addition, is mass mortality, usually of localized nature in areas of heaviest contamination. Examples of this phenomenon are becoming increasingly abundant. One of the most recent and the most devastating concerns repeated and extensive mortalities of fish and shellfish in Escambia Bay in northern Florida—a bay grossly polluted, principally by the poorly controlled effluent of several large chemical production plants. Beginning in 1967, summer fish kills have occurred there with increasing frequency and severity, and in 1971 over 90% of the oyster population of that Bay was destroyed within the space of a few days. Fish mortalities have been attributed to toxic chemicals dumped in the Bay, and to low oxygen levels resulting from massive eutrophication. Mortalities of fish and shellfish have also been characteristic of other chemically polluted bays such as Raritan Bay in New Jersey.

It is important to note, though, that mass mortalities due to natural causes are probably more abundant and more significant than those caused by human activities. Man has merely added another group of stress factors.

Changes in Species Composition

The next best indication of environmental degradation takes the form of drastic or subtle changes in the flora and fauna of an area, either in terms of reduced abundance or in disappearance of certain species. Generally such changes can be summarized in 3 categories:

a) the decline and disappearance of species valuable as food or sport for man, and their replacement by rough species with lower value to man;

b) the development of a monotonous fauna consisting of fewer and more resistant species (such as certain worms) able to tolerate low oxygen conditions; and

c) changes in the algal flora, often resulting in appearance of blooms (often as red tides); and the predominance of blue-green and brown algae, the latter often occurring as a scum on inshore bottoms.

Occasionally, environmental changes may also result in population explosions of certain animal species which are normally inconspicuous parts of the fauna. An invasion of sea urchins in a sector of Florida coast previously affected by a massive red tide outbreak in the summer of 1971 is a most recent example. An earlier invasion by sea urchins occurred several years ago in kelp beds on the California coast.

Several reports (Raney, 1952; Chittenden, 1971) point to habitat destruction by industrial and domestic pollution as a cause for drastic decline of striped bass and other anadromous fishes from certain Middle Atlantic estuaries, particularly the lower Delaware River.

An interesting recent report by Glover *et al.* (1971) indicates that over the past 22 years there has been a progressive decline in the abundance of many species and in the biomass of zooplankton in parts of the North Atlantic, together with a shortened season of biological activity. Among the many variables suggested as potential causes was the depressive affect of pesticides on phytoplankton photosynthesis. Such large-scale, long-term observations in the sea are all to rare, but they may indicate major derangements of man-made origin.

Abnormalities and Diseases

Another, and a more recently identified indicator of environmental contamination and degradation is the appearance of unusual or increased frequencies of abnormalities and diseases in eggs, larvae, juveniles and adults of estuarine and marine species. Documentation of this phenomenon is still very incomplete but is adequate enough even at present to suggest that it will become a powerful tool in assessing the extent of damage to the marine environment caused by effluvia of human civilization. Some of the varied forms include:

a) an apparent increase in observations of tumors and abnormal growths (Fig. 1) on fish taken from grossly polluted waters (information is available from California and Florida waters);

b) appearance of fin and skin erosion—called "fin rot"—(Fig. 2) in fish from polluted waters (information is available from waters of the New York Bight, California and Florida);

c) erosion of the exoskeletal projections of Crustacea taken from polluted waters (information is available from New York Bight waters);

d) increased frequency of fungus infections of eggs carried by Crustacea, in areas of gross pollution (Sheader and Chia, 1970);

e) growth abnormalities in certain sessile invertebrates associated with chemical contaminants (Powell *et al.*, 1970); and

f) appearance of lymphocystis (a virus disease of fish) in certain Gulf of Mexico estuaries with high pollution loads, and absence of the disease in certain other less polluted areas (Christmas and Howse, 1970).

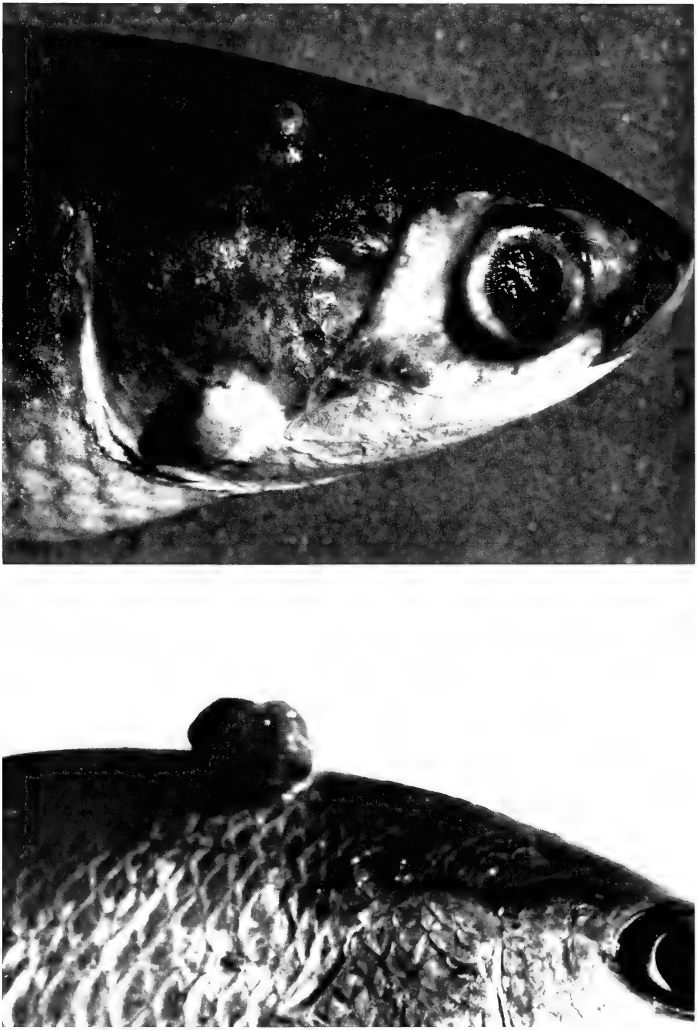


Fig. 1.–Abnormal growths on mullet (above) and snapper (below) taken from Biscayne Bay, Florida.

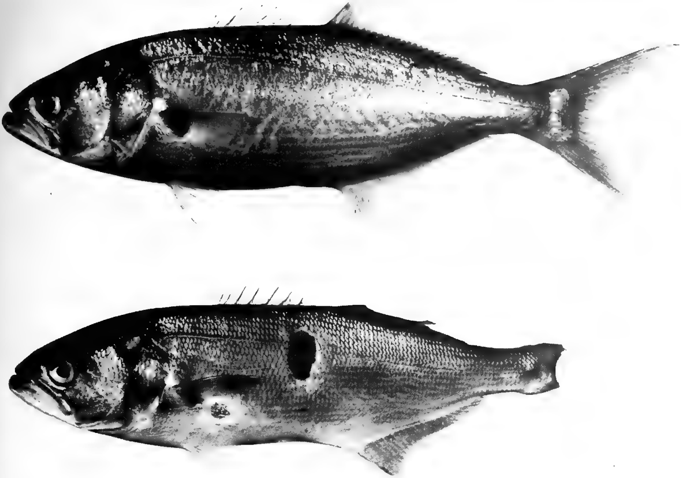


Fig. 2.—Normal (above) and fin rot infected (below) bluefish from the New York Bight area (photographs by Malcolm J. Silverman, NMFS).

Several of these conditions (such as fin rot and lymphocystis) could result from increasing infection pressure by facultative pathogens, possibly combined with increasing environmental stress imposed by pollutants. Domestic and industrial effluents containing carcinogenic compounds or viruses introduce additional environmental hazards for estuarine and inshore species.

Egg and larval abnormalities may also serve as sensitive indicators of environmental pollution. Sheader and Chia (1970), reporting on a study of a bay on the coast of Britain, found that amphipods (*Marinogammarus obtusatus*) tended to be more abundant near a sewer effluent, and those nearest the effluent carried a much higher percentage of diseased eggs than those remote from the effluent (27% of a sample of 92 mature females versus less than 1% of females from other parts of the bay). The authors suggested that microorganisms in the sewage may produce egg infections directly or that low salinities near effluents could kill the eggs or render them more susceptible to infection.

Crustacean and molluscan larvae can serve as extremely sensitive indicators of environmental degradation. Use of larvae as bioassay organisms has a significant history on the west coast in pulp mill pollution studies (Woelke, 1967; 1968), and is receiving increasing attention on the east coast as well—particularly at the Milford (Connecticut) laboratory of the National Marine Fisheries Service, where current studies concern the effects of heavy metals on survival and development of eggs and larvae.

Speculations

The signals, then, are present, if we are observant or perceptive enough to recognize and interpret them. I am particularly intrigued by the possible role that viruses and bacteria may play in contaminated coastal waters. Allowing for some speculation, certain of the viruses of human origin may possibly be pathogenic to marine animals in their natural or mutated state. Interesting recent reports (Farley, 1969) of very high prevalences of neoplastic disease in shellfish, and observations of tumors in fish from polluted zones, offer some basis for such a possibility. Viruses which might be benign or hidden in humans could produce quite different effects in marine animals. Evidence exists, for example, that fish cell lines are susceptible to a wide array of viruses of homoiothermic origin (Solis and Mora, 1970). Carrying speculation one step further, it is conceivable that viruses (and bacteria) of human origin may be able to multiply in certain marine species without causing an observable effect, and then serve as a reservoir of infection for humans who enter the marine environment or who eat the animals. This might result, just as an example, in an increase in superficial skin warts or other skin infections among skin divers or bathers who frequent grossly polluted waters.

I have already suggested that bacteria of human origin may be facultatively pathogenic in stressed populations of marine animals, where they may produce effects unlike those produced (if any) in normal hosts. Organic loads from sewer effluents and sludge dumping could promote bacterial growth, including that of heterotrophic marine or estuarine bacterial species, leading to tremendous infection pressure on fish and other animals by such facultative microorganisms. The suggestion has been made, and some limited evidence exists (Janssen and Meyers, 1968), that certain bacterial pathogens of humans are able to infect fish. Antibodies against such pathogens were demonstrated in fish from polluted waters, but not in those from relatively clean waters. This work needs to be extended, but it does suggest that antibodies in fish may be used as sensitive indicators of pollution, whether the fish become grossly infected or not. There is also the likelihood that populations of bacteria such as the vibrios and pseudomonads, which may be pathogenic for humans who enter marine waters or eat the animals, may be enormously expanded by the availability of rich organic soups in outfall and sludge dumping areas.

In terms of impact on living marine resources, it seems reasonable to expect that the synergistic, cumulative effect of pollutants may well exceed the mere summation of individual effects. Thus, for example, chemical erosion of the mucus of a fish may expose it to invasion by facultative microorganisms; or modification of the physiology of a marine animal by high levels of heavy metals may lower its resistance to such facultative microorganisms.

Suggested Areas for Research

With the present climate of increasing concern about the state of well-being of the planet and its continued ability to support life as we know it, the opportunity to conduct relevant research is enhanced. Some of the indications of marine environmental damage considered in this paper are just that–indications–and so require substantial study. Among the research areas which need augmentation are the following:

1. Firmer data should be obtained linking decline or disappearance of certain species to pollution (at present, alternative causes could be argued). This will require both field and experimental studies and will require careful continued assessment of abundance of such species.

2. Broad trends in ocean productivity should be examined and a search made for causes of any changes detected. The analysis of copepod abundance by Glover *et al.* (1972) is an excellent example of what should be done regionally and locally, as well as on a broader scale. Fish and benthic organisms should be examined in the same way.

3. Bioassay work, especially that using larvae and juveniles of fish and invertebrates, should be expanded. Since larval survival to a large extent determines abundance of adults, and since larvae are remarkably sensitive to many environmental contaminants, such studies have far-reaching significance. Studies should include consideration of growth rates, metamorphosis, and abnormalities, as well as mere survival.

4. Tumors and neoplasms of marine fish and shellfish should be carefully examined, and the role of environmental carcinogens introduced by man as well as that of viruses should be determined.

5. Increasing reports of localized and widespread red tides should be studied in relation to pollution levels and other man-induced environmental changes.

6. The non-commercial marine animals should be scrutinized for changes in species composition and for abnormalities indicative of environmental stress. This is particularly needed in coastal areas with gross contamination.

7. Specific and obvious leads—such as the appearance of fin rot disease in fish from polluted waters, and the occurrence of antibodies in fish to human pathogens—should be exploited vigorously.

Conclusion

These indications can be considered as small, scarcely audible voices of protest and warning—protest against effluvia from the land that threatens the existence and well-being of coastal species, and warning of possibly more serious disruption of marine ecosystems if the degrading processes persist. Running throughout is also a thread of increasing danger to humans who enter the corrupted marine waters, or who consume products from that source.

References Cited

Chittenden, M.E. 1971. Status of the striped bass, *Morone saxatilis*, in the Delaware River. Chesapeake Sci. 12: 131-136.

Christmas, J.Y., and H.D. Howse. 1970. The occurrence of lymphocystis in *Micropogon undulatus* and *Cynoscion arenarius* from Mississippi estuaries. Gulf Res. Repts. 3: 131-154.

Farley, C.A. 1969. Sarcomatid proliferative disease in a wild population of blue mussels (*Mytilus edulis*). J. Nat. Cancer Inst. 43: 509-516.

Glover, R.S., G.A. Robinson, and J.M. Colebrook. 1970. Plankton in the North Atlantic—an example of the problems of analysing variability in the environment. F.A.O. Technical Conference on Marine Pollution (preprints of conference papers).

Janssen, W.A., and C.D. Meyers. 1968. Fish: serologic evidence of infection with human pathogens. Science 159: 547-548.

Powell, N.A., C.S. Sayce, and D.F. Tufts. 1970. Hyperplasia in an estuarine bryozoan attributable to coal tar derivatives. J. Fish. Res. Board Canada 27: 2095-2096.

Raney, E.C. 1952. The life history of the striped bass, *Roccus saxatilis* (Walbaum). Bull. Bingham Oceanog. Coll. 14: 5-97.

Sheader, M., and F-S. Chia. 1970 Development, fecundity and brooding behavior of the amphipod, *Marinogammarus obtusatus*. J. Mar. Biol. Assoc. U.K. 50: 1079-1099.

Solis, J., and E.C. Mora. 1970. Viral Susceptibility range of the fathead minnow (*Pimephales promelas*) poikilothermic cell line. Appl. Microbiol. 19: 1-4.

Woelke, C.E. 1967. Measurement of water quality with the Pacific oyster embryo bioassay. Water Qual. Criteria, ASTM, STP 416, Amer. Soc. Testing Mats. 112-120 (1967).

____________. 1968. Application of shellfish bioassay results to the Puget Sound pulp mill pollution problem. Northwest Sci. 42: 125-133.

The Corps of Engineers Chesapeake Bay Study

Col. Louis W. Prentiss, Jr.[1]

*Baltimore District, Corps of Engineers,
U.S. Army, P.O. Box 1715, Baltimore, Md. 21203*

ABSTRACT

The Corps of Engineers Chesapeake Bay Study is a comprehensive estuarine study encompassing engineering and the physical, biological, and social sciences. The primary output of the study will be a water-land management program which will include urgently needed programs, a mechanism for evaluating proposed actions, and identification of the institutional arrangement that appears most desirable for management of the Chesapeake Bay's water and associated land resources. The primary tool in the development of the management program will be a Hydraulic Model of the Chesapeake Bay which will provide a means of reproducing some of the physical phenomena that occur throughout this large and complex system as a result of various structural and management alternatives.

The Corps of Engineers Chesapeake Bay Study is by no stretch of the imagination a pure research effort, but it represents a most important step forward in research activity. Through the Chesapeake Bay Committee the research community will have for the first time an opportunity to gain an overview of the proposed research activities of all Federal, State, and local agencies and institutions. The researchers will also be able to gain an insight into what the future holds for the Bay and focus attention, where necessary, on those unknowns which may be the key elements in a harmonius man-ecology relationship.

Problems

The rapid growth of the population and the accompanying rapid increase of water oriented pursuits have created conflicting opinions regarding optimum development of the Bay's resources. Increasing nutrient, chemical, and thermal waste loads; diversion of freshwater inflows; disposal of dredged materials; sedimentation and shoaling; erosion and hurricane damage are some of the many problems which are becoming more and more critical in the Bay.

Chesapeake Bay Study

Authority and Scope of Study

The complexities of the hydraulic characteristics and the emerging environmental problems of the Bay generated within the Maryland and Virginia Congressmen the need for a comprehensive study and hydraulic model. To meet this need, Section 312 of the River and Harbor Act of 1965 authorized a complete investigation and study of water utilization and control of the Chesapeake Bay basin. In order to carry out this task, a hydraulic model of the Chesapeake Bay and an associated technical center is to be constructed in the State of Maryland. A monetary limit of $6,000,000 was set for the study and model at that time.

Objectives

The objectives of the Corps Chesapeake Bay Study can be divided into 3 broad categories. The first objective is to provide an understanding of the existing physical,

[1]Col. Prentiss is a native of Washington, D.C. He is a graduate of the U.S. Military Academy and received his Master of Science degree from Princeton University. A registered professional engineer, he is a member of the Society of American Military Engineers, American Society of Civil Engineers, and the National Society of Professional Engineers. He is currently serving as District Engineer of the Baltimore District, Corps of Engineers.

chemical, biological, economic, and environmental conditions of the Bay. The study will serve as a focal point for all research and management programs of the various Federal, State, and local agencies having an impact on Chesapeake Bay.

The second objective is to define the standards or levels of attainment for the water-land resources of the Bay which are required to meet the needs of the people. These standards will be formulated based on the following criteria: economic efficiency, regional development, environmental quality, and the well-being of the people. It will be most important that the standards set for each water resource activity be made compatible with all other activities.

The last objective of the study will be to provide a water-land management program to be used by all Bay-management organizations for development, enhancement, conservation, preservation, and restoration of the Bay's resources. The program would consist of guidelines, management strategies, and programs that may be needed to assure wise utilization of the Bay's resources.

Organization and Management

General.—The magnitude of this study, the large number of participants, and the complex spectrum of problems to be analyzed requires smooth coordination of activities. The planning of this study was coordinated with the National Council on Marine Resources and Engineering Development through its Committee on Multiple Use of the Coastal Zone. This study is conceived as a coordinated partnership between Federal, State, and interested educational institutions. Each involved agency is charged with exercising leadership in those disciplines in which it has special competence and will be expected to review and comment on work performed by others. To realize these ends, an Advisory Group, a Steering Committee, and 5 Task Groups were established.

Advisory Group.—The Advisory Group assists the District Engineer in establishing broad guidance and providing general direction under which all participants will work in producing the resource study and the final management program. The group also advises the District Engineer on establishing policy regarding both the execution of tasks and the resolution of conflicts that may arise during the study. The group is made up of representatives from various Federal agencies, each involved State, and several of the scientific institutions.

Steering Committee.—The Steering Committee is responsible for reviewing the work of the other groups and bringing to their attention any pertinent advances in the art of water resource development or the environmental sciences, and making recommendations as to their utilization. This group will also formulate plans for scientific activities that may become a necessary adjunct to this study.

Task Groups.—The Chesapeake Bay Study is divided into 5 general areas—Economic Projections; Water Quality and Supply, Waste Treatment, and Noxious Weeds; Flood Control, Navigation, Erosion, and Fisheries; Recreation and Fish and Wildlife Coordination. Task Groups have been established and are functioning as basic work groups in each of the 5 study areas. The individual task groups are composed of those agencies interested in the study problems assigned to that group. Through this mechanism, it is intended that constant liaison, work review, and agency interaction be maintained between the various participants. Details on the composition, chairmanship, and assignments of the coordination groups have not been mentioned, as subsequent parts of this presentation will indicate how the task groups have functioned to date and the degree of coordination accomplished. Coordination with non-governmental agencies and the public will also be covered later in the presentation.

Study Management.—The overall management of the Chesapeake Bay Study is the responsibility of the Planning Division, Baltimore District, under the direction of the District Engineer. Within the newly formed Planning Division a Chesapeake Bay Study Group consisting of 2 sections has been formed—a Study Coordination and Evaluation Section, responsible for the overall management of the study and model and coordination of the study work with other participating agencies; and a Technical Studies and Data Development Section, responsible for data collection activities for both the study and model and preparation of designs and cost estimates for water resources projects in the Chesapeake Bay.

Outputs

The primary output of the study will be a water-land management program for the Chesapeake Bay. The major tool in the development of the program will be the hydraulic model, shelter, and technical center, which will be used to provide presently unavailable cause-and-effect information. Additional outputs of the study will be 6 distinct reports, each to be published following a phase of the study. The preparation of these periodic reports will provide all who are concerned with management of the Bay a better understanding of the problems outside their own activities, and also provide a starting point for the next phase of the study.

Report on Existing Conditions.—The first report, a report on existing conditions, is scheduled for completion in June 1972 and will describe the existing physical, biological, economic, social, and environmental conditions of the Bay and the various Federal, State, and local programs in the Bay area. Only existing data will be used, and the report will be divided into a main report and 4 appendices titled, "The People and the Economy," "The Land-Use and Resources," "The Bay-Processes and Resources," and a "Map Folio." Each of the water-resources categories will be discussed and available existing information will be displayed. For example, the navigation portion would describe the existing projects and programs, the existing and past waterborne commerce, existing dredging requirements and methods, and the existing recreational boating facilities and boats. This report will also identify areas where additional studies or model tests are required to further define the existing conditions. Standard mapping at a scale of 1:250,000, to be prepared and distributed by the Corps, will be used in the map folio to present some of the inventory data and will indicate areas where conflicts exist or may be expected to occur.

Report on Future Conditions.—The second report will describe the future conditions of the Bay based on the existing conditions, the economic and population projections, and the proposed actions and developments by public and private interests. Again, the report will be divided into the different water resource categories and will further identify areas requiring model studies.

Economic Base Study Report.—Concurrent with the future conditions report, an economic base study will be prepared. This will be a combined report of the final economic and population projections and the studies of the activities which have special significance on the economy or utilization of water resources of the area. The economic and population projections will be based on recent economic base studies of the Chesapeake Bay modified by projections from the Office of Business Economics (OBE) and 1970 census data.

Definition of Objectives Report.—In June 1974 an objectives report will be published. This report will thoroughly describe, with numerical parameters where possible, the objectives or goals which all future programs should seek to obtain. Objectives will be established for all water resource categories for the Bay and tributaries, with care taken to assure that all objectives are compatible and meet the needs of the people. For example, the water quality objectives must be compatible with the amount and type of recreation envisioned and the planned fish and wildlife utilization of the area.

Report on Alternative Management Strategies.—Following a definition of the objectives, a report on the alternative management strategies will be prepared. Management strategies are defined as the programs, projects, and the various methods of managing the resources of the Chesapeake Bay. This report would discuss possible management strategies which would help meet the defined objectives or goals. The anlaysis of each strategy would include the results of model testing, costs of instituting the management strategy, the benefits from the strategy, and any positive or negative environmental, social, or economic effects of the strategy.

Final Report on Formulated Management Strategy.—The final report scheduled for completion in December 1976 will present a management strategy which may include urgently needed programs, a mechanism for evaluating proposed actions, and an identification of the institutional arrangement that appears most desirable for management of the Chesapeake Bay's water and associated land resources.

Hydraulic Model

As I mentioned previously, the Hydraulic Model will be the major tool in the development of the water-land management program and will be used to evaluate the effects of proposed structural and management programs. The model will provide a means of reproducing, to a manageable scale, some of the physical phenomena that occur throughout this large and complex system as a result of various alternative management strategies. In addition, as an instrument and physical display, the model will be unexcelled in its potential for the education of an interested public in the scope and magnitude of the problems and conflicts of use that can beset this water resource in the future. As an operational focal point, it will promote more effective liaison among the agencies working in the Bay waters, helping to reduce duplication of research and leading also to accelerated dissemination of knowledge among the interested parties and the public. Following completion of those tests required for the resource study, the model will continue to be used by the decision makers to evaluate the impact of proposed management actions.

The model will be of the fixed-bed type and will be a formed concrete slab with the topography of the Bay reproduced through the use of templates. The model will be built with scales of 1 to 1000 horizontally and 1 to 100 vertically and will encompass the Bay proper, all of its tributaries up to the head of tidewater, and the adjacent overbank areas to the 20-foot-above-mean-sea-level contour. Based on the shallow depths of the Bay, the effects of distortion on the dynamic similitude of the model and prior Corps' experience with hydraulic models, the horizontal and vertical scales selected were considered to be the smallest practical scales suitable for solving Bay problems.

Shelter and Technical Center

Protection of the model against the elements is considered essential as wind and rain would adversely affect water surface elevation and salinity measurements. There is an equally important need for keeping the model clean of dust, leaves, and other airborne debris. In selecting the type of building for housing the model, the large size and configuration of the model, the need for column-free space, required clear-height for model photography, and the aesthetic appearance of the structure were the governing factors. The most economic and funcitonal of the building types considered, which meet the above criteria, is a prefabricated conventional steel truss frame structure.

While the Technical Center is not further defined in the authorizing act, facilities to include administrative offices, conference rooms, an electronic computer system, and space for visiting consultants and research workers have been included. Inexpensive accommodations for visitors and tourists, which include a small exhibition hall and auditorium, were also considered desirable.

Prototype Data Collection Program

In order to verify that model hydraulic and salinity phenomena are in acceptable agreement with those of the prototype, the tidal elevations, tidal current velocities and directions and salinities must be measured at many locations in the prototype. The total collection program will cost approximately $2,000,000 and will include 72 recording tide gages for tidal observations and a total of 743 velocity and salinity observation points along 105 ranges established throughout the Bay. Freshwater inflow from all tributaries and various meteorological data will also be compiled concurrent with the Bay collection program.

Interagency Coordination

As the Bay offers such potential for the study of the environmental impact of urbanization on a large natural resource, keeping an inventory of and coordinating with the many governmental and non-governmental agencies studying the Bay is a major undertaking. The organization of this study with an Advisory Group, Steering Committee, and Task Groups has provided, to date, an excellent vehicle to meet this task. However, to further coordinate Bay activities, the Interagency Committee on Marine Science and Engineering has requested the Corps to form a Chesapeake Bay Committee composed of Washington representatives of Federal agencies and representatives of affected states. The charge to the committee is to:

a. Inventory agency programs.

b. Review future program plans.

c. Review legislative authorization of Federal programs.

d. Perform an analysis of the above programs to uncover any unknowing duplication and recommend program coordination accordingly.

The initial meeting of this committee will be held next week with future meetings to be held periodically to review and analyze marine science and engineering and related programs in the Chesapeake Bay area.

Public Participation and Information Program

Public participation for the Chesapeake Bay Study is a continuous two-way communication process which has as its objectives:

a. Promoting a full public understanding of the processes by which water resources problems and needs are investigated and solved.

b. Keeping the public fully informed about the status and progress of studies and the findings and implications of plan formulation and evaluation activities.

c. Actively soliciting from all concerned citizens their opinions and perceptions of objectives and needs, their preferences regarding resource use and alternative development or management strategies, and any other information and assistance relevant to plan formulation and evaluation.

To meet the aforementioned objectives, a program consisting of periodic publications, public meetings (formal and informal), coordination with non-governmental or citizens groups through a citizens advisory group, and local planner workshops has been formulated.

Study Progress

Since the initial study allotment in 1967, significant progress has been made on the Chesapeake Bay Study Program. A site at Matapeake, Maryland, was chosen for the location of the Hydraulic Model and Technical Center and the land was donated by the State of Maryland. Design of the hydraulic model is being conducted at the Waterways Experiment Station in Vicksburg, Mississippi, and to date has consisted of sizing the hydraulic components of the model water supply and tide generator, plotting moulding templates for model construction and defining prototype date requirements for model verification. The General Design Memorandum for the model and shelter has been approved and a consultant is currently preparing the plans and specifications for the shelter and technical center. Agreements have been reached with the Virginia Institute of Marine Science, The Chesapeake Bay Institute (JHU), the Chesapeake Biological Laboratory (U. of Md.) and the National Ocean Survey for collection of the prototype data. Tidal elevation, current, and salinity date have been collected in the Potomac, Rappahannock, and James Rivers; Mobjack Bay and in the upper Bay. With regard to the resource study, work has been progressing well on the existing conditions report. Corps work by both the Baltimore and Norfolk Districts has included inventories of flood control, navigation, water supply, hydrologic, and land-use data, and interagency agreements have been reached with the Office of Business Economics, the Bureau of Outdoor Recreation, the U.S. Geological Survey, the Bureau of Sport Fisheries and Wildlife, the National Marine Fisheries Service, and the National Science Foundation for various segments of the report lying within their areas of expertise.

Future Study Activities

Contingent upon timely receipt of funding from the Congress, some of the major program milestones in the near future include:

a. Completion of the existing conditions report in June 1972.

b. Collection of prototype data in the York River the Middle Bay and several of the major Eastern Shore tributaries in the summer of this year.

c. Start of Shelter and Hydraulic Model construction in FY 1973.

Other Bay-Related Corps Activities

C&D Canal Study

In addition to the Chesapeake Bay Study, I would also like to mention briefly several other Bay-related Corps activities. The Philadelphia District of the Corps has an ongoing contract with the Natural Resources Institute of the University of Maryland for an investigation of the hydrographic and ecological effects of the enlargement of the C&D Canal. The objective of the investigation is to develop basic hydrographic and biological data for the long-term study of the effects of the canal on the ecology of the upper Bay. The work includes hydrographic and biological field data collection, the construction of a hydraulic model of the C&D Canal, and the development of math models to define salinity distribution in the Canal and adjacent waters.

Permit Program

Another Corps responsibility which has a major impact on the Bay is the issuing of permits for certain activities. Section 10 of the River and Harbor Act of 1899, which is also known as the Refuse Act, requires that a Department of the Army permit be obtained prior to commencement of any work, such as the construction of structures, dredging and filling in navigable waters. Under current policies and procedures of the Corps, all applications are now reviewed to assure that the work will not be adverse to the environment. Also, Section 13 of the same act requires that permits be obtained for existing and future discharges and deposits into navigable waters and their tributaries. While this program covers only industrial and other non-domestic wastes, it is both an important and necessary action required to help clean up our nation's waters.

Summary

In summary, the Corps' Chesapeake Bay Study is a comprehensive estuarine study encompassing engineering and the physical, biological, and social sciences. The primary output of the study will be a water-land management program which will include urgently needed programs, a mechanism for evaluating proposed actions, and identification of the institutional arrangement that appears most desirable for management of the Chesapeake Bay's water and associated land resources. While the study is not a pure research effort, the hydraulic model and prototype data collection program will provide the scientific community with valuable information on some of the physical phenomena that occur throughout this large and complex system. In turn, the scientific community must take the available physical, chemical, and biological data and provide the decision-makers an assessment of the impact of various alternative management actions. With this melding of viewpoints and expertise, I feel a dynamic management program can be developed for this dynamic natural resource.

Interdisciplinary Research in Chesapeake Bay

Howard Seliger[1]

McCollum Pratt Institute, The Johns Hopkins University, Baltimore, Maryland 21218

ABSTRACT

Some questions are asked about environmental priorities, about the ways in which problems can be formulated. The success of some types of biological monitoring is doubted. An interdisciplinary approach to ecosystem study at the Rhode River is described.

It is a pleasure to have been here these past 2 days. I am really very surprised, first of all at the number of people who were here yesterday, and even more at the number of people who are still here today, which is Saturday. I've been asked to talk aobut some of our research on the Bay, and I am very pleased to be considered as qualified. An expert is usually someone from out of town; I'm not quite sure that I have come a great enough distance to fit the category. I do have some ideas about the Bay and about the environment in general, and I would like to preface my remarks about our Rhode River research with some of these ideas.

Usually in discussions with my students about their own research, to get them to think, to overcome the feeling of being spoken to by a PROFESSOR and therefore having been told the truth with capital letters, I usually make a lot of statements in a very declarative way. Some of the statements are true because I have been able to prove them experimentally. Some of them I have very little evidence for and some of them are actually the result of very faulty reasoning. The student must weigh therefore what we talk about, question some of the basic ideas and not be embarrassed to ask sometimes rather naive questions. I feel that I'm on my way to developing a scientist rather than a technician when a student can say, "No. that's wrong, let's look at it this way." During this talk, I would like to play this game with you, and possibly you can pick out which of my statements I truly believe in and which of them I have put there to make you question. And so let's talk a little bit about priorities.

The title of this symposium is "The Fate of the Chesapeake Bay"—and by the way, I agree with Frank Williamson; that sounds like a rather somber title. It's almost like a Victorian melodrama, and in this case we have 3 acts. Yesterday morning we saw the Bay with her magnificent meandering shorelines. In the afternoon a villain, actually a renegade ex-army officer called MAJOR THREATS, was assaulting the longevity of this young lady—plying her with nutrients, intent on anaerobic layering and eventually dredging her canals. Now this morning in the third act, our hero, pure research—is going to solve the problem and save our fair Bay aided by the forces of goodness—Jim Coulter, Lee Zeni, and the National Science Foundation.

But is the Bay in danger? Are Col. Love's rashes growing together? Jerry Schubel seems to think that heating from power plants is negligible. Although he is going to hedge and say he's not quite sure about

[1]Dr. Seliger is Professor of Biology at The Johns Hopkins University. He is also chairman of the Committee on Radiation Protection and Radiation Safety Officer for the University. He has been a member of both the Governor's Task Force on Nuclear Power Plants and the Maryland Academy of Sciences Panel on Power Plants. At present he is chairman of the Maryland Academy of Sciences Advisory Panel on Monitoring the Environmental Effects of Power Plants. He has been studying bioluminescent bays in Jamaica and Puerto Rico since 1960, but considers himself a neophyte on the Chesapeake Bay.

long-term effects. Mike Bender can find heavy metals anyplace he sets his instruments. Dr. Walsh can find pesticides and Dr. Patrick and many other people in this audience are aware that heat is required in order to steam crabs. But the question really is how much and how long? This is a basic research question and it is a question that becomes answerable from so many sources because there is an adage that says in the presence of ignorance everybody is an expert. So we have to ask questions in a slightly different way than before. Before we even ask questions about the Bay, we might ask some of the following very simple questions: Do we really want to swim in Baltimore Harbor when we are truly afraid to walk down the streets to get to it? And must our rivers be made sparkling clean when roaches march in ghettos? I'd like to make a distinction here. For an oyster, the ecosystem is the Chesapeake Bay. For we human beings, our ecosystem is our cities and our people and our air *and* our Bay. And so it is our *way of life* that is our ecosystem. The Bay is only a small part of this. And we can't really clean the one while we ignore the magnificent piles of garbage in other areas of our ecosystem.

In the early sixties, during the previous boom in cancer research, Dr. Szent-Gyorgyi remarked, facetiously of course, that cancer was supporting more people than it was killing. Interestingly enough and contrary to most biological trends, pollution has actually been responsible for staggering increases in both standing crops and diversity of ecologists in city, county, State, and federal agencies and symposia devoted to its control. There have even been days on the Rhode River when the scientists taking readings have outnumbered the citizens.

The new power plant siting law in the State of Maryland is unique. It is unique in that it pays for itself and specifically states that the tax money shall go for research and monitoring in areas that are considered important for the environment in the State of Maryland. There is an interesting history in terms of the development of this power plant siting law which is paying for a large fraction of this research. It was mainly the result of a great deal of emotionalism about 2 subjects which are really relatively minor in the ordering system of priorities for our human ecosystem. These are of course radioactivity pollution and thermal pollution. But we mustn't look a gift horse in the mouth. We have a very good law, because it says we have to look at the environment carefully. It doesn't say anything about eutrophication. It doesn't say anything about the fact that sewerage plants are putting a great deal of nutrients into our waters, or that faulty septic sewage systems are putting a great deal of nutrients into our waters, or that poor erosion control practices are putting a great deal of sediments into our waters. It really doesn't matter. The main thing is that in order to get the research done, one has to look at eutrophication because it occurs in the same body of water where one might be looking for the effects of the emissions of power plants.

There is a way of thinking about these problems in general. We tend to try to solve what we consider to be problems with the techniques of the preceding generation. With things that we know have worked for us before and therefore are obviously the method of choice today. It is difficult to change this way of thinking. Not only that, it requires taking risks. The risks are mainly financial and therefore to my mind retrievable, but this is not generally considered to be the case in fiscal offices. Above all, it requires thinking. Let me give you an example of what I mean. Instead of the piecemeal approach to the location of power plants, might it be possible to improve and develop for commercial use in an extremely short time the breeder reactor in order to replace the present light-water reactor? At our projected rate of use of nuclear fuel with a light-water reactor program the inexpensive nuclear fuel will be dissipated within the next 25 to 30 years. If we develop a breeder reactor we won't have to worry about the availability of nuclear fuel for at least the next 10 generations which will give us sufficient time to approach the problem of fusion reactors if we desire to do so. There is a very specific break that has to be made here in the decision to change over from a type of reactor for which fuel is becoming more and more scarce. With this leeway, then, to develop a fusion reactor which in a sense will give us an unlimited source of energy, we will be able to worry about the limitations to our environment. We will be able to set these limitations in terms of total heat loads that can be delivered to the environment without changing the mean temperature and increasing the sea level by melting some of the polar ice. We can devote our attention to the amount of CO_2 we put into the air, which as far as I can see is not considered to be a pollutant by anyone. We can develop the technology for long-range underground power transmission. Any country which is able to develop the technology for sending people to the moon or for sending space stations waiting outside when we have to wait longer for buses on some of our corners, should be able to develop technology for long-range underground power transmission. This one technological breakthrough will allow us to locate power centers and power plants away from the places where the power is used. This has always been the restriction on power plants—they must be placed close to the place where energy is used. If we are able to do this we can build our power plants up north where presumably the excess heat can be put to really beneficial use. We could build power plants on the continental shelf where they would be far enough away from cities and people so that even in the unlikely case of accident there would be no possibility for the loss of human life. We could designate various lakes or rivers in our country as ecological sacrifices and use them *specifically* for cooling. This would leave everything else beautiful. The principle is very old—it is called the principle of the garbage dump. We don't spread our garbage around uniformly—we use one place to put our garbage. We surround it with a fence, we paint the fence green and we still have a clean place where we can proceed with our technology. This would eliminate a great deal of fossil fuel requirement. It would eliminate a great deal of the stripping of Appalachia. It would eliminate a great deal of unsightliness associated with delivery of coals and disposal of coal wastes. It would reduce the amount of SO_2 and particulates added to our atmosphere and possibly reduce the greenhouse effect if there truly is such a thing.

We might also recognize that economic growth in this country and in the developed nations is truly being limited by critical supplies of raw materials. We have a population problem, not a problem in cleanliness. But it relates to our entire ecosystem approach to the setting of priorities. I think we must think about important things first. I think that old tires and debris in Baltimore Harbor are actually placed there by politicians who want to get their pictures taken. I think that noise pollution is being pushed by physicists who can measure decibels and who feel neglected because of the recent cutbacks in physics research. We sold 10 million automobiles last year. The Ford Motor Company estimates that antipollution devices will cost $750 per automobile. That is an additional cost to the public of 7.5 billion dollars per year. That is just about enough to build rapid transit from Sacramento all the way to Coney Island.

Talking a little more directly about some research on the Bay: I had a different hat on sometime ago when I was a member of the Governor's TaskForce on Power Plants in the State of Maryland. With that different hat I listened while a large number of people who had been working on the Bay for quite a long time were asked to visit with us and give us their feelings about what effect the Calvert Cliffs plant might have on the Chesapeake Bay. It was at that time I decided that, although the research that had been done on the Chesapeake Bay was good—was very good—it was not tied together because the research was individual reserach. It was related to individual species. It related to specific times of the year. In some cases it related to distributions of various organisms but it didn't tie anything together in terms of asking the questions, "What would happen to a species distribution if the mean temperature changed by 0.5°C?" "What would happen to the mean species distribution if the nutrients were increased by

10%?" There is a problem of man-made perturbations. But as Don Pritchard has put it, unless (and in some cases this has occurred) there are evidences of gross stupidity in the placing of power plants, no acute effects have been observed. The point is that individual power plants, individual sewage treatment plants, individual housing developments, produce effects which are small compared to the natural oscillations which you have heard described during the past 2 days by the various speakers. How can we then determine what the cumulative effects of these man-made perturbations would be when we are working in a noisy system? How can we work within the noise of this system in order to determine for example how many Calvert Cliffs plants can be placed at Cove point—one, two, six?

I will make a prediction: I predict that it will be impossible to observe any significant biological effects due to the presence of the Calvert Cliffs plant at Cove Point. But that doesn't mean that the Calvert Cliffs plant will not have an effect on the Chesapeake Bay—on the biota of the Chesapeake Bay. The reason I'm able to propose that we will not observe a significant effect is I believe that the natural variations will be such as to obscure most of the effects of the Calvert Cliffs Plant, which admittedly will be small. When we are finished with this research, will we be able to say how many Calvert Cliffs plants would be permitted at Cove Point or whether a plant should go into Bush River or whether a plant should be taken out of Chalk Point?

The power company is involved in this ecological program in a rather strange way. During World War II, there was a method of paying for airplanes and munitions that was called CPFF, cost-plus-fixed-fee. It was the easiest way to get things done because the manufacturer could make all the mistakes he wanted and he got a percentage of what he spent. The power company is regulated by the Public Service Commission and it gets a percentage of what it spends. There is no financial incentive for the power company to decide that it is going to go out of its way to improve the environment. It is going to do exactly what the State asks it to do. If the State were to say to BG&E, "In order to have a permit at Calvert Cliffs, I want you to turn the water blue after it comes out of your condensor-" that water would be blue. The State has said, "We want a 10°F change in temperature and no greater," we have a 10° change in temperature. Should it have been 9°, or could 18° have been as good? These really are the questions that we have to answer and these are the decisions for which the State Department of Natural Resources cannot pass the buck. In the final analysis it has to say what the regulations must be. I think the approach that the State has been using in terms of this new law and even prior to it has been an excellent one because it has turned to the scientist and it has asked the scientist what should we do—"How can we translate your data into regulations?"

This leads us to the work that we are doing at the Rhode River. I'll release you from the questioning. This is somehting that I truly do believe in. I believe it is a slight change in the way in which research is approached, in the kinds of questions that are being asked. The individual research may be the same. It may be as good or better or it may not be as good as the research that has been done before in other areas and at other times. We are trying to ask slightly different questions. The Rhode River estuary research program is directed by Frank Williamson. I am Deputy Director of the program. Frank and I have worked for a long time, with several others who are associated with this research program, in order to develop the concepts and the mechanism to get people to work in a particular direction. This is not applied research in the prosaic sense. We are not talking about engineering. I was a little nonplused to find that the Corps of Engineers plans to have its final report completed by 1976, because that really doesn't give too much time to do the next 100 years of research. I hope we can work faster. The problem as we see it is the following: If we are interested in studying terrestrial plants, water quality, heavy metal concentrations, or algal physiology, we can do each one of these things separately. We can do it in various parts of the Bay. We can do it in the laboratory—we can do it essentially in the way research has been done previously in universities, in individual laboratories, with occasional communication. Or we can ask the following questions: If all of these physical, chemical, and biological parameters are involved in the ecosystem, how do they interact with one another? Might it be possible to describe this ecosystem in terms of both the kinetics and the description of the population distributions? When you visit your doctor and you want to know the state of your health there are 2 things a doctor can do, he can take a series of measurements of your blood pressure, your heart rate, your EKG, your urine, and he can plot these as a function of time. Eventually you will die and he will have very good data documenting your deterioration. But this is not why you go to him, and I would think, Mr. Coulter, this is not why you come to the University. The documentation does not require the research. What we would like to do is to develop techniques for prediction as differentiated from the recognition of crisis indicators. This is a difficult problem because this is where the basic research comes in. We are working again in a black area, and it is necessary to probe and to spend money (and sometimes to spend money without success or in directions which will not be fruitful) in order to gain a sufficient understanding of the biochemistry and physiology of the organisms with which we are working.

I will give you a brief example of what I mean. I thought the easiest way to do this would be to read to you some of the questions that we have proposed in our plankton research program to give you some idea of the direct interdisciplinary nature of the kinds of questions that are asked. For example, we must know waterflow patterns in the various areas in order to compare dilution, predation, and changes of growth patterns. A distinction must be made between dissolved nutrients, nutrients bound to detritus, and the requirements of the plankton populations for both forms. To what extent does tidal resuspension of benthic sediments contribute to the nutrient requirements of the plankton? Are there different types and size distributions of delivered sediments depending on land use in the watershed? How do sediment distributions affect the spectral distribution of the underwater light? How do sediment distributions affect the distributions of attached aquatic plants? How much of the nutrient budget in the estuary is delivered by land runoff, how much from the marshes, and how much from attached aquatic plants and their epifauna as well as their epiflora? What is the turnover rate of phosphorus and nitrogen in benthic sediments? Do the observed phytoplankton standing crops have any direct effects on oyster and clam growth rates? How do nutrient pulses due to runoff affect the rate of development of the anaerobic bottom layer in the Bay during the summer? How would a known increase of treated waste delivered to the Rhode River affect the observed plankton distribution? What would be the increase in erosion and sedimentation and the subsequent decrease in the depth of the photic zone if a wooded area were cut down or if a roadbed were constructed?

It is obvious, therefore, that what we are talking about here is the interaction of a great many disciplines in describing one particular watershed where the measurements are made coincident in space and time. This is an approach which, while obvious, has not been carried out in very many places. We have gathered together a group of researchers from the University of Maryland, from the Smithsonian Institution, from the U.S. Geological Survey, from the Catholic University, and from The Johns Hopkins University who are working on problems of hydrology, sedimentation, aquatic plants, epifaunal populations, foraminifera, benthic bivalves, protozoan and bacterial populations, benthic sediments, phytoplankton and zooplankton energy budgets in the wetland area at the Rhode River, and the way in which scientific decisions can be translated into community action. This latter is a very basic point. In our Rhode River research we are actually integrating the scientific program with the community. When any scientific decisions are made they do not come as a shock to the community because this is part of the total effort. We hope to use this kind of approach in a small area. Admittedly Rhode River is a small area and not necessarily representative of some polluted tributaries on the Chesapeake Bay. However, it is a manageable area and there should be a great deal, in terms not only of the way in which the methodology is developed for this research but the way in which this research is applied to community programming, that can be transferable to a great many other areas.

I would like to close with a very short historical note. This is a very little known fact in the life of Rembrandt van Rijn. Rembrandt never made out very well. He was a true artist and a craftsman in the use of paints and pigments but nobody ever supported him. Occasionally he would get a fee from a rich merchant or a group of politicians down at City Hall who wanted their portraits painted. All of a sudden the paint began to peel very seriously from the City Hall, which was constructed of wood. None of the other painters in town, who were just ordinary house painters, could succeed in keeping a layer of paint on the City Hall, possibly because it had never occurred to the town that knowing *why* paint stuck to wood was as important as brushing it on. And so the city fathers went to Rembrandt and said, "Rembrandt, we need you to paint the City Hall," and Rembrandt said, "I'm engaged in doing something creative like making portraits," and they said, "Don't bother us with art, don't you have any patriotism? We want you to paint the City Hall before it falls apart." And Rembrandt made a very interesting decision. He said, "If you really haven't been interested in me as an artist, I'm really not very interested in painting your City Hall." And so at the present time we have magnificent paintings and the City Hall has fallen to dust. There might be a moral to this in terms of basic research—we could have had both.

Certainties and Uncertainties in Economic Development as they Relate to the Future of the Chesapeake Bay

Edwin E. Holm[1]

Division of Industrial Development, Commonwealth of Virginia, 1010 State Office Building, Richmond, Va. 23219

ABSTRACT

It will mainly be people-growth rather than industry-growth that will put pressure on the resources of the Chesapeake Bay. Of the 7.5 million people living in the Chesapeake Bay-Tidewater region, approximately 6.5 million are in 4 metropolitan areas. To the year 2000 the population of this region is expected to grow at double the national rate and to be even more highly concentrated in these metropolitan areas, with the Washington area accounting for 50% of the region's population. It is Federal government employment, not manufacturing or industry growth, that has caused and is likely to cause the high rate of growth for the region.

I would like to emphasize at the beginning the word "uncertainties" in my subject. In looking to the future, there is much less certainty in projecting the course of the social factors that will affect the Bay than in the physical factors. I would also like to point out that we will be taking a look at the economies of the larger communities in the Chesapeake Bay area rather than analyzing the economy of the Bay as a whole. These communities have largely been independent of one another in their development to date—proceeding in this way will give us a better understanding of the impact of the economic growth on the environmental problems of the Bay. We shall give the broad-brush treatment to the economies of the major communities, attempting to isolate those factors which have accounted for growth or lack of growth and which are most likely to be important in the future.

Most of this discussion will deal with the tidal areas of the Bay only, but before proceeding, it is worthwhile to examine recent economic development in some of the main tributaries—the Susquehanna, the Shenandoah before it enters the Potomac, and the James.

The Susquehanna drainage area from its headwaters in New York, through its passage in Pennsylvania, to its entrance in the Chesapeake Bay in Maryland has been a slow-growth area during the past decade. The metropolitan areas of Scranton and Wilkes-Barre experienced absolute losses in population during the decade of the 60's. Binghamton increased by only 5%, and Harrisburg, even though it is the capital of Pennsylvania, experienced only a 10% growth in population. The striking fact about the Susquehanna drainage area, however, is that on the whole it has a substantial rate of manufacturing growth, and this was in contrast to the lack of such growth in the metropolitan areas of New York and Pennsylvania to the east. This manufacturing growth did not contribute to much population growth, largely because it was offset by sharp employment declines in agriculture and mining. The growth of manufacturing in this area would appear to be promising in the future and, therefore, would contribute to the pollution problems that arise from having more people and more industry. The drainage areas of the Shenandoah and the James, both in Virginia, experienced a very high

[1]Edwin E. Holm is currently Director of Research with the Virginia Division of Industrial Development. He did graduate work at the University of Virginia and the University of Chicago and for twenty years has worked on various research projects for the State of Virginia.

rate of manufacturing growth during the decade of the 60's, and this growth can be expected to continue for the next 10 and 20 years into the future. The type of industry that has been coming into these areas, however, has been dry-process industries that have not placed the demands upon the water resources that the pulp mills, chemical plants, and other wet-process industries did that came into the areas in earlier periods. The communities in these areas, even at the largest population centers of Charlottesville and Lynchburg, are quite small compared to the population of the major metropolitan areas in the tidal portion of the Chesapeake Bay and therefore are not likely to generate any great strain on the water resources of the Chesapeake Bay.

Now let us take a look at the tidal portion of the Chesapeake Bay, an area with a population of 7.5 million people. A significant fact is the concentration of this population in a few large metropolitan areas. Three million persons are in the Washington metropolitan area alone. Two million are in the Baltimore area. One-half million is in the Richmond area and 1 million is in the Hampton Roads area, which includes Norfolk-Portsmouth and Newport News-Hampton. These few population centers account for 6.5 of the 7.5 million people in the tidal portion of the Chesapeake Bay. The remaining 1 million persons are scattered on the Virginia-Maryland Eastern Shore and on the fingers that jut into the Chesapeake Bay on the west side. These areas have been experiencing a slow rate of growth and, as a whole, have a population density of less than 100 persons/mi^2.

The Washington metropolitan area in the decade of the 60's was the most rapidly growing metropolitan area of 2 million or more in the nation, increasing by 38%. There is much speculation as to how rapidly it will continue to grow. A study prepared for the Council of Governments gave the most probable population for the year 2000 as 7.7 million people. This would be an increase of 3½%/yr. Federal government employment is overwhelmingly the basic cause of the growth in the Washington area. It was projected to more than double, thereby causing this huge increase in population. In relation to its size there is only a modest amount of manufacturing in the Washington area. The 50,000 persons employed in manufacturing are largely in food processing, the manufacture of building materials, and in printing—all service-type manufacturing for the area's population.

Baltimore, with its 2 million population, increased by 13% during the decade of the 60's. This was the same rate of growth as was experienced nationally. Manufacturing has been of great significance in the Baltimore area, which accounts for 200,000 of Maryland's 270,000 in this segment of the economy. It is important to note that there

Table 1.—Percentage distribution of personal earnings by broad industrial sources for metropolitan areas in the Chesapeake Bay area, 1969.[1]

	Government	Manufacturing	Transportation, communications, & public utilities	Wholesale & retail trade	Finance, insurance, & real estate	Services	Farm mining, contract construction	Total
Sum of all SMSA areas in nation	16.0	29.8	7.4	17.1	6.0	15.7	7.9	100.0
Baltimore, Md.	24.2	26.9	7.8	16.3	5.0	13.3	6.5	100.0
Washington, D.C.–Md.–Va.	43.5	4.1	5.6	14.0	4.9	31.1	6.5	100.0
Richmond	16.6	14.4	8.9	19.8	8.6	13.8	7.7	100.0
Newport News–Hampton	42.5	27.3	3.2	9.6	2.5	9.7	4.9	100.0
Norfolk–Portsmouth	53.3	7.6	6.1	13.7	3.3	10.4	5.7	100.0

[1]Source: Survey of Current Business, U.S. Department of Commerce, May 1971.

was no increase in manufacturing in the Baltimore area in the decade of the 60's. Actually, manufacturing employment declined by 4 or 5 thousand, and there were significant shifts in the types of manufacturing in the area. In spite of this no-growth situation, Baltimore's performance was better than that of the Philadelphia or New York City area. The growth in population experienced in the Baltimore area during the 60's was not caused by manufacturing but by the other diversified activities that grew in importance.

The Richmond area, with somewhat more than 0.5 million population, has 50,000 persons employed in manufacturing. If the Hopewell area to the south, with its chemical complex, is included, and if the West Point area 25 miles to the southeast, which has the only pulp mill on the Chesapeake Bay, is also included, we have an area with a manufacturing employment of 70,000. During the 1960's the Richmond area grew in population at substantially above the national rate but at a considerably less rapid rate than in the 2 preceding decades. As we have noted earlier, most metropolitan areas in the country are experiencing retardation in their growth.

Approximately 70% of the population in the Hampton Roads area live on the Norfolk-Portsmouth side and the remaining 30% on the Newport News-Hampton side. As was the case with the Washington area, overwhelmingly the most important source of basic employment is the Federal government. In the Norfolk-Portsmouth area, 53% of the income received by individuals is derived from Federal government employment. This is a higher proportion than for any large metropolitan area in the country. This area has only 20,000 persons in manufacturing, and much of this manufacturing in its initial location was closely tied to the waterways of the area. On the Newport News-Hampton side the Federal government is also basic to the economy, and manufacturing features more prominently because of the large Newport News Shipbuilding and Drydock Company. This one company accounts for approximately 0.75 of the manufacturing employment. The remaining 6,000 manufacturing employment is in a variety of industries, many of which have located in recent years. In summary, in the Hampton Roads area manufacturing has been of only modest importance, and it is really the Federal government activities which have brought the people there.

The tidal areas of the Chesapeake Bay have been experiencing a much higher rate of population growth than the nation. What is the outlook for population growth for this region in the future—say to the year 2000—and what will be the impact of this people growth on the environmental resources of the Bay? The most important single point to consider is what is happening to the rate of population growth for the nation as a whole. This rate has slowed considerably in recent years and currently is averaging 1.2% annually. There is much uncertainty as to what this rate will be 10, 20, or 30 years from now, but perhaps the safest estimate is to project at a rate of 1.2% annual increase to the year 2000.

As has been the case in the recent past, there is likely to be great differences in the rate of population growth for the 5 major metropolitan areas in the Bay region. You will recall that consultants in a major study for the Washington metropolitan area projected as the most probable population in the year 2000 for that area 7.7 million people. This would be an increase of over 3½% annually during the 30-year period. Again, there is much uncertainty as to whether this increase will actually develop. As indicated earlier, growth in the Washington area will be largely determined by the rate of continuing expansion in Federal employment. It is possible that decisions could be made that would slow down this rate from that which has been projected, thereby reducing the projected rate of population growth. Perhaps the safest assumption for the Baltimore area is to assume that it would continue to grow at approximately the national rate to the year 2000, thereby increasing the population of 2 million in 1970 to 2.7 million by the year 2000. For the Richmond area our Virginia estimates are that it will continue to grow at a higher than national rate, increasing the population from slightly over 0.5 million to approximately 1 million by the year 2000. The 2 metropolitan areas in Hampton Roads have a combined 1970 population of approximately 1 million. Currently, the Newport News-Hampton side is growing at somewhat above the national rate, while the Norfolk-Portsmouth side is growing somewhat below the national rate. If we project this area at the national rate of growth of 1.2% to the year 2000, it would have a population of 1.4 million. The remaining portion of the Chesapeake Bay region, outside these 5 metropolitan areas, has a population of approximately 1 million. These areas have been growing very slowly and in some communities there have been actual declines in population. There is nothing on the horizon to indicate a greatly stepped-up rate of growth, so we assume that these more rural areas will be growing at less than the national rate to the year 2000.

In summary, the rates of growth assumed above for each of the metropolitan areas would give the Chesapeake Bay region an annual rate of growth of 2.4% to the year 2000—double the annual rate of 1.2% for the nation—and the Washington area alone by the year 2000 would account for more than 0.5 of the population in the Basin. This would indicate that our environmental problems resulting from people growth are likely to be increasingly concentrated in the metropolitan areas.

Skipping from people growth to industrial growth in the Bay region, I think the major point to grasp is that since World War II this region has not attracted the heavy water-using industries that it did in earlier periods. These conditions may continue in the future. A use of census of manufacturing figures for 1964 showing water intake and water discharge for each type of manufacturing industry is helpful in examing this point (Table 2). Four of the 20 major manufacturing categories—chemicals, primary metals, pulp and paper, and petroleum refining—account for 85% of all the water intake by manufacturing in the nation. Even within these broad categories, it is only selected subindustry groups that are actually large water users. In the Chesapeake Bay region 3 of the major categories—chemicals, primary metals, and pulp and paper—account for 85% of the water intake by industry.

Let us look ahead. It is true that in recent years we have a few examples of chemical-process industries that have located in Maryland and Virginia, but they are modest in their water use compared to particular plants that came in earlier. There is the large Bethlehem Steel facility at Sparrows Point. About 10 years ago, a study was made to determine whether another large steel facility would be feasible in the Hampton Roads area. The study indicated, largely because of the lack of a large enough market and also because of a change in technology, that another large steel facility was not feasible

Table 2.—Water intake by major manufacturing industries, United States and Chesapeake Bay region, 1964 (in billions gallons).[1]

Industry Groups	Chesapeake Bay	% Distribution	U.S.	% Distribution
Totals	757	100.0	14,050	100.0
Food and kindred products	29	3.8	760	5.4
Textile mill products	3	.4	148	1.1
Paper and allied products	119	15.7	2,071	14.8
Chemicals and allied products	180	23.8	3,889	27.7
Petroleum and coal products	–	–	1,398	9.5
Rubber and plastic products	8	1.1	163	1.2
Stone, clay, and galss products	15	2.0	249	1.8
Primary metal industries	341	45.0	4,578	32.6
Electrical machinery	5	.7	105	.8
Transportation equipment	14	1.8	247	1.8
All other		5.7		3.3

[1]Source: U.S. Bureau of the Census, *Water Use in Manufacturing*, 1963 Census of Manufacturers.

for the Chesapeake Bay area and was not on the horizon in the foreseeable future. A few years ago, primary aluminum producers were taking a look at the Chesapeake Bay area. The high cost of electric power quickly brought an end to their consideration. As for pulp and paper, there is a single mill in Virginia on the York River. It is the belief of our forestry people that the timber resource of the area is not sufficiently large to support another facility.

There are 2 major categories of large water-using industries—petroleum refining and chemicals—for which the Chesapeake Bay region may have a potential in the future. The modest Amoco refinery at Yorktown is the only petroleum refinery that has located in this region since World War II. Currently, the nation has a demand for slightly more than 5 billion gallons of crude or refined petroleum annually. Approximately 0.25 of this is imported. The pressure has been steadily building up for this nation to receive much larger quantities of imports. The National Petroleum Council in its *Interim Report on U.S. Energy Outlook* predicts that the demand for oil imports to the United States in 1975 will more than double the 1970's demand, and by 1980 more than triple it. We are therefore facing considerable pressure along the Atlantic Seaboard as to where this refining capacity should be located. What draft will these large petroleum ships require? What receiving areas will be accessible to them? Can the unloading of the petroleum product be made absolutely safe? Are there any polluting effects from new refineries using the current technology? I believe that the Corps of Engineers is giving some attention to this problem of greater imports of petroleum products, but this would appear to be a responsibility of our States and the people in the Maryland-Virginia area, too.

Only about 5% of the output of the petroleum industry goes into petrochemicals. If petrochemicals were available in the Chesapeake Bay area, it is the thought of many that it would rejuvenate the growth of the chemical industry in this area. One advantage of the chemical industry is the high wage paid, leading to higher per capita income for those employed. I believe that what is in front of us on petroleum refining and the chemical industry in the Chesapeake Bay region is a much stickier consideration than the location of new power plants to which we have given so much time in this Symposium.

In closing, let us give some attention to the major portion of the land area of the Chesapeake Bay region—that portion that falls outside the metropolitan areas. Minus the metropolitan areas, the Chesapeake Bay region has a population of approximately 100 persons/mi^2 and has experienced little or no growth in recent years. Most of this area is outside the commuting range of the metropolitan areas that are growing so rapidly. This rural area has a strong recreational resource but its continuing development will give only modest employment. It is possible that in the years ahead the local leadership in these more rural areas will be more determined to promote industrial development, and such development would mean jobs to keep the young people at home, would raise per capita income, and would lead to new investments subject to local taxation. While there is nothing on the horizon to point to a greatly stepped-up development, I would point out that this is another area of uncertainty for the long run.

Questions and Answers

The Fate of the Chesapeake Bay: Research to Counter the Threats

Moderator: **Dr. Rita Colwell,** *Georgetown University*

Panelists: **The Hon. James B. Coulter,** *Secretary, Maryland Department of Natural Resources*
Mr. Jerome Williams, *U.S. Naval Academy*
Dr. Carl Sindermann, *U.S. Bureau of Commercial Fisheries*
Col. Louis W. Prentiss, *U.S. Army Corps of Engineers*
Dr. Howard Seliger, *The Johns Hopkins University*
Mr. Edwin Holm, *Virginia Division of Industrial Development*
Dr. Joel Hedgpeth, *Oregon State University*

Q—After 10,000 years of apparent extinction, the brackish water clam *Rangia kinyata* has experienced a population explosion all along the Atlantic Coast, including the Chesapeake. Could this now be considered a crisis indicator?

DR. SINDERMANN—This raises a very important point. We should be aware, not only of the decline or disappearance of species as a result of environmental changes, but of the positive explosion type of response as well. As an example, sea urchins on the west coast of Florida increased in abundance dramatically in the autumn of 1971, in an area previously ravaged by extensive red tides. It may well be that those forms which already have developed, or which can develop, resistance to pollutants of various kinds will be the ones which populate the inshore waters. Simplification of inshore ecosystems often results in population explosion of certain species, and we should expect to see more of this phenomenon.

Q—Has there been a comprehensive survey of significant changes in commercial fisheries patterns as a function of time. Has there been any attempt to define such changes as natural or man-made?

DR. SINDERMANN—A paper should be available from the National Marine Fisheries Service within the next 6 months, as far as I know, covering just about the last 2 decades for most of the significant commercial and sport species of the Atlantic Coast. I don't think this study will attempt to relate to environmental changes, but at least it will give a rather interesting picture of what has happened to the abundance and distribution of a number of species. It is surprising at the present time the amount of misinformation available. Most of us feel intuitively that many species have declined and virtually disappeared. But some of the species which one might assume to be most severely affected by inshore environmental modifications are just as abundant overall as they were a decade or two ago. True, there may be local extinction or reduction in abundance, but looking at the species as a whole, the kinds of decline in abundance you might anticipate don't exist. This statement anticipates the findings of the paper, which I have no right to do, but this is one general statement that could be made about it.

Q—Are there any field or laboratory data suggesting that pesticides, even at concentrations an order of magnitude greater than those found in North Atlantic waters, have measurable effects on plankton? Can you cite a figure for pesticide levels in North Atlantic Ocean water?

DR. SINDERMANN—I'm sure there are others in the audience who could give a more satisfactory answer. There are many papers on the effects of pesticides on phytoplankton and zooplankton organisms. Most of them, however, are concerned with effects of relatively high pesticide levels on animals in experimental situations. Among those which might be mentioned are: Wurster (Science, 159, 1474-1475, 1968) documenting reduction of photosynthesis by 4 species of phytoplankton exposed to DDT; Bookhout et al. (Water, Air and Soil Pollution, 1; 44-59, 1972; and Harvey *et. al.* (Nobel Symposium, Chlorinated Hydrocarbons in Open Ocean Organisms, *In* Nobel Symposium, "Changing Chemistry of the Oceans."

Q—How much will your hydraulic model cost?

COL. PRENTISS—The total study program is authorized by the Congress at $15 million, which includes money for the model and all the study elements. An estimate for the model to include all of the supporting facilities is about $10 million.

Q—Who determines and manages programs for the future of the upper Chesapeake Bay: the State of Maryland or the Army Engineers?

MR. COULTER—Both the State of Maryland and the Army Engineers are influential in programs that determine the future of the upper Chesapeake Bay. In addition, there are many others that have a strong voice. In the first place, given a democratic setting, the people of the region will have much to say about the future of the Bay. The Susquehanna River Basin Commission has been created and is just now becoming active. Maryland is a full participant in the Commission because we expect it to take actions that will protect our interests in the Bay.

The Corps of Engineers study and the knowledge obtained from experiments with the hydraulic model will produce needed and useful information. But I have confidence that the State of Maryland will survive for many thousands of years and that the State will have a major voice in matters concerning the Bay. In that respect, I think we must avoid a parochial attitude and recognize that although Maryland has a responsibility for custodianship, the Chesapeake Bay doesn't belong to us exclusively. It is a treasured asset for the nation, and I would hope that the federal government recognizes its custodial responsibility also.

Finally, in thinking of the future of the Bay, let me point out that I have two children who are smarter than I am and that they are going to be derelict in their duty if my grandchildren aren't smarter than they are. That being so, we might be wise to concentrate on the problems that we have inherited and be careful not to create new problems in our own time. If we do that, I have a good deal of confidence that the future in the hands of future generations will be secure.

Q—Can you give any specific examples of success in your inter-disciplinary approach at the Rhode River?

DR. SELIGER—I'm glad that question was asked. Frank Williamson and I spent a whole year putting a proposal together, getting the investigators sufficiently enthusiastic so that they would divert their activities from the particular areas where they were operating to operate at Rhode River. We were funded 2 weeks ago, and at the present time we have spent all of our time writing a proposal for renewal.

Q—You emphasized that we cannot look at the environment piece by piece. How does coordination come about? Who does it and what does it consist of?

MR. WILLIAMS—One of the things I don't know anything about is coordination. Perhaps someone else on the panel could help.

Q—Please repeat and elaborate on the work of Thomas at Harvard 15 years ago relative to benefit costs, and how you feel his findings relate to water quality standards [apparently the questioner did not find the significance of this reference clear].

MR. COULTER—Harold Thomas is a remarkable scholar and a professor at Harvard University who, some years ago, wrote a little treatis called the *Animal Farm*. It was published in one of the economic journals—I am sorry I can't cite it for you right now.

Essentially he took the Howard Seliger approach. He described a farmer's daughter who had somehow broken the male barrier and gone to Harvard University. Her father had a problem with chickens that became ill from some disease. The question was whether the father should take the losses from the disease, which by the way was transmitted through water, or treat the water and get more income from the birds thus saved. In this little treatis Dr. Thomas brought in the factors that should be considered in almost every problem of standard setting and through a series of fundamental mathematical manipulations showed how these factors actually imputed a cost-benefit ratio. It is like the law of gravity—you can't escape it. Any standard deliberately set has costs and benefits associated with it. Or if you do nothing and just let things happen to you, then by your indifference you establish a standard which has costs and benefits associated with it.

Q—What is the planning construction timetable of the model at Matapeake? What is the plan of the disposal of the sewage and waste?

COL. PRENTISS—We have not been funded for construction at this time. Until we are funded for construction, a definite schedule cannot be established; however, if funding is received in a timely manner, the model and shelter could be completed in 1974. Regarding sewage disposal, a treatment plant utilizing secondary treatment measures will be constructed at the model site.

Q—How many people are to be employed at the hydraulic model?

COL. PRENTISS—In the construction phase we would have about 50 Corps of Engineers employees, especially trained in model construction. We would use contracts for the structure and supporting facilities; contractors could have perhaps up to 100 employees. After construction, the operational requirement will be about 25 to 50 employees.

Q—Dr. Williams implied that "normal" means a single valued function. On the contrary, we must recognize that normal is a dynamic function of given characteristics. Man's attempt to reduce its natural variations may be exactly the wrong thing to do. However, we are sufficiently sophisticated to be able to determine variations from the norm if that norm is a complex function. Would you like to comment on that?

MR. WILLIAMS—I certainly agree with the first part of the statement, and I'm sorry if my meaning was misconstrued. The normal function is a very dynamic thing and therefore very difficult to determine. I was trying to say that this is another way of looking at normalcy—to draw an envelope around the excursions of a particular parameter and treat it as a normal function rather than a single valued function. I'm not so sure that we are sufficiently sophisticated to be able to determine variations from the norm, especially if we don't know what the norm is.

Q—Have you formulated a mathematical model to display observable functional relations in the framework of necessary boundary conditions?

MR. WILLIAMS—No.

Q—Do you really think there would be no effects from Calvert Cliffs, considering that the 10° rise would cause large kills during mid-winter shutdowns; that EPA and many aquatic biologists consider a 10° rise excessive; and that the power company knew the standard would be revised downward long ago during the design.

DR. SELIGER—The pedagogical trick that I told you about during my talk has several advantages. If I say something dumb, and a student comes out later and disproves it, he is never quite sure whether I meant it or not. No one can say "no effects." Using a concept in statistics called normalization, we have to talk about the *relative* effects. Now, Dr. Pritchard has made very strong noises about the difference between a temperature rise in a laboratory container and temperature-time relationships for moving organisms in a dynamic plume. I think this is a rather critical point. When we consider a 10°

temperature rise, we have to consider the time during which an organism may be entrained at that temperature and then develop its subsequent history. A 10° rise is excessive if it occurs at the optimum temperature for that particular species. In fact, at the maximum temperature for a species, a 0.1° rise could be quite serious. These are all very relative terms, so I don't think it is possible to discuss the problem in terms of absolute numbers. What if water that flowed through the Calvert Cliffs plant were disposed of inland in some black hole, causing whatever biota were contained in this volume of water to disappear from the Bay. Would this cause an irreversible change in the species distribution of all of the upper trophic levels in the Chesapeake Bay? This is rather an important question and I think if we try to answer it, we might be able to relate it to what we might consider the maximum effects of this temperature-time relationship.

MR. WILLIAMS–I think I detected in that question an assumption that the Chesapeake Bay or some significant portion of it would be raised 10° in temperature. This is not so. The 10° that was referred to is the ΔT, or the drop across the condenser plates in the plant with the water that comes in contact with the plants. Many people have asked how we could fry all those delicate organisms in that system. Bear in mind that the steam being used is about 90-92°F on the hot side of the condenser. The design at Chesapeake Laboratory limits the 10° drop across the condenser such that you will not have a mixing zone in the Chesapeake Bay itself. In fact the temperature impact at the surface will be a rise in temperature of about 0.5° within several acres of the discharge site. I want to make it quite clear that the Chesapeake Laboratory has not raised the temperature of the Chesapeake Bay or any significant portion of it by 10°.

Q–You have talked about the industrial impact on the ecosystem. I understand your statistics to show there is negligible industrial growth in Baltimore and hardly any industry at all in D.C. and Virginia. I am curious to know if industry is supposed to be a problem in the Bay, or if will become a problem. Please explain whether your statistics were supposed to be optimistic or pessimistic as to the future of the ecosystem of the Bay.

MR. HOLM–It has been said many times here that we have more of a people problem in the Bay area than an industry problem. We will not have export industries in any great size developing in the Washington area and I think that the Baltimore area's outlook is for growth in non-manufacturing activities. The point I was emphasizing concerning any model for the future is that there are certain industrial crises that I would not foresee today but that may well be on the horizon 10 years from now.

Q–What State and federal agencies are involved in your Chesapeake Bay study, and what is their contribution?

COL. PRENTISS–All federal and State agencies that are involved in water-resource planning, such as the Department of Interior, EPA, Fish & Wildlife Service, Smithsonian, and State agencies like Mr. Coulter's organization which is involved in the Chesapeake Bay. Their contributions are in their area of expertise.

Q–How many biologists are involved directly in planning the Bay study?

COL. PRENTISS–I have no idea of the numbers the various agencies have employed, but I am sure they will be in the hundreds.

Q–What scale factors had to be taken into account in developing that hydraulic model?

COL. PRENTISS–Empirical data from the Vicksburg waterway experimental Station has shown that, for a model of the depth we are working with, 1:100 vertical and 1:1000 horizontal are the optimum scales that will accurately reproduce hydraulic phenomena of the Bay.

Q–In your list of objectives you said, "and lastly the well-being of the people." Is this the last, or perhaps the least, consideration?

COL. PRENTISS—No, you could put them in any order. They are obviously the 4 national objectives. The well-being of the people is being considered more and more in all planning these days and it's probably at the top, certainly with this group.

Q—How long will it be before a person will be swimming in the Potomac below Blue Plains; the Annapolis area, Back Creek, Spa Creek, etc; or the Baltimore area? How long will it be before a person will not be able to safely swim in the Bay at all?

MR. COULTER—Blue Plains depends on Congress. The Blue Plains sewage treatment plant, as many of you know, has been the subject of an interminable federal conference. It started in 1957 and has gone through several sessions and several sets of recommendations. The primary problem since 1957, as we said yesterday, has been money. Financing, I believe, has been arranged, depending upon how the final amendments to the Federal Water Pollution Control Act are handled. That financing provides for an investment in this one sewage treatment plant alone of something like 1/3 to 1/2 billion dollars. When those investments are in place, the water that is discharged from the Blue Plains plant will be of a very much higher quality than any conceivable natural water in the Potomac estuary or in the Potomac River. Concerning the other places that were mentioned, the State of Maryland's objective is to restore all waters to a quality suitable to support recreation. Back in 1966, more than 1 million people in this State flushed their toilets and let the material go directly to the waterways without treatment. At that time Maryland provided the money and undertook a program to make sure that the flushing from every toilet ran through a tight pipe to a cleansing plant with final disinfection. I'm happy to say that tremendous progress has been made. The objective was to have all of the plants either constructed, or under design, or under construction and financed by 1971. I think it's rather healthy that that objective has been achieved. The State is now moving on to higher objectives: Where, what, and how to remove things like phosphorous. We do wonder what in the world would-be scientists are talking about when they demand nitrogen removal. In an atmosphere around us of 85% nitrogen, and considering the solubility of the gas, we have a little bit of trouble in designing a sewage treatment plant that will remove 98% of the nitrogen. When we know what is involved, then we will proceed with designs. We are taking on those higher objectives in the next year or so, and we will have the common parameters for swimming pretty well under control.

Q—What are some of the facultative pathogens? Have you demonstrated this ability directly? I think there is some confusion on that term.

DR. SINDERMANN—Probably one of the best examples would be finrot disease, characteristic of the New York Blight area since 1967. Three different genera of bacteria (*Aeromonas, Pseudomonas* and *Vibrio*) have been shown to be responsible for this condition. These organisms—some of them at least—are capable of multiplying in the organic soups that we are depositing in the Bays. In sufficient concentration they are able to invade and infect fish. In this sense they are facultative. They are not noted—most of them at least—as primary pathogens of fish or invertebrates, but when they are concentrated, sufficient infection pressure is created to infect fish. I think it has probably been best demonstrated in the case of the finrot condition. There probably will be other examples of the same kind of phenomenon in the future.

Q—With respect to your graph of 10-year ranges of pH, salinity, temperature, oxygen: Do we know indeed that these are normal ranges due to natural causes, especially at the northern-most station? Do these same data evidence any trends? Also, have there been any discernible changes in the quantity and/or quality of fisheries in the same general area as the northern-most station?

MR. WILLIAMS—Generally speaking, it is very difficult to determine whether these tremendous ranges and variables are exclusively man-made, exclusively non-man-made, or some combination of the two. I tried to pick stations halfway between the 2 shores to get out in the water that was least affected by man, and I also picked a period of time, approximately 1950 to 1960, when the excursions by man on Chesapeake Bay were not as great as at present. Generally speaking, the data do not show any trends. The extremes seem to occur in more or less random years. The data is similar to weather data, which doesn't show any particular trends. Although some people seem to think there has been a slight warming trend over the last 50 or 60 years, this can be disputed depending upon where the temperature is measured. It seems to me the natural variations in fisheries are so great that it's very difficult to determine whether anything really significant has happened during such a short period as 10 years.

Q—Many speakers have pointed out that changes in temperature produced by power plants are small compared to natural variations. However, it has been argued by some that natural variations are always random, whereas power-planning effects are unidirectional. Would you comment on this?

DR. HEDGPETH—In the first place, natural temperature variations in the environment should not be considered random. There are seasonal cycles, both of temperature and light, and these are interrelated. We have yet to sort out the effects of light and temperature cycles in many plants and animals. There are of course many minor variations within the annual temperature cycles that are unpredictable and might be thought of as random. The temperature effects of a power plant in a recirculating system such as an estuary may be such as to stabilize the temperature or at least narrow its range, and thus to smooth out the annual cycles. We do know that many organisms seem to require a seasonal or regular variation in temperature and do not do so well under constant conditions. Also, a rapid rise of temperature at a certain period of the year, which may or may not be related to length of day or quantity of light, may affect or stimulate development of gonads. It has been demonstrated in England in some work with warm water from a power plant that it is possible with a steady source of heat to advance reproduction so that larval stages may be out of phase with the rest of the system. Something like this may have happened naturally to the California sardine. For a period of perhaps 9 years the natural fluctuation of temperature was less than it had been for the previous 25-50 years, and reproduction of the sardines was reduced. It is possible that the sardine larvae got out of phase with the phytoplankton cycle, which is more closely related to light conditions than temperature. Heavy fishing at the same time added to the effect and we had a major population crash of an important fishery. In tropical or even warm-temperature situations, the steady increase in temperature and damping of seasonal ranges could reduce the margin of safety between death and survival of many warm water species, already living near the limits of their temperature tolerances in natural conditions.

Q—How do you plan to integrate the changing shoreline configuration of Chesapeake Bay with the fixed shore-line configuration of the model?

COL. PRENTISS—Just change the model. If there is a desire to make a major man-made variation in the Bay area, we will remove the old section, put the new configuration in, run the model, and see what happens. That is the purpose of a model like this. It will be a dynamic model that can be changed at will.

Q—Will the hydraulic model reproduce the salt and freshwater layers of the Bay and its mixing processes? What other parameters will be reproduced—tides, currents, flushing, etc?

COL. PRENTISS—Yes, all of them. That's what we are going after.

Q—Can nonfederal and private agencies use the model?

COL. PRENTISS—That is the proposal. After the model is completed, we will verify the model using field data being collected at the present time. We have over 200 collection stations all over the Bay to determine various temperatures, salinities, tidal fluctuations, and current velocities. After the model verification and the testing program to be undertaken as part of the study, the model will be available to any research agency desiring to use it for Bay research. How it will be managed at that particular point has yet to be determined.

Q—If that model merely represents physical characteristics, how can it help to answer biological questions which seem much harder to understand, since their interaction with physical characteristics have not yet been adequately defined? What critical answers will this model provide?

COL. PRENTISS—Certainly it will provide the physical answers to support the biologist who is trying to make that kind of determination. The model should be able to provide what he requires from a physical standpoint to further his investigation.

Q—You indicated that money spent to control phosphorous is wasted, if it could be shown that there is a net import of phosphorous to the Bay from the ocean. In view of the extensive data available from the Chesapeake Bay Institute and John Rathers' work at Woods Hole, this seems rather to be an impossibility. Can you amplify what you meant?

MR. COULTER—It certainly wouldn't be the first time in my life that I suggested something that was impossible. I don't know of information from Woods Hole or anywhere else that gives the basis for a mass balance. It seems to me there are 2 valid questions that the rational manager would ask: First, after I take this step, what impact will it have on the total budget of the natural system, or the system as it exists—in other words, after I take out all of the phosphorous being contributed with domestic sewage, what will that do to change the phosphorous budget of the Chesapeake Bay? And the second question that is very important to me and I think should be important to you: If I replace phosphorous with some other material to do the cleansing that we want in our washing, ablutions, or whatever, what will that do to the Chesapeake Bay and the creatures living in it, and what countermeasures should I take in order to offset any undesirable effects? Without knowing the answers to those 2 questions, I would reserve some judgement on the investments that are being made for phosphorous reduction.

Q—In reference to heavy metals, you noted that the level in sediment cores is already in excess of levels allowable in water quality standards. In those standards the reference is to the water, not to what is contained in the mud.

MR. COULTER—I don't know who asked the question, but that is not so. The figures that I am talking about are ones in guidelines that have not been promulgated as standards, so they have not had the scrutiny that standards would have. Furthermore, the figures in the guidelines refer to the dry weight of substance in the mud being dredged from the Bay.

Q—Col. Prentiss mentioned that some of the pbulic seems to feel that action, not studies, is required. This implies an anti-intellectual attitude that could be a fundamental threat to the programs we have been talking about. Do you have any feeling that the public's tolerance of research may be lessening, thus providing a roadblock to solving some of the Bay's problems?

DR. HEDGPETH—I didn't intend to impugn any anti-intellectual approach to the urgent feelings of some people that something has to be done. As I indicated, the anti-ecologic interpretation that some people are getting a little impatient with studies is confusing matters here. I don't know how much research the public tolerates. Certainly it seems to tolerate a great deal in the San Francisco Bay area, and by the public there, I mean industry and the local governments that have put up very substantial sums of money. The City of San Francisco hired consulting engineers who certainly aren't cheap, and the communities in the southern part of the Bay hired other consultants. The real problem is that too many people are treading over each other's grapes and the wine is getting a bit thin.

The Fate of the Chesapeake Bay (Dinner Address)

David H. Wallace[1]

Associate Administrator for Marine Resources, NOAA,
U.S. Department of Commerce, Rockville, Maryland 20852

ABSTRACT

In the 1930's, pollution of Chesapeake Bay was considered to be of limited significance and environmental modification was seldom mentioned, industrial pollutants being limited to areas near Baltimore, Hampton Roads, and Norfolk. It is obvious that environmental problems now are of far greater concern than in 1936; one indicator is the change in abundance of key species of fish and shellfish. Although some conservationists contend the resources of the Bay are depleted, this is not so. But estuarine development has deteriorated, and if allowed to continue, this deterioration could result in the destruction of the Bay's productivity. The Bay must be studied as a single biological system, possibly as a subset of an even larger one including Delaware Bay and the Atlantic waters. All levels of government must be involved in planning, law-making, and resource management and development.

It is always a pleasure for me to participate in a discussion of the Chesapeake Bay. Since I was raised on the Eastern Shore of Maryland, did my academic training at Maryland institutions, and spent a major part of my career in marine biological research and management on the Chesapeake, it is not surprising that I have some rather strong feelings about the future of this magnificant body of water. I want to make it clear in the very beginning that I do not subscribe to the emotional concepts of the "Harbingers of Doom" who believe that it is already too late to preserve the Bay for future generations. Nor can I support the views of some—I hope a limited number—that the Bay is capable of withstanding great alterations and large amounts of pollutants without substantial changes in its future productivity. I suppose I could be categorized as a conservative moderate who wants to see decisions made involving conflicting uses on the best facts available and with options weighed and evaluated. This talk this evening is subjective since I will attempt to recall my impressions of the Bay as it appeared to me as a young research biologist at the Chesapeake Biological Laboratory in 1936 and my impressions of it some 35 years later in 1972.

Up to 1936 the amount of research that had been carried out on the Chesapeake Bay and its resources was relatively limited except for continuing studies of oysters. Dr. R.V. Truitt at the University of Maryland had been struggling for a number of years to obtain support to establish a marine laboratory and had finally obtained enough funds to build a modest teaching-research laboratory in the early 1930's. Dr. Truitt himself had been carrying out studies on the oyster following after the pioneer works of Dr. Brooks of Johns Hopkins University and Dr. Caswell Graves. Dr. Truitt and his students had also done some research on the blue crab and other limited research projects had been carried out by scientists of the U.S. Bureau of Fisheries and during the twenties by Drs. Cowles and Bramble of The Johns Hopkins University.

---

[1]Mr. Wallace received his M.S. degree from the University of Maryland and has been closely associated with Bay activities as a research biologist and as Administrative Assistant, Executive Secretary, and Director and Chairman of the Maryland Department of Tidewater Fisheries. He was Executive Director of the Oyster Institute of North America and the Sponge and Chamois Institute from 1951 to 1962, and has held a number of significant positions in the Federal government. He is the author of many technical and popular articles on fish, shellfish, and ecology and belongs to a number of professional societies.

Mr. Wallace was dinner speaker for the Symposium, but his talk was not detailed in pre-conference announcements.

Dr. Truitt was determined to expand studies of the Bay. He formed a group of Maryland Colleges who contributed support to the laboratory. Summer courses for advanced students were developed and outside visiting scientists were encouraged to spend the summer doing research in the areas of their interest.

The main concern about the Bay in the 1930's was depletion of certain fisheries allegedly because of overfighting and creeping pollution from Baltimore Harbor into the Upper Bay. Pollution was considered of limited significance then and environmental modification was hardly ever mentioned except in the case of the Conowingo Dam and its possible adverse affect on anadromous fish such as the shad. It is not surprising that these attitudes prevailed at that time. Most stretches of the shores of the Bay were relatively free of developed communities. Large farms encompassing hundreds of acres and small groups of summer cottages nestled adjacent to the sandy beaches dominated the shoreline. Vast salt marshes stretched for miles along the southern Eastern Shore of Maryland and northern Virginia. Water quality based on coliform measurements indicated a high degree of purity with only limited areas adjacent to a few of the larger cities and towns closed to the taking of shellfish.

Industrial pollution was limited to areas around Norfolk, Hampton Roads, and Baltimore. Since it was confined to very limited stretches of the Bay and its tributaries, such pollution aroused little concern from either conservationists, biologists or the public. Some people complained sufficiently to bring about pollution studies of Baltimore Harbor and the Hampton Roads area, but the overall threat of pollution was considered minimal.

Heated water effluents released to the Bay and its tributaries from power plants were unheard of as a possible pollutant. While a small power plant existed near the headwaters of the Nanticoke River, where striped bass spawn, the only apparent effect of its effluent was to stimulate the stripers to spawn a few weeks earlier in the River than elsewhere in the Bay. Very few industrial plants of any kind were located along the Bay and its tributaries except in the vicinity of the larger cities.

The C&P Canal was built but little was known about what ecological changes had resulted from its construction. The Baltimore Harbor Channel was dredged regularly and the sludge-muck was dumped in deep water off Kent Island, but this operation seemed to have no effect on fish and shellfish. Silting was changing the Susquehanna flats as a result of farming practices in upstate New York and in Pennsylvania. Some fishermen were predicting that the Conowingo Dam would end the runs of anadromous fish in the Chesapeake, but shad and herring were still relatively abundant.

Other than these few "minor" pressure points, no problems seemed to be significant environmentally. What were considered depleted fisheries held the interest and attention of the States and the public.

In Virginia waters, where extensive private oyster farming was encouraged, the oyster business was thriving and providing employment for thousands. The supply of seed oysters from the James River seed grounds seemed inexhaustible. Every weekday evening from fall until spring, many buy boats were on the James River to take aboard their seed from the tongers. The James River was considered the finest seed oyster grounds in the world and there was little reason to believe this would change. The James River seed, when planted in the lower Bay, produced excellent oysters. This enormous production, coupled with production from public beds yields in Maryland, made the Chesapeake Bay the foremost oyster producing body of water in the world.

Catches of crabs fluctuated widely from year to year. Almost continuously, charges of lack of conservation were hurled back and forth between Maryland and Virginia government officials and watermen. On each occasion, just as the crab catches declined to low levels, a large-year class would come along to replenish the stocks and peace and harmony would be restored again between the brothers–Maryland and Virginia watermen.

Croakers and weakfish could be caught everywhere. Almost anyone could row out a quarter of a mile from shore in a skiff and catch quickly as many of these species as he would need. But all was not rosy in the fishing area. In 1933 and 1934 landings of striped bass—called rockfish by people around the Chesapeake Bay—dropped to the lowest recorded commercial catch in history, even though hundreds of nets of all descriptions were being fished. Many conservationists and sportsmen bemoaned the wanton overfishing allegedly taking place and predicted that this species would become extinct if all commercial fishing was not halted immediately.

In 1935 the Maryland General Assembly, faced with this concern, appropriated $15,000 to study this fish, looking toward a management program which would save the striped bass. It was at this point I came to be involved with research and management, since I was appointed as the Assistant to Dr. V.D. Vladykov, who was employed to conduct the study.

The shad and herring also had declined drastically and during the late thirties and early forties Federal and State agencies studied the shad, hoping to stem the decline. Overproduction had already declined drastically since the turn of the century in Maryland, and the trend had not been halted in spite of extensive shell planting on the part of the State.

In summary, in 1935 we had a series of contradictions—while some species were depleted, others were at peak abundance, and there appeared to be no correlation between the intensity of fishing and the abundance or scarcity of a given species.

What are the conditions of the environment and the living resources in the Chesapeake Bay some 35 years later? I am unable to give personal appraisal of the Bay since I have not been intimately associated with the Bay and its resources in recent years. However, the proceedings of the Governor's Conference on the Chesapeake Bay in 1968 and some papers in the proceedings of the seminar held in 1970 by the Sports Fishing Institute on the biological significance of estuaries give considerable insight on current levels of production of living organisms, the conflicts in use which exist, and the environmental alterations which have and are taking place.

It is apparent that environmental problems now are of far greater concern than in 1936. In the view of many, these problems are more significant and important than the current status and health of the individual species of living organisms.

Pollution of the tributaries of the Bay has increased greatly compared to 1936. Adverse conditions have resulted from discharges from sewage affecting the biological and chemical qualities of such major tributaries the James and Potomac Rivers. While *coliform* levels are still generally acceptable for shellfish production, some 42,000 acres of shellfish ground are now closed because of domestic sewage pollution and some 250,000 acres are less desirable for finfish because of pollution. Contamination of Bay waters near Baltimore is still a fact of life just as it was in 1935. The threat of oil pollution is a constantly growing one as the demands for this energy source continues to grow and ever-increasing qualities of oil are transported into the Chesapeake area.

Major power plants using Chesapeake water for cooling purposes are now located at several sites and more are under construction or in the offing. The demand for electrical energy is growing at an extraordinary rate. The impact of the heated water on the Bay system is already being given careful study and scrutiny by various Federal and State agencies and other academic and public institutions.

Navigational channel dredging has increased greatly to accommodate to the changing ocean transport methods with major impact on the Chesapeake system—for example, the deepening of the Chesapeake and Delaware Bays. This will affect the fresh water salt balance. The extent of the total impact remains to be seen. Dredging requires the disposal of spoil. In the last 10 years such disposal has become of major importance and concern. Various studies have demonstrated the adverse effects of spoil deposition on salt marshes, and underwater disposal poses major problems.

The changes in the abundance of key species of fish and shellfish are just as startling in some instances as the changes in the environment. Instead of becoming extinct as was feared by some in 1935, the striped bass is at a peak level of abundance and catch. The commercial landings exceed 8 million pounds as compared to less than 1 million in 1935. Furthermore, over the past 4 years there have been several highly successful dominant year classes which should ensure a high level of abundance for years to come. On the other hand, croakers and weakfish have become so scarce they are of little significance in fin fish production in the Bay.

Oyster production has also changed significantly. While production in Maryland has been maintained by a massive subsidy by the State for public shell planting, seed transplanting, and other cultural practices, the lower Bay has suffered a disastrous decline because of the disease organism *Minchinia nelsonii* (commonly called MSX). This oyster disease in 1959 decimated the stocks of oysters in the lower parts of the Bay, where salinity is high. It still remains virulent and because of it, oyster production is confined to waters of low salinity. Crab abundance still continues to fluctuate widely from year to year, just in the 1930's.

Shellfish production has actually increased because of the development of gear which made it possible to harvest economically the soft clam in the upper Chesapeake below the low tide mark. This species was known to exist in 1935 but no equipment had been developed to extract the clams from the bottom.

While some conservationists still contend the resources of the Bay are depleted, the facts are that the productive capability of the Bay has not been destroyed and if the striped bass was used as an example one could even say it had been enhanced.

The simple facts are that the estuarine environment has deteriorated and if this deterioration is allowed to continue unchecked it could result in the destruction of its basic productivity. I am sure all of us would like to be able to visualize what will be the condition of the Bay in 2007, another 35 years from now. Will we have allowed pollution to continue to grow? Will we have modified the environment with forethought in such a way as to have destroyed the capability to support living organisms? Will we have dredged the Bay to great depths to accommodate deep draft tankers? Will we have raised substantially the overall temperature of the Bay by permitting unrestricted numbers of power plants to use the Bay waters for cooling purposes?

Or will we have joined together to develop a comprehensive plan for the wise management and use of the Chesapeake Bay and its resources, and having done so, taken all necessary steps at one or another level of government to see that the necessary controls are carried out. I think it is apparent to all of us here, who are leaders in marine science, planning and management, that this is the course we must and will follow. Even now major steps are being taken in this direction. The comprehensive Federal study currently underway with the participation of both States and the academic community could well be the mechanism to do the long-term job. The knowledge base available and potentially available through the 3 major research institutions—Chesapeake Bay Institute of The Johns Hopkins University, Natural Resources Institute of the University of Maryland, and the Institute of Marine Sciences in Virginia—is probably as broad and with as much scientific capability as any other place in the United States. If one adds to this scientific capability the multiple management tools of the States and the determination of the Federal government to participate aggressivley in research, planning, mangement, and enforcement, it is apparent that the components are already acting and reacting to insure the future welfare of the Bay. I am not saying the problems are solved—far from it. Many things must be considered! The Bay must be treated as the single biological entity it is. The moving waters and the fish don't know the boundary line existing between Maryland

and Virginia. Our government and people must also forget about the artificial line in their planning and management. The Bay must be handled as a single system, possibly even as a subset of an even larger system including Delaware Bay and the adjacent Atlantic waters. All levels of Government must be involved and carry out the responsibilities in planning and zoning, laws to control environmental modification, and resource management and development.

It seems to me that a great opportunity exists for the development of a plan and attainment of management of the Chesapeake Bay which could serve as a model for the rest of the country. NOAA is vitally interested in working with and assisting other Federal agencies, the States and local government in developing such a concept so that our children and our childrens' children will have the same kind of benefits from the Chesapeake as we have been so fortunate to have ourselves.

Symposium Summary

Joel W. Hedgpeth[1]

Yaquina Biology Laboratory, Oregon State University, Newport, Oregon 97365

It's a large order to attempt a summary of a conference, but I suspect I was brought here from 3,000 miles in the hope I would be neutral, impartial, and objective.

It was my understanding that the purpose of this Conference was to bring together the working scientists of the Chesapeake area to discuss the present status of the Chesapeake Bay, to determine what should be done, and apply the collective knowledge to the problems. Management was implicit in this idea, I believe. However, the real management of this area, the Chesapeake Bay and its watershed, does not reside in this conference. The decision makers, who may not always realize it, are the power-and-light people, Bethlehem Steel, the coal diggers of Pennsylvania, and the pesticide spreaders of the Shenandoah. Most of you are here trying to figure out what to do because of what these people have done. Nevertheless, they must hear the evidence and come to some decision on their own. Perhaps they have been to other meetings (indeed some of them were—one such meeting was held here September 16-18, 1971; see Bergoffin, 1971). Perhaps a lot of them will be back on the 24th of February to attend "The 10th Annual Maryland Asphalt Paving Conference" in this room. The closest to management at this meeting is the State official from Maryland but he also, like the scientists, is trying to catch up with the people who are doing the shaking and moving.

I was reminded of a meeting held about 2 weeks ago on the problems of San Francisco Bay. Today, as at that meeting, I have heard the usual complaint of how little is known and how more research is needed. At the same time we are being reassured that the Chesapeake Bay is not sick yet and things aren't all that bad—there is hope we can still save the environment. A new note creeps in. Everything must be done at once—bring the biologists, geographers, social and physical scientists together and get all possible permutations into a categorized inventory. Feed it into a giant problem solver. The name of this game of expensive problem solving is "Systems Analysis." I presume it will tell us

---

[1]Dr. Hedgpeth was born and educated in California. He received all of his advanced degrees, including his Ph.D., at the University of California at Berkeley in zoology. He is an outstanding specialist in marine ecology and pycnogonids and the author of many papers (in his own words, "environmental polemics"), including "Guide to Seashore Animals of the San Francisco Bay Region." He acts as Head of the Yaquina Biology Laboratory.

what to decide—perhaps to abolish the asphalt paving people. Naturally it's safe to do studies—our commitments and decisions can thus be deferred. I don't think we really have to consider for very long in order to decide how we want things to be—we choose to eat our cake and have it: we want a heavily industrialized region in as near a natural environment as possible. It reminds me of a prayer breakfast at which I was asked to speak on coastal problems. The divine gentleman who prayed for our souls and gave thanks for the food asked the Lord to help us exploit this environment and keep it lovely in His sight. I, of course, could not resist saying that was quite a tall order to ask even of God Almighty.

In some of the remarks at this conference there is the feeling that we want to go home again to the good old days without giving up too many of the bad new ones. The answer is a comprehensive multidisciplinary study to produce a giant holistic view. A disturbing aspect of the systems-analysis approach is the assumption that diversity is a real property related to long-term stability in biological systems. This is implicit in some of the remarks made during the conference. This concept is, however, a point of contention among theoretical ecologists. Putting this theoretical idea as a circuit into the system may be simply holding something in front of a mirror and getting the same picture back as held up. Thus, there is the danger of grinding a preconceived idea into the system. What is stability? What is the age of this system? It is a comparatively young system—estuaries are young, they don't last very long in time. They fill up and disappear or, if the sea level rises, they expand—that might be a solution to all our problems. If 20 billion people were now on earth, the earth would be heated up enough to melt the ice without the need for power plants.

Estuaries may be old in an evolutionary sense, but individual estuaries are not. The Chesapeake is a mere few tens of thousands of years old and perhaps never had time to develop a natural system of diverse ecological specialists, viz. coral reefs, tropical rain forests, or even Antarctic bottom communities, which are surprisingly diverse.

I wonder if some diverse groupings are not a sign of ecological senescence and instability. Over-specialization may slow up a process, like our civilization right now—people able to turn only one knob or not allowed to open the door to the furnace room to open the furnace door—a carpenter's union must open the door to the furnace room, or something similar. We don't know. Whatever the situation of ecological theory and fancy, we shouldn't forget we are examining the Chesapeake Bay. Perhaps when *Homo sapiens* var. *pollutans* arrived on the scene, this Bay was just beginning to stabilize in an ecological sense. It may have been a few thousand or a few hundred thousand years after the glacial period and the Chesapeake Bay was beginning to settle down and become less productive. It was silty and very rich. Incidentally, very little is given in the history of the country, especially for school boys, of the significance of this area for the development of the United States, i.e., sheltered harbors and abundant fish and shellfish upon which the pioneers were able to survive. True, the original settlers also survived in New England, but what a difference in the life there and here in Chesapeake Bay.

Resedimenting the Bay perhaps kept it in its productive state. The example of the striped bass is a very interesting one, which we ought to remember. The striped bass is a remarkably hardy fish. Short of fishing them all out of the Bay, there doesn't seem to be too much that you can do to them. Of course, this may be a slight overstatement. It is known that striped bass will not live in still or slack water. They live in moving water. The young striped bass in San Francisco Bay require a certain density or level of total dissolved solids (a lovely sewage engineers' term).

About 100 years ago, some striped bass were taken across North America in old fashioned tank cars filled with cakes of ice. The fish were dumped in San Francisco Bay at a time when the sedimentary load deposited in the Bay was at its height due to mining operations. Hydraulic mining was not stopped in California until 1884; the striped bass were naturalized natives by

1879. Here was an ecologically simple system with "a big hole in it" in terms of niches. The striped bass simply took it over. We must keep this example in mind when we hear striped bass are doing well in a disturbed environment. At the same time we must not be complacent about the present state of affairs. Several speakers stated that we cannot continue an uncontrolled modification of our environment. Sooner or later we come to the crunch. Other speakers said we must face up to meeting our needs for energy; we have got to keep moving. I failed to hear anybody really say they thought progress was good, a very consoling thought for me, since, as some of you know, I founded the Society for the Prevention of Progress in 1944. We are slowly getting there, or at least we now hear it clearly said that we must recognize the error of our ways.

I do believe that the people of the Chesapeake Bay region are much ahead of those of San Francisco Bay. I didn't hear anybody exhibit such a complete lack of understanding of tidal hydraulics as demonstrated by several people in the California State government, where those in charge of the California Water Plan have no idea what an estuary is all about.

In Oregon there is the Western Environmental Trade Association, established about 2 weeks ago to offset ecological hysteria and get rid of "ecological McCarthyism." Members include the leader of organized labor in Oregon (a sad commentary on where they stand in a conservative State), a newspaper man, and a gentleman from Georgia Pacific. A picture of the members of the Western Environmental Trade Association appeared in a newspaper. The picture reminded me of a remark at an environmental meeting by the economist Kenneth Boulding, who waved his hand over the audience and said, "Here we talk about our needs for food and our overpopulation problem. At least 59% of the people in this room are overweight."

Much has been said at this conference about highest and best use, benefits, "trade-offs" etc., in terms suggesting we believe we are the owners of this estuary. Enough was not said about the problem of the entire system, all 64,000 square miles of it.

Much information about temperature, salinity, pesticides, metals, and enlightened dredging policies has been given here. All of it seemed assuring—at least no one is proposing to turn off the water as they have threatened to do in California. Yet the mere indication that most of what we have been changing is still within tolerable limits does not tell the whole story, because living processes are subject to subtle pervasive factors and we could, as has been implied, destroy the whole system before we knew it. We could suddenly wake up and find that 10 or 15 years ago something might have gone wrong. It has been pointed out, for example, that it took 50 years after the Erie Canal was opened for migration of certain fishes through the Canal to be accomplished, with the consequent disruption of the ecology of the Great Lakes.

This little matter of calefaction, as Dan Merriman called it in an article in the *Scientific American*, merits comment. That term means a bit of heat, a little warming up. Merriman dredged that word out of the unabridged dictionary. I looked it up—it's there and I couldn't help but realize that it had the same stem as "malefactor" and is the same kind of word. Well, perhaps in the Connecticut River the warming up by the Haddam's Neck Plant hasn't done much more than be associated (we must use the scientific weasel words very carefully) with a marasmus of catfish. I had to look that word up as well, and it means wasting away. An article written by Merriman was published in the establishments' establishment convention proceedings, the International Atomic Energy Authority meeting in New York on this same subject. It was a little less reassuring. Merriman did state that perhaps the thermal loading of the Connecticut River had about reached its limit—perhaps they shouldn't do any more (see Merriman, 1970, 1971).

The entire temperature cycle must be considered. It may be logical to say that a little jolt through a whole cycle keeps a nice big, wide curve just a degree or so higher. A couple of problems are involved with this. At the peak of the curve a lethal limit for many animals in the tropics, as well as in the

Chesapeake, is reached. At 34 to 35°C many animals in nature will die. Thus in summer the peak load of power plants in this area occurs, since everybody has air conditioning. We lived as a species for thousands of years without air conditioning. In fact, the Constitution of the United States was drawn up over a long hot summer by people without air conditioning. Perhaps cooling off our brains is not good for us! I might mention that power companies in the Pacific Northwest are trying to sell air conditioning in order to get a more stable load situation. Nobody in Oregon needs air conditioning and may even need electric heat sometimes in cool summers. In any case, to return to the subject at hand, a degree or two increase in summer will be lethal for some organisms. It is also possible that down in the lower ranges where not much effect is noted (apparently organisms are not killed), larval cycles may be upset. In *Chesapeake Science* an article suggests just this in the case of bivalve larvae (see Kennedy and Mihursky, 1971). By some rather small temperature changes, larvae develop a little out of phase, emerging too early for the food provided in the environment. It is little things like this that start the bad cycles going–like picking out the bottom can in the supermarket and the confounded pyramid collapses.

Biological processes do not fit engineering design criteria, so we need these fluctuations within limits, even if we don't completely understand them. Not mentioned during this conference is the possibility that our experimental protocol may have something to do with our results, especially toxicity tests and LD-50 answers obtained by placing animals in tanks and running water through. The tanks are kept as clean as possible and are changed while maintaining a constant concentration of whatever is being tested. Thus a system is set up that does not exist in nature. It has already been demonstrated for some tests with oyster and mussel larvae that the lag time (so-called biological half-life) in the laboratory is much less than it is in the field (see Romeril, 1971). In other words, in nature the animals don't flush quite as rapidly as they may in laboratory tanks and we are getting misleading answers. Animals may not be quite as hardy under natural conditions where the lag may be longer. This is why we need to keep checking all these things in the field.

Another little problem I was reminded of by a question asked from the floor is that we ought to try to avoid confusing people with terminology. The hepatopancreas of a shrimp is a very different organ from the liver and pancreas of *Homo sapiens*. What happens to the hepatopancreas of a shrimp may have no relationship to what happens to the liver of man. I am sure Dr. Sindermann knows very well the confusion that has arisen in the study of neoplasms, especially of oysters, because, let us say, some non-M.D. invertebrate pathologists applied what they ill-remembered of mammalian histology to oyster tissues. This can lead to very misleading ideas.

It is my opinion that the real problem of the Chesapeake Bay is people. I didn't hear, except delicately stated, that population limitation is an answer. If we want to save the Bay for the chosen few as a beautiful environment, there must be fewer people—that is the logic. People will have to be one of the "trade-offs."

We have spoken of some of the decisions which will affect the next or following generations. We are being affected by the decisions made by the generation before us, which is, then, the same problem. Our patient, the Chesapeake, does indeed have many fine doctors and preventive medicine should be possible.

A brief summary of what the real problems are was given us: (1) money; (2) a good model (really meaning the need for an adequate understanding of what is going on); (3) a benevolent dictator; and (4) a change in our social philosophy. Certainly we cannot say, as some people have, that when it comes to a choice between ecology and people, ecology will have to go. Ecology is simply a word for processes. It is not a fashion like beards and strings of beads. What we are really asking is how we can manage ourselves so we can have both pelicans and people, a value decision. It is obvious a good life for pelicans and people is meant. It may very well mean fewer people, as well as fewer pelicans. To achieve this goal, we must surrender a certain degree of sovereignty over what we are doing, at least to nature. An example is the San Francisco Bay situation where things were getting out of hand. Approximately 49 governmental entities had a finger in the pie; something had to be done before San Francisco Bay was absolutely filled up and subdivided, (the most irrevocable change that can be made in an estuary—fill it up and subdivide it). The industrial interests and the politicians have to yield. Without the giving and yielding, the Chesapeake will give and yield beyond its capacity to regenerate.

It was my impression that the Honorable Mr. Coulter stated that our concern is based on a false sense of our own importance. An irreversible change is not, therefore, desired. We are trying to avoid that, but, at the same time, we want to go home again, to paraphrase Thomas Wolfe. The problem is that within the last 25 years we have developed the capacity to change the environment exponentially. Our enemy is the complacent accpetance of, "we just have to keep growing." Mr. Coulter didn't say this as such, because as an officer of the State of Maryland he couldn't, but somebody had to run this system. He did say we need the ability to assemble and display data and this implies a central situation, a sort of war room for operations, so we can all see what is going on, *i.e.*, a physical locus as well as some sort of controlling entity for the 64,000 square miles of the drainage area. Where is the pentagon of power to rule the Bay? It sounds as if the Army Corps of Engineers wants to do the job. This may be what you want and if so, it's your decision. I don't feel that a physical model will answer all the questions. I am sure that Col. Prentiss doesn't believe it either, but I am a little less optimistic about the model than he is. With the discussion of decisions and trade-offs, you should examine the implications of the Chesapeake Study very carefully. The big model and its central command post is a glittering package but needs very careful consideration. Some way should be found for the people concerned with the Chesapeake area to have a voice in deciding whether the Army should take them over and run the Chesapeake Bay for them or whether they should have a different kind of entity. I hope it's realized this is a matter of governmental decisions, of invoking the democratic process. I feel a little uneasy when I'm confronted with an implied take-over.

I shall not attempt to summarize for the last 2 speakers. Dr. Seliger summarized some things himself, but I did get a little concerned in hearing Mr. Holm's discussion of oil—a great amoeboid movement of oil and huge tankers in deep channels in the Bay. Again, who is making the decision? He did say that local interests seek the tax dollar, which influences their decisions. Decisions are coming, perhaps in the United States Supreme Court and certainly they have come up in State courts, that are going to make this local thirst for tax dollars a bit academic, especially for schools that have to be equalized over a State-wide basis. This may, I hope, do away with some of the rather thirsty governmental types, who have the highest motives—dispassionate and disinterested—yet viewing all the lovely tax dollars in their coffers as a gain for the best interests of the people.

Postscript

Although I did not suggest that there should be an end to the State of Maryland, and I have no quarrel with the idea that it should last a thousand years, I would like to emphasize that if it is the preservation and/or continued utilization of an ecosystem like the Chesapeake that concerns us, we cannot expect to attain such a goal with a system of governing our actions in relation to the ecosystem without some respect for the needs of the system itself. In short, an ecosystem must be ordered and husbanded within its own terms. Unfortunately, human political jurisdictions and limitations are too often anti-ecological in their ultimate impact. Maryland can exist for a millenium, but too much insistence on simply existing may assure the death of the Chesapeake long before that time. It seems unfortunate that we apparently have competing forces in rivalry for largesse from the federal treasury in order to obtain the power and the glory of doing the research. Often these involve some of the same people or at least the same organizations sitting in somewhat different chairs around slightly different tables. Finally, with respect to the very large and expensive model proposed by the Corps of Engineers, the question was asked and not really answered about the capacity of this model to elucidate ecological impacts. I might raise a parting question in this context: Will such a model be capable of making an empirical demonstration of the hypothesis that oyster larvae move upstream along the boundary region or zone of "no net motion?" In other words, can we test hypotheses of larval dispersion as related to density differences and similar situations? We might finally ask, how will the inherent properties of a model of this size as opposed to the system to be modeled be adjusted to predict the real world?

References Cited

Bergoffin, W. (ed). 1971. Conference Report. Citizens Program for the Chesapeake Bay. The working conference University of Maryland, College Park, Maryland, September 16-18, 1971. National Resources Institute. University of Maryland, NRI Reference 71-77, 86 pp. (mimeo).

Kennedy, V.S., and J.A. Mihursky. 1971. Upper temperature tolerances of some estuarine bivalves. Chesapeake Sci. 12(4): 193-204.

Merriman, D. 1970. The calefaction of a river. Sci. Amer. 222(5): 42-52.

_______________ . 1971. Does industrial calefaction jeopardize the ecosystem of a long tidal river? Symposium on Environmental Aspects of Nuclear Power Stations, International Atomic Energy Agency, United Nations, pp. 507-533, 5 figs.

Romeril, M.G. 1971. The uptake and distribution of ^{65}ZN in oysters. Marine Biol. 9: 347-354, 5 figs.

SCIENTISTS RECEIVE ACADEMY'S ANNUAL AWARDS

Awards for outstanding scientific achievement were conferred on five research scientists at the annual awards dinner meeting of the Academy on March 16 at the Cosmos Club.

The scientists honored were W. French Anderson of the National Institutes of Health in the biological sciences, O.W. Greenberg of the University of Maryland in the physical sciences, C. Nicholas Pryor of the Naval Ordnance Laboratory in the engineering sciences, Alfred Gray of the University of Maryland in mathematics, and Gart Westerhout of the University of Maryland in the teaching of science.

Award winners were introduced by Donald S. Fredrickson, Director of Intramural Research, National Heart and Lung Institute, National Institutes of Health; John S. Toll, President of the State University of New York at Stony Brook; G.K. Hartman, Technical Director of the Naval Ordnance Laboratory; and Charles Bishop, Chancellor of the University of Maryland.

The Academy's awards program was initiated in 1939 to recognize young scientists of the area for "noteworthy discovery, accomplishment, or publication" in the biological, physical and engineering sciences. An award for outstanding teaching was added in 1955, and another for mathematics in 1959. Except in teaching, where no age limit is set, candidates for awards must be under 40. Previous award winners are listed at the end of this article.

Biological Sciences

W. French Anderson was cited "for the first successful isolation of human messenger RNA from diseased human cells."

Dr. Anderson has been studying the mechanism of protein synthesis in mammalian cells for several years and has been investigating hemoglobin synthesis in rabbit and human red blood cells, both normal and diseased. In 1968 he showed that the rate that proteins are synthesized in the cell could be influenced by the numbers and types of transfer RNA molecules within the cell. He then turned his attention to developing a cell-free protein-synthesizing system

W. French Anderson

which could actively initiate the synthesis of new hemoglobin chains. During these investigations he succeeded in isolating and characterizing three initiation factors (called M_1, M_2, and M_3) from mammalian red blood cells (reticulocytes). These protein factors are required for starting the synthesis of new polypeptide chains. Over the past 2½ years, Dr. Anderson and his colleagues have been able to determine many of the properties as well as the biological function of these initiation factors. Many other laboratories around the world are now isolating initiation factors from various types of higher organisms using the techniques originally developed by the Anderson group.

Utilizing the initiation factors, Dr. Anderson and his coworkers succeeded in developing a completely fractionated cell-free system which was able to synthesize complete chains of hemoglobin. The basic technique was simple: fractionate the red blood cell into each of the many components required in protein synthesis, then add all the compounds back together in the right way and incubate the mixture. This system has been described in a series of papers published in *Journal of Biological Chemistry, Proceedings of the National Academy of Sciences,* and *Nature*. In the November, 1971, issue of *Proceedings* is a paper culminating much of this work: the precise requirements for the synthesis of complete hemoglobin chains utilizing isolated and purified messenger RNA.

Concurrent with his studies on the rabbit red blood cell, Dr. Anderson carried out investigations with blood from patients suffering various types of hemolytic anemias. He was able to develop cell-free systems from human red blood cells capable of synthesizing human hemoglobin chains in a manner similar to that of intact cells. He then investigated the molecular defect in the synthesis of hemoglobin found in the human hereditary anemia called β-thalassemia. This is a genetic anemia which, in the homozygous state, is usually lethal in the first decade of life. Patients require blood transfusions every 6-8 weeks to sustain life from the age of one year. Dr. Anderson and his laboratory were able to fractionate the red blood cells from patients with β-thalassemia and were able to substitute normal cell components one at a time for the thalassemic components in the cell-free system. As a result of these studies, Dr. Anderson was able to demonstrate that the molecular defect in β-thalassemia had to reside in the ribosome-messenger RNA portion of the cell. He then succeeded in isolating the messenger RNA from the thalassemic cells, as well as from normal human cells, and was able to demonstrate that the molecular defect in the genetic disease β-thalassemia could be reproduced in the test tube utilizing only the messenger RNA from the diseased cell with all other components from normal cells. This is the first time that a human genetic disease has been reproduced in the test tube by utilizing just the defective molecule from the diseased cell in an otherwise normal system. Similar studies have been successful in isolating messenger RNA from sickle cell anemia patients and reproducing the synthesis of the defective hemoglobin S in the test tube. It has also been shown that both thalassemic and sickle cell anemia cells will synthesize normal human hemoglobin in response to normal human messenger RNA.

Dr. Anderson was born in Tulsa, Oklahoma, December 31, 1936. He received his A.B. degree, *magna cum laude*, from Harvard College in 1958; an M.A. degree with honors from Cambridge University, (England), in 1960; and an M.D. degree, *magna cum laude*, from Harvard Medical School in 1963. He interned at Children's Hospital Medical Center (Boston, Massachusetts) in 1963-4 and was a postdoctoral fellow in the Department of Bacteriology and Immunology at Harvard Medical School, 1964-5. Since 1965 he has worked in Biochemical Genetics at the National Heart Institute, N.I.H., Bethesda, Maryland. At present he is Head, Section on Molecular Hematology, Molecular Disease Branch, National Heart and Lung Institute, N.I.H.

Physical Sciences

O.W. Greenberg was cited "for contributions to the understanding of the spectra of elementary particles." Professor Greenberg has made several outstanding contributions to the theory of elementary-particle and high-energy physics. One very significant contribution was his development of a quark model for baryon resonances. This was a simple and elegant extension and modification of the idea, first introduced by Gell-Mann, that baryons, heavy subnuclear particles including protons and neutrons, were built up out of more "elementary" constituents called quarks. Professor Greenberg showed, in a series of papers over a three-year period, how this theory could be made more realistic and more attractive. He demonstrated that the Pauli Exclusion Principle would not be violated for quarks and pointed out that dozens of baryon excited states could be described in a simple way using the same quark constituents. Quarks have not yet been found experimentally, but the success and plausability of the quark model leads experimentalists to search for them in each new energy range that becomes available.

O.W. Greenberg

Professor Greenberg has also shown a great critical sense. He analyzed in depth the concept of parastatistics, a sype of particle statistics different from the usual Fermi-Dirac or Bose-Einstein statistics that were introduced in the 1920's. With a sophisticated analysis of a very large amount of experimental data, he and Professor Messiah showed that no known particles could obey this kind of statistics. An additional significant critical contribution was his timely paper that showed that space-time symmetries and internal symmetries could not be coupled in any simple way. (This paper was reproduced in a book on "Symmetry Groups in Nuclear and Particle Physics" edited by F.J. Dyson.)

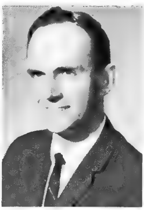
He first came to the attention of the theoretical physics community by a brilliant work with Professor F.E. Low in 1961 that established rigorous high-energy limits for scattering cross-sections of any two particles. He has made many other interesting and important contributions in the field of scattering theory, both from the very abstract rigorous approach and from a rather practical approach with which he introduced a new quantum mechanical approximation technique. He is a brilliant lecturer and has guided many students in their Ph.D. dissertations.

O.W. Greenberg was born in 1932 in New York City. Following his undergraduate training at Rutgers University, where he was elected to Phi Beta Kappa, Dr. Greenberg entered Princeton University where he was awarded the Ph.D. degree in 1957. A holder of an NSF postdoctoral fellowship at MIT, he proceeded to serve as a physics instructor at Brandeis Univeristy until 1961. Dr. Greenberg became Assistant Professor of Physics at the University of Maryland in 1961, achieving the rank of Professor of Physics in 1967, a position he now holds. He is the recipient of an Alfred P. Sloan Fellowship, a John Simon Guggenheim Memorial Fellowship, and recently was elected a Fellow of the Physical Society.

Engineering Sciences

C. Nicholas Pryor was cited "for outstanding contributions to the field of signal processing." Dr. Pryor is the U.S. Naval Ordnance Laboratory's Program Manager of the Airborne Signal Processing WEPTASK as well as being NOL's inhouse expert in the general field of signal processing.

During the past two years, Dr. Pryor has been heavily involved in Vietnam-oriented programs, the most significant of which was his work in the field of intrusion-detection devices. Because of his unusual talent and



C. Nicholas Pryor

grasp of all aspects of signal processing, he was able to diagnose a specific problem and generate a unique solution. Under his direction, a group of young engineers did all the experimental work, construction, and final testing within a period of less than a year. His design has been accepted by the Navy and assigned for production to one of the largest electronic companies.

Dr. Pryor's ancillary duties include teaching courses at the University of Maryland and Catholic University, serving as an advisor to NOL employees who are pursuing advanced degrees in Electrical Engineering, and serving in a staff capacity in NOL's MIT Co-op Program by teaching courses and directing Master's thesis research. He is also a frequent speaker in the Laboratory's Lecture Bureau, which supplies speakers for technical presentations to colleges and universities across the nation.

One of Dr. Pryor's noteworthy achievements is his contribution to the new airborne anti-submarine warfare system (DIFAR), which is of critical importance to the Navy. Parallel development contracts were let to two very large companies so that there would be competitive bidding for the production contract for the system. Dr. Pryor, designated to follow the technical progress of these efforts, was able to determine that one of the companies would be in serious trouble if it did not drastically change its approach. Recognizing the validity of over twenty specific recommendations by Dr. Pryor, the company accepted them and regained its competitive status. On the basis of the low production bid later submitted by this company, Dr. Pryor's work on this project was very instrumental in saving the government in excess of 100 million dollars.

The true measure of Dr. Pryor's exceptional career is brought out by his original contributions to the theory and design of automatic digital electronic trackers, transistorized post integrators, digital filters, the utilization of large digital computers to simulate multiplier correlators and learning machines, and, recently, the successful design and development of a small digital simulator and computer (DISAC) from commercially available logical building blocks and accessory input-output equipment. DISAC has been used successfully in the quantitative evaluation of a large ASW fire control sonar in the laboratory. This computer is of his conception. He either designed or supervised the design of all the logic circuits in the computation sections. He provided the specifications for all of the input-output equipment and the computer memory and solved all of the interface problems associated with the computer. He personally completed much of the documentation on design, prepared instructions for its use, and developed a programming system oriented to problems in signal processing.

C. Nicholas Pryor had an exceptional college record at MIT where he graduated from the 5-year cooperative electrical engineering program in June 1960 (BS and MS degrees) with a 4.9 average out of a possible 5-point average. During the course of his studies at MIT, Dr. Pryor became interested in the work of NOL, and initially entered on duty at the Laboratory as an MIT Co-op student in September 1957. He served in this capacity until February 1958; and subsequently was employed as a Co-op student from June to September 1958, February to June 1959, and June to September 1959. Following his graduation, Dr. Pryor came to the Naval Ordnance Laboratory in June 1960. Since then his advancement has been rapid. He has received numerous performance awards, including seven Superior Accomplishment awards for inventions. In 1961 he received a Meritorious Civilian Service Award for "contributions to the improvement of submarine trackers, post integrators, digital filters and, in particular, to the successful utilization of the NOL digital computer to simulate a learning machine for ASW application." Dr. Pryor has 29 NOL technical reports and memoranda and 3 publications in Navy journals to his credit. He has also published numerous magazine articles (electronics and flying subjects) over the period 1957 to present.

Mathematics

Alfred Gray was cited "for fundamental research in differential geometry." Professor Gray had done significant work in two areas of mathematics, in the theory of entire functions of a complex variable, and in differential geometry.

His work on entire functions (done jointly with Professor S.M. Shah) centered on a conjecture of P. Erdos that $\mu(r)/M(r)$ has a limit as r increases, where $\mu(r)$ and $M(r)$ are the maximum term and the maximum modulus of an entire function. Gray and Shah succeeded in establishing this conjecture in many interesting cases, though in full generality the conjecture turned out to be incorrect.

Alfred Gray

In differential geometry his work has centered in four areas: almost complex manifolds, holonomy groups, relations between curvature operators, and characteristic classes and symmetric spaces.

Aside from the classical types of almost complex manifolds–Kähler and Hermitian–Dr. Gray has shown that there are several other types of interesting almost complex manifolds. He has extended to these manifolds a large number of results about the cohomology of Kähler manifolds, and in a joint paper with J. Wolfe he has given amny interesting examples of nearly Kähler manifolds.

In the course of his work on describing the holonomy groups of Riemannian manifolds, Dr. Gray has shown the significance of vector cross products on manifolds which generalize to higher dimensional manifolds the ordinary vector cross product of elementary physics. He has extensively investigated the relations between vector cross products, non-associative algebras, holonomy groups and obstruction theory. A very readable exposition of the elementary theory of vector cross products may be found in his paper with R.B. Brown, Vectors cross products, Comment. Math. Helv. 42:226-236 (1967).

Professor Gray has made several interesting contributions to the problems of describing topological properties of Riemannian manifolds by means of its curvature operator. The importance of results of this type is that the formulas for topological invariants in terms of the curvature are independent of the particular choice of the metric.

Dr. Gray has recently prepared for publication an excellent paper on homogeneous spaces, "Riemannian manifolds with geodesic symmetries of order 3." A Riemannian manifold with a geodesic symmetry of order 2 is called a symmetric space. Such spaces were first studied by E. Cartan, who classified them in terms of irreducible symmetric spaces, which are homogeneous. These spaces are so important that many mathematicians today study them exclusively. In his paper, Dr. Gray completely classified all Riemannian manifolds with geodesic symmetries of order 3. Hence, using his paper, it may be possible to generalize many theorems about symmetric spaces to this setting.

Alfred Gray was born in Dallas, Texas on October 22, 1939. He received his BA degree in 1960 from the University of Kansas and his M.A. from the same University in 1961. In 1964 he received his Ph.D. from the University of California at Los Angeles. He was an NDEA Fellow at the University of Kansas from 1960 to 1961. From 1961 until 1964 he was an NSF Fellow and Research Fellow at U.C.L.A. From 1964 until 1968 he was at the University of California at Berkeley as Instructor, NSF Postdoctoral Fellow, and Assistant Professor. In 1968, he came to the Mathematics Department of the Unviersity of Maryland, where he now holds the rank of Professor. He is a member of many professional and honorary societies, including AMS, MAA, AWM, Phi Beta Kappa, Sigma Xi, and Pi Mu Epsilon. Dr. Gray is the author of more than thirty papers.

Teaching of Science

Gart Westerhout was cited "for contribution to the teaching, appreciation and public enjoyment of astronomy." Dr. Westerhout has been instrumental in the creation and building of the Astronomy Program of the University of Maryland. It was begun only in 1962, and by 1970 had taken a place among the top ten graduate astronomy programs in the periodic survey by the American Council on Education. The Program has already granted 18 Ph.D.'s, 26 Master of Science degrees, and 17 B.S. degrees in its short 9 years of existence. There are currently 60 graduate students and 50 undergraduate majors enrolled.

Gart Westerhaut

Among the undergraduates on the campus, however, the Astronomy Program is better known for two things, both Professor Westerhout's creations. The first is Astronomy 100, his course in Astronomy for the non-scientist, and the second is the highly popular Open House at the Observatory.

At the University of Maryland, every student is required to take at least one course in a physical science, however reluctantly. The overwhelming choice of a majority of students is Astronomy 100, which has grown in enrollment from 150 students in 1963-64 to 3,500 students enrolled in 1970-71. This is largely a result of Dr. Westerhout's conception of the course as a vehicle for stressing the methods of science and what it is like to be a scientist, as well as a subject matter general enough for even the most non-scientifically oriented student.

The success of the course is primarily a reflection of Professor Westerhout's conception of the teaching role of the Department and the University. It is significant that he has made one of his principal interests the development of a course for non-scientists. He stresses strongly the idea that his Department should be concerned not only with the students who come to it for specialized training, but equally in educating and providing a cultural resource for the entire community.

In the same spirit is the bimonthly Open House at the Observatory. The University Observatory is primarily a teaching facility, and Professor Westerhout has successfully turned it into a community resource as well. Twice a month the Observatory is open to visitors from within and outside the University for viewing celestial objects and short discourses on Astronomy. These have been enormously popular; on a recent clear night there were 600 visitors, long lines, and a major traffic jam on Metzerott Road.

Dr. Westerhout was born June 15, 1927 in The Hague, Netherlands, and received his doctor's degree in Astronomy and Physics from the University of Leiden in 1958. He was the Chief Scientific Officer, Leiden Observatory from 1956 to 1962 and Professor and Director of Astronomy at the University of Maryland from 1962 to the present. Dr. Westerhout is a member of the Dutch Astronomical Society, the Royal Astronomical Society, the International Astronomical Union, the American Astronomical Society, the Astronomical Society of the Pacific, the Scientific Radio Union, Sigma Xi, and NATO Fellowship—1959. He is the author of more than 40 publications.

Past Winners of Scientific Achievement Awards

BIOLOGICAL SCIENCES

1939	Herbert Friedman	1952	Ernest A. Lachner	1962	Marshall W. Nirenberg
1940	No award given	1953	Bernard L. Horecker	1963	Brian J. McCarthy
1941	G. Arthur Cooper	1954	Leon Jacobs	1964	Bruce N. Ames

Past Winners of Scientific Achievement Awards *(Continued)*

1942 Robert S. Campbell
1943 Jason R. Swallen
1944 Norman H. Topping
1945 Henry K. Townes
1946 Waldo R. Wedel
1947 No award given
1948 Robert J. Huebner
1949 Edward G. Hampp
1950 David H. Dunkle
1951 Edward W. Baker
1955 Clifford Evans
Betty J. Meggers
Robert Traub
1956 Earl Reese Stadtman
1957 Maurice R. Hilleman
1958 Ellis T. Bolton
H. George Mandel
1959 Dwight W. Taylor
1960 Louis S. Baron
1961 Robert W. Krauss
1965 Gordon M. Tomkins
1966 James L. Hilton
1967 Marie M. Cassidy
Charles S. Tidball
1968 Janet W. Hartley
1969 Maxine F. Singer
1970 Glenn W. Patterson
1971 W. French Anderson

ENGINEERING SCIENCES

1939 Paul A. Smith
1940 Harry Diamond
1941 Theodore R. Gilliland
1942 Walter Ramberg
1943 Lloyd V. Berkner
1944 Galen B. Schubauer
1945 Kenneth L. Sherman
1946 Martin A. Mason
1947 Harry W. Wells
1948 Maxwell K. Goldstein
1949 Richard K. Cook
1950 Samuel Levy
1951 Max A. Kohler
1952 William R. Campbell
1953 Robert L. Henry
1954 W. S. Pellini
1955 Arthur E. Bonney
1956 M. L. Greenough
1957 Joseph Weber
1958 San-fu Shen
1959 Harvey R. Chaplin, Jr.
1960 Romald E. Bowles
1961 Rodney E. Grantham
1962 Lindell E. Steele
1963 Gordon L. Dugger
1964 Thorndike Saville, Jr.
1965 Ronald E. Walker
1966 Henry H. Plotkin
1967 Robert D. Cutkosky
1968 Charles R. Gunn
1969 Thomas E. McGunigal
1970 Robert L. Dedrick
1971 C. Nicholas Pryor

PHYSICAL SCIENCES

1939 Wilmot H. Bradley
1940 Ferdinand G. Brickwedde
1941 Sterling B. Hendricks
1942 Milton Harris
1943 Lawrence A. Wood
1944 George A. Gamow
1945 Robert Simha
1946 G. W. Irving, Jr.
1947 Robert D. Huntoon
1948 J. A. Van Allen
1949 John A. Hipple
1950 Philip H. Abelson
1951 Milton S. Schechter
1952 Harold Lyons
1953 John R. Pellam
1954 Samual N. Foner
1955 Terrell Leslie Hill
1956 Elias Burstein
1957 Ernest Ambler
Raymond Hayward
Dale Hoppes
Ralph P. Hudson
1958 Lewis M. Branscomb
Meyer Rubin
1959 Alan C. Kolb
1960 Richard A. Ferrell
1961 John Hoffman
1962 Edward A. Mason
1963 George A. Snow
1964 James W. Butler
1965 Albert L. Schindler
Robert P. Madden
Keith Codling
1966 Robert W. Zwanzig
1967 Charles W. Misner
1968 Marilyn E. Jacox
Dolphus E. Milligan
1969 W. Kent Ford, Jr.
1970 Edwin C. Becker
Thomas C. Farrar
1971 O.W. Greenberg

MATHEMATICS

1959 Geoffrey S.S. Ludford
1960 Philip J. Davis
1961 Lawrence E. Payne
1962 Bruce L. Reinhart
1963 James H. Bramble
1964 David W. Fox
1965 Joan R. Rosenblatt
1966 George H. Weiss
Marvin Zelen
1967 Leon Greenberg
1968 Joseph Auslander
1969 William W. Adams
1970 Alan J. Goldman
1971 Alfred Gray

TEACHING OF SCIENCE

1955 Helen N. Cooper
1956 Phoebe H. Knipling
1957 Dale E. Gerster
1958 Carol V. McCammon
1959 Betty Schaaf
Helen Garstens
1960 Karl F. Herzfeld
Pauline Diamond
1961 Ralph D. Myers
Charles R. Naeser
1962 Francis J. Heyden, S.J.
1963 Frank T. Davenport
George M. Koehl
Leo Schubert
1964 Donald F. Brandewie
Herman R. Branson
1965 Irving Lindsay
Stephen H. Schot
1966 Martha L. Walsh
1967 Raymond A. Galloway
1968 Kelso B. Morris
1969 John Fowler
1970 William W. Dunkum
1971 Gart Westerhaut

TEACHING OF SCIENCE SPECIAL AWARDS

1951 Howard B. Owens
1952 Keith C. Johnson

BOARD OF MANAGERS MEETING NOTES

February, 1972

The 618th meeting of the Board of Managers of the Washington Academy of Sciences was called to order by President Robbins at 8:10 p.m. on February 10, 1972 in the Conference room of the Lee Bldg. at FASEB.

Announcements.—President Robbins observed that the Board members had received copies of the minutes of the 617th meeting and that each member was probably familiar with the contents. After inviting corrections or comments and hearing none she declared the minutes to be accepted as prepared.

New delegates have been appointed from three societies that change officers on a calendar-year basis. Dr. Lewis F. Affronti replaces Dr. Rita R. Colwell for the American Society for Microbiology, Dr. Edward E. Beasley replaces Dr. L. Marton for the Philosophical Society of Washington, and Dr. Charles Milton replaces Dr. Ralph Miller for the Geological Society of Washington.

Dr. Robbins acknowledged receiving a copy of Dr. R.K. Cook's letter to Dr. Ripley thanking him for an appointment to the Advisory Committee of the AAAS Meeting in Washington in December 1972.

A contribution of $100 has been received from the IEEE.

Dr. Alfred Weissler has agreed to chair an *ad hoc* committee to determine the interests of the local universities in an award for an undergraduate college student. He will select other members for the committee.

Dr. Irving A. Berger has resigned from the Joint Board on Science Education due to reasons of health.

Dr. Robbins expressed concern that there has been no concerted effort to recruit members or to identify candidates for fellow. A much larger membership is essential to the maintenance of the office services and facilities. She will appoint a committee on membership promotion; however, she asked everyone to try to exceed her goal of five new fellows sponsored by herself.

Policy Planning.—Dr. Stern stated that the American Congress on Surveying and Mapping has inquired about but has not formally applied for affiliation.

Treasurer's Report.—Dr. Honig provided the members with a tabulation of receipts and of expenses for the calendar years 1969, 1970, and 1971. Included were budgeted values for 1971 and proposed values for 1972. After considerable discussion it was moved and seconded that the financial report be accepted. It was accepted by voice vote. Discussion on the proposed budget concerned the basis of agreements for sharing the expenses of operating the office, the cash flow problem indicative of our operation on next years income, and the possibility of receiving a grant to help defray part of the expenses of Symposium II. Subsequently there was a motion by Dr. Cook, a second by Mr. Gaum, and a voice vote to approve the budget.

Membership.—Chairman Landis' written report showed that of the new delegates, Dr. Affronti and Dr. Milton, were already members of the Academy, but by virtue of being delegates all three were candidates for Fellow of the Academy. Following a motion by Dr. Boek, a second by Dr. Foote, and a voice vote, the delegates were elected to be Fellows. Mr. Landis' report included the nominations of three candidates for Fellow. The first reading of the report was accomplished. Dr. Benjamin L. Snavely requested reinstatement as an active fellow and paid his back dues. Mr. Detwiler and Dr. Cook initiated a motion for Dr. Snavely's reinstatement. It was approved.

Dr. Robbins acknowledged that there has been an oversight of the formality to be followed in the election of new delegates to be Fellows. Last fall the formality was not followed at the time Mrs. Elsie DuPre, Mr. Carl H. Gaum, and Dr. Conrad B. Link were introduced. Upon a motion by Dr. Cook and a second by Dr. Sailer, an affirmative vote by the delegates accomplished the procedure.

Meetings.—In the absence of Dr. Irving, Dr. Robbins stated that Dr. E.E. Saulmon would speak at the February meeting at Georgetown University. The March meeting would be the occasion for Awards for Scientific Achievement.

Scientific Achievement.–Chairman Dickson announced the following award winners for 1971: Biological Sciences, W. French Anderson; Physical Sciences, O.W. Greenberg; Engineering Sciences, C. Nicholas Pryor; Mathematics, Alfred Gray; Teaching of Science, Gart Westerhout.

Symposium II.–Dr. Colwell has met with her committee prior to the meeting of the Board of Managers. She spoke briefly of the accomplishments, the large attendance, and the evidence of increased interest of the scientific community in additional symposia sponsored by the Washington Academy of Sciences. She urged that plans for Symposium III for next year be started at once.

AAAS Council.–Dr. Cook reported on proposed changes in the constitution of AAAS that would reduce the size of the Council. Also that the national meetings probably will not be held at Christmastime after this year. He expressed hope that he would continue to work with the *ad hoc* committee until the Christmas meetings were over.

Editor.–Dr. Foote stated that the June issue of the *Journal* would contain the papers presented at the Symposium, that all speakers have been contacted, and that five manuscripts are now ready to edit.

Joint Board on Science Education.–In the absence of Dr. Oswald, Dr. Robbins reported that letters had been sent to previous donors and to prospective new donors, requesting donations to support the current programs of the JBSE.

New Business.–Dr. Boek inquired about the selection of the Areas for Awards for Scientific Achievement. She desired that an award be considered for outstanding work in Anthropology. The opinion was expressed that the committee had authority to recommend special awards in other areas.

Stimulated by a comment by Dr. Foote, discussion generated the proposal that the new committee on membership promotion establish follow-through procedures that will hasten the processing of membership applications and fellow nominations.

Dr. Noyes expressed concern that the Symposium issues of the *Journal* were not selling fast enough. Several suggestions pointed to the desirability of his working with Dr. Foote to promote the sale of the *Journal*.

JOURNAL OF THE WASHINGTON ACADEMY OF SCIENCES

Instructions to Contributors

General

Type manuscripts on white bond paper either 8½ by 11 or 8 by 10½ inches. Double space all lines, including those in abstracts, tables, legends, quoted matter, acknowledgments, and references cited. Number pages consecutively. Place your name and complete address in the upper right hand corner of the title page.

Title, Author, and Affiliation

Page 1 of your manuscript should contain only this information and your name and address. Choose a concise but complete and meaningful title. In research papers concerning biological subjects, include an indication of the order and family of the taxa discussed. Academic degrees will not normally be included unless the author so specifies. If possible, combine your affiliation and mailing address (including Zip) so that readers can write to you directly.

Abstract

Type on a separate sheet at the end of the manuscript. Make the abstract intelligible without reference to the text of the paper. Write an informative digest of the significant content and conclusions, not a mere description. Generally, the abstract should not exceed 3% of the text.

Footnotes

Use footnotes as sparingly as possible. Number text footnotes consecutively with Arabic numerals and type them on a separate sheet of paper at the end of the manuscript. Type table footnotes, if any, below each pertinent table on the same page.

Illustrations and Legends

The quality of all original illustrations must be high enough to facilitate good offset reproduction. They should have ample margins and be drawn on heavy stock or fastened to stiff cardboard to prevent bending. They should be proportioned to column (1 x 3) or page (2 x 3) type-dimensions, leaving space for legend material. Photographs should have a glossy finish. They reproduce best when the contrast is fairly high. Identify each illustration with number and author in light pencil marks on the reverse side. Submit all illustrations separately – please do not glue or clip them to the pages of the manuscript.

Do not type or write legends directly on the illustrations. Type legends on a separate sheet or sheets at the end of the manuscript. Indicate where you want illustrations to appear in the printed paper by writing the figure numbers lightly in the text margins, and be sure that each figure is properly referenced in the text itself. Original "art" will be returned only at the author's request and expense.

Tables

Include tables only when the same information cannot be presented economically in the text, or when a table presents the data in a more meaningful way. Consider preparing extremely complicated tabular matter in a form suitable for direct reproduction as an illustration. In such cases, the use of the typewriter is not recommended.

References to Literature

Limit references within the text and in synonymies to author and year (and page if needed). In a "Reference Cited" section, list alphabetically by senior author only those papers you have included in the text. Likewise, be sure all the text references are listed. Type the "References Cited" section on a separate sheet after the last page of text. Abbreviations should follow the *USA Standard for Periodical Title Abbreviations*, Z39.5-1963.

Submission of Manuscripts

Send completed manuscripts and supporting material to the Academy office (see address inside front cover) in care of the Editor. Authors will be requested to read Xerox "proofs" and invited to submit reprint orders prior to publication.

Reprints – Prices for reprints may be obtained on request.

CONTENTS (Continued from Front Cover)

Research to Counter the Threats to Chesapeake Bay—Opening Remarks

RITA R. COLWELL: Opening Remarks 169

JAMES B. COULTER: Research and Decisions 170

JEROME WILLIAMS: Physical-Chemical Crisis Indicators—Are There Any? 174

CARL J. SINDERMANN: Some Biological Indicators of Marine Environmental Degradation 184

LOUIS W. PRENTISS, JR.: The Corps of Engineers Chesapeake Bay Study 190

HOWARD SELIGER: Interdisciplinary Research in Chesapeake Bay 196

EDWIN E. HOLM: Certainties and Uncertainties in Economic Development as they Relate to the Future of Chesapeake Bay 202

QUESTIONS AND ANSWERS 207

DAVID H. WALLACE: The Fate of the Chesapeake Bay—(Dinner Address) . . 214

JOEL W. HEDGPETH: Symposium Summary 218

Academy Affairs: Scientists Receive Academy's Annual Awards . . 224

Board of Managers Meeting Notes 231

Washington Academy of Sciences
Room 29, 9650 Rockville Pike (Bethesda)
Washington, D.C. 20014
Return Requested with Form 3579

2nd Class Postage
Paid at
Washington, D.C.

VOLUME 62
Number 3
SEPTEMBER, 1972

Journal of the WASHINGTON ACADEMY OF SCIENCES

Issued Quarterly
at Washington, D.C.

Directory Issue

CONTENTS

Features:

MARY LOUISE ROBBINS: A Smoother Road for Women Scientists? .234
GEORGE W. IRVING, JR.: The Role and Future of Pesticides in Maintaining Food Supply 240

Research Reports:

HENRY MERCHANT: Estimated Population Size and Home Range of the Salamanders *Plethodon jordani* and *Plethodon glutinosus* 248
D.E. HOPKINS and W.F. CHAMBERLAIN: Susceptibility of the Stages of the Cattle Biting Louse (Mallophaga; Trichodectidae) to Juveth, An Insect Juvenile Hormone Analog 258
WILLIAM E. BICKELY: Some Aspects of Behavior of Mosquito Larvae (Diptera: Culicidae) 261
GEORGE C. STEYSKAL: Two New Species of *Melanagromyza* Hendel (Diptera: Agromyzidae) that Bore in Tomato Stalks in Colombia and Ecuador 265

Academy Affairs:

Scientists in the News 268
Washington Junior Academy of Sciences 271
Bylaws of the Academy 273
DIRECTORY, 1972
Foreward 279
Code for Societies, and Society Officers 279
Alphabetical List of Fellows and Members 282

Washington Academy of Sciences

Founded in 1898

ACADEMY OFFICE

9650 Rockville Pike (Bethesda)
Washington, D. C. 20014
Telephone (301) 530-1402

The Journal

This journal, the official organ of the Washington Academy of Sciences, publishes historical articles, critical reviews, and scholarly scientific articles; proceedings of meetings of the Academy and its Board of Managers; and other items of interest to Academy members. The *Journal* appears four times a year (March, June, September, and December) – the September issue contains a directory of the Academy membership.

Subscription Rates

Members, fellows, and patrons in good standing receive the *Journal* without charge. Subscriptions are available on a calendar year basis only, payable in advance. Payment must be made in U.S. currency at the following rates:

U.S. and Canada	$10.00
Foreign	11.00
Single Copy Price	3.00

Back Issues

Obtainable from the Academy office (address at bottom of opposite column): **Proceedings:** Vols. 1-13 (1898-1910) **Index:** To Vols. 1-13 of the *Proceedings* and Vols. 1-40 of the *Journal* **Journal:** Back issues, volumes, and sets (Vols. 1-62, 1911-1972) and all current issues.

Claims for Missing Numbers

Claims will not be allowed if received more than 60 days after date of mailing plus time normally required for postal delivery and claim. No claims will be allowed because of failure to notify the Academy of a change in address.

Changes of Address

Address changes should be sent promptly to the Academy office. Such notification should show both old and new addresses and zip number.

Published quarterly in March, June, September, and December of each year by the Washington Academy of Sciences, 9650 Rockville Pike, Washington, D.C. Second class postage paid at Washington, D.C.

DELEGATES TO THE WASHINGTON ACADEMY OF SCIENCES, REPRESENTING THE LOCAL AFFILIATED SOCIETIES

Philosophical Society of Washington	Edward Beasley
Anthropological Society of Washington	Jean K. Boek
Biological Society of Washington	Delegate not appointed
Chemical Society of Washington	Harvey Alter
Entomological Society of Washington	Reece I. Sailer
National Geographic Society	Alexander Wetmore
Geological Society of Washington	Charles Milton
Medical Society of the District of Columbia	Delegate not appointed
Columbia Historical Society	Paul H. Oehser
Botanical Society of Washington	Conrad B. Link
Society of American Foresters	Robert Callaham
Washington Society of Engineers	George Abraham
Institute of Electrical and Electronics Engineers	Leland D. Whitelock
American Society of Mechanical Engineers	William G. Allen
Helminthological Society of Washington	Aurel O. Foster
American Society for Microbiology	Lewis Affronti
Society of American Military Engineers	H.P. Demuth
American Society of Civil Engineers	Carl H. Gaum
Society for Experimental Biology and Medicine	Carlton Treadwell
American Society for Metals	Glen W. Wensch
International Association for Dental Research	Norman H.C. Griffiths
American Institute of Aeronautics and Astronautics	Robert J. Burger
American Meteorological Society	Harold A. Steiner
Insecticide Society of Washington	H. Ivan Rainwater
Acoustical Society of America	Alfred Weissler
American Nuclear Society	Delegate not appointed
Institute of Food Technologists	Lowrie M. Beacham
American Ceramic Society	J.J. Diamond
Electrochemical Society	Stanley D. James
Washington History of Science Club	Delegate not appointed
American Association of Physics Teachers	Bernard B. Watson
Optical Society of America	Elsie F. DuPré
American Society of Plant Physiologists	Walter Shropshire
Washington Operations Research Council	John G. Honig
Instrument Society of America	Delegate not appointed
American Institute of Mining, Metallurgical and Petroleum Engineers	Delegate not appointed
National Capitol Astronomers	John A. Eisele
Mathematical Society of America	Daniel B. Lloyd

Delegates continue in office until new selections are made by the respective societies.

FEATURES

A Smoother Road for Women Scientists?[1]

Mary Louise Robbins

Department of Microbiology, The George Washington University School of Medicine, 1339 H St., N.W., Washington, D.C. 20005

ABSTRACT

The road traveled by women scientists has always been an obstacle course. Now the women themselves are beginning to tear down the obstacles. Whether with kid gloves or, if necessary, with bared claws, some progress is being made in smoothing the road.

A look into the past reveals that women are not by any means new to science. They have been engaged in scientific activities of various sorts for thousands of years. Of course no one knows exactly who deserves the title of "first woman scientist," but a very early contender would be Mary the Jewess, who was just possibly the sister of Moses. In her work as an alchemist, Mary invented the water bath, one type of which is still known as "Bain-Marie."

Scattered throughout history, but always in small numbers, are names of successful women scientists. Five have received the very epitome of recognition, the Nobel Prize: Marie Curie (twice); Irene Joliet-Curie; Gerty Cori; Maria Goeppert Mayer (who died this year); and Dorothy Hodgkin. Two have been presidents of the most prestigious scientific organizations: Dame Kathleen Lonsdale, President of the British Association for the Advancement of Science, and Dr. Mina Rees, of the *American* Association for the Advancement of Science. (Unfortunately, not a one of these very top-ranking scientists could possibly be a member of the club whose membership qualifications are based on professional excellence, which is why we are not meeting at the Cosmos Club tonight.) Of course there are thousands of less distinguished but highly successful women in science today. But the list of such women is all too short in comparison with successful *men* in science. I must give you a few statistics here.

According to the National Science Foundation (NSF) National Registry of Scientific and Technical Personnel for 1970, 9% of the 313,000 scientists in America are women (National Science Foundation, 1972). (The percentage for the Washington Academy of Sciences is only 7.7%.) This percentage is of course all too small. But even worse is the tiny number of these women in the high-success brackets. There are only 11 women in the National Academy of Sciences out of a membership of 950. In 10 leading universities, less than 1% of the full professors in physics, biology, and the social sciences are women. Microbiology is considered more of a woman's field than is physics, let's say, or certainly engineering; 24.5% of the members of the American Society for Microbiology are women. Yet only 4.5% of these women are full professors as compared with 15% of the men. And only 9 of the 309 academic departments that give degrees in microbiology are headed by wo-

[1]Presidential address delivered to a meeting of the Washington Academy of Sciences on May 16, 1972.

men—and 4 of those 9 are in women's colleges!

Another measure of success, which of course cannot be completely separated from high position, is salary. The median salary for male scientists in 1970 was 31% higher than for women scientists (National Science Foundation, 1972). I found a disconcertingly interesting parallel in my analysis of microbiologists with the doctoral degree—the difference was 32%. The highest paid scientists are physicists, computer scientists, statisticians, and economists. Women scientists are concentrated in chemistry, mathematics, psychology, and the biological sciences, none of which are in the high-salary categories. Furthermore, the lowest salaries are in teaching—the dominant scientific activity for women. Even in teaching, as I've already pointed out, women are not generally in the top ranks.

Still other measures of success come in the forms of service on government advisory panels and editorial boards of scientific publications, election to office in scientific societies, chairing of sessions at scientific meetincs, etc. The percentage of women serving in such capacities is much smaller than the percentage of women in science itself. This kind of activity results in visibility of our scientific colleagues and its absence means low visibility and therefore low recognition of women.

I could—but I won't—give you many many more examples of the lower status of women in scientific fields. I could—but I won't—compare the situation in America with that in other parts of the world. (If I did, you might be surprised at the similarity in many instances, rather than at the frequently publicized differences.) All I wanted to do with my brief statistical survey was to remind you that the rough road does indeed still exist.

Acknowledging that the road is rougher for women, let's see if we can account for the bumps. Many reasons are offered, many of them blaming women. Some are myths, some are real. A questionnaire designed to explore some of the myths was given to participants at the 1971 annual meeting of the American Society for Microbiology. Here are some of the myths and some of their refutations:[2]

1. Women's lower status is the result of her family responsibilities. If this were so, women who combined family and career would be less successful in microbiology than their unmarried female colleagues. The married women do make less. Married women 20-29 years after receiving the Ph.D. degree make $2600 less than single women in the same category. But these single women make $5700 less than their male counterparts!

2. Women move more often than men because their husbands move to new jobs. Actually there is *no* difference in their mobility—only in the reason for it. The fact that a man might move to take a better position seems to be more acceptable to a prospective employer than the possibility that his female employee might move to accompany her husband who is leaving a different employer!

3. Women take off too much time from their careers to expect to advance to the top. In fact, 62% of the married women questioned had taken *no* time off, except presumably to have their babies. One very successful woman scientist I heard of recently had all her children on the Fourth of July, and I believe she had 4 of them. Of course this sort of planning takes a certain amount of cooperation from a sympathetic husband. Back to the microbiologists—of those women who did take time off from their careers, ¾ took off less than 1 year.

4. Women like it the way it is; they want less demanding posts. This too is only partly true. At the Ph.D. level, 38% of the women said that their present positions were not commensurate with their ability, as opposed to 25% of the men.

If we have exploded some of the favorite myths, what then do we have left to account for this rocky road? There are plenty of real reasons—no myths are needed. And under-

---

[2]Presented by Dr. Loretta Leive and Dr. Eva Kashket at a seminar, "A Current Problem in Microbiology: Women," at the 1972 Annual Meeting of the American Society for Microbiology.

lying almost all of them is the attitude of society. This attitude has been described as "occupational segregation" and as a "caste system" (Bergman, 1972). A "high-status scientist" is not the proper caste for a woman, in the eyes of most people, who are uncomfortable about any change in caste. Along with that attitude is the historical one that femininity and high achievement are incompatible. This attitude gives rise to what Dr. Mary Bunting, President of Radcliffe College, calls the "climate of unexpectation" among college girls (Bunting, 1971) and to the "motive to avoid success," to use the term coined by psychologist Dr. Matina Horner (Horner, 1969). Unfortunately this negativism toward successful women is increasing among college women—from 66% in 1964 to 88% in 1970, in one study (Horner, 1969; Horner and Walsh, 1972). However, this reverse motivation is no longer limited to women. The same surveys showed that fear of success for *themselves* increased in college *men* from 10% in 1964 to 50% in 1970. This attitude in *women* college students is certainly heightened by something I wish were a myth, but unfortunately isn't always—that is an actual distrust of successful women by women themselves. Among a number of studies that bring out this trait is an intriguing one in which a fictitious scientific report was distributed to 2 groups of college women (Goldberg, 1968). The report given to one group was said to have been written by John T. McKay. The identical report given to the other group was purportedly written by Joan T. McKay. Answers to appropriate questions revealed that for the paper written by *Joan* McKay the students didn't trust the author, questioned the validity of the data, claimed the author was too emotional, etc. But the identical paper written by *John* McKay was a perfectly valid, well-balanced report of good scientific research, according to the girls.

Other much discussed factors that tend to keep many women out of science in the first place are subtle pressures at home against being "different"; the advice by some high school teachers and vocational counselors that science isn't for girls; and the absence of successful women scientists to serve as role models.

A very important factor that makes it difficult for the many women who want to combine family life with a full-time career is the extreme shortage in modern America of both adequate domestic help and adequate day-care facilities. This shortage is of course behind much of the current demand for day-care centers.

What about the factors that act against a woman when she has overcome the obstacles and has her graduate degree and is looking for a job, or when she wants to change positions, or when she feels that she is entitled to a promotion? Here we run into a whole gamut of actions that are actually discriminatory, even though not always intentionally so. Many times women are simply not thought of when a position is open, because of their small numbers and their low visibility, and because positions are so often filled by means of the peer referral system, which tends to overlook the women. Antinepotism laws were not specifically designed to discriminate against women—after all, they were originally aimed at nephews! But in effect they usually act against wives. Other times discrimination is outright and intentional, as indicated by studies in which identical fictitious curricula vitae are made up, one under a man's name, one under a women's name. The evaluation of these curricula vitae for possible employment indicates a real bias by some prospective employers in favor of the men, in some cases even in favor of "ordinary" men over "superior" women.

Certainly the picture is not as bright as it should be in this enlightened end-of-the-20th-century era. The road for women scientists is indeed full of obstacles. But the abstract to my talk says that some progress is being made in smoothing the road. Everyone who knows me well knows that I am an incurable optimist. My optimism sees a number of good omens.

Earlier I had quite a bit to say about salary differentials between men and women. The differences are great, but 2 separate studies show a slight narrowing of the gap. According to NSF figures, salaries for male scientists increased 12.6% between 1968 and 1970; for women the increase was 16% (National Science Foundation, 1970, 1972). The differential was thus reduced from 35% to 31% in just 2 years. The same trend was shown in microbiologists' salaries for 1970 and 1971. (Of course the increases were much less than for the less belt-tightening years of 1968 to 1970 reported by NSF.) In that 1 year (1970-71) women microbiologists' salaries rose 5.3%; the increase for men was 3.1%.

On a quantitatively small but qualitatively large scale, recognition of women scientists is increasing. Of the 11 current women members of the National Academy of Sciences, 6 were elected in the 3 years 1970, 1971, and 1972. The other 5 were elected over a span of 25 years—1944 - 1968. The percentage of women members is only 1.1; the percentage of women elected in 1970 through 1972 is 3.4.

These examples of straws in the wind do suggest a much-needed change in direction, but they are only a small step. Many concerted efforts are being made to speed up the process of change, and to initiate it where it has not already started. There is no question that the cries of liberal women throughout the land are having their effect. Women's caucuses and committees have been formed within scientific organizations. Independent women's science associations have been established. (One of these, Graduate Women in Science, is hardly new; it celebrated its Golden Anniversary last year, just after its name was changed from Sigma Delta Epsilon.) These groups are very active in trying to improve the status of women in science. There has been so much emphasis in the news media on the sometimes radical activities of a very few of these groups—even a very few members of some of them—that the real accomplishments of the groups have not always had the recognition that they deserve. I shall quote from a statement in an article on "Women in the Professional Caucuses" by Dr. Ruth Oltman, of the American Association of University Women:

> These caucuses have succeeded in gaining acceptance by their total associations by increasing the number of women on governing boards, official adoption of recommendations on policy, and inclusion of more women on convention programs. Through careful research efforts, they have dispelled many myths and documented their recommendations with objective facts, gaining the support of many men thereby. They have disseminated information widely, established rosters of women, encouraged more active recruitment of women for their respective graduate disciplines, developed women's studies programs, and defined new research areas (Oltman, 1971).

Lest you are under the impression that it is only the *caucuses* that are effective, I want to say something about the *committees* on the status of women. Dr. Oltman was including the committees in her statement about caucuses. At least 8 scientific organizations have responded to requests from members—sometimes demands by caucuses—for the establishment of such committees as part of the official organizational structure. These 8 are:

American Anthropological Association
American Association of Geographers
American Association of Immunologists
American Chemical Society
American Physical Society
American Psychological Association
American Society for Microbiology
American Society of Biological Chemists

These committees have the opportunity to work with their organizations and to propose constructive actions that might be endorsed by the organization's hierarchy. For example, last year the Council of the American Society for Microbiology approved of 2 important resolutions submitted by the Society's Committee on the Status of Women Microbiologists. One was to support the Equal Rights Amendment, and the Executive Director of the Society notified Congress of the Council's support. The other concerned guidelines for employers of microbiologists to assist them in improving the status of their present and future female employees. The committee sponsored seminars on the status of women microbiologists at the 1971 and 1972 annual meetings of the Society. It was also instrumental in increasing the number of sessions chaired by women from 7 in 1971 to 31 in 1972. This same committee has been invited to work with the Society's Placement Committee and Board of Education and Training on some of their programs. I am sure that other committees have won the support of their organizations for similar activities as well. I just used as an example the one I am most familiar with, since I am its chairperson.

Last December the Council of the American Association for the Advancement of Science (AAAS) agreed to request the Board of Directors of the Association to consider establishing an Office for Women's Equality to work toward full representation and opportunity for women in scientific training and employment, affairs of the Association, and in the direction of national science policy. The Board has since then established an ad hoc committee to study the question. The committee's recommendations are due in a few weeks. If such an office is set up in the AAAS, women scientists would have a most powerful aid in removing road blocks.[3]

Another way the organizations are helping their female members is exemplified by a conference I attended recently. This "Conference on Successful Women in the Sciences: An Analysis of Determinants," sponsored by the New York Academy of Sciences, was handled exactly the same way the Academy's strictly scientific meetings are handled, and will be published in a regular issue of the Academy's annals.

Certainly the biggest roadscraper in use for smoothing the road is the Federal Government. Beginning with the Equal Pay Act of 1964, a whole series of antidiscrimination measures has been passed. These measures are designed for women (as well as minority groups) in many kinds of employment, of course, not just scientists. But women scientists are covered by many of the provisions. I will briefly review a few of the measures for you.

First of all is the Equal Pay Act, followed quickly by the Civil Rights Act of 1964 with its famous Title VI. It is Title VII that prohibits discrimination based on race, color, religion, sex, or national origin. You are all too well acquainted with the general provisions of Title VII for me to repeat them. But there is an intriguing one I hadn't known about that might interest you: an employer may not discharge female employees because of marriage or parenthood unless it treats men equally!

An Executive Order of October 1968 requires federal government contractors to develop and implement affirmative action programs to eliminate sex discrimination. Another Executive Order, the next year, extended sex discrimination provisions to Federal Government positions. Now there is an amended Title VII, the Equal Employment Opportunity Act of 1972, signed by President Nixon on March 24. Among other provisions, it puts teachers and administrative personnel in educational institutions under the Title.

These various measures under Title VII, and the Executive Orders to establish affirmative action plans, have led to some interesting developments in university administration. I am now receiving letters from women with such titles as Associate Provost of Wesleyan University; Affirmative Action Consultant, San Francisco State College; Special Assistant for Women's Affairs, Office of the President, Ohio University, as well as from male administrators. These letters ask for everything from a roster of women microbiologists to the names of women who might be considered for presidencies of 4 campuses of the State University of New York. Mina Rees, last year's President of the AAAS, is President of the Graduate Division of the City University of New York, so these requests are not to be taken lightly.

Other ways to get positions and qualified women scientists together are being developed. The Ford Foundation has just awarded a grant to the New England Consortium for Women in Higher Education to establish a placement office that will serve 200 New England schools. Rosters of women in science are being prepared by various societies and organizations. And the legalities of some of this "discrimination in reverse" are being ironed out!

---

[3]At its meeting in June, 1972, the Board of Directors voted to establish an office that will include concerns of women scientists among its duties.

Nobody—either man or woman—should be anywhere nearly satisfied with the smoothing out of the few bumps that has occurred during the past few years. There is still a long long way to go before the great majority of women scientists receive the same opportunities for full advancement in their professions as do the men, and probably an even longer way before the factors that keep women out of science in the first place are removed. Women as well as men must work to change the attitudes that dictate that little girls are given nurses' kits but never doctors' kits, and that cause some students to address the senior professor of a department as "Miss" but all the junior male teachers as "Doctor." Women must make it perfectly obvious that they *do* want positions of responsibility in their professions. So many women have demonstrated that they are eminently capable in these positions when given the chance to be so that there is no reason in the world for any qualified women who wants it not to have that chance. When this goal is reached, the road for women scientists still may not be exactly smooth, but it will not any longer be so much rougher than the road traveled by their male colleagues.

References Cited

Bergman, B. 1972. The economics of Women's Liberation. *In* Conference on Successful Women in the Sciences: an Analysis of Determinants. New York Academy of Sciences, May 11-13, 1972 (to be published).

Bunting, M.I. 1971. From *Serratia* to Women's Lib and a bit beyond. ASM News 37(3): 46-52.

Goldberg, P. 1968. Are women prejudiced against women? Trans-action (April 1968): 28-30.

Horner, M.A. 1969. Fail:bright women. Psychol. Today (Nov. 1969): 36.

Horner, M.A. and Walsh, M.R. 1972. Causes and consequences of the existence of psychological barriers to self-actualization. *In* Conference on Successful Women in the Sciences: an Analysis of Determinants. New York Academy of Sciences, May 11-13, 1972 (to be published).

National Science Foundation. 1969. American Science Manpower, 1968. NSF Bull. No. 69-38. G.P.O., Washington, D.C.

———————. 1971. American Science Manpower, 1970. NSF Bull. No. 71-45. G.P.O., Washington, D.C.

Oltman, R.M. 1971. Women in the professional caucuses. Amer. Behavioral Sci. (Nov.-Dec. 1971): 281-302.

The Role and Future of Pesticides in Maintaining Food Supply[1]

George W. Irving, Jr.

Research Associate, Life Sciences Research Office, Federation of American Societies for Experimental Biology, Bethesda, Md.

ABSTRACT

During the next few decades, U.S. farm population and land available for farming will decline while total population will be increasing steeply. It follows that food production per farm and labor unit must be increased. To accomplish this, agriculture must not only continue to use its most effective, efficient tools and practices in all operations, but must significantly improve most of them. Among the most important of these operations is control of diseases and pests. The most efficient tools now available for this purpose are chemicals. Alternatives to the use of chemicals, the use of biological or physical means or combinations of them with or without small amounts of chemicals, exist, several show great potential and most have advantages ecologically. But the development of these tools is inherently slow at best, and few will reach the stage of practical application in time to have much impact in the decades immediately ahead. Meantime, we will continue to depend on chemicals, used selectively and prudently, to assure maintaining adequate food supply. Use of some chemicals will decrease, and some will cease to be used altogether, but the total used for disease and pest control in agriculture can be expected to increase as the need for food production increases.

Discussion of a topic like this requires that we make some assumptions. We recognize it is difficult to assess and predict the net impact of change among the many dependent, controllable variables that characterize the agricultural food production complex, superimposed as they are on the uncontrollable ones. An excellent report, prepared by the College of Agriculture, Texas A & M University, is but one of many that illustrate these complexities (1). This means that it is difficult, in turn, to provide the consumer and those who need to make decisions all along the line with a rough picture, let alone a precise and uncomplicated one, of the tradeoffs, consequences and cost of maintaining food supply using each of the several options we have for achieving it. Moreover, if and when the advantages and disadvantages of the alternative ways we have for creating and/or maintaining a food supply are clearly delineated, it is speculative at best how soon people will be forced, or be ready to accept some of them.

Yet today, concerned as we are with the quality of the environment, people in the U.S. and some other countries are demanding, or at least expecting, that our ways of doing things be changed to avoid or ameliorate adverse environmental impacts. Some are urging that we adopt alternatives immediately for those traditional agricultural practices that now foul the public nest, and could insist here in the U.S. for example, through public involvement in the decision-making process, that significant changes be made. Some have already been made and others are possible but largely unpredictable.

These uncertainties lead one to be less confident about assumptions than he would like to be but we will make some simple ones to get on with our topic.

Assumptions

We will consider the "future" as the next 25-30 years. In this period:

1. The world's population will increase. Effective population controls will not be instituted or felt within the next quarter cen-

[1]A talk presented before the Seventh Middle Atlantic Regional Meeting, American Chemical Society, Symposium on the Problem of Food, Feb. 16, 1972 at the Marriott Motor Hotel, Philadelphia, Pa. At that time Dr. Irving was a consultant and Administrator, Agricultural Research Service, USDA, retired. He is indebted to Dr. E.F. Knipling, Agricultural Research Service, U.S.D.A. for advice and assistance in preparation of this paper.

tury. There will be more people to feed—conservatively 40% more—by the year 2000 than there are now (2).

2. The character—basic make-up, variety and quality—of food will not change significantly. In some parts of the world this could be wrong. Certainly, amino acid supplementation, shifts from cereals to legumes, use of textured meat extenders and supplements from vegetable protein, consumption of more marine products, and use of foods derived from petroleum will be a choice or necessity in some areas. But in the developed countries, present food preferences are unlikely to change.

3. We will continue to produce non-food crops—forest products, cotton and other fibers—at about present levels, scaled up in proportion to population increase.

4. All pesticidal chemicals will not be cancelled for agricultural use.

I add the following assumptions as particularly applicable to the U.S.:

5. We will maintain and probably increase present levels of food export.

6. The competitive level for the food production industry will continue to be determined by the one-fifth, or less, of his take home pay that the consumer now pays for food.

7. There will be a net loss in farm labor before farm-city migration diminishes, in about 1985, to the point where farm population is stabilized (3).

General Projections

With such assumptions it is possible, of course, to make some general projections with respect to several of the inputs and outputs of agriculture. My topic is pesticides so we'll stick to that and in rather general terms.

Bearing in mind that the world will need to produce more food in each year of the next three decades than it did in the preceding year, let's look at some relevant considerations.

Of the earth's land area (33 billion acres), one-third is now tilled or in pasture; one-fifth is in perpetual snow and ice; two-fifths is taken up by mountains, inhospitable plateaus, deserts and arid zones. Borgstrom (4) has calculated that the reserve available for tillage is less than 1 billion acres. If this were added to what we now till, and water (a most important if) and other essentials were also available, this would increase agricultural production area about 10%—hardly enough to meet the additional needs of the population increase we expect by 2000. And this 1 billion new acres does not visualize leveling forests needed for water collection and erosion prevention. Nor does it include substantial additional use of tropical soils which, while fertile, resist intensive cropping. So the limits to agricultural land expansion are very real. It is this fact that has startled many in recent years as the problems of a burgeoning population have become reality. Moreover, without workable systems of population control, we will have even less land for agricultural use as time goes on.

The necessary increase in food must come, then, largely from the way available land—essentially present farm land—is used, and from non-agricultural sources. In any event, to fulfill its role, conventional agriculture is going to have to produce to the maximum and take prompt advantage of research developments to improve the efficiency of all its practices. We must also solve the second and third generation problems that will be emerging from the "green revolution". By maximum we mean the greatest output per unit of input through the use of the best yielding varieties for the locality, the best land and water management and production practices, the most efficient blend of hand labor and machines, and the most efficient means for the control of insects, weeds, diseases and other pests. Said in another way, conventional agriculture cannot afford to be less efficient than it now is, despite the great benefits of the "green revolution or the good possibilities of food from non-agricultural sources.

Pest Control

We'll look now in detail at pest control and the alternatives for accomplishing it. Use of pesticidal chemicals is now the method of choice in most of the world's agriculture. Let's see why this is so and what the outlook is for doing it differently in the next quarter century.

To meet the pressures for more food, world agriculture will move, when it can, toward the efficient monoculture system that the United States and some others have employed so successfully. In such a system, crops and livestock are produced in regions of a country that are best suited in soils and climate for optimum production both in quantity and quality. However, large unbroken acreages of a single crop or large concentrations of livestock provide inviting environments for pests and diseases to thrive and spread. The balance is heavily weighted on the side of the pests unless steps are taken to suppress or control them. The synthetic organic pesticides, which can be applied quickly over great areas at relatively low cost, are particularly well suited to the control of pests in this kind of agriculture.

But in the light of the questions that have been raised concerning the wisdom of continuing to add pesticides, some of which are quite persistent, to the environment, it is reasonable to examine and adopt where practicable, alternatives to the use of pesticides.

What is the "state-of-the-art" with respect to these alternatives?

In regions of the world that are fortunate enough to be free of a particular, important pest, an obvious first step in avoiding the problems this pest could create, is to keep it out of the country. In many countries, quarantines are used for this purpose and the United States has had as much successful experience as any with this means of protecting its agriculture. An example is the Mediterranean fruit fly (Medfly), which is exotic to the United States and which attacks citrus and many other soft fruits and vegetables. Plant quarantine inspectors intercept and destroy the Medfly in incoming cargo and baggage some 150 times each year. Despite such a vigorous quarantine, the Medfly has invaded the United States 4 times in the past 15 years. Three of these invasions were discovered and eradicated fairly quickly but 1 cost some $10 million to eradicate through intensive use of pesticides and other practices. To have been invaded 4 times in 15 years is nothing to be proud of, but it could have been worse and more costly without the quarantine. At the very least we could have had many more than 4 expensive battles with this insect if 150 times a year it had not been intercepted at our borders.

Quarantine, then, is effective but can never be completely effective. This will be especially true in the years ahead. Even now, at a time when international travel is rapid and frequent and plane capacity for passengers and freight is increasing steeply, inspection systems are being taxed beyond their effective limits. Moreover, travelers and shippers are understandably impatient with delays occasioned by the present inspection process and would be even more so if more intensive and time consuming practices were instituted. This means that countries can rely less now than formerly upon quarantines to keep out unwanted pests, even though they will be continued as appropriate as a means for reducing the total ultimate cost of pest control. Foreign pests and diseases can and will gain entry to any part of the world where conditions are favorable for their survival.

Eradication of a pest that creates expensive problems is another way of avoiding, ultimately, the problem of controlling it. The United States, for example, eradicated the screwworm, a serious pest of livestock, and we believe now that we may have the necessary tools to eradicate the boll weevil, the picture-book pest of cotton. Attractive as it is, eradication is usually a most expensive process, and with the limited tools available in the past, the efforts made have often been unsuccessful. When it appears technologically feasible to eradicate, decisions must be made as to whether the immediate and long-term benefits justify the commitment of money and other resources to such an effort in lieu of continuing indefinitely, present means of control. Not counting the cost of the research that made it possible, it cost $22 million to earadicate the screwworm, spent over a period of 7 years. More than $5 million continues to be spent each year to prevent re-establishment of the pest from Mexico. As a result, however, the U.S. livestock industry now suffers no damage from a pest that formerly caused

$120 million worth of damage each year in losses and control costs. The $5 million continuing, annual expenditure could be reduced substantially by moving the barrier that now protects us, from the region of the Rio Grande to the narrower Isthmus of Tehuantepec, but this requires a joint effort with Mexico to rid that country of the pest at an estimated cost of $38 million and will probably take as much as 5 years. The question before the decision-makers in both the U.S. and Mexico is: Are such costs presently justifiable?

Currently, a pilot eradication trial for the boll weevil is underway on 25,000 acres in the South, in a cooperative effort by Federal and State Departments of Agriculture and the cotton industry. Several biological, physical and chemical methods are being integrated, timed and spaced, to accomplish the job over a period of at least 2 crop years. The cost of this trial is $2 million per year. If the trial demonstrates that eradication is technologically feasible, decision-makers will be faced with the problem of deciding whether total eradication should be undertaken. The cost of such a program, if undertaken, has not been determined, but the scientists involved believe the job could be done at less cost than the annual losses now suffered due to this pest, which range between $200 and $300 million. If this were the case, the economic benefits are clearly apparent but this would not be the only, or even the greatest, reward. It is estimated that the elimination of this pest would reduce the need for insecticides for agriculture by at least one-third.

It should be emphasized that registered insecticides will need to be used as part of the boll weevil eradication process and in areas awaiting the eradication effort as well. This eradication program, if implemented, would require a minimum of 6 to 8 years and would be expected to have small net impact on the use of insecticides on cotton in the next 10 years. When one considers that the boll weevil is but 1 important pest of 1 important crop, and visualizes the development of analagous, practical programs for eradicating others, the cost and time required are evident.

In the case of a country's native pests, and those that slip through National quarantines and become established, regional quarantines can delay spread, but ultimately it becomes a matter of "living with" the pest—of using every available means to suppress it to levels that can be tolerated. As a practical matter, living with native pests and with more recent invaders is more nearly the normal way of life for agriculture. To refine our means for doing so there is a current effort by Federal and State extension agencies to organize pest management programs involving cotton and other major crops. The objective is to keep the numbers of key insects in a given area below the level that can cause economic damage. The program calls for close supervision of pest conditions and for application of minimum amounts of insecticides based on need. Such programs, if fully developed could reduce substantially the need for insecticides within the next decade.

However, despite these efforts, so great is the need that much research the world over is being focused on additional tools for improving the farmer's competitive position in the "living with" process: resistant crop varieties; improved cultural practices; the use of parasites, predators, and pathogens as biological agents; development of genetic defects such as sterility; physical devices; and more selective chemicals such as attractants and hormonal insecticides. Many believe that integrated use of such of these tools as are found practicable to suppress pest numbers, is likely to be the practice of the future. I might add that prudent use of chemicals is visualized as essential in such integrated procedures.

Let's look at the prospects for a number of these alternatives (5).

Resistant crop varieties and cultural practices.—The development of resistant crop varieties is obviously an ideal means for pest control. By growing crops that are substantially resistant to diseases and insects we compound benefits by avoiding crop losses, saving costs of other control measures, and reduce contamination of the enviornment. But breeding crops that are resistant to diseases, and particularly to insects, is not a simple undertaking. The relationship between the host and the parasite is intricate and the physiology of each is complex. Breeders have been successful in developing varieties, notably wheat, corn, alfalfa and potatoes, that are resistant to certain diseases, and continuing research keeps them so despite loss of resistance due to mutation of pathogens. Progress in developing crop varieties resistant to insects, however, has been less spectacular although several successes have been achieved. Wheat varieties, for example, have been developed and are grown on millions of acres that are virtually immune to the Hessian fly. More effort in recent years is going into this means of attack on insects and substantial progress can be anticipated in the long range future. However, since it requires, generally, 10 years or longer to discover and transfer insect resistant germ plasm into varieties that possess all desired agronomic qualities, such future developments are not likely to reduce significantly the need for insecticides in the next couple of decades.

Meantime, cultural practices, the chief resort of farmers before other sophisticated methods were available, continue to be exploited: Sanitation, early planting, destruction of crop residues, tillage, crop and animal rotation, where feasible, strip cropping, destruction of volunteer plants, and specific harvesting procedures. These practices are still used to the extent circumstances warrant but in the monoculture system they are inadequate unless used in conjunction with other methods. Most frequently, chemical control is also needed and used.

Biological control.—The use of parasites, predators, and diseases is another attractive way of controlling pest numbers. Research to discover such beneficial agents in parts of the world where they are now reasonably effective, and their establishment in parts of the world where they are not, has been going on for nearly a century. A few examples will illustrate extent of progress. Of better than 500 species of insect parasites and predators imported into the U.S., slightly more than 100 have become established and barely 20 have provided significant control, among them coccinellid beetles against the citrus mealy bug and parasitic wasps against the pea aphid. *Bacillus thuringiensis* has received considerable attention as a pathogen against the cotton bollworm and certain pests of vegetables, and recently received approval of the Environmental Protection Agency for use against the gypsy moth. Field studies of a polyhedrosis virus for control of bollworm and cabbage looper have shown it to be promising, but approval of its use awaits completion of extensive safety tests and economical production of the viruses has not yet been perfected. A flea beetle, introduced to control alligator weed in Florida and South Carolina, has multiplied sufficiently to make an important contribution to the control of this reservoir- and canal-choking pest. Such experience is promising enough to justify continuing the quest for other biological agents to control weeds, but we cannot anticipate any marked reduction in the need for herbicides as the result of introductions of biological agents in the foreseeable future. Research is also underway on the possibilities of mass-producing parasites and predators to control certain insects but here again we cannot expect developments in this field to obviate the need for insecticides within the next decade or two.

Insect sterility.—The manipulation of insects for their own destruction by inducing sexual sterility, or introducing other harmful genetic traits, is relatively new and, where applicable, has been quite successful. Two methods of using sterility as a control are being exploited. One method is based on rearing massive numbers of a pest, sterilizing them with gamma radiation, and releasing the insects to compete for mates in the natural population. The resulting eggs do not hatch and the insect population dwindles. The second method involves the application of chemosterilants to native populations at a central source. The treated insects then disperse and serve to reduce the reproduction of target pests in the environment. The first method was used to eradicate the screwworm as has been mentioned, and is proving effective against the Mexican and Oriental fruit flies. Work is being done to develop this method for use against the boll weevil, pink bollworm, codling moth, gypsy moth, corn earworm, tobacco hornworm, tobacco budworm, cabbage looper, fall armyworm, and hornfly. The sterility principle is most attractive but it requires for its application a thorough knowledge of the biology, ecology, and population dynamics of each target insect. Each insect presents unique problems with respect to the mass rearing of the billions needed to flood adequately the target population, and in accomplishing sterilization without impairing the aggressive characteristics of the released insects to enable them to compete for mates in the native population. Another limiting factor is that the method is effective only when the target population is at a natural low ebb or when the population is first reduced by insecticides or other methods of control (6). The sterility technique is usually successful as a tool for eradication or continuous suppression of an insect only when used in conjunction with other methods of pest control or when insect populations are reduced by natural causes. It will take a great many years to develop such practical means, even for those insects where it appears now to be feasible, for control of very many of the insects that plague agriculture.

Attractants and hormones.—One of the latest trends is research to identify and develop attractants and hormones for insect control; some insects are attracted or repelled by substances in the host, by chemical sex attractants, by light, and by sound. Naturally occurring attractants are highly specific and active in infinitesimal amounts. The synthetic lure, methyl eugenol, has been used experimentally to eradicate the Oriental fruit fly on the island of Rota. Another recent trend is research on hormones and hormone-like materials that may be used as insecticides to disrupt insect development rather than cause immediate death. These, too, are generally species specific and effective in fantastically small amounts. Sterility in adult insects may result soon after treatment with molting hormones. Juvenile hormones act by interrupting insect development and producing monster insects that eventually die, or if they become adults, cannot reproduce. There is very active cooperation among Federal, State, university and industrial scientists to push developmental research on the juvenile and molting hormones and their analogs. Extensive screening programs involving hundreds of compounds are under way. Interesting leads are emerging but at present they can hardly be considered more than that. It will be some time in the future before some of these chemicals will be ready for practical use. Not many are likely to be established very soon.

It should be pointed out and emphasized that the development and implementation of certain biological control methods, such as the sterility technique for insect control, require extensive, costly and time-consuming research. Depending on the insect and our knowledge of it, considerable new information may be needed concerning the numbers of different stages of the insect per acre, the nutritional requirements for mass rearing, the comparative vigor and competitiveness of reared and sterilized insects and the native strains. After the basic data have been obtained, areawide control procedures for each insect must be tested in a large area or an isolated area such as an island. If results are favorable, it may still be necessary to perfect mass rearing methods for the agents to be used then test them in an area where they are required to protect an agricultural crop. At the conclusion of the testing, it must be decided whether the procedure is worth the cost of using it and who should be responsible for its further development. An obstacle to the rapid advancement of such means of insect control is, I repeat, the high cost of research and development.

I conclude from all of this that pesticides will be with us as an important part, perhaps the most important part, of our armamentarium in controlling pests for the foreseeable future. This does not mean that use of pesticides is the only method we will have available for combatting pests and diseases. Nor does it mean that current pesticides must continue to be used in present quantities. It does mean that chemicals are now the most effective weapons agriculture has for pest control and that in the future chemicals will continue to be an essential part of the integrated control programs farmers will have to use. The use of some pesticides will decrease and some will cease to be used entirely, but the total amount of chemicals used for control of insects, weeds, and other agricultural pests can be expected to increase as the need for agricultural production increases and until alternative methods are eventually perfected.

I don't by any means want to imply pessimism about either the attractiveness of biological controls for pests or the liklihood that many will indeed become a part of our weaponry before the next quarter century ends. I can agree in principle with Huffaker's statement in "Biological Control", (7) a collection of papers he recently edited, even if I disagree with his choice of some words which I believe magnify the gravity of our present situation with respect to pesticidal chemicals and the environment . . . . . "If we are to reverse the trend toward an ever-intensified over-loading of the environment with polluting and highly toxic pesticides, we must show that biological control, combined with restricted usage of selective chemicals, use of resistant varieties and other integrative measures can, in fact, solve many of our pest problems without resort to such disturbing and polluting chemicals." I only contend that it will take longer, even with a wholly adequate research and development effort, than some proponents of change think it will.

But because there is reason to be sensible about the hazards—known, unknown, and doubtful—of the accumulation of unnatural chemicals in the environment, there will be change. Perhaps the greatest change in the pesticide picture will be a qualitative one. One of the beauties of the 3-decade pesticide era just concluding, is that many of the most-used synthetic pesticides are relatively non specific and are persistent, making them capable of controlling many different pests with a limited number of applications. These very attributes are the Achilles' heel of pesticidal chemicals as the environmentalists view it. Qualitatively, pesticides will change toward chemicals that are more specific with respect to target insects and less persistent after application. The research needed to find and develop chemicals of this sort is enormous compared to that which was required, great though it was, to yield effective, broad spectrum pesticides. And the cost to the farmer of the application of several non persistent pesticides more frequently to control the variety of deleterious pests that beset a crop, will also be greater. It would be meaningless to attempt, however, to estimate the quantitative change to be expected in the use of pesticides between now and the year 2000.

I might add, parenthetically, that we like now to make quantitative comparisons of the use and environmental accumulation of pesticides by years, and we will continue to, but there is no common denominator for such comparisons. Tons of production or use mean nothing with chemicals of different effectiveness, persistence, and degradation products, the nature and toxicity of which are largely unknown. But we need one, if only to provide a mutually acceptable measure of change in the debates on this issue that will continue.

This is the end of my story. It goes without saying, of course, that if one chooses to make different assumptions than I made at the outset, his projections would likely be different. If one believes, for instance, that a substantial fraction of the world's food will come from non-agricultural sources within the next 30 years, conventional agriculture could be spared by that much, probably with concomitant sparing of the pesticides needed to control pests. If one believes that people of developed countries like the United States will decide to spend more for food—say one-fourth rather than one-fifth of their pay—and the difference is used to defray the added cost of using presently less efficient methods to control pests, the need for pesticides could be somewhat reduced.

I'd like to share one final thought with you. I believe that the creators and adherents of the environmental ethic are showing signs of mellowing—not weakening, just mellowing. And so are those in agriculture and industry. The environmentalists are becoming aware that some of the consequences of summary banning of pesticides are very real and are less eager to insist on changes that, as Handler (8) says, will "replace known devils with insufficiently understood unknown devils." Those of us close to agriculture or industry are more ready to agree that we have had and still have ample room to improve the way we do our jobs and are not as reluctant to move away from the status quo. I believe most of us now realize that we are not at the brink of disaster in projecting the continued prudent use of certain pesticides. In the years ahead the necessary tradeoffs of change will be more clearly understood. Short and long term hazards of pesticides will also be better understood and will find their appropriate position relative to the other hazards to which we deliberately expose ourselves. We will be increasingly willing to accept certain risks in the use of pesticides just as we accept the risks of driving an automobile and riding airplanes. We will strive to become better informed and we will have more help in this regard than we have had in the past from all parties at interest. And being better informed, we will come closer to knowing than in the past, the meaning and consequences of the National actions we insist upon.

It might be a good thing too, I believe, for all parties in the environmental controversy to devote some of their zeal and considerable energies to solving the key problem—unlimited world population increase. McHarg (9) suggests that people are a planetary disease, and it's hard to disagree with him. Scarcely a major problem exists that does not arise because of population pressures or the certainty that they will worsen. One might ask a host of questions around this point, but since our topic is food, I'll leave you with just 2. Why strain our resources to feed ever increasing numbers of people when we know there will come a day when we will not be able to? Why not harness all of our 20th. century sophistication, surmount the apparently insurmountable, and find and set in motion a sensible, workable, acceptable means for limiting the number of people we will impose on Earth?

References Cited

(1) Impact of drastic reduction in the use of agricultural chemicals on food and fiber production and cost to the consumer. Special Report College of Agriculture, Texas A. and M. University, July, 1970.

(2) Population Reference Bureau. July, 1970.

(3) Irving, G.W., Jr., Agriculture's future in an urban society. Presented as part of a symposium, Man and Environment II, Second National Biological Congress, Miami Beach, Fla., October 23, 1971.

(4) Borgstrom, G.A. Food Science Department, Michigan State University.

(5) Irving, G.W., Jr. Agricultural pest control and the environment. Science 168: 1419-1424 (1970).

(6) Knipling, E.F. Agricultural Science Review 1: 2 (1963).

(7) Huffaker, C.B. Biological Control. Plenum Press, September, 1971.

(8) Handler, Philip In defense of science. Jour Washington Acad. Sci. 61: 175-84 (1971).

(9) McHarg, I.L. Man: planetary disease? Catalyst for Environmental Quality II: 13-15 (1971).

RESEARCH REPORTS

Estimated Population Size and Home Range of the Salamanders Plethodon jordani and Plethodon glutinosus

Henry Merchant

Department of Biology, George Washington University, Washington, D.C. 20006

ABSTRACT

In a study area in the Great Smoky Mountains National Park, North Carolina, the density of *Plethodon jordani* (one individual for every 12.5 ft^2) was estimated to be about 4 times that of *Plethodon glutinosus* (1 individual for every 46.3 ft^2). The proportion recaptured estimates agreed well with the Lincoln-index estimates. Male *P. jordani* moved significantly farther between captures than female or juvenile *P. jordani*. For *P. jordani*, the estimated home range sizes were: males, 123.5 ft^2; females, 30.3 ft^2; juveniles, 18.5 ft^2. For *P. glutinosus*, the estimated home range sizes were: males, 154.9 ft^2; females, 70.2 ft^2; juveniles, 81.1 ft^2. Within the study area, both species were associated with large logs and trees. The adults of the 2 species did not appear to be intermixed within the study area.

Regardless of the parameter being considered, the impact of a species upon the community in which it lives is dependent upon the density of that species. In this respect, the density of a species becomes an important constant by which the influence of the individual member of the species must be multiplied in order to determine the quantitative effect of the species upon its environment.

Plethodon jordani Blatchley and *Plethodon glutinosus* (Green) are 2 closely related species of lungless woodland salamanders which are sympatric in some areas of the southern Appalachian Mountains (Hairston, 1951; Highton, 1962). In these areas, it is readily apparent to collectors that the 2 forms are not equally abundant. Closer study of the relative abundance in a given area might better quantify the numerical relationships of these 2 species.

With these considerations in mind, a study, the objective of which was the estimation of the relative densities of these forms in an area where they were sympatric, was undertaken during the summers of 1963, 1964, and 1965. Mark-release techniques were employed so that the movements of individual salamanders could be monitored throughout the summer. This provided information regarding the home range, migration, and dispersion, as well as density of the 2 species.

The study area was located 50 yards north of a small creek (Taywa Creek) at an elevation of 4,000 ft. above sea level on the western slope of Hughes Ridge in the Great Smoky Mountains National Park, Swain County, North Carolina. A grid 100 x 50 ft. was established such that the long axis extended in an east-west direction. Population size estimates were made for the eastern half of the study area (Fig. 1). For the first 2 summers, the entire 5,000 ft^2 were used in the study of movements and home range. Throughout the grid, stakes were placed at

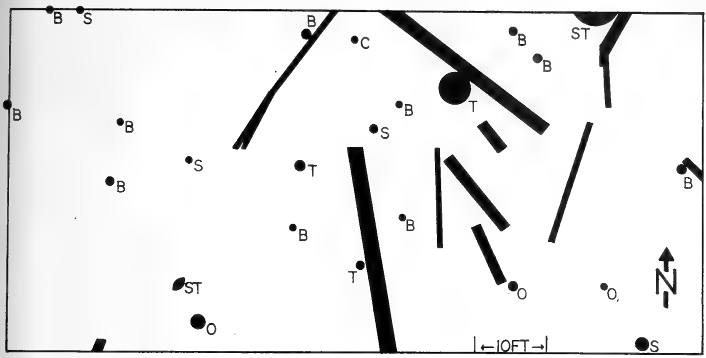


Fig. 1. Scale diagram of the study area. The population size estimates reported in the text are for the eastern half of the study area. The entire area was used to study movements and home range during 1963 and 1964. Darkened rectangular areas represent fallen logs greater than 4 inches in diameter. Other objects are stumps (St) or trees greater than 4 inches in diameter: beech (B), silverbell (S), tulip (T), oak (O), cherry (C).

intervals of 10 ft., subdividing the grid into 50 ten-by-ten squares, and making no point in the grid more than 7 ft from a stake. Of the 12 trees greater than 4 inches dbh, 5 were beech (*Fagus grandifolia*), 2 were silverbell-tree (*Halesia carolina*), 2 were red oak (*Quercus rubra*), 2 were tulip-tree (*Liriodendron tulipifera*), and 1 was cherry (*Prunus* sp.). Of the 12 trees that were less than 4 inches dbh (but were at least 5 ft tall before the trunk forked), 11 were beech (*Fagus grandifolia*), and 1 was sugar maple (*Acer saccharum*). The floor was covered with much litter and debris including decaying chestnut (*Castanea dentata*).

Materials and Methods

As an attempt to standardize the level of darkness at which sampling began, entering the grid was delayed until it became too dark to see a given tree from a fixed place 10 yards away. As soon as this level of darkness was reached, a systematic search of the study area along established routes was begun. In order to avoid sampling the same portion of the grid at the same time, the place of initial sampling was determined randomly.

While sampling, the grid was carefully scrutinized with the aid of a 6-v dry cell-powered lantern. Only animals found walking on the surface or extending part-way from burrows were recorded. Thus there was a minimum of destruction to the habitat. When an animal was observed, it was captured and identified as to species and sex. If it had not previously been marked, a unique combination of toes was clipped with scissors or fingernail clippers. The animal was measured (tip of snout to anterior angle of vent) in millimeters by stretching it along the edge of a ruler. The distance from the nearest stake was estimated. The animal was then released exactly where it had been captured, taking care to see that when released, at least the animal's head was beneath a leaf or similar object so that the light and further activity in the immediate vicinity would not disturb it. This precaution was taken after it was observed that occasionally a released animal would start moving rapidly away and in a straight line—neither of which it had been doing before it was captured. Animals thus carefully released were never observed to begin moving rapidly, but would either push their way farther under the leaves or would remain stationary with their heads under the leaves. Normally, depending upon the number of animals present on the surface, from 2 to 4 hr were spent in this manner going through the grid. Identification as to sex was based upon the fact that the adult males of these species possess a swollen mental gland beneath the chin. Animals without the gland and greater than 44 mm (snout-vent length) were considered to be adult females. Without the gland and less than 48 mm, they were regarded as juveniles. Because of regeneration of the toes, marking could not be recognized from one summer to the next, and so new marking were given to all animals each year. Sampling in 1963 extended from June 14 through September 1; in 1964, from June 16 through July 19; in 1965, from June 13 through August 24.

In arriving at an estimate of the population size, the data gathered in the above manner were analyzed in 2 ways. In the first analysis, use was made of the Lincoln-index technique in which P = MN/m (where P is the estimate of the population size, M is the number of marked animals released into the population, N is the size of a subsequent sample, and m is the number of marked animals in the subsequent sample). Since more than 2 samples were taken, the same method was applied by grouping the samples into 2 groups—a marking and a recapture group. Outings were grouped such that the 1st half of the samples were considered as used for marking and releasing, and the 2nd half of the samples were considered as used for recapturing. In all cases, for an odd number of samples, the odd sample was included in the marking and releasing group.

The standard deviations associated with the Lincoln-index estimates were calculated using the method summarized by Southwood (1966), in which the variance associated with the estimate is given by the following formula:

$$\text{Var P} = \frac{M^2N(N-m)}{m^3}$$

where: M, N, and m are as defined above.

The second method of analyzing the data made use of the fact that as marked animals were continually released into the population, subsequent samples showed an increase in the proportion of marked animals. This increase in proportion of marked animals should continue until at 1 point, subsequent samples consist of 100% marked animals (Hayne, 1949b). In the present study, the point of 100% recaptures was never reached, but the population size was estimated by fitting the best line (method of least squares) to a plot of proportion recaptured vs. the cumulative marked. From the resulting graph, the number of animals needed to be marked to give 100% recaptures was determined. The fitted line as pointed out by Hayne (1949b) must be forced through the origin, since at 0 cumulative marked, 0 recaptures is the only possible observation.

The size of the home range of an individual was estimated by using the method described by Hayne (1949a). In this method, the center of activity of an individual animal was determined by calculating the geometric center of the capture locations. The average distance from this center of activity to the capture locations was calculated and was used as the radius of the home range. The estimated home range then extended as a circle around the center of activity.

Results

The results obtained by using the Lincoln-index methods of estimating numbers are reported in Table 1 for *Plethodon jordani* and in Table 2 for *Plethodon glutinosus*.

The proportion recaptured results for *P. jordani* are presented graphically in Fig. 2 and are summarized in Table 3. The data for *P. glutinosus* were not treated with this method because the sample sizes were too small.

Support for the hypothesis that the population of *P. jordani* did not change from year to year was obtained by comparison of the rate at which the population was marked each year. If the population were greatly larger or smaller one year than another, then the rate at which the population was marked should be significantly different. The slope of the lines in Fig. 2 is a measure of the rate at which the population was marked. Confidence intervals for the slopes were calculated according to Snedecor and Cochran (1967). The 95% confidence intervals for the slopes all overlapped, and so there was no significant difference in the rate at which the population was marked from one year to the

Table 1. Estimated number of *Plethodon jordani* using the Lincoln-index method. See text for method of calculating the standard error.

Number of Samples in Estimate	1963	1964	1965
2	39 ± 25.4	—	196 ± 188.9
3	170 ± 161.3	95 ± 60.1	102 ± 104.6
4	102 ± 53.8	171 ± 114.0	144 ± 74.9
5	140 ± 56.7	—	148 ± 90.6
6	140 ± 44.6	208 ± 112.8	159 ± 52.5
7	188 ± 99.1	198 ± 73.5	153 ± 38.1
8	162 ± 40.4	193 ± 61.6	163 ± 37.8
9	162 ± 31.1	156 ± 41.5	177 ± 36.2
10	166 ± 31.2	156 ± 34.9	198 ± 41.4
11	165 ± 26.8	219 ± 53.4	203 ± 34.7
12	167 ± 26.0		198 ± 31.9
13	186 ± 27.5		202 ± 29.4
14	187 ± 27.3		217 ± 31.7
15	221 ± 34.7		217 ± 28.4
16	230 ± 35.1		228 ± 27.7
17	244 ± 35.6		
18	243 ± 34.3		
19	243 ± 32.2		
20	249 ± 33.0		
21	268 ± 37.2		
22	278 ± 38.5		
23	289 ± 40.0		
24	283 ± 37.2		
25	277 ± 31.9		
26	283 ± 31.7		
27	275 ± 29.7		
28	295 ± 32.4		
29	248 ± 22.0		
30	295 ± 27.0		
31	295 ± 21.0		

Ave. est. number: 216 174 184

Ave. est. number for all 3 years: 200

next. Since the differences among the years were not significant at the 95% level, a combined regression line was fitted to all the data, and a combined estimate calculated (Fig. 2 and Table 3). Using the confidence limits of the slopes, estimated population sizes were calculated, and the resulting range of values are reported in Table 3.

The points of capture for each individual were mapped and the distances moved between captures were measured. The resulting distribution of movements approximated a Poisson distribution, so the data were transformed by using the transformation $(x + 1)^{1/2}$ (Snedecor and Cochran, 1967). The transformed data were then subjected to an analysis of variance (Table 4). The mean male, female, and juvenile movements and the mean for each year are reported in Fig. 3. In view of the non-overlapping of the confidence interval of the males with that of the females or juveniles, it was decided that separate estimates of the male, female, and juvenile home range size should be made. The lack of a significant difference between the years indicated that the average movement was not significantly different from year to year, and so all movements within a sex were summed over the 3 years to obtain the results in Tables 5 and 6. Because of the small number of individuals involved, and because of the large variation observed in the results obtained, no statistical analysis of the movements or home range size of *P. glutinosus* was performed. The results reported for *P. glutinosus* are therefore estimates, the validity of which is unmeasured.

The results of estimating the home ranges are in Table 5 for *P. jordani* and in Table 6 for *P. glutinosus*. Individuals which were

Table 2. Estimated number of *Plethodon glutinosus* using the Lincoln-index method. See text for method of calculating the standard error.

Number of Samples in Estimate	1963	1964	1965
2	—	—	—
3	—	—	—
4	—	—	—
5	—	—	—
6	—	12 ± 6.9	—
7	35 ± 19.2	14 ± 8.4	—
8	63 ± 39.3	20 ± 10.0	—
9	51 ± 35.3	20 ± 20.0	—
10	61 ± 30.7	37 ± 11.9	—
11	48 ± 17.5	52 ± 33.8	—
12	51 ± 19.0		—
13	54 ± 20.2		—
14	58 ± 21.7		50 ± 14.1
15	45 ± 12.4		50 ± 14.1
16	45 ± 12.4		37 ± 9.7
17	44 ± 11.8		
18	53 ± 15.5		
19	55 ± 15.6		
20	55 ± 15.6		
21	68 ± 23.7		
22	78 ± 28.5		
23	101 ± 43.4		
24	73 ± 22.0		
25	77 ± 21.7		
26	71 ± 18.6		
27	60 ± 12.0		
28	60 ± 11.6		
29	62 ± 12.1		
30	62 ± 12.5		
31	64 ± 12.7		

Ave. est. number: 60 26 46
Ave. est. number for all 3 years: 53

captured only 2 times are included in the results in Tables 5 and 6. Their inclusion in Table 5, however, does not alter the conclusions, since the large variance associated with the estimates calculated on the basis of 3 or more captures included the mean calculated on the basis of only 2 captures. Again, the small sample size of *P. glutinosus* prevented such a comparison for that species.

In obtaining the results in Tables 5 and 6, the home ranges are represented as circles. It must be emphasized that no claim is made to the effect that the actual home ranges are circular. The circles are merely a convenient estimate of the size of the home range.

It was readily apparent while in the field that not all portions of the study grid were used to the same degree by the salamanders. Thus, an analysis of the dispersion of the individuals within the study area became a consideration. The total number of captures within each 10-ft subsquare was determined, and a variance/mean ratio for the resulting data was calcualted. For *P. jordani*, this ratio equalled 8.964, and for *P. glutinosus*, the ratio was 5.059. Both ratios were significantly greater than expected on the basis of chance (*P. jordani*: $t = 29.822$, $df = 49$, $P < .001$; *P. glutinosus*: $t = 20.296$, $df = 49$, $P < .001$). A variance/mean ratio significantly greater than one indicates a clumped dispersion (Greig-Smith, 1964). Comparison of the centers of activity with the distribution of large objects (logs and trees) in the study area (Fig. 1) suggested that the dispersion might be associated with the distribution of the large objects. The area occupied by large logs and trees plus an area bounded by 1 ft in all directions from the edges of these objects represented 26% of the total area in the

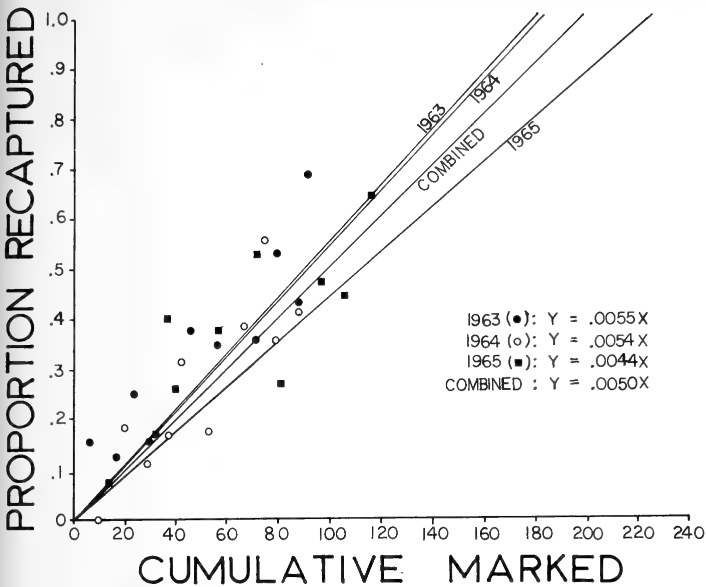


Fig. 2. Proportion recaptured vs. cumulative marked. Thepopulation size estimates (i.e. the values on the abscissa corresponding to the point 1.0 on the ordinate) for 1963, 1964, 1965, and for all years combined are respectively 182, 185, 227, and 200 individuals. See Table 3 for the confidence intervals of the slopes.

study area. The distance of 1 ft from the edge of these objects was arbitrarily decided to be a reasonable quantitative estimate of "close to" these objects. If the animals were distributed about the area independently of the objects within it, then there should be proportionally no greater number of captures "close to" the objects than "far from" them. Comparison of the observed number of captures "close to" and "far from" the large objects for each year with the number expected on the basis of the proportion of the total area which the objects occupy revealed that there was a significantly greater number of captures "close to" the large objects that expected on the basis of the area occupied by the objects (*P. jordani*: $X^2 = 18.96$, df - 1, $P < .005$; *P. glutinosus*: $X^2 = 10.45$, df = 1, $P < .005$).

The number of centers of activity falling "close to" large objects and the number of centers of activity falling "far from" large objects for each year was not significantly different from what was expected on the basis of the number of captures occurring "close to" and "far from" large objects (*P. jordani*: $X^2 = 0.29$, df = 2, $.75 < P < .90$; *P. glutinosus*: $X^2 = 3.74$, df = 2, $.10 < P < .25$).

If one ignores juveniles, then *P. jordani* and *P. glutinosus* had centers of activity which did not appear to be readily interspersed but rather appeared to be grouped in different regions of the study area.

Discussion

It is concluded that the density of *Plethodon jordani* in the study area was about

Table 3. Population size estimates of *Plethodon jordani* based on the proportion recaptured method.

Year	Slope	Est. population size	95% confidence interval of slope	Range of Population-size estimates based on confidence interval of slope
1963	.0055	182	$.0072 > b > .0038$	139-263
1964	.0054	185	$.0065 > b > .0025$	154-400
1965	.0044	227	$.0063 > b > .0025$	159-400
Combined	.0050	200	$.0060 > b > .0040$	167-250

200 animals per 2500 ft^2, or 1 *P. jordani* for every 12.5 ft^2. *Plethodon glutinosus* was found to be only about ¼ as abundant as *P. jordani*, there being an estimated 54 *P. glutinosus* in the study area, or 1 *P. glutinosus* for every 46 ft^2.

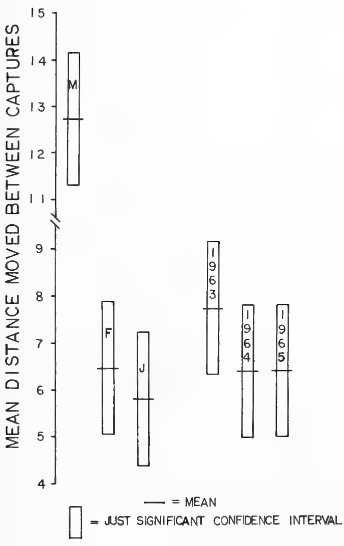


Fig. 3. Comparison of mean movements in feet between captures for *Plethodon jordani*. The means for males, females, and juveniles summed over years are compared and the means for 1963, 1964, and 1965 summed over sex are compared. Non-overlapping Just Significant Confidence Intervals (JSCI's) indicate significant differences at the 95% level. JSCI corresponds to the D value of Snedecor and Cochran (1967).

While other estimates of the population density of *P. jordani* and *P. glutinosus* are not available for comparison with the results obtained in the present study, several estimates of the population density of *Plethodon cinereus* have been reported. Burger (1935), working in Pennsylvania and New Jersey, stated that densities of *P. cinereus* may equal 1 individual for every 18 ft^2. Test and Bingham (1948) reported densities in Michigan of 1 individual for every 189 ft^2, but implied that the real density was greater. Klein (1960) in Pennsylvania estimated the density of *P. cinereus* to be 1 individual for every 51 ft^2.

The present study was an attempt to estimate the number of salamanders in the open on the surface and during the time period of approximately 8:30 to 11:30 P.M.. The major assumption was that on successive nights the same population was being dealt with. Taub (1961) found that with mark-release techniques applied to caged populations of *P. cinereus*, better estimates (estimates closer to the actual number present) were obtained when the individuals were kept on the litter and not permitted to penetrate to lower soil layers. Thus exchange of individuals between the lower soil levels and the litter layer—which could not be prevented in the field study—have undoubtedly influenced the estimates herein reported. Horizontal migration, while not conclusively disproved, is assumed to be of little importance in the present study for several reasons. First, whenever studies have been made of *Plethodon* with regard to horizontal movements of non-displaced individuals, no evidence for their occurrence has been uncovered. Klein (1960) reported that no marked *P. cinereus* were found outside his study area; Test and Bingham (1948) stated that there appeared

Table 4. Analysis of variance for movements of *Plethodon jordani*.

Source	DF	SS	MS	EMS
Total	455	1551.2433		
Years	2	25.9660	12.9830	$\sigma^2 + \sigma_s^2 + 2.2\sigma_i^2 + 51.7\sigma_s^2 + 130.3\sigma_y^2$
Sex (years)	6	260.7156	43.4526	$\sigma^2 + \sigma_s^2 + 1.8\sigma_i^2 + 46.6\sigma_s^2$
Individ. (sex)	245	886.8456	3.6198	$\sigma^2 + \sigma_s^2 + 1.8\sigma_i^2$
Samples (individ.)	202	377.7131	1.8699	$\sigma^2 + \sigma_s^2$

to be little shifting in the population after a census had been taken. Taub (1961) reported no evidence of horizontal migration of *P. cinereus*. Highton (1956) reported that the largest observed movement between captures of marked *P. glutinosus* was 14.5 ft. This movement took place during an interval of 28 days, however, other individuals showed no movement over intervals of as much as 341 days. Secondly, searches of the peripheral area in the present study and the direction of recorded movements within the study area gave no indication of migration. Thirdly, a significant difference in the percentage of animals recaptured in inner areas of the grid (44.75%) vs. the percentage of animals recaptured in border areas of the grid (45.89%) might have indicated migration, but no such difference was found. Comparison of the number of recaptured individuals and the number of individuals never recaptured in border and inner squares gave a X^2 value of 0.12 (df = 1, $.50 < P < .75$).

Variation within an individual's activity period (as measured by its being out in the open) may also have contributed to the error in the estimates. On several occasions, the study area was sampled a second time, beginning after the 1st sample was completed at approximately 11:30 P.M.. When 2 samples were taken on the same night, the majority of the animals in the 2nd sample were different from those taken in the earlier sample. The 2nd sample always included animals which had been marked in 8:30-11:30 samples. A more striking aspect of this can be seen by looking at the results of a sample taken from 3:00-4:00 A.M. in another study area. In this sample, all the animals which were recaptured had been marked in 8:30-11:30 samples. The percentage of recaptures (50%) in this early morning sample was greater than the percentage (27%) in the sample taken at 11:30 P.M. the night before. In addition, 1 marked animal captured at 3:00 A.M. was recaptured again at 8:30 P.M. that night. Thus it appears that a given animal does not always have the same period of activity. This report includes only data taken in 8:30-11:30 samples, and thus differences in activity periods of an individual as well as vertical migration could have influenced the estimated numbers reported herein.

The movement-between-captures data for *P. jordani* were highly variable, and no attempt was made to eliminate outliers. In spite of this, the difference in the mean movement between males and females or juveniles was significant, and thus the difference can be taken as a biologically real and presumbably important difference associated with the sex of the individual. A possible explanation of this difference may be related to the reproductive behavior of this species. The general pattern of courtship of the plethodontid salamanders has been described by Noble and Brady (1930), and that of *P. jordani* and *P. glutinsosus* by Organ (1958, 1960). In these descriptions, it is the male that initiates courtship, the role of the female during the initial phases being described as passive. Thus, the larger home range of the males may be the result of their moving farther during periods of activity which results, during the breeding season, in a greater probability of their contacting a receptive female.

The fact that there was no significant difference between the mean home range of *P. jordani* based upon 3 or more captures, and the mean home range based upon 2 captures is expected, considering that the small number of captures for a given individual probably does not indicate loss of the individual from the study area but probably means that the individual was either not at the surface or was not active at the time of

Table 5. Estimated mean radius and mean area of home range of *Plethodon jordani.*

Year	Radius of home range in ft Males	Females	Juveniles	Area of home range in ft^2 Males	Females	Juveniles
1963	6.43	3.56	2.35	128.68	39.81	17.35
1964	6.73[a]	2.75	2.52	141.02[a]	23.76	19.95
1965	5.38	2.46	2.51	91.61	19.01	19.79
Ave.	6.27	3.11	2.42	123.46	30.27	18.46

[a]Based on less than 10 animals.

Table 6. Estimated mean radius and mean area of home range of *Plethodon glutinosus*.

Year	Radius of home range in ft Males	Females	Juveniles	Area of home range in ft^2 Males	Females	Juveniles
1963	7.70[a]	3.06[a]	5.88[a]	186.26[a]	29.42[a]	108.66[a]
1964	9.20[b]	8.63	—	256.99[b]	233.86	—
1965	1.50[b]	—	3.65[a]	7.07[b]	—	41.85[a]
Ave.	7.02[a]	4.73	5.08	154.88[a]	70.24	81.11

[a]Based on less than 10 animals.

[b]based on 1 animal.

the survey. In addition, in many cases the 2 captures were 4 or more weeks apart, thereby supporting the hypothesis that only 2 captures does not necessarily indicate a home range which is really an artifact of the method of analysis applied to an individual which does not actually have a home range.

The selection of 1 ft away from the edge of large objects as a measure of "close to" the objects, while arbitrary, was not unreasonable since it is well within the mean distance moved between captures of both sexes and juveniles.

The agreement between the location of the centers of activity and the locations of capture indicates that the mathematically determined centers of activity reflect the biology of the species in 2 ways. First, the centers of activity are positionally located "close to" large objects in the area as are the sites of capture. Thus, an individual animal directs its activities about these objects. Secondly, the individual's movements, as revealed by changes in the location of capture, are such that for the most part they do not cross large areas that lack either large logs or large trees. If such areas were crossed, then, although the individual might always be captured near large objects, the geometric center of the capture sites would more often that was observed by shifted away from the objects toward the center of the areas lacking large objects.

The interesting aspect of the association of *P. jordani* and *P. glutinosus* with large logs or trees is that the asosciation exists after dark. Daytime collection of these forms reveals that, in general, more individuals are found by looking beside or under logs, bark, stones, etc. than by scratching around under leaves. But the daytime association is not just the result of retreat into sheltered areas which the individuals abandon after dark. The activity of the animal after dark, as revealed by its position at the time of capture, is also restricted to areas "close to" these large objects. The association with large objects is not necessarily to the exclusion of smaller objects, and in fact, the association with large trees may very well be due to the fact that many of the trees possessed hollow bases, sloughed off bark around the base, or obvious crevices about the visible portion of the roots. There probably are minimum requirements which cover must fulfill before it is suitable—requirements that a layer of fallen leaves does not fulfill—and which are provided by objects other than large logs and large trees, but the data as collected do not include the location of these smaller objects. With reference to the observed association between these species of *Plethodon* and large objects, it should be emphasized that areas of the grid without large objects were scrutinized for salamanders just as carefully as were those areas with large objects.

The distribution of the 2 species relative to each other may reflect an interaction between the adults of these 2 closely related species, but a firm conclusion relative to this matter must await further investigation.

Acknowledgment

The advice and encouragement of Dr. Richard Highton in carrying out this work is gratefully acknowledged. NSF research participantships and an NSF grant to Dr. Highton supported this work.

References Cited

Burger, J.W. 1935. *Plethodon cinereus* (Green) in eastern Pennsylvania and New Jersey. Amer. Nat. 69: 578-586.

Greig-Smith, P. 1964. Quantitative Plant Ecology. 2nd ed. Plenum Publ. Corp., New York.

Hairston, N.G. 1951. Interspecies competition and its probable influence upon the vertical distribution of Appalachian salamanders of the genus *Plethodon*. Ecology 32: 266-274.

Hayne, D.W. 1949a. Calculation of the size of home range. J. Mammal. 30: 1-18.

____________ . 1949b. Two methods for estimating populations from trapping records. J. Mammal. 30: 399-411.

Highton, R. 1956. The life history of the slimy salamander, *Plethodon glutinosus*, in Florida. Copeia 1956: 75-93.

____________ . 1962. Revision of North American salamanders of the genus *Plethodon*. Bull. Fla. State Mus. 6: 235-367.

Klein, H.G. 1960. Population estimate of the red-backed salamander. Herpetologica 16: 52-54.

Noble, G.K., and M.K. Brady. 1930. The courtship of the plethodontid salamanders. Copeia 1930: 52-54.

Organ, J.A. 1958. Courtship and spermatophore of *Plethodon jordani metcalfi*. Copeia 1958: 251-259.

____________ . 1960. The courtship and spermatophore of the salamander *Plethodon glutinosus*. Copeia 1960: 34-40.

Snedecor, G.W., and W.G. Cochran. 1967. Statistical Methods. 6th ed. Iowa State Univ. Press. Ames.

Southwood, T.R.E. 1966. Ecological Methods. Methuen and Co. Ltd., London.

Taub, F.B. 1961. The distribution of the red-backed salamander, *Plethodon c. cinereus*. within the soil. Ecology 42: 681-698.

Test, F.H., and B.A. Bingham. 1948. Census of a population of the red-backed salamander (*Plethodon cinereus*). Amer. Midl. Nat. 39: 362-372;

Susceptibility of the Stages of the Cattle Biting Louse (Mallophaga: Trichodectidae) to Juveth, an Insect Juvenile Hormone Analog

D.E. Hopkins and W.F. Chamberlain

Agr. Res. Serv., USDA, Kerrville, Texas 78028

ABSTRACT

When eggs of the cattle biting louse, *Bovicola bovis* (L.), were exposed to the vapors of or treated topically with juveth, an analog of the insect juvenile hormone, a supernumerary nymphs resulted. However, metamorphosis was affected only when the penultimate stage (3rd-instar nymph) was exposed to hormonal residues from the treated eggs. Latent or programmed effects did not occur.

We previously reported that *Bovicola limbata* (Gervais) treated topically in the first 2 days of the 3rd stage with juveth (ethyl 10,11-epoxy-7-ethyl-3,11-dimethyl-2,6-tridecadienoate), a juvenile hormone analog, developed to atypical 4th-stage lice, but that those treated during the latter part of the 3rd stage developed to typical adults (Hopkins et al. 1970).

Latent effects that altered the adult metamorphosis of Hemiptera (Riddiford 1969, 1970) and Homoptera (White 1968) but left 1 or more immature stages apparently unchanged have reportedly occurred as a result of treatment of eggs or early instars with synthetic juvenile hormone or with analogs of synthetic juvenile hormone. A like result was observed in Lepidoptera (Riddiford and Williams 1967) after treatment of eggs.

Willis and Lawrence (1970) also observed metamorphic changes in late-stage *Oncopeltus fasciatus* after eggs were treated. They indicated that the effects were deferred, the result of the hormone's being progressively transferred through the integument as each molt occurred, but not the result of latent action.

We report here that treating eggs of *B. bovis* (L.), the cattle biting louse, with juveth resulted in atypical phenotypes (Hopkins et al. 1970) only when 3rd- or penultimate-stage nymphs were reared on diet that contained residues from treated eggs and mohair.

In preliminary tests, we observed that atypical 4th-instar phenotypes developed from eggs of *B. bovis* exposed to juveth vapor. However, we also observed that atypical phenotypes developed on diet coated with 50 ppm of juveth only if the lice were reared on the diet during the 3rd nymphal stage. Those that were reared on the diet during only the 1st or only the 1st and 2nd stages developed to typical adults.

This inconsistency of results when eggs and nymphal forms were treated and the possibility that latent effects might occur was investigated by a variety of tests. The test eggs were taken from our colony of *B. bovis* which is fed a diet of the surface scrapings of cowskin (Hopkins and Chamberlain 1972). The tests were always conducted at 72% RH and 37±1.5°C except that during the period of exposure to vapor the eggs were in vials that had been sealed at room RH.

For the exposure to juveth vapor, the juveth was dissolved in glass-distilled acetone (1 mg/200 μl), and 200 μl of the solution was pipetted into a 20-ml glass vial. The lower two-thirds (ca.) of the inner surface of the vial was coated with the juveth by tilting and rotating the vial by hand until the acetone had evaporated. Then bundles of mohair (10-15 pieces each about 1.5 cm long) each with 20 attached 0- to 1-day-old louse eggs were secured to the center of the cork-backed metal foil liner of the screw cap of the vial with two 2X8-mm strips of masking tape, and the cap was screwed onto the vial (care was taken that the eggs or hair did not touch the treated surface). A similar untreated vial contained bundles with control eggs. On the 6th day of exposure (the eggs began to hatch the 7th day), the eggs and hair were removed from the vials, and each bundle was dipped once in and flushed twice with acetone in an attempt to remove any juveth that might have been deposited on the surfaces of the eggs or the hair. The controls were treated similarly. The hair and eggs were then placed at 3 conditions to determine which stage(s) were susceptible to the effects of the juveth: (1) a bundle with treated eggs was placed in a 0.5-dr glass shell vial with 20 mg of diet; (2) a bundle with control eggs was placed in a similar vial along with another bundle containing 20 vapor-treated eggs that had been killed by freezing (held at -5°C for 1-2 hr); (3) a bundle with control eggs was placed in a vial with diet. Each of these vial tests was replicated 4 times. The vials were then held in normal rearing conditions. At 6 days posthatch, the unhatched eggs, egg shells, and mohair were removed from all vials, and the nymphs were left to feed on the diet for 2 more days.

At 8 days posthatch, most nymphs were 2nd instars, and the numbers alive were recorded. Some late 2nd instars that had hatched from treated eggs and some that had hatched from untreated eggs subsequently confined with killed vapor-treated eggs were placed on new diet in new vials. The remainder in the test vials and those in the control vials were allowed to finish development on original diet. When all lice had molted to the 4th instar or had died, the numbers of typical and atypical phenotypes in each vial were recorded.

As shown in Table 1, atypical (nymphoid) 4th instars developed only from 3rd instars that had been left on diet exposed to treated eggs and hair, and latent effects were not demonstrated.

In a 2nd test, eggs of *B. bovis* were treated topically with juveth in acetone solution in a manner similar to the way Riddiford (1970) treated the eggs of *Pyrrhocoris apterus* and *Oncopeltus fasciatus*. Three acetone solutions of juveth were prepared, and each was applied to separate groups of twenty 0- to 1-day-old and 6- to 7-day-old eggs (2 replications of each age and each solution) with micrometer-actuated syringes: 0.52 μl of 0.5%/egg with a 0.25-ml syringe and 0.05 μl of 1 or 2%/egg with a 100-μl syringe. Also, 2 control groups of each age (20/group) were treated with each amount of acetone alone. Each group was placed in a

Table 1. Phenotypes of 4th-Instar *B. bovis* Resulting from Eggs Treated with Juveth and Subsequent Rearing on Diet Containing Hormonal Residues and Control Diets.

Treatment	Diet of Nymphs Beginning 8 Days Posthatch	No. and Phenotype of 4th Instars
	Vapor treatment	
Treated	15 on original diet	12 nymphs
	12 on fresh diet	11 adults
Untreated[a]	30 on original diet	27 nymphs
	27 on fresh diet	26 adults
Untreated	70 on original diet	67 adults
	Topical treatment	
0.5 μg/egg	16 on original diet	12 nymphs
	14 on fresh diet	11 adults
Untreated	20 on original diet	18 adults
	14 on old[b] diet	8 nymphs

[a]Held with treated frozen eggs and mohair for last day of egg stage and first 6 days of nymphal stage.

[b]Diet that had been in a vial with treated eggs for about 9 days.

0.5-dr glass shell vial with diet and allowed to hatch and develop for 8 days; then new diet in a new vial was provided for some of the lice while the remainder were left on the original diet, and records were taken when all lice had molted to the 4th instar or died. In addition, some diet that had originally been exposed to treated eggs and mohair was used as food for some 2nd-instar nymphs from the acetone-treated controls.

In each test, 0- to 1-day-old eggs treated topically with juveth failed to hatch, but all controls hatched. The hatchability of treated 6- to 7-day-old eggs equaled that of the controls, but the rate of survival of nymphs was low ($<50\%$) for the higher doses. The results of the test with 0.05 μl of 1%/egg or 0.5 μg/egg are presented in Table 1 (the results of the other tests were similar, but survival was best in this test). Obviously latent effects from treated eggs were not demonstrated, but atypical phenotypes developed when lice were exposed to contaminated diet.

For 50 ppm of juveth, which was an effective dose, to be present in the 20 mg of diet used in the vapor tests, at least 1000 ng would have to be transferred somehow from the wall of the vial to the eggs and hair and subsequently, despite the washing of the eggs and hair, to the diet; we placed 1 mg (or 1000X that amount) of juveth on the wall of the vial. In the tests of topical treatment, we used 10X (10,000 ng/20 eggs) that amount per vial. We feel that these amounts of juveth were adequate so at least 50 ppm could have been transferred to the diet.

We conclude that, in this species of Mallophaga, treatment with an active juvenile hormone analog produces a response only if the lice are treated during the 3rd instar. The occurrence of latent or deferred effects when hemipteran and lepidopteran eggs were treated with an analog of JH and not when mallophagan eggs were treated may be the result of fundamental differences in the respective metamorphoses. However, hormonally active materials usually act at such low concentrations that the carryover of minute amounts affects results.

References Cited

Hopkins, D.E., and W.F. Chamberlain. 1972. In vitro colonization of the cattle biting louse, *Bovicola bovis*. Ann. Entomol. Soc. Amer. 65(3):771-2.

Hopkins, D.E., W.F. Chamberlain, and J.E. Wright. 1970. Morphological and physiological changes in *Bovicola limbata* (Mallophaga: Trichodectidae) treated topically with a juvenile hormone analogue. Ann. Entomol. Soc. Amer. 63(5): 1360-3.

Riddiford, L.M. 1969. Juvenile hormone application to hemipteran eggs: delayed effects on postembryonic development. Amer. Zool. 9: 1120.

________________ . 1970. Prevention of metamorphosis by exposure of insect eggs to juvenile hormone analogs. Science 167(3916): 287-8.

Riddiford, L.M., and C.M. Williams. 1967. The effects of juvenile hormone analogues on the embryonic development of silkworms. Proc. Nat. Acad. Sci. U. S. 57: 595-601.

White, Dinah F. 1968. Postnatal treatment of the cabbage aphid with a synthetic juvenile hormone. J. Insect Physiol. 14(7): 901-12.

Willis, J.H., and P.A. Lawrence. 1970. Deferred action of juvenile hormone. Nature 225: 81-83.

Some Aspects of the Behavior of Mosquito Larvae (Diptera: Culicidae)[1]

William E. Bickley

Department of Entomology, University of Maryland, College Park, Maryland 20742

ABSTRACT

This review of the recent literature dealing with behavior of mosquito larvae emphasizes newer knowledge of feeding habits, orientation to the water surface, reactions to physical stimuli, formation of aggregations or clusters, and effects of overcrowding. Of particular interest are growth retardant factors produced by larvae of a given species which play a part in competitive displacement.

In recent years considerable attention has been given to the eggs of mosquitoes with particular reference to quiescence, diapause, and hatching stimuli. Much research has been conducted on adult behavior, with special emphasis on feeding, mating, oviposition, and flight. Not so much consideration has been given to the behavior of larvae. Clements (1963) reviewed the subject very briefly.

The larva, for all practical purposes, is unable to choose its environment. Its mother has that responsibility. It can move only short distances to select slightly different conditions of temperature and light, to reach food sources, or to evade enemies. Because predaceous larvae are relatively rare they will not be considered here. Larvae of various species have evolved adaptations to many different kinds of water. Variations in the nature of the aquatic environment, for the most part, involve the following factors: temperature, light, movement of water, dissolved gases, hydrogen-ion concentration, organic matter, and inorganic salts. Each of these may have an effect indirectly as well as directly. For example, shade may influence the growth of micro-organisms which constitute the larval diet. Quantities of salts which larvae will tolerate are known for several species.

[1]Scientific Article No. A1777, Contribution No. 4567, of the Maryland Agricultural Experiment Station, Department of Entomology. Aided by a grant from the Society of the Sigma Xi and RESA Research Fund.

According to Bates (1949), food is rarely a limiting factor. That is, competition for food is hardly ever intense, although larvae in small containers at times are affected by food shortages. Young larvae are said to feed primarily on bacteria. Older larvae take in larger micro-organisms such as algae, yeasts, fungi, and protozoa. They also swallow small particles of organic matter. Laboratory investigations by several workers show that suboptimum amounts of food cause an increase in the duration of larval and pupal stages and a decrease in size and weight of adults. Larvae of *Aedes aegypti* were reared under sterile conditions by Trager (1935). He was able to dissolve the right combination of nutrients and vitamins in water so that the larvae in his experiments swallowed sufficient quantities of the medium to develop to maturity. The surfaces of eggs were sterilized, and the medium was kept entirely free of micro-organisms. Similar procedures have been carried out by several other workers using a few different species. Recently Wallis and Lite (1970) reported on the axenic rearing of *Culex salinarius*. Vitamins are an essential part of an artificial diet. In nature bacteria and other micro-organisms appear to produce growth-stimulating substances.

Normally larvae use their mouth brushes to filter out particulate matter. *Anopheles* larvae which remain at the surface create eddies and tend to suck so that currents at the surface film move toward them (Renn, 1941). This facilitates the filtering out of particles resting on the surface. Surtees (1959) classified non-predaceous larvae as either filter feeders or browsers. Many culicines are filter feeders and produce currents below the water surface. Browsers are usually bottom feeders. The brushes of their mouth parts are shorter and stiffer than those of filter feeders. Browsers abrade solid material and manipulate fairly large particles, breaking them down to smaller sizes so that they can be swallowed. For example, they break loose clusters of micro-organisms clinging to large pieces of debris. They frequently are seen browsing on their own bodies. According to Pucat (1965), filter feeders may feed on particles stirred up by browsers.

Locomotion of larvae depends largely on body jerks, but the mouth brushes are used for pulling the body along. The ventral brush is used as a sculling organ (Ross, 1951), and it probably serves at times as a rudder.

Larvae are sensitive to changes in light, to vibrations, and to differences in temperature. Nearly all of them are heavier than water. When they are at the surface they respond to shadows moving across the water or to vibrations by sinking to the bottom of the medium. These alarm reactions were studied in some detail by Folger (1946), Thomas (1950), and Mellanby (1958). "Crash diving" is not demonstrable in some species but is well developed in many *Anopheles* and other species which spend most of the time at the water surface. Some species are more responsive to vibrations than to changes in light intensity. Mellanby (1958) showed that *Aedes aegypti* larvae can be conditioned or habituated to the rapid repetition of a stimulus that initially causes an alarm response. Crash-diving results when the side of a dish containing *A. aegypti* larvae is tapped, and the larvae stay at the bottom for 4 minutes. But if the container is tapped once every second the larvae, in effect, ignore the tapping. One may reasonably ask if these larvae go through a learning process! Contitioning to light changes has also been observed.

One of my students, Shahin Navai, is currently studying responses of *Aedes atropalpus* larvae to vibrations and has found that they behave somewhat like *A. aegypti* larvae. However, tapping the container produces different reactions among larvae which are part of a group of 10 compared with reactions of single larva in a dish. We are now studying the effects of vibrations from a tuning fork, and perhaps we can ascertain whether or not these larvae are capable of "hearing".

Nearly all mosquito workers have observed the "balling" or clustering of large numbers of larvae in a relatively small pool or in a container. Hocking (1953) attributed such aggregations to mutual orientation of larvae toward their shadows. Detailed studies of *Aedes taeniorhynchus* larvae by Nayar and Sauerman (1968) have shown that aggregations probably occur in response to visual stimuli and bodily contacts. Aggregations do not occur at night. They are related to temperature and the nutritional state of the larvae, and it is suggested that they aid in the synchronization of pupal ecdysis. A relatively few controlled experiments prove that photo-period, apart from temperature, affects growth rates. Chiba (1968) found that in the case of *Armigeres subalbatus*, which overwinters in the larval stage, long days activate larvae to pupate and short days cause larvae to remain in the 4th instar. Some larvae, of course, complete their development in complete darkness (Bickley, 1954).

There are numerous studies on temperature effects. One of the most interesting concerns the aggregation of larvae in Arctic pools. Clusters of larvae move around small pools in a clockwise direction just as the sunlight strikes the pools. Haufe (1957) measured horizontal and vertical temperature gradients which cause a 3-dimensional displacement of larvae. The balling of larvae was also considered in relation to light and gravity.

Optimum, minimum, and maximum temperatures for a number of species have been established. Larvae of nearly all species are killed when actually frozen. The effects of low temperatures may be ameliorated by a process of acclimatization. In other words, a gradual decline in temperature to a low point is not as detrimental as a sudden change (Mellanby, 1960).

There have been few experiments using water with temperature gradients. *Aedes aegypti* larvae respond to horizontal gradients and select a favorable zone. According to Omardeen (1957), they move to the spot which is less irritating to them.

It is generally recognized that the orientation of culicine larvae to the surface essentially is a result of the need for obtaining air. Temperature, light, and gravity are entirely secondary. Meola (1961) reared larvae of *Aedes aegypti* in culture tubes where the only source of air was from below. Keeping the tail-end down caused no serious problems. One of my students, John B. Duvall, has reared larvae of *Aedes atropalpus* "upside down". We can get the larvae to pupate but have been unable to obtain adults.

Mosquito larvae with few exceptions avoid currents. This, in part, accounts for the fact that larvae are generally absent from open water. The other reason why they shun open water may be attributed to a natural thigmotropism or thigmotaxis. It may be assumed that, as species evolved, the instinct to touch or at least stay close to vegetation or other objects in the water had tremendous adaptive value in protecting larvae from fish and other predators. Even so, it is rather surprising to find that in small ponds elimination of vegetation around the edges generally prevents development of mosquito larvae.

Schober (1966) reported that agitation of the water surface by continuous sprinkling actually killed larvae and pupae of *Culex pipiens* and prevented oviposition. This procedure has practical value in controlling mosquito breeding in lagoons designed for holding organic wastes.

In most aquatic communities mosquito larvae are not dominant members (Bates, 1949). There are certain notable exceptions such as bromeliads, small containers, temporary rain-pools, and certain types of heavily polluted water.

Shannon and Putnam (1934) were among the first to report on the effects of overcrowding of *Aedes aegypti* and on the effect of water "previously fouled" by larvae. In recent years there has been increasing interest in competition among larvae of the same species and between different species. If a given species competes favorably against another species and is dominant, then it is said that that species occupies a particular ecological niche. The less successful species is said to occupy a different ecological niche. It is difficult to explain just how these specific adaptations evolved and why they persist. It now appears that in several cases the most important single factor involved in population regulation or competitive displacement is a substance produced by larvae. Moore and Fisher (1969) have suggested GRF, or growth retardant factor, as the name for this substance. In their studies, *A. aegypti* larvae produced a substance which slowed down the growth of *A. albopictus*. This was proved by placing larvae of *A. albopictus* in water "fouled" by *A. aegypti*. Peters et al. (1969) reported that the presence of *A. aegypti* larvae in a culture of *Culex pipiens* caused significant mortality of the latter species. Barbosa et al. (1972) reared *A. aegypti* larvae at various densities. Overcrowding resulted in decreased survival and pupal weights. Mechanical agitation probably caused a decrease in feeding although there appeared to be evidence that metabolites had an effect on growth. Wada (1965) stated that the detrimental effects of high densities on *A. aegypti* larvae could not be attributed to metabolic wastes. Wilton (1968) found that *A. aegypti* larvae were more efficient in utilizing food than *A. triseriatus* larvae. Consequently *A. aegypti* has a competitive advantage. Ikeshoji and Mulla (1970) reared *Culex pipiens quinquefasciatus* larvae under crowded conditions and found that toxic chemical factors produced by the larvae affected larvae of the same species and larvae of *C. tarsalis, A. aegypti*, and *Anopheles albimanus*. Toxic factors were ether extractable, and progress was made in identifying biologically active materials by thin layer chromatography. There is good reason to believe that at some time toxic factors produced by larvae can be further identified and synthesized. These substances may be the larvicides of the future.

References Cited

Barbosa, P., T.M. Peters, and N.C. Greenough. 1972. Overcrowding of mosquito populations:

Response of larval *Aedes aegypti* to stress. Environ. Entomol. 1(1):89-93.

Bates, M. 1949. The Natural History of Mosquitoes. The Macmillan Co., New York, 379 pp.

Bickley, W.E. 1954. Notes on the light reactions of larvae of *Culex restuans* Theo. N.J. Mosquito Extermin. Assoc. Proc. 41:198-199.

Chiba, Y. 1968. The effect of photoperiod on the pupation of *Armigeres subalbatus*. Jap. J. Ecol. 18(1):43-45.

Clements, A.N. 1963. The physiology of mosquitoes. New York: The Macmillan Co. 393 pp.

Folger, H.T. 1946. The reactions of *Culex* larvae and pupae to gravity, light, and mechanical shock. Physiol. Zool. 19(2):190-202.

Haufe, W.O. 1957. Physical environment and behaviour of immature stages of *Aedes communis* (deg.) (Diptera: Culicidae) in subarctic Canada. Canadian Entomol. 89(3):120-139.

Hocking, B. 1953. Notes on the activities of *Aedes* larvae. Mosquito News 13(2):77-81.

Ikeshoji, T., and M.S. Mulla. 1970. Overcrowding factors of mosquito larvae. J. Econ. Entomol. 63(1):90-96.

Mellanby, K. 1958. The alarm reaction of mosquito larvae. Entomol. Exp. Appl. 1(3):153-160.

________________ . 1960. Acclimatization affecting the position of the cold and heat death points of larvae of *Aedes aegypti*. Bull. Entomol. Res. 50(4):821-823.

Meola, R. 1961. Some preliminary observations of mosquito larvae and pupae confined to a bottom air-water interface. Ohio J. Sci. 61(1):38.

Moore, C.G., and B.R. Fisher. 1969. Competition in mosquitoes. Density and species ratio effects on growth, mortality, fecundity, and production of growth retardant. Ann. Entomol. Soc. Amer. 62(6):1325-31.

Nayar, J.K., and D.M. Sauerman, Jr. 1968. Larval aggregation formation and population density interrelations in *Aedes taeniorhynchus*, their effects on pupal ecdysis and adult characteristics at emergence. Entomol. Exp. Appl. 11(4):423-442.

Omardeen, T.A. 1957. The behaviour of larvae and pupae of *Aedes aegypti* (L.) in light and temperature gradients. Bull. Entomol. Res. 48(2):349-357.

Peters, T.M., B.I. Chevone, and R.R. Callahan. 1969. Interactions between larvae of *Aedes aegypti*(L.) and *Culex pipiens* L. in mixed experimental populations. Mosquito News 29(3):435-438.

Pucat, A.M. 1965. The functional morphology of the mouthparts of some mosquito larvae. Quaestiones Entomol. 1(2):41-86.

Renn, C.E. 1941. The food economy of *Anopheles quadrimaculatus* and *A. crucians* larvae: Relationships of the air-water interface and the surface-feeding mechanism, *in* "A Symposium on Hydrobiology". Univ. of Wisc. Press, Madison, pp. 329-342.

Ross, H.H. 1951. Conflict with *Culex*. Mosquito News 11(3):128-132.

Schober, H. 1966. Agitation of water surfaces by sprinkling to prevent mosquito breeding. Mosquito News 26(2):144-149.

Shannon, R.C., and P. Putnam. 1934. The biology of *Stegomyia* under laboratory conditions. 1. The analysis of factors which influence larval development. Proc. Entomol. Soc. Wash. 36(7):185-216.

Surtees, G. 1959. Functional and morphological adaptations of the larval mouthparts in the sub-family Culicinae (Diptera) with a review of some related studies by Montschadsky. Proc. Roy. Entomol. Soc. London (A)34(1/3):7-16.

Thomas, I.M. 1950. The reactions of mosquito larvae to regular repetitions of shadows as stimuli. Austral. J. Sci. Res. (B) 3(1):113-123.

Trager, W. 1935. The culture of mosquito larvae free of microorganisms. Amer. J. Hyg. 22:18-25.

Wada, Y. 1965. Effect of larval density on the development of *Aedes aegypti* (L.) and the size of the adults. Quaestiones Entomol. 1(4):223-249.

Wallis, R.C., and S.W. Lite. 1970. Axenic rearing of *Culex salinarius*. Mosquito News 30(3):427-429.

Wilton, D.P. 1968. A laboratory study of larval competition between *Aedes aegypti* (L.) and *Aedes triseriatus* (Say). Mosquito News 28(4):627-630.

Two New Species of Melanagromyza Hendel (Diptera, Agromyzidae) that Bore in Tomato Stalks in Colombia and Ecuador

George C. Steyskal

Systematic Entomology Laboratory, Agricultural Research Service, USDA (mail address: c/o U.S. National Museum, Washington, D.C. 20560).

ABSTRACT

Melanagromyza caucensis and *M. tomaterae* (Diptera: Agromyzidae), the former from Colombia and the latter from Colombia and Ecuador, are described as new to science. Both species were reared from larvae boring in the stems of tomato plants.

The species here described were received, one of them several times, from workers in South America who reared them from the stalks of tomato (*Lycopersicon esculentum* Mill., family Solanaceae). Owing to their habit of boring in the stems, the early stages of even a heavy infestation will produce little or no visible indication. No published information is available on the effect of agromyzid stem miners in such crops as tomato, but it is likely that weakened or broken stalks and considerable reduction in yield of fruit could result.

The species of *Melangromyza* are small black flies very similar to each other in general appearance. Many species may be distinguished only by postabdominal characters requiring dissection. As noted below, the species here described are very similar to certain described species, *M. tomaterae* being very similar to *M. colombiensis* Spencer, the host of which is not known, and *M. caucensis* being apparently most closely related to *M. chenopodii* Spencer (host, *Chenopodium ambrosioides* Linnaeus) and an undescribed species noted by Spencer.

Both new species run in the key to neotropical *Melanagromyza* by Spencer (1963: 306) to the first part ("squamal fringe pale, whitish"). *M. tomaterae* will run to couplet 3 because of its partly white halter, but *M. caucensis*, with wholly black halter, 2 pairs of dorsocentral bristles, orbits and ocellar triangle only moderately shining, and foretibia lacking lateral bristle, will go to couplet 12; among the species which follow thereafter, only the male postabdomen will give reliable differentiation.

Melanagromyza caucensis, new species (Fig. 1)

Very similar to *M. chenopodii* Spencer (1963: 308) and an unnamed species figured by Spencer in the same place, possibly even identical with the latter. It differs from *M. chenopodii* in narrower cheek, lower lunule, and in postabdominal details.

Male.–Length of wing 2.6-2.7 mm. Head with frons distinctly raised above eye margin, matt black, 0.35 of head-width; orbits and ocellar triangle only weakly shining; orbital bristles strong; orbital setulae largely reclinate, except for a few in front; eyes bare; lunule parabolic, half as high as wide; cheek 0.18 of eye-height; arista short-pubescent. Mesoscutum and abdomen shining blackish, a little bronzy greenish. Postabdomen as in Fig. 1; anterior process of epandrium short, acute, with a few short apical setae; basiphallus a complete ring; sperm pump (Fig. 1A) with short, thick subcapitular process.

Holotype (male) and 1 male paratype, Pradera, Valle, Colombia, 28 September 1968, ex tomato stem (Ingeborg Zenner J.), no. 72252 in U.S. National Museum.

The name is an adjective pertaining to the Cauca Valley of Colombia.

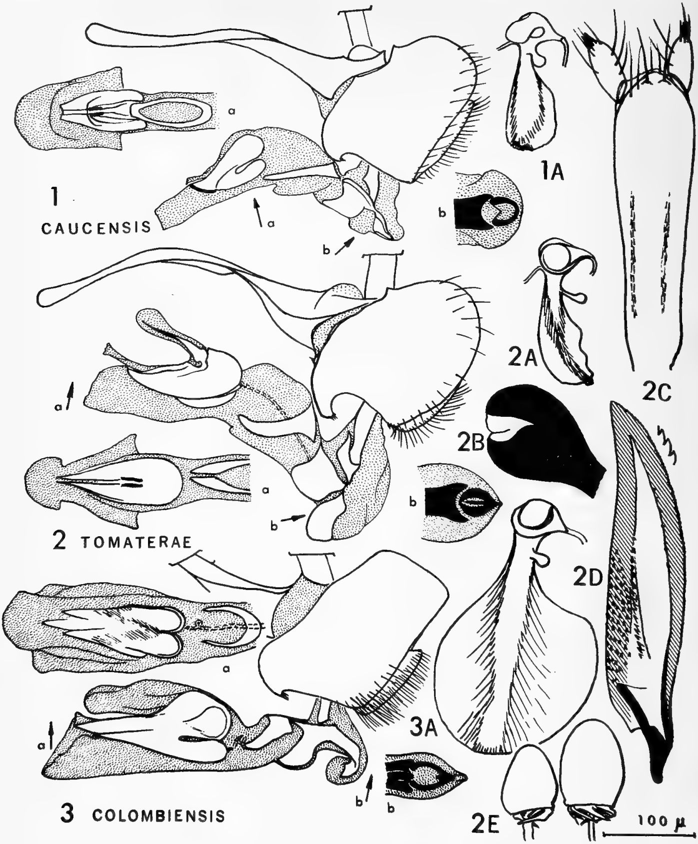


Fig. 1. *Melanagromyza caucensis*, n. sp., male postabdomen; 1A, sperm pump. Fig. 2. *M. tomaterae*, n. sp., male postabdomen; 2A, sperm pump; 2C, apical segment of ovipositor; 2D, egg guide; 2E, spermathecae. The 100-micron scale refers only to figs. 2C, 2D, and 2E. Fig. 3. *M. colombiensis* Spencer, postabdomen of male paratype. All figures show a lateral view of the postabdomen together with aedeagus (a) and fulcral region (b) viewed in direction of arrows.

Melanagromyza tomaterae, new species (Fig. 2)

Similar to *M. colombiensis* Spencer, differing in narrower front, 3 lower orbital bristles, conspicuously pubescent arista, and in postabdominal details.

Male.—Length of wing 2.7 mm. Head with front matt black, very slightly raised above eye margin, 0.37 of head-width; orbits and ocellar triangle clearly distinguishable, but only weakly shining; lower orbital bristles 3, distinctly smaller than upper orbitals; orbital setulae numerous and long, usually all reclinate; eye rather densely pilose on upper surface; lunule parabolic, half as high as wide; cheek 0.12-0.20 of eye-height; antenna with 3rd segment roundish, moderate in size, arista long-pubescent. Mesoscutum and abdomen shining blackish, with rather strong bluish to greenish metallic glint. Wing with costa extending to 4th vein, last section of 5th vein more than half as long as penultimate section. Halter (fig. 2B) black, with broad white margin along apical sulcus (most apparent in fresh specimens or those preserved in liquid). Postabdomen as in Fig. 2; anterior process of epandrium curved, projecting more than 1/3 of length of epandrium and bearing a few short setae apically; arms of basiphallus rather broad apically and narrowly disjunct; sperm pump (Fig. 2A) with narrow blade sinuate on side with long, slender subcapitular process.

Female.–Length of wing 2.8-3.2 mm. Postabdomen with ovipositor sheath only little tapering, 0.33 mm long; ovipositor with apical segment as Fig. 2C, egg guide as in Fig. 2D, and spermathecae as in Fig. 2E.

Holotype (male), allotype, and 10 male and 16 female paratypes from the following localities: Cauca Valley, Colombia, 1968, ex stem mines in tomato (Mario Calderon C.), including holotype and allotype; Medellin, Antioquia, Colombia, December 1971, en tomato (Raul Velez-Angel); Pradera, Valle, Colombia, 28 September 1968, ex tomato stem (Ingeborg Zenner J.); Portoviejo, Manabi, Ecuador, 6 October 1970 (P. Alcivar A.); all deposited in U.S. National Museum, type no. 72253.

The name is from Spanish *tomatera* 'tomato plant,' treated as Latin and placed in the genitive case.

For purposes of comparison the male postabdomen of a paratype of *M. colombiensis* (topotypical, from Bogota, Colombia) in the U.S. National Museum is shown in Fig. 3.

Reference Cited

Spencer, K.A. 1963. A synopsis of the neotropical Agromyzidae (Diptera). Trans. Entomol. Soc. London 115: 291-389.

SCIENTISTS IN THE NEWS

Contributions in this section of your Journal are earnestly solicited. They should be typed double-spaced and sent to the Editor by the 10th of the month preceding the issue for which they are intended.

CARNEGIE INSTITUTION

Hatton S. Yoder, Jr. is the first recipient of the Arthur L. Day Prize and Lectureship of the National Academy of Sciences. Dr. Yoder is director of the Geophysical Laboratory of the Carnegie Institution of Washington. The award includes a sum of $10,000 and the invitation to deliver from four to six lectures, which would be published in a monograph or book. A leading petrologist, Dr. Yoder developed an apparatus that enables scientists to investigate a wide range of phenomena within the earth's crust.

DEPARTMENT OF AGRICULTURE

Ruth M. Leverton, ARS, has received the Federal Woman's Award in recognition of her significant contributions in the field of nutrition.

Dr. Leverton is science advisor in nutrition, Office of the Administrator, ARS. As science advisor, she appraises nutrition research developments that affect human welfare and the quality of life. She evaluates the need for new nutrition knowledge and reviews nutrition research policies of ARS.

Dr. Leverton came to USDA in 1957, and in 1961 became Assistant Administrator of ARS. Her chief responsibility was for the program in nutrition and consumer and food economics, textiles and clothing, and housing and household equipment. She was named science advisor in 1970.

Dr. Leverton has represented the United States at four Biennial Conferences of the Food and Agriculture Organization, United Nations, since 1965. She has been a contributing member of U.S. delegations to international nutrition conferences in the Far East and Pacific areas, Latin America and Europe.

Theodore C. Byerly, Assistant Director of Science and Education for the U.S. Department of Agriculture, has been honored in special ceremonies, after 42 years of distinguished service. A plague presented to Dr. Byerly on the occasion was inscribed:

"To Theodore C. Byerly, scientist, administrator, world citizen—In recognition of his many years of outstanding leadership in the service of agriculture and with gratitude for his dedication and extraordinary intellectual competence as a scientist in the service of man."

Among those who paid tribute to Dr. Byerly's achievements at the ceremony were Secretary of Agriculture, Earl L. Butz; Dr. Ned D. Bayley, Director of Science and Education for USDA; representatives of: the National Academy of Science; the American Association for the Advancement of Science; the National Science Foundation; the Agricultural Research Policy Advisory Committee; the Departments of Interior, State, and Health, Education and Welfare; and the Environmental Protection Agency as well as hundreds of his coworkers.

Dr. Byerly will continue his present duties, including those of USDA Coordinator of Environmental Quality Activities.

Paul R. Miller has just returned from Buenos Aires, Argentina, where he conducted a graduate course in crop disease losses, epidemiology and forecasting at the Instituto Nacional Tecnologia Agropecuaria (National Institute of Agricultural Technology). INTA is a federal experiment station with branches throughout Argentina devoted largely to research. It gives graduate training in selected agricultural sciences at headquarters in Buenos Aires. Specialists from the United States and other countries are brought in to lecture in certain subject areas.

George W. Irving Jr., has been appointed as the program coordinator of a study being undertaken by the FASEB Life Sciences Research Office for the Food and Drug Administration to evaluate data being collected on items on the Generally Recognized as Safe (GRAS) List of substances added to foods.

Dr. Irving, Administrator retired, Agricultural Research Service, USDA, was born November 20, 1910, in Caribou, Maine. He holds a B.S. degree in chemistry and M.A. and Ph.D. degrees in biochemistry from George Washington University. Dr. Irving serves as a Public Trustee of The Nutrition Foundation and as a member of the Agricultural Board of the National Research Council. Author of more than 50 scientific articles and books on pituitary hormones, amino acid and protein chemistry and metabolism, plant and animal proteolytic enzymes, antibiotics and plant growth regulators, and an equal number of articles on various aspects of research administration, he was elected to membership in the American Society of Biological Chemists in 1946.

DEPARTMENT OF INTERIOR

Alfred T. Myers, research chemist for the U.S. Dept. of Interior, Denver, Colorado, 80225, retired on June 30, 1972, from the U.S. Geological Survey after 46 years of Government Service. His career in spectrochemistry began in the U.S. Dept. of Agriculture (22 years of service) in 1936, where he made numerous contributions to spectrochemistry and plant nutrition research. In the Geological Survey he served for 25 years, and in particular for the past 20 years, in Denver, he supervised the Spectrographic Services and Project. He has made many contributions to both spectrochemical and geochemical research.

Mr. Myers was Vice President and President of the Rocky Mountain Section, Society for Applied Spectroscopy. Later he was general chairman of the Fourth National Meeting of the Society for Applied Spectroscopy held in Denver. He is a member of the Washington Academy of Sciences and the American Institute of Chemists. He received an outstanding service award for 1969, from the Rocky Mt. Section of S.A.S. He also is a member of the American Chemical Society, the Mineralogical Society of America, the Geochemical Society and the Colorado Scientific Society.

NATIONAL GEOGRAPHIC SOCIETY

Leonard Carmichael, vice president for research and exploration, National Geographic Society, is the 1972 recipient of the Hartley Public Welfare Medal, the only National Academy of Sciences medal presented for achievements other than direct contributions to scientific knowledge. The gold metal is presented approximately every three years for "eminence in the application of science to the public welfare." Former secretary of the Smithsonian Institution and president of Tufts University, Dr. Carmichael has studied, written, and lectured in many fields of research.

NATIONAL INSTITUTES OF HEALTH

Maxine F. Singer, of NIA-MDD's Laboratory of Biochemistry and Metabolism, has been appointed to a 6-year term on the board of trustees of Wesleyan University, Middletown, Conn.

Dr. Singer is a research biochemist in the laboratory's Section on Enzymes and Cellular Biochemistry, National Institute of Arthritis, Metabolism, and Digestive Diseases.

Maurice Bender has been named Acting Director of the Arctic Health Research Center at Fairbanks, Alaska. He has served as an executive level Scientist-Administrator in the Public Health Service since 1958.

Dr. Bender was HSMHA study chairman of the FAST Task Force in the Office of the Deputy Under Secretary and also served as Pharmacologist-Administrator for liaison between the Division of Air Pollution and the Air Pollution Research Center at the University of California. He was chief, research and training, grants branch, Division of Air Pollution, PHS, from 1960 to 1965. Earlier, he was executive secretary to the Cancer Chemotheraphy Study Section at NIH and a public health research program analyst also at NIH.

Ileen E. Stewart has been appointed to a 3-year term on the NIH Library Advisory Committee as a representative of the Division of Research Grants and the extramural program staff of the Institutes. She is executive secretary of the Applied Physiology, Biomedical Communications, and History of the Life Sciences Study Sections.

G. Burroughs Mider, deputy director of the National Library of Medicine, was honored on June 26 at a retirement dinner in Bethesda.

Dr. Mider, who came to NLM in 1968, was previously Director of Laboratories and Clinics, NIH, and has been on the staff of NIH for 24 years.

He will replace Dr. Ralph Knutti, former National Heart Institute Director, as Executive Officer for the Universities Associated for Research and Education in Pathology, Inc., and the American Society of Experimental Pathology.

At the retirement party, Dr. John F. Sherman, NIH Deputy Director, discussed "A Man to Remember," stressing the high esteem in which Dr. Mider is held.

He will be remembered, said Dr. Sherman, not only as a tough-minded administrator but also for the breadth of his knowledge and his humanistic interests.

As tokens of this esteem, Dr. Mider was presented with an engraved silver tray from NLM's Board of Regents; a silver pitcher and a 1937 edition of Audubon's *Birds of America* from the staff at NLM, and from other friends at NIH, a telescope and tripod to aid his birdwatching.

Kenneth Cole, senior biophysicist, National Institute of Neurological Diseases and Stroke, has been named a Foreign Member of the Royal Society of London. Only a few Americans have received this honor.

Dr. Cole will participate in the formal admission ceremonies of the society next November, in London.

In 1954, the year he came to NINDS, Dr. Cole organized the Laboratory of Biophysics, and he also served as chief of that laboratory.

He is internationally known for his pioneering studies of electrical properties of nerves and other living cells. His electrical studies, particularly those done on the axon of the giant squid, have been found to apply to membranes of various other nerve cells and muscle fibers.

Dr. Cole's explanation of the electrical aspects of living cell membranes has given impetus to numerous biophysical research projects, particularly those related to the nervous system.

For this work he has received the National Order of the Southern Cross of Brazil, particularly in recognition of his work at the Instituto de Biofisca of the University of Brazil.

He has also received the honorary degree of Doctor of Medicine from the University of Uppsala, Sweden, and honorary doctorates in Science from Oberlin and the University of Chicago.

He was also given the Silver Medallion commemorating the 200th Anniversary of Columbia University College of Physicians and Surgeons, and the 1967 National Medal of Science award.

Dr. Cole's book, *Membranes, Ions and Impulses*, which was written in 1968 under the joint auspices of the University of California at Berkeley and NIH, has entered its second printing.

NAVAL RESEARCH LABORATORY

Lendell E. Steele, supervisory research physicist, head, Reactor Materials Branch, and J. Russell Hawthorne, research metallurgist, consultant in advanced structural metals, Reactor Materials Branch, both of the Metallurgy Division, Naval Research Laboratory, Washington, D.C., received on June 27 (1972) the Charles B. Dudley Medal from the American Society for Testing and Materials (ASTM). The award presentation was made by Andrew Van Echo, assistant chief, U.S. Atomic Energy Commission, during the 75th Annual Meeting of ASTM in Los Angeles, Calif.

The Charles B. Dudley Medal is given to the author(s) of a paper or series of papers, published by ASTM, of outstanding merit constituting an original contribution in the technical areas of the society. Steele and Hawthorne received the award for a series of papers on "Structure and Composition Ef-

Lendell E. Steele

fects on Irradiation Sensitivity of Pressure Vessel Steels and Welds."

A native of Kannapolis, N.C., Steele received his B.S. degree from George Washington University in 1950, and his M.A. degree from American University in 1959.

He began his professional career in 1948 as a physical science aid with the National Bureau of Standards. He was later with the U.S. Geological Survey as a scientific aid and later a chemist with the National Agricultural Research Center. Steele joined the Naval Research Laboratory in 1951 as a chemist for a short period prior to spending several years as a research and development and radiological safety officer with the U.S. Air Force. He returned to the Naval Research Laboratory as a chemist, 1953-1956; a physicist, 1956-1964; and as a research physicist, head, Reactor Materials Branch, 1964-1966. During 1967 he was a metallurgical engineer with the U.S. Atomic Energy Commission Steele assumed his present position in 1968 with the broad program responsibility for fundamental and applied research on radiation damage phenomena and on materials for advanced nuclear power systems including thermal, fast and thermonuclear reactors. He directs the related High Level Radiation Laboratory for Naval Research Laboratory serves as co-director of the new inter-divisional research effort called Cooperative Radiation Effects Stimulation (CORES) Program. He has authored more than 100 technical articles in his field.

A member of ASTM, Steele was the first vice-chairman of Committee E-10 on Radiation Effects and Radioisotopes from 1970 to 1972 when he was elected chairman. He is also a member of the American Nuclear Society, American Society for Metals, Research Society of America, and the Washington Academy of Sciences. Included in his honors are the Washington Academy of Sciences Award in Engineering Sciences, 1962; Research Society of America Award for Applied Science, 1964; and the American Nuclear Society Special Award for work in Neutron Damage of Materials.

WASHINGTON JUNIOR ACADEMY OF SCIENCES

Officers for 1972-1973

President	William R. Kanter	299-9446
Vice-President	Luther Miller	966-0195
Secretary	Charles Green	387-3735
Treasurer	Cindee Corthell	451-5992

Membership Councilors

Nathan Tickel	Arlington-Alexandria	671-1438
Michelle Bonhomme	District of Columbia	829-4604
Mike Bragale	Montgomery County	299-6206
Donald Barber	Prince Georges County	772-3537
Roy Beverige	Independent	536-6328

(Washington Junior Academy of Sciences—continued)

Committee Chairmen

Alumni Affairs	Mitch Kanter
Membership	John Cini
Field Trips	Henry Salton

Sponsors and Advisors

Elizabeth Miller	966-0195
Lewis Townsend	
Joseph Yao	299-4379

Sponsors and Advisors

David Ederer	966-9157
Elaine Shafrin	638-0164
Berenice Lamberton	337-9010

BYLAWS

Washington Academy of Sciences

Last Revised in February 1972

Article I. OBJECTIVES

Section 1. The purposes of the Washington Academy of Sciences shall be: (a) to stimulate interest in the sciences, both pure and applied, and (b) to promote their advancement and the development of their philosophical aspects by the Academy membership and through cooperative action by the affiliated societies.

Section 2. These objectives may be attained by, but are not limited to:

(a) Publication of a periodical and of occasional scientific monographs and such other publications as may be deemed desirable.
(b) Public lectures of broad scope and interest in the fields of science.
(c) Sponsoring a Washington Junior Academy of Sciences.
(d) Promoting science education and a professional interest in science among people of high school and college age.
(e) Accepting or making grants of funds to aid special research projects.
(f) Symposia, both formal and small informal, on any aspects of science.
(g) Scientific conferences.
(h) Organization of, or assistance in, scientific expeditions.
(i) Cooperation with other Academies and scientific organizations.
(j) Awards of prizes and citations for special merit in science.
(k) Maintaining an office and staff to aid in carrying out the purposes of the Academy.

Article II. MEMBERSHIP

Section 1. The membership shall consist of three general classes: members, fellows and patrons.

Section 2. Members shall be persons who are interested in and will support the objectives of the Academy and who are otherwise acceptable to at least two-thirds of the Committee on Membership. A letter or application form requesting membership and signed by the applicant may suffice for action by the Committee; approval by the Committee constitutes election to membership.

Section 3. Fellows shall be persons who by reason of original research or other outstanding service to the sciences, mathematics, or engineering are deemed worthy of the honor of election to Academy fellowship.

Section 4. Nominations of fellows shall be presented to the Committee on Membership as a form approved by the Committee. The form shall be signed by the sponsor, a fellow who has knowledge of the nominee's field, and shall be endorsed by at least one other fellow. An explanatory letter from the sponsor and a bibliography of the nominee's publications shall accompany the completed nomination form.

Section 5. Election to fellowship shall be by vote of the Board of Managers upon recommendation of the Committee on Membership. Final action on nominations shall be deferred at least one week after presentation to the Board, and two-thirds of the vote cast shall be necessary to elect.

Section 6. Each individual (not already a fellow) who has been nominated as a Delegate by a local affiliated society or who has been chosen to be the recipient of an Academy Award for Scientific Achievement shall be considered nominated for immediate election to fellowship by the Board of Managers without the necessity for compliance with the provisions of Sections 4 and 5.

Section 7. An individual of unquestioned eminence may be recommended by vote of the Committee on Membership Promotion for immediate election to fellowship by the Board of Managers, without the necessity for compliance with the provisions of Sections 4 and 5.

Section 8. Persons who have given to the Academy not less than one thousand (1,000) dollars or its equivalent in property shall be eligible for election by the Board of Managers as patrons (for life) of the Academy.

Section 9. Life members or fellows shall be those individuals who have made a single payment in accordance with Article III, Section 2, in lieu of annual dues.

Section 10. Members or fellows in good standing who are retired and are no longer engaged in regular gainful employment may be placed in emeritus status. Upon request to the treasurer for transfer to this status, they shall be relieved of the further payment of dues, beginning with the following January first; shall receive notices of meetings without charge; and at their request, shall be entitled to receive the Academy periodical at cost.

Section 11. Members or fellows living more than 50 miles from the White House, Washington, D.C., shall be classed as nonresident members or fellows.

Section 12. An election to any dues-paying class of membership shall be void if the candidate does not within three months thereafter pay his dues or satisfactorily explain his failure to do so.

Section 13. Former members or fellows who resigned in good standing may be reinstated upon application to the Secretary and approval by the Board of Managers. No reconsideration of the applicant's qualifications need be made by the Membership Committee in these cases.

Article III. DUES

Section 1. The annual dues of each class of members shall be fixed by the Board of Managers. No dues shall be paid by emeritus members and fellows, life members and fellows, and patrons.

Section 2. Members and fellows in good standing may be relieved of further payment of dues by making a single payment to provide an annuity equal to their annual dues. (See Article II, Section 9.) The amount of the single payment shall be computed on the basis of an interest rate to be determined by the Board of Managers.

Section 3. Members or fellows whose dues are in arrears for one year shall not be entitled to receive Academy publications.

Section 4. Members or fellows whose dues are in arrears for more than two years shall be dropped from the rolls of the Academy, upon notice to the Board of Managers, unless the Board shall otherwise direct. Persons who have been dropped from membership for nonpayment of dues may be reinstated upon approval of the Board and upon payment of back dues for two years together with dues for the year of reinstatement.

Article IV. OFFICERS

Section 1. The officers of the Academy shall be a President, a President-elect, a Secretary, and a Treasurer. All shall be chosen from resident fellows of the Academy.

Section 2. The President, with the approval of the Board of Managers, shall appoint a Nominating Committee of six Fellows of the Academy, at least one of whom shall be a past President of the Academy, and at least three of whom shall have served as Delegates for at least one year. The Chairman shall be a past President. (See Article IV, Section 9.)

Section 3. The Secretary shall act as secretary to the Board of Managers and to the Academy at large. He shall conduct all correspondence relating thereto, except as otherwise provided, and shall be the custodian of the corporate seal of the Academy. He shall arrange for the publication in the Academy periodical of the names and professional connections of new members, and also of such proceedings of the Academy, including meetings of the Board of Managers, as may appropriately be of interest to the membership. He shall be responsible for keeping a register of the membership, showing such information as qualifications, elections, acceptances, changes of residence, lapses of membership, resignations and deaths, and for informing the Treasurer of changes affecting the status of members. He shall act as secretary to the Nominating Committee (see Art. VI, Sect. 2).

Section 4. The Treasurer shall be responsible for keeping an accurate account of all receipts and disbursements, shall select a suitable depository for current funds which shall be approved by the Executive Committee, and shall invest the permanent funds of the Academy as directed by that Committee. He shall prepare a budget at the beginning of each year which shall be reviewed by the Executive Committee for presentation to and acceptance by the Board of Managers. He shall notify the Secretary of the date when each new member qualifies by payment of dues. He shall act as business advisor to the Editor and shall keep necessary records pertaining to the subscription list. In view of his position as Treasurer, however, he shall not be required to sign contracts. He shall pay no bill until it has been approved in writing by the chairman of the committee or other persons authorized to incur it. The fiscal year of the Academy shall be the same as the calendar year.

Section 5. The President and the Treasurer, as directed by the Board of Managers, shall jointly assign securities belonging to the Academy and indorse financial and legal papers necessary for the uses of the Academy, except those relating to current expenditures authorized by the Board. In case of disability or absence of the President or Treasurer, the Board of Managers may designate the President-elect or a qualified Delegate as Acting President or an officer of the Academy as Acting Treasurer, who shall perform the duties of these officers during such disability or absence.

Section 6. An Editor shall be in charge of all activities connected with the Academy's publications. He shall be nominated by the Executive Committee and appointed by the President for an indefinite term subject to annual review by the Board of Managers. The Editor shall serve as a member of the Board.

Section 7. An Archivist may be appointed by the President. If appointed, he shall maintain the permanent records of the Academy, including important records which are no longer in current use by the Secretary, Treasurer, or other officer, and such other documents and material as the Board of Managers may direct.

Section 8. All officers and chairmen of standing committees shall submit annual reports at the May meeting of the Board of Managers.

Section 9. The Nominating Committee (Article VI, Section 2) shall prepare a slate listing two or more persons for each of the offices of President-elect, of Secretary and of Treasurer, and four or more persons for the two Managers-at-large whose terms expire each year and at least two persons to fill each vacant unexpired term of manager-at-large. The slate shall be presented for approval to the Board of Managers at its first meeting in October. Not later than November 15, the Secretary shall forward to each Academy Member and Fellow an announcement of the election, the committee's nomination for the offices to be filled, and a list of incumbents. Additional candidates for such offices may be proposed by any Member or Fellow in good standing by letter received by the Secretary not later than Dec. 1. The name of any eligible candidate so proposed by ten Members or Fellows shall be entered on the ballot.

Section 10. Not later than December 15, the Secretary shall prepare and mail ballots to members and fellows. Independent nominations shall be included on the ballot, and the names of the nominees shall be arranged in alphabetical order. When more than two candidates are nominated for the same office the voting shall be by preferential ballot in the manner prescribed by the Board of Managers. The ballot shall contain also a notice to the effect that votes not received by the Secretary before the first Thursday of January, and votes of individuals whose dues are in arrears for one year or more, will not be counted. The Committee of Tellers shall count the votes and report the results at the annual meeting of the Academy.

Section 11. The newly elected officers shall take office at the close of the annual meeting, the President-elect of the previous year automatically becoming President.

Article V. BOARD OF MANAGERS

Section 1. The activities of the Academy shall be guided by the Board of Managers, consisting of the President, the President-elect, the immediate past President, one Delegate from each of the affiliated societies, the Secretary, the Treasurer, six elected Managers-at-Large, and the Editor. The elected officers of the Academy shall hold like offices on the Board of Managers.

Section 2. One Delegate shall be selected by each affiliated society. He shall serve until replaced by his society. Each Delegate is expected to participate in the meetings of the Board of Managers and vote on behalf of his society.

Section 3. The Board of Managers shall transact all business of the Academy not otherwise provided for. A quorum of the Board shall be nine of its members.

Section 4. The Board of Managers may provide for such standing and special committees as it deems necessary.

Section 5. The Board shall have power to fill vacancies in its own membership until the next annual election. This does not apply to the offices of President and Treasurer (see Art. IV, Sect. 5), nor to Delegates (see Art. V, Sect. 2).

Article VI. COMMITTEES

Section 1. An Executive Committee shall have general supervision of Academy finances, approve the selection of a depository for the current funds, and direct the investment of the permanent funds. At the beginning of the year it shall present to the Board of Managers an itemized statement of receipts and expenditures of the preceding year and a budget based on the estimated receipts and disbursements of the coming year, with such recommendations as may seem desirable. It shall be charged with the duty of considering all activities of the Academy which may tend to maintain and promote relations with the affiliated societies, and with any other business which may be assigned to it by the Board. The Executive Committee shall consist of the President, the President-elect, the Secretary and the Treasurer (or Acting Treasurer) ex officio, as well as two members appointed annually by the President from the membership of the Board.

Section 2. The Delegates shall constitute a Nominating Committee (see Art. IV, Sect. 9). The Delegate from the Philosophical Society shall be chairman of the Committee, or, in his absence, the Delegate from another society in the order of seniority as given in Article VIII, Section 1.

Section 3. The President shall appoint in advance of the annual meeting an Auditing Committee consisting of three persons, none of whom is an officer, to audit the accounts of the Treasurer (Art. VII, Sect. 1).

Section 4. On or before the last Thursday of each year the President shall appoint a committee of three Tellers whose duty it shall be to canvass the ballots (Art. IV, Sect. 10, Art. VII, Sect. 1).

Section 5. The President shall appoint from the Academy membership such committees as are authorized by the Board of Managers and such special committees as necessary to carry out his functions. Committee appointments shall be staggered as to term whenever it is determined by the Board to be in the interest of continuity of committee affairs.

Article VII. MEETINGS

Section 1. The annual meeting shall be held each year in May. It shall be held on the third Thursday of the month unless otherwise directed by the Board of Managers. At this meeting the reports of the Secretary, Treasurer, Auditing Committee (see Article VI, Sect. 3), and Committee of Tellers shall be presented.

Section 2. Other meetings may be held at such time and place as the Board of Managers may determine.

Section 3. The rules contained in "Robert's Rules of Order Revised" shall govern the Academy in all cases to which they are applicable, and in which they are not inconsistent with the bylaws or special rules of order of the Academy.

Article VIII. COOPERATION

Section 1. The term "affiliated societies" in their order of seniority (see Art. VI, Sect. 2) shall be held to cover the:

Philosophical Society of Washington
Anthropological Society of Washington
Biological Society of Washington
Chemical Society of Washington
Entomological Society of Washington
National Geographic Society
Geological Society of Washington
Medical Society of the District of Columbia
Columbia Historical Society
Botanical Society of Washington
Washington Section of Society of American Foresters
Washington Society of Engineers
Washington Section of Institute of Electrical and Electronics Engineers
Washington Section of American Society of Mechanical Engineers
Helminthological Society of Washington
Washington Branch of American Society for Microbiology
Washington Post of Society of American Military Engineers
National Capital Section of American Society of Civil Engineers
District of Columbia Section of Society for Experimental Biology and Medicine

Washington Chapter of American Society for Metals
Washington Section of the International Association for Dental Research
Washington Section of American Institute of Aeronautics and Astronautics
D.C. Branch of American Meteorological Society
Insecticide Society of Washington
Washington Chapter of the Acoustical Society of America
Washington Section of the American Nuclear Society
Washington Section of Institute of Food Technologists
Baltimore-Washington Section of the American Ceramic Society
Washington-Baltimore Section of the Electrochemical Society
Washington History of Science Club
Chesapeake Section of American Association of Physics Teachers
National Capital Section of Optical Society of America
Washington Section of American Society of Plant Physiologists
Washington Operations Research Council
Washington Section of Instrument Society of America
American Institute of Mining, Metallurgical, and Petroleum Engineers
National Capital Astronomers
Maryland-District of Columbia-Virginia Section of the Mathematical Association of America

and such others as may be hereafter recommended by the Board and elected by two-thirds of the members of the Academy voting, the vote being taken by correspondence. A society may be released from affiliation on recommendation of the Board of Managers, and the concurrence of two-thirds of the members of the Academy voting.

Section 2. The Academy may assist the affiliated scientific societies of Washington in any matter of common interest, as in joint meetings, or in the publication of a joint directory: Provided, it shall not have power to incur for or in the name of one or more of these societies any expense or liability not previously authorized by said society or societies, nor shall it without action of the Board of Managers be responsible for any expenses incurred by one or more of the affiliated societies.

Section 3. No affiliated society shall be committed by the Academy to any action in conflict with the charter, constitution, or bylaws of said society, or of its parent society.

Section 4. The Academy may establish and assist a Washington Junior Academy of Sciences for the encouragement of interest in science among students in the Washington area of high school and college age.

Article IX. AWARDS AND GRANTS-IN-AID

Section 1. The Academy may award medals and prizes, or otherwise express its recognition and commendation of scientific work of high merit and distinction in the Washington area. Such recognition shall be given only on approval by the Board of Managers of a recommendation by a committee on awards for scientific achievement.

Section 2. The Academy may receive or make grants to aid scientific research in the Washington area. Grants shall be received or made only on approval by the Board of Managers of a recommendation by a committee on grants-in-aid for scientific research.

Article X. AMENDMENTS

Section 1. Amendments to these bylaws shall be proposed by the Board of Managers and submitted to the members of the Academy in the form of a mail ballot accompanied by a statement of the reasons for the proposed amendment. A two-thirds majority of those members voting is required for adoption. At least two weeks shall be allowed for the ballots to be returned.

Section 2. Any affiliated society or any group of ten or more members may propose an amendment to the Board of Managers in writing. The action of the Board in accepting or rejecting this proposal to amend the bylaws shall be by a vote on roll call, and the complete roll call shall be entered in the minutes of the meeting.

ACT OF INCORPORATION OF THE WASHINGTON ACADEMY OF SCIENCES

We, the undersigned, persons of full age and citizens of the United States, and a majority being citizens of the District of Columbia, pursuant to and in conformity with sections 545 to 552, inclusive, of the Revised Statutes of the United States relating to the District of Columbia, as amended by an Act of Congress entitled "An Act to amend the Revised Statutes of the United States relating to the District of Columbia and for other purposes," approved April 23, 1884, hereby associate ourselves together as a society or body corporate and certify in writing:

1. That the name of the society is the Washington Academy of Sciences.
2. That the term for which the Corporation is organized shall be perpetual.
3. That the Corporation is organized and shall be operated exclusively for charitable, educational and scientific purposes and in furtherance of these purposes and for no other purpose shall have, but not be limited to , the following specific powers and purposes:
   a. To encourage in the broadest and most liberal manner the advancement and promotion of science.
   b. To acquire, hold, and convey real estate and other property and to establish general and special funds.
   c. To hold meetings.
   d. To publish and distribute documents.
   e. To conduct lectures.
   f. To conduct, endow, or assist investigation in any department of science.
   g. To acquire and maintain a library.
   h. And, in general, to transact any business pertinent to an academy of aciences.

   Provided, however, that notwithstanding the foregoing enumerated powers, the Corporation shall not engage in activities, other than as an insubstantial part thereof, which are not in themselves in furtherance of its charitable, educational and scientific purposes.
4. That the affairs, funds, and property of the Corporation shall be in general charge of a Board of Managers, the number of whose members for the first year shall be nineteen, all of whom shall be chosen from among the members of the Academy.
5. That in the event of dissolution or termination of the Corporation, title to and possession of all the property of the Corporation shall pass to such organization, or organizations, as may be designated by the Board of Managers; provided, however, that in no event shall any property of the Corporation be transmitted to or vested in any organization other than an organization which is then in existence and then qualified for exemption as a charitable, educational or scientific organization under the Internal Revenue Code of 1954, as amended.

Editor's Note: This Act of Incorporation is shown as amended in 1964 by Francois N. Frenkiel, President, and George W. Irving, Jr., Secretary, acting for the Washington Academy of Sciences, in a Certificate of Amendment notarized on September 16, 1964. A copy of the original Act of Incorporation dated February 18, 1898, appears in the Journal for November 1963, page 212.

THE DIRECTORY OF THE ACADEMY FOR 1972

Foreward

The present, 47th issue of the Academy's directory is again this year issued as part of the September number of the Journal. As in previous years, the alphabetical listing is based on a postcard questionnaire sent to the Academy membership. Members were asked to update the data concerning address and membership in affiliated societies by July 30, 1972. In cases in which cards were not received by that date, the address appears as it was used during 1971, and the remaining data were taken from the directory for 1971. Corrections should be called to the attention of the Academy office.

Code for Affiliated Societies, and Society Officers

1 **The Philosophical Society of Washington (1898)**

President:	Edward E. Beasley, Physics Dept., Gallaudet College, Washington, D.C. 20002
Vice-president	Bradley F. Bennett, 3301 Macomb St., N.W., Washington, D.C. 20008
Secretary:	Robert J. Rubin, 3308 McKinley St., N.W., Washington, D.C. 20015
Delegate:	Edward E. Beasley

2. **Anthropological Society of Washington (1898)**

President:	Wilton Dillon, Smithsonian Institution, Washington, D.C. 20560
Vice-president:	Mrs. Hertzog-Flannay
Secretary:	Cjarny Hume, Dept. of Anthropology, American University, Washington, D.C. 20016
Delegate:	Jean K. Boek, National Graduate Univ., 1630 Kalmia Rd., N.W., Washington, D.C. 20012

3 **Biological Society of Washington (1898)**

President:	Joseph Rosewater, Smithsonian Institution
Secretary:	Richard C. Banks, Smithsonian Institution

4 **Chemical Society of Washington (1898)**

President:	F.E. Saalfeld, Naval Research Lab., Washington, D.C. 20390
President-elect:	Harvey Alter, Gillette Research Institute, Rockville, Md. 20850
Secretary:	Robert Brady, Bureau of Customs, Washington, D.C.
Delegate:	Harvey Alter

5 **Entomological Society of Washington (1898)**

President:	Curtis W. Sabrosky, 8610 Grant St., Bethesda, Md. 20034
President-elect:	Arthur K. Burditt, 4218 Ulster Rd., Beltsville, Md. 20704
Secretary:	Dewey M. Caron, 11262 Evans Trail, Beltsville, Md. 20705
Delegate:	Reece I. Sailer, 11144 Oak Leaf Dr., Silver Spring, Md.

6 **National Geographic Society (1898)**

President:	Melvin M. Payne, National Geographic Society, Washington, D.C. 20036
Secretary:	Robert E. Doyle, National Geographic Society, Washington, D.C. 20036
Delegate:	Alexander Wetmore, Smithsonian Institution, Washington, D.C. 20560

7 **Geological Society of Washington (1898)**

President:	David B. Stewart, U.S. Geological Survey, Washington, D.C. 20242
Vice-president:	Edwin Roedder, U.S. Geological Survey, Washington, D.C. 20242
Secretary:	J. Stephen Huebner, U.S. Geological Survey, Washington, D.C. 20242
Delegate:	Charles Milton, Dept. of Geology, George Washington Univ. Washington, D.C. 20005

8 **Medical Society of the District of Columbia (1898)**

President:	William S. McCune
President-elect:	Frank S. Bacon
Secretary:	Thomas Sadler

9 **Columbia Historical Society (1899)**

Exec. Secretary:	Col. R.J. McCarthy, 1307 New Hampshire Ave., N.W., Washington, D.C.
Vice-president:	Wilcomb E. Washburn, Smithsonian Institution, Washington, D.C. 20560
Secretary:	William L. Ellis, 1307 New Hampshire Ave., N.W., Washington, D.C.
Delegate:	Paul H. Oehser, National Geographic Society, Washington, D.C. 20036

10 **Botanical Society of Washington (1902)**

President:	William L. Stern, Dept. of Botany, Univ. of Md., College Park, Md. 20742
Vice-president:	William L. Ackerman, U.S. Plant Industry Station, Glen Dale, Md. 20769
Secretary:	Tom van der Zwet, Plant Industry Station, USDA, Beltsville, Md. 20705
Delegate:	Conrad B. Link, Dept. of Horticulture, Univ. of Md., College Park, Md. 20742

11 **Society of American Foresters, Washington Section (1904)**

Chairman:	Malcolm E. Hardy, 6924 Fern Lane, Annandale, Va. 22003
Vice-president:	Carrow Prout, R.D. Box 210, Owings, Md. 20836
Secretary:	Elmer Shaw, 1101 Third St., S.W., No. 813, Washington, D.C. 20024
Delegate:	R.Z. Callaham, 3720 Acosta Rd., Fairfax, Va. 22030

12 **Washington Society of Engineers (1907)**

President:	Burton H. Tower 2009 14th St. No. Arlington, Va. 22201
Vice-president:	Walter H. McCartha, 3804 14th St. No. Arlington, Va. 22201
Secretary:	Gerald H. Laird, 6006 N. 35th St., Arlington, Va. 22207
Delegate:	George Abraham, Code 4024, Naval Research Lab., Washington, D.C. 20390

13 **Institute of Electrical & Electronics Engineers, Washington Section (1912)**

Chairman:	Forrest G. Hogg, 611 Frederick St., S.W., Vienna, Va. 22180
Vice-chairman:	Stuart Bouchey, PEPCO Bldg., Rm. 307, 1900 Pa. Ave., N.W. Washington, D.C. 20006
Secretary:	Marjorie Townsend, 3529 Tilden St., N.W., Washington, D.C. 20008
Delegate:	L.D. Whitelock, 5614 Greentree Rd., Bethesda, Md. 20034

14 **American Society of Mechanical Engineers, Washington Section (1923)**

Chairman:	Charles P. Howard, Catholic University of America
Vice-chairman:	Robert A. Cahn, Agency for International Development
Secretary:	Patrick F. Cunniff, University of Maryland
Delegate:	William G. Allen, 8306 Custer Rd., Bethesda, Md. 20014

15 **Helminthological Society of Washington (1923)**

President:	E.J.L. Soulsby, Dept. of Pathobiology, Univ. of Pa., Phila., Pa. 19104
Vice-president	Frank Douvres, National Animal Parasite Lab., USDA, Beltsville, Md. 20705
Secretary:	Edna M. Buhrer, 5415 Conn. Ave., N.W., Washington, D.C. 20015
Delegate:	A.O. Foster, 4613 Drexel Rd., College Park, Md. 20740

16 **Washington Society for Microbiology, Washington Branch (1923)**

President:	Carl Lamanna, Dept. of Army, 3045 Columbia Pike, Arlington, Va. 22204
Vice-president:	Rita R. Colwell, Dept. of Biology, Georgetown Univ., Washington, D.C. 20007
Secretary:	Charles R. Manclark, Division of Biological Standards, NIH, Bethesda, Md. 20014
Delegate:	Lewis F. Affronti, Dept. of Microbiology, George Washington Univ. Medical School, Washington, D.C. 20005

17 **Society of American Military Engineers, Washington Post (1927)**

President:	Capt. W.F. Reed, Jr., 3319 Albion Ct., Fairfax, Va. 22030
Vice-president:	Capt. Robert Munson, Washington Sci. Ctr., Bldg. 1, Rockville, Md. 20852
Secretary:	LCDR. W.G. Matthews, 8811 Queen Elizabeth Blvd., Annandale, Va. 22003
Delegate:	Hal P. Demuth, 4025 Pinebrook Rd., Alexandria, Va. 22310

18 **American Society of Civil Engineers, National Capital Section (1942)**

President:	W. Cambell Graeub, 5202 West Park Rd., Washington, D.C. 20015
Vice-president:	Alfred W. Maner, 1092 Wooded Court, Adelphi, Md. 20783
Secretary:	Herbert A. Pennock, 2101 Constitution Ave., N.W., Washington, D.C. 20418
Delegate:	Carl H. Gaum, 9609 Carriage Rd., Kensington, Md. 20795

19 **Society for Experimental Biology & Medicine, D.C. Section (1952)**

Chairman:	Donald Flick, 930 19th St. South, Arlington, Va. 22202
President-elect:	Harriet F.M. Maling, Bldg. 3, Rm. 202, NIH, Bethesda, Md. 20014
Secretary:	Vera Usdin, 2924 N. Oxford St., Arlington, Va. 22207
Delegate:	Carleton R. Treadwell, 1339 H St., N.W., Washington, D.C. 20005

20 **American Society for Metals, Washington Chapter (1953)**

Chairman: Klaus M. Zwilsky, U.S. Atomic Energy Comm., Washington, D.C. 20545
Vice-chairman: Alan H. Rosenstein, Air Force Office of Scientific Res., 1400 Wilson Blvd., Arlington, Va. 22209
Secretary: Joseph Malz, NASA, Code RWM, Washington, D.C. 20546
Delegate: Glen W. Wensch, U.S. Atomic Energy Comm., Washington, D.C. 20545

21 **International Association for Dental Research, Washington Section (1953)**

President: H.I. Copeland, Andrews Air Force Base
Vice-president: Jeanne C. Sinkford, Howard University
Secretary: Maj. E.F. Huget, Walter Reed Army Medical Ctr.
Delegate: N.H. Griffiths, Dental School, Howard Univ., Washington, D.C. 20001

22 **American Institute of Aeronautics and Astronautics, National Capital Section (1953)**

Chairman: Robert H. Herrmann, Thiokol Chemical Co.
Vice-chairman: James D. Redding, Univac
Secretary: Charles K. Kraus, Rocketdyne, Division of North American Rockwell Corp.
Delegate: Col. Robert J. Burger, National Academy of Engineering, 2101 Constitution Ave., Washington, D.C. 20418

23 **American Meteorological Society, D.C. Chapter (1954)**

Chairman: Clifford J. Murino, National Science Foundation
Vice-chairman: James K. Angell, ESSA
Secretary: Mary Ann Ruzecki, ESSA
Delegate: Harold A. Steiner, Hq., U.S. Air Force, The Pentagon, Rm. 5-D-982, Washington, D.C. 20330

24 **Insecticide Society of Washington (1959)**

President: Alexej B. Borkovec, Entomology Research Div. USDA, Beltsville, Md. 20705
Vice-president: Richard L. Cowden, Plant Protection Div., USDA, Hyattsville, Md. 20740
Secretary: Robert E. Menzer, Dept. of Entomology, Univ. of Md., College Park, Md. 20740
Delegate: H. Ivan Rainwater, Agricultural Quarantine Inspection Div., USDA, Hyattsville, Md. 20782

25 **Acoustical Society of America (1959)**

Chairman: Richard K. Cook, National Bureau of Standards, Washington, D.C. 20234
Vice-chairman: Herbert M. Nenstadt, Electrical Engineering Dept., U.S. Naval Academy, Annapolis, Md. 21402
Secretary: Gerald J. Franz, Naval Ship R&D Ctr., Washington, D.C. 20034
Delegate: Alfred Weissler, Food & Drug Admin., Code SC-8, Washington, D.C. 20204

26 **American Nuclear Society, Washington Section (1960)**

Chairman: Oscar M. Bizzell, Atomic Energy Comm.
Vice-chairman: Justin L. Bloom, Atomic Energy Comm.
Secretary: Leslie S. Ayres, Arms Control & Disarmament Agency

27 **Institute of Food Technologists, Washington Section (1961)**

Chairman: Richard W. Sternberg, 1133 20th St., N.W., Washington, D.C. 20036
Vice-chairman: John N. Yeatman, ARS Market Quality Res., Color Res. Lab., Beltsville, Md. 20705
Secretary: Cleve B. Denny, 1133 20th St., N.W., Washington, D.C.
Delegate: Lowrie M. Beacham, Food & Drug Adm., Rm. 3171, S. Bldg., Washington, D.C. 20204

28 **American Ceramic Society, Baltimore-Washington Section (1962)**

Chairman: Samuel J. Schneider, Jr., Rm. A305, Matls. Bldg., National Bureau of Standards, Washington, D.C. 20234
Chairman-elect: Wate T. Bakker, General Refractories Co., P.O. Box 1672, Baltimore, Md. 21203
Secretary: Roy Rice, Code 6136, Naval Research Lab., Washington, D.C. 20390
Delegate: Jacob J. Diamond, National Bureau of Standards, Rm. B150, Physics Bldg., Washington, D.C. 20234

29 **Electrochemical Society, National Capital Section (1963)**

Chairman:	Gerald Halpert, 5011 Regina Dr., Annandale, Va. 22003
Vice-chairman:	James R. Huff, 8603 Buckboard Dr., Alexandria, Va. 22308
Secretary:	Judith Ambrus, 13128 Greenmount Ave., Beltsville, Md. 20705
Delegate:	Stanley D. James, U.S. Naval Ordnance Lab., Code 232, White Oak, Md. 20910

30 **Washington History of Science Club (1965)**

Chairman:	Richard G. Hewlett, Atomic Energy Comm.
Vice-chairman	Deborah Warner, Smithsonian Institution
Secretary:	Dean C. Allard

31 **American Association of Physics Teachers, Chesapeake Section (1965)**

President:	Lee Anthony, Roanoke College, Salem, Va. 24153
Vice-president:	Bernard Weigman, Loyola College, Baltimore, Md. 21212
Secretary:	John B. Newman, Towson State College, Baltimore, Md. 21204
Delegate:	Bernard B. Watson, Res. Analysis Corp., McLean, Va. 22101

32 **Optical Society of America, National Capital Section (1966)**

President:	Elsie F. DuPre, Optical Sciences Div., Naval Res. Lab., Washington, D.C. 20390
Vice-president:	Bruce Steiner, Rm. B-312, Metrology Bldg., National Bureau of Standards, Washington, D.C. 20015
Secretary:	Irving H. Malitson, A-251 Physics Bldg., National Bureau of Standards, Washington, D.C. 20234
Delegate:	Elsie F. DuPre

33 **American Society of Plant Physiologists, Washington Section (1966)**

President:	Donald T. Krizek, USDA, Plant Industry Station, Beltsville, Md. 20705
Vice-president:	Neal Barnett, Botany Dept., Univ. of Md., College Park, Md. 20742
Secretary:	William R. Krul, USDA, Plant Industry Station, Beltsville, Md. 20705
Delegate:	W. Shropshire, Jr., Radiation Biology Lab., Smithsonian Institution, 12441 Parklawn Dr., Rockville, Md. 20852

34 **Washington Operations Research Council (1966)**

President:	Ellison Burton, Environmental Protection Agency, Washington, D.C. 20242
President-elect:	Armand Weiss, Logistics Management Institute, 4701 Sangamore Rd., Washington, D.C. 20016
Secretary:	Charles Kezar, General Accounting Office, Washington, D.C. 20548
Delegate:	John G. Honig, Office Chief of Staff, Army, The Pentagon, Rm. 1E 620, Washington, D.C. 20310

35 **Instrument Society of America, Washington Section (1967)**

President:	Francis C. Quinn
President-elect:	John I. Peterson
Secretary:	Frank L. Carou

36 **American Institute of Mining, Metallurgical & Petroleum Engineers (1968)**

President:	Robert N. Morris, Southern Railway Systems
Vice-president:	Ralph C. Kirby, Bureau of Mines
Secretary:	Harold W. Lynde, Jr., Department of Commerce

37 **National Capital Astronomers (1969)**

President:	John A. Eisele, 3310 Curtis Dr., No. 202, Hillcrest Heights, Md. 20023
Vice-president:	Henning E. Leidecker, 4811 Avondale Rd., Washington, D.C. 20018
Secretary:	Estelle Finkle, 939 26th St., N.W., Washington, D.C. 20037
Delegate:	John A. Eisele

38 **Maryland-District of Columbia and Virginia Section of Mathematical Assoc. of America (1971)**

Chairman:	Geraldine A. Coon, Goucher College, Baltimore, Md.
Secretary:	John Smith, George Mason College, Fairfax, Va.
Delegate:	Daniel B. Lloyd, 5604 Overlea Rd., Bethesda, Md. 20016

Alphabetical List of Members

M=Member; F=Fellow; E=Emeritus member. Numbers in parentheses refer to numerical code in foregoing list of affiliated societies.

A

AARONSON, STUART A., 1600 S. Joyce St., Arlington, Va. 22202 (F)

ABBOT, CHARLES G., Smithsonian Institution, Washington, D.C. 20560 (E-1, 23,32)

ABELSON, PHILIP H., President, Carnegie Institution of Washington, 1530 P St., N.W., Washington, D.C. 20005 (F-1,4,7,16)

ABRAHAM, GEORGE, M.S., 3107 Westover Dr., S.E., Washington, D.C. 20020 (F-1, 6, 12, 13, 31)

ACHTER, M.R., Code 6306, U.S. Naval Research Lab., Washington, D.C. 20390 (F-20, 36)

ADAMS, CAROLINE L., 242 North Granada St., Arlington, Va. 22203 (E-10)

ADAMS, ELLIOT Q., 1889 Edgewood Dr., Twinsberg, Ohio 44087 (E)

ADAMS, ELLIOT Q., 1889 Edgewood Dr., Twinsberg, Ohio 44087 (E)

AFFRONTI, LEWIS,Ph.D, Dept. of Microbiology, George Washington Univ. Sch. of Med., 1339 H St., N.W., Washington, D.C. 20005 (F-16)

AHEARN, ARTHUR J., Ph.D., 9621 East Bexhill Dr., Box 294, Kensington, Md. 20795 (F-1)

AKERS, ROBERT P., Ph.D., 9912 Silverbrook Dr., Rockville, Md. 20850 (F-6)

ALBUS, JAMES S., 6100 Westchester, #1406, College Park, Md. 20740 (F)

ALDRICH, JOHN W., Ph.D., 6324 Lakeview Dr., Falls Church, Va. 22041 (F-3)

ALDRIDGE, MARY H., Ph.D., Dept. of Chemistry, American University, Washington, D.C. 20016 (F-4)

ALEXANDER, ALLEN L., Ph.D., Code 6120, Naval Research Lab., Washington, D.C. 20390 (F-4)

ALEXANDER, BENJAMIN H., Ph.D., 2522 S. Dakota Ave., N.E., Washington, D.C. 20018 (F-4)

ALLEN, J. FRANCES, 7507 23rd Ave., Hyattsville, Md. 20783 (F-3)

ALLEN, WILLIAM G., 8306 Custer Rd., Bethesda, Md. 20034 (F-14)

ALTER, HARVEY, Ph.D., Nat. Center for Resource Recovery, Inc., 1211 Connecticut Ave., N.W., Washington, D.C. 20036 (F)

ALTMAN, PHILIP L., 9206 Ewing Dr., Bethesda, Md. 20034 (M)

AMIRIKIAN, ARSHAM, Sc.D., 6526 Western Ave., Chevy Chase, Md. 20015 (F-17, 18)

ANDERSON, ELIZABETH P., 6017 Tilden Lane, Rockville, Md. 20852 (M)

ANDERSON, FRENCH, Nat. Heart & Lung Inst., Nat. Inst. Health, Bethesda, Md. 20014 (F).

ANDERSON, MYRON S., Ph.D., 1433 Manchester Lane, N.W., Washington, D.C. 20011 (F-4)

ANDERSON, WENDELL L., Rural Rt. 2, Box 2069G, La Plata, Md. 20646 (F-4)

ANDREWS, JOHN S., Sc.D., Animal Parasitology Inst., Agr. Res. Cent., USDA, Beltsville, Md. 20705 (F-15)

APPEL, WILLIAM D., B.S., 12416 Regent Ave., N.E., Albuquerque, N.Mex. 87112 (E-6)

APSTEIN, MAURICE, Ph.D., Harry Diamond Labs., Connecticut Ave. & Van Ness St., N.W., Washington, D.C. 20438 (F-13)

ARGAUER, ROBERT J., Ph.D., 4208 Everett St., Kensington, Md. 20795 (F)

ARMSTRONG, GEORGE T., Ph.D., Natl. Bureau of Standards, Washington, D.C. 20234 (F-1, 4, 6)

ARNOLD, KIETH, Ph.D., 6303 Cedell St., Camp Springs, Md. 20031 (F)

ARSEM, COLLINS, 6405 Maiden Lane, Bethesda, Md. 20034 (M-1, 6, 13)

ASLAKSON, CARL I., 5707 Wilson Lane, Bethesda, Md. 20034 (F-1, 6, 12, 18)

ASTIN, ALLEN V., Ph.D., 5008 Battery Lane, Bethesda, Md. 20014 (F-1, 13, 22, 31, 35)

AXILROD, BENJAMIN M., 9915 Marquette Dr., Bethesda, Md. 20034 (F-1)

AYENSU, EDWARD S., Ph.D., 103 G St., N.W.,B219, Washington, D.C. 20024 (F-10)

B

BAKER, ARTHUR A., Ph.D., 5201 Westwood Dr., N.W., Washington, D.C. 20016 (F-7)

BAKER, LOUIS C.W., Ph.D., Dept. of Chemistry, Georgetown University, N.W., Washington, D.C. 20007 (F-4)

BALLARD, LOWELL D., 722 So. Colonial, Sterling, Va. 22170 (M-1, 13, 32)

BARBEAU, MARIUS, Natl. Museum of Canada, Ottawa, Ont., Can. (F)

BARBROW, LOUIS E., Natl. Bureau of Standards, Washington, D.C. 20234 (F-1, 13, 32)

BARGER, GERALD L., 1527 Ainsley Rd., Silver Spring, Md. 20904 (F-23)

BARNHART, CLYDE S., Sr., 715 Joppa Farm Rd., Joppatowne, Md. 21085 (F).

BARRETT, MORRIS K., Mrs. Ph.D., 5528 Johnson Ave., Bethesda, Md. 20034 (F-6)

BARSS, H.P., 2545 S.W. Terwilliger Blvd., Apt. 534, Portland, Oregon 97201 (E-3, 10)

BARTONE, JOHN C., Sci. & Life Consultants Bur., 4111 Gallows Rd., Annandale, Va. 22003 (M-19)

BASS, ARNOLD M., Ph.D., 11920 Coldstream Dr., Potomac, Md. 20854 (F-1, 32)

BEACH, LOUIS A., Ph.D., 1200 Waynewood Blvd., Alexandria, Va. 22308 (F-1, 6)

BEACHAM, LOWRIE M., Jr., 200 C St., N.W., Washington, D.C. 20250 (F-4, 27)

BEACHEM, CEDRIC D., Code 6322 Metallurgy Div., Naval Res. Lab., Washington, D.C. 20390 (F-6, 20, 36)

BEASLEY, EDWARD E., Ph.D., Physics Dept., Gallaudet College, Washington, D.C. 20002 (F-1)

BECKER, EDWIN D., Inst. Arthritis & Metabolic Dis., National Institutes of Health, Bethesda, Md. 20014 (F-4)

BECKETT, CHARLES W., 5624 Madison St., Bethesda, Md. 20014 (F-1, 4)

BECKMANN, ROBERT B., Dean, College of Engineering, Univ. of Maryland, College Park, Md. 20742 (F-4, 6)

BEDINI, SILVIO A., 4303 47th St., N.W., Washington, D.C. 20016 (F)

BEIJ, K. HILDING, B.S., 69 Morningside Dr., Laconia, N.H. 03246 (F-1)

BEKKEDAHL, NORMAN, Ph.D., 405 N. Ocean Blvd., Apt. 1001, Pompano Beach, Fla. 33062 (E-4, 6)

BELSHEIM, ROBERT, Ph.D., Code 8403, U.S. Naval Research Lab., Washington, D.C. 20390 (F-1, 12, 14)

BENDER, MAURICE, Ph.D., Arctic Health Res. Center, PHS, Fairbanks, Alaska 99701 (F)

BENESCH, WILLIAM, Inst. for Molecular Physics, Univ. of Maryland, College Park, Md. 20742 (F-1, 32)

BENJAMIN, C.R., Ph.D., 10/AGR, Dept. of State, Washington, D.C. 20520 (F-10)

BENNETT, JOHN A., 7405 Denton Rd., Bethesda, Md. 20014 (F-20)

BENNETT, LAWRENCE H., 6524 E. Halbert Rd., Bethesda, Md. 20034 (F-20)

BENNETT, MARTIN TOSCAN, 1775 Church St., N.W., Washington, D.C. 20036 (F)

BENNETT, ROBERT R., 5312 Yorktown Rd., Washington, D.C. 20016 (F-6, 7)

BENNETT, WILLARD H., Dept. of Physics, North Carolina State Univ., Raleigh, N.C. 27607 (F)

BERCH, JULIAN, Gillette Res. Inst., 1413 Res. Blvd., Rockville, Md. 20850 (F-4)

BERLINER, ROBERT W., M.D., National Institutes of Health, Bethesda, Md. 20014 (F)

BERNTON, HARRY S., 4000 Cathedral Ave., N.W., Washington, D.C. 20016 (F-8)

BEROZA, MORTON, Ph.D., Agr. Res. Center (East), USDA, Beltsville, Md. 20705 (F-4, 5, 19, 24)

BESTUL, ALDEN B., 9400 Overlea Ave., Rockville, Md. 20850 (F-1, 6)

BICKLEY, WILLIAM E., Ph.D., Dept. of Entomology, Univ. of Maryland, College Park, Md. 20742 (F-5, 24)

BIRD, H.R., USAID/Education, American Embassy, APO San Francisco, Calif. 96356 (F)

BIRKS, L.S., Code 6680, U.S. Naval Research Lab., Washington, D.C. 20390 (F)

BLAKE, DORIS H., M.A., 3416 Glebe Rd., North, Arlington, Va. 22207 (E-5)

BLANDFORD, J., Miss, Blair Plaza, Apt. 1624, 1401 Blair Mill Rd., Silver Spring, Md. 20910 (F)

BLANK, CHARLES A., 5110 Sideburn Rd., Fairfax, Va. 22030 (M-6)

BLOCK, STANLEY, Ph.D., National Bureau of Standards, Washington, D.C. 20234 (F-4—

LUM, WILLIAM, Ph.D., 5525 Partridge Lane, Washington, D.C. 20016 (E-4, 6, 20, 29)

BLUNT, ROBERT F., 5411 Moorland Lane, Bethesda, Md. 20014 (F)

BOEK, JEAN K., Ph.D., Natl. Graduate Univ., 1630 Kalmia Rd., N.W., Washington, D.C. 20012 (F-2)

BOGLE, ROBERT W., 1400 S. Joyce, Apt. B1608, Arlington, Va. 22202 (F-1, 6, 22)

BONDELID, ROLLON O., Ph.D., Code 6610, Naval Research Lab., Washington, D.C. 20390 (F)

BORTHWICK, HARRY A., 13700 Creekside Dr., Silver Spring, Md. 20904 (E-10, 33)

BOWLES, RONALD E., Ph.D., Bowles Fluidics Corp., 9347 Fraser Ave., Silver Spring, Md. 20910 (F)

BOWMAN, PAUL W., 3114 5th St. N., Arlington, Va. 22201 (F)

BOWMAN, THOMAS E., Ph.D., Div. of Crustacea, U.S. Nat. Mus. Nat. Hist., Smithsonian Institution, Washington, D.C. 20560 (F-3)

BOZEMAN, F. MARILYN, Dept. of Rickettsia Disease, Walter Reed Army Inst. of Res., Walter Reed Army Med. Ctr., Washington, D.C. 20012 (F-16, 19)

BRANCATO, E.L., Code 4004, U.S. Naval Research Lab., Washington, D.C. 20390 (F)

BRANDEWIE, DONALD F., 6811 Field Master Dr., Springfield, Va. 22153 (F)

BRAUER, G.M., Dental Research A-123 Polymer, Natl. Bureau of Standards, Washington, D.C. 20234 (F-4, 21)

BRAZEE, RUTLAGE J., 619 Kenbrook Dr., Silver Spring, Md. 20902 (M)

BRECKENRIDGE, R.G., Atomics International, P.O. Box 309, Canoga Park, Calif. 91364 (F)

BREGER, IRVING A., Ph.D., 212 Hillsboro Dr., Silver Spring, Md. 20902 (F-4, 6, 7)

BREIT, GREGORY, State Univ. of N.Y. at Buffalo, 4248 Ridge Lea Rd., Amherst, N.Y. 14226 (F)

BRENNER, ABNER, Ph.D., 7204 Pomander Lane, Chevy Chase, Md. 20015 (F-4, 6, 29)

BREWER, CARL R., Ph.D., 8113 Lilly Stone Dr., Bethesda, Md. 20034 (F-16)

BRICKWEDDE, F.G., Ph.D., 104 Davey Lab., Dept. of Physics, Penn. State University, University Park, Pa. 16802 (F-1)

BRIER, GLENN W., M.A., 1729 N. Harrison St., Arlington, Va. 22205 (F-23)
BROADHURST, MARTIN G., 504 Calvin Lane, Rockville, Md. 20851 (F)
BROMBACHER, W.G., 6914 Ridgewood Ave., Chevy Chase, Md. 20015 (E-1)
BROOKS, RICHARD C., M.S.E., 301 Tiger Lane, Apt. 417, Columbia, Mo., 65201 (M-13)
BROWN, B.F., Sc.D., Code 6320, Naval Research Lab., Washington, D.C. 20390 (F-20, 29)
BROWN, EDWARD H., U.S. Office of Education, P.O. Box 8240, Washington, D.C. 20024 (M)
BROWN, RUSSELL G., Dept. of Botany, Univ. of Maryland, College Park, Md. 20742 (F-10)
BROWN, THOMAS McP., S. 25th St. and Army-Navy Dr., Arlington, Va. 22206 (F)
BRUCK, STEPHEN D., Ph.D., 1113 Pipestem Pl., Rockville, Md. 20854 (F-4, 6)
BRYAN, MILTON M., 3322 N. Glebe Rd., Arlington, Va. 22207 (M-11)
BRYANT, JAMES I., Ph.D., Office Chief of Res. & Develop., Dept. of Army, Washington, D.C. 20310 (M)
BUGGS, C.W., Dean, Fac. Allied Health Sci., Drew Postgrad. Med. School, 1620 E. 119th St., Los Angeles, Calif. 90059 (F-6, 16, 19)
BUNN, RALPH W., M.P.H., Box 411A, Route 3, Wild Rose Shores, Annapolis, Md. 21403 (F-5)
BURAS, EDMUND M., Jr., Gillette Research Inst., 1413 Research Blvd., Rockville, Md. 20850 (F)
BURGERS, J.M., D.M.P.S., 4622 Knox Road, Apt. 7, College Park, Md. 20740 (F-1)
BURINGTON, RICHARD S., Ph.D., 1834 N. Hartford St., Arlington, Va. 22201 (F-1, 6)
BURK, DEAN, Natl. Cancer Institute, Bethesda, Md. 20014 (F)
BURNETT, H.C., Metallurgy Division, Natl Bureau of Standards, Washington, D.C. 20234 (F)
BYERLY, PERRY, Ph.D., Dept. of Geology & Geophysics, Univ. of California, Berkeley, Calif. 94720 (F)
BYERLY, T.C., Asst. Director, Science & Education, U.S. Dept. of Agriculture, Washington, D.C. 20250 (F)

C

CALDWELL, FRANK R., 4821 47th St., N.W., Washington, D.C. 20016 (E-1, 6)
CALDWELL, JOSEPH M., 2732 N. Kensington St., Arlington, Va. 22207 (E-18)
CALLAHAM, ROBERT Z., Ph.D., 3720 Acosta Rd., Fairfax, Va. 22030 (F-11)
CAMERON, JOSEPH M., A345 Physics Bldg., Natl. Bureau of Standards, Washington, D.C. 20234 (F-1)
CAMPAGNONE, ALFRED F., P.E., F., 9321 Warfield Rd., Gaithersburg, Md. 20760 (F)
CAMPANELLA, S. JOSEPH, 18917 Whetstone Circle, Gaithersburg, Md. 20760 (F)
CAMPBELL, F.L., Ph.D., 2475 Virginia Ave., N.W., Washington, D.C. 20037 (F-5, 24)
CANNON, E.W., 5 Vassar Circle, Glen Echo, Md. 20768 (F-1)
CARDER, DEAN S., Ph.D., 682 Forest St., Ashland, Oreg. 97520 (E)
CAREY, FRANCIS E., 12 N. Edison St., Arlington, Va. 22203 (F)
CARHART, HOMER W., Ph.D., 6919 Lee Place, Annandale, Va. 22003 (F-1, 6)
CARLISS, JOSEPH J., 6618 Bellview Dr., Ellicott City, Md. 21043 (M)
CARLSTON, RICHARD C., Calif. State Polytechnic Coll., San Luis Obispo, Calif. 93401 (F-6, 20, 29)
CARMICHAEL, LEONARD, Ph.D., Natl. Geographic Society, 17th & M Sts., N.W., Washington, D.C. 20036 (F-19)
CARROLL, WILLIAM R., 4802 Broad Brook Dr., Bethesda, Md. 20014 (F)
CARRON, MAXWELL K., U.S. Geological Survey, Washington, D.C. 20242 (F-4, 71)
CARTER, HUGH, 2039 New Hampshire Ave., N.W., Washington, D.C. 20009 (F)
CASH, EDITH K., Box 44, Nineveh, N.Y., 13813 (E-10)
CASSEL, JAMES M., Route 1, Sunnyview Dr., Germantown, Md. 20767 (F-4, 20)
CATHEY, HENRY M., 1817 Bart Dr., Silver Spring, Md. 20904 (F-33)
CHALKLEY, HAROLD W., Ph.D., 4609 Highland Ave., Bethesda, Md. 20014 (E-19)
CHAPLIN, HARVEY P., Jr., 1561 Forest Villa Lane, McLean, Va. 22101 (F-22)
CHAPLINE, W.R., 4225 43rd St., N.W., Washington, D.C. 20016 (E-6, 10, 11)
CHEEK, CONRAD H., Ph.D., Code 8330, U.S. Naval Research Lab., Washington, D.C. 20390 (F-4)
CHEZEM, CURTIS G., Ph.D., Mgr., Nuclear Activities, Middle South Services, Box 61000, New Orleans, La. 70160 (F-26)
CHURCH, LLOYD E., D.D.S., Ph.D., 8218 Wisconsin Ave., Bethesda, Md. 20014 (F-1)
CLARK, FRANCIS E., ARS Research Lab., P.O. Box E, Ft. Collins, Colo. 80521 (F)
CLARK, GEORGE E., Jr., 4022 North Stafford St., Arlington, Va. 22207 (F)
CLARK, JOAN ROBINSON, Ph.D., U.S. Geological Survey, Washington, D.C. 20242 (F-7)
CLARK, KENNETH G., Ph.D., 4816 46th St., N.W., Washington, D.C. 20016 (E-4)
CLAIRE, CHARLES N., 4403 14th St., N.W., Washington, D.C. 20011 (F)
CLAUSEN, CURTIS P., University of California, Riverside, Calif. 92507 (E-5)
CLEMENT, J. REID, Jr., 3720 Weltham St., Washington, D.C. 20023 (F)
CLEVEN, GALE W., Ph.D., Normandy House, Apt. 107, 1701 N. Kent St., Arlington, Va. 22209 (F-1, 6)
COHN, ERNST M., 103 G St., S.W., Apt. 620-B, Washington, D.C. 20024 (M-4, 29)
COHN, ROBERT, M.D., 7221 Pyle Road, Bethesda, Md. 20034 (F-1)

COLE, KENNETH S., Ph.D., National Institutes of Health, Bethesda, Md. 20014 (F-1)
COLLINS, HENRY B., Dept. Anthropoloty, Smithsonian Inst., Washington, D.C. 20560 (E-2)
COLWELL, R.R., Ph.D., Dept. of Microbiology, Univ. of Maryland, College Park, Md. 20742 (F-6,16)
COMPTON, W. DALE, Executive Dir., Sci. Res. Staff, Ford Motor Co., 20000 Rotunda Drive, Dearborn, Mich. 48121 (F)
CONGER, PAUL S., M.S., U.S. National Museum, Washington, D.C. 20560 (E)
COOK, HAROLD T., Ph.D., Box 303, Rt. 3, Edgewater, Md. 21037 (E-10)
COOK, RICHARD K., Ph.D., Room A311, Bldg. 226, Natl. Bur. Standards, Washington, D.C. (F-1, 25)
COOKE, C. WYTHE, Ph.D., Princess Issena Hotel, Daytona Beach, Fla. 32020 (E-7)
COOLIDGE, HAROLD J., 2101 Constitution Ave., Washington, D.C. 20037 (E-6)
COOLIDGE, WILLIAM D., 1480 Lenox Rd., Schenectady, N.Y. 12308 (F)
COONS, GEORGE H., Ph.D., 7415 Oak Lane, Chevy Chase, Md., 20015 (E-10)
COOPER, G. ARTHUR, U.S. Natl. Museum, Washington, D.C. 20560 (F-7)
CORNFIELD, JEROME, 9650 Rockville Pike, Bethesda, Md. 20014 (F)
CORY, ERNEST N., Ph.D., 4710 College Ave., College Park, Md. 20742 (E-5, 24)
COSTRELL, LOUIS, 241,02 Natl. Bureau of Standards, Washington, D.C. 20234 (F-1, 13)
COTTAM, C., Welder Wildlife Foundation, Box 1400, Sinton, Texas 78387 (F-3, 6)
COX, EDWIN L., Biometrical Services, ARS, Ag. Res. Center, Bldg. 228, Beltsville, Md. 20705 (F-6)
COYLE, THOMAS D., National Bureau of Standards, Washington, D.C. 20234 (F-4, 6)
CRAFT, CHARLES C., U.S. Dept. of Agriculture, Box 700, Pomona, Calif. 91766 (F)
CRAFTON, PAUL A., P.O. Box 454, Rockville, Md. 20850 (F)
CRAGOE, CARL S., 6206 Singleton Place, Bethesda, Md. 20034 (E-1)
CRANE, LANGDON T., Jr., 7103 Oakridge Ave., Chevy Chase, Md. 20015 (F-1, 6)
CREITZ, E. CARROLL, 10145 Cedar Lane, Kensington, Md. 20795 (E)
CRESSMAN, GEORGE P., 9 Old Stage Court, Rockville, Md. 20852 (F-23)
CROSSETTE, GEORGE, 4217 Glenrose St., Kensington, Md. 20795 (M-6, 9, 11, 17)
CULBERT, DOROTHY K., 812 A St., S.E., Washington, D.C. 20003 (M-6)
CULLINAN, FRANK P., 4402 Beechwood Rd., Hyattsville, Md. 20782 (E-6, 10, 33)
CURRAN, HAROLD R., Ph.D., 3431 N. Randolph St., Arlington, Va. 22207 (E-16)
CURRIE, CHARLES L., S.J., Dept. of Chemistry, Georgetown Univ., Washington, D.C. 20007 (F-4)
CURTIS, ROGER W., Ph.D., 6308 Valley Rd., Bethesda, Md. 20034 (F)
CURTISS, LEON F., 1690 Bayshore Drive, Englewood, Fla. 33533 (E-1)
CUTHILL, JOHN R., Ph.D., 12700 River Rd., Potomac, Md. 20854 (F-20, 36)
CUTKOSKY, ROBERT Dale, 19150 Roman Way, Gaithersburg, Md. 20760 (F-6, 13)
CUTTITTA, FRANK, 12911 Bluhill Rd., Silver Spring, Md. 20906 (F-4, 6, 7)

D

DACONS, JOSEPH C., Ph.D., Naval Ordnance Lab., White Oak, Silver Spring, Md. 20910 (F-4)
DARRACOTT, HALVOR T., M.S., 3325 Mansfield Rd., Falls Church, Va. 22041 (F-13)
DAVENPORT, JAMES C., Virginia State College, Petersburg, Va. 23803 (M)
DAVIS, CHARLES M., Jr., 8458 Portland Place, McLean, Virginia 22101 (M-25)
DAVIS, MARION MACLEAN, M.M.D., 5315 29th St., N.W., Washington, D.C. 20015 (F-4, 6)
DAVIS, R.F., Ph.D., Head, Dept. of Dairy Science, University of Maryland, College Park, Md. 20742 (F)
DAVIS, RAYMOND, 5315 29th St., N.W., Washington, D.C. 20015 (E-1, 4)
DAVISSON, JAMES W., 4654 Cedar Ridge Dr., S.E., Washington, D.C. 20021 (F-1)
DAWSON, ROY C., 4019 Beechwood Rd., Univ. Park, Md. 20782 (E-16)
DAWSON, VICTOR C.D., 9406 Curran Road, Silver Spring, Md. 20901 (F-6, 14, 20, 22)
DE BERRY, MARIAN B., 1116 Lamont St., N.W., Washington, D.C. 20010 (M)
DE CARLO, MICHAEL, Rt. 1, Box 131, Cypress Way, Carmel, Calif. 93921 (M)
DE FERIET, J. KAMPE, Prof. A. La Faculte Des-Sci., de L'Univ. de Lille, 82 Rue Meurein, Lille, France (F)
DE PACKH, DAVID, 100 Vista Terrace, S.E., Washington, D.C. 20022 (F-1)
DE PUE, LELAND A., Ph.D., Code 2302.3, Naval Research Lab., Washington, D.C. 20390 (F-6, 20)
DE VOE, JAMES R., 17708 Parkridge Dr., Gaithersburg, Md. 20760 (F-4, 6)
DE VORE, CHARLES, 2243 N. Trenton St., Arlington, Va. 22207 (M-12, 13, 26)
DE WIT, ROLAND, Metallurgy Division, National Bureau of Standards, Washington, D.C. 20234 (F-1, 6, 36)
DEDRICK, ROBERT L., Ph.D., Natl. Insts. Health, Bg. 13, Room 3W13, Bethesda, Md. 20014 (F-1)

DEHL, RONALD E., 3895 Rodman St., N.W., Washington, D.C. 20016 (F)
DEITZ, VICTOR R., 3310 Winnett Rd., Chevy Chase, Md. 20015 (F-28)
DEMUTH, HAL P., M.S., 4025 Pinebrook Rd., Alexandria, Va. 22310 (F-13, 17)
DENNIS, BERNARD K., 915 Country Club Dr., Vienna, Va. 22180 (F)
DESLATTES, RICHARD D., Jr., 610 Aster Blvd., Rockville, Md. 20850 (F)
DETWILER, ROBERT H., 5027 N. 30th St., Arlington, Va. 22210 (M)
DETWILER, S.B., Sr., 631 S. Walter Reed Dr., Arlington, Va. 22204 (E)
DETWILER, SAMUEL B., Jr., 631 S. Walter Reed Drive, Arlington, Va. 22204 (F-4)
DI MARZIO, E.A., 14205 Parkvale Rd., Rockville, Md. 20853 (F)
DIAMOND, J.J., Physics B-150, National Bureau of Standards, Washington, D.C. 20234 (F-1,4, 6, 28)
DIAMOND, PAULINE, 6436 Bannockburn Dr., Bethesda, Md. 20034 (F-1, 4, 28)
DICKSON, GEORGE, M.A., Dental Research Section, National Bureau of Standards, Washington, D.C. 20234 (F-6, 21)
DIEHL, WALTER S., 4501 Lowell St., N.W., Washington, D.C. 20016 (F-22)
DIEHL, WILLIAM W., Ph.D., 1512 N. McKinley Rd., Arlington, Va. 22205 (E-3, 10)
DIGGES, THOMAS G., 3900 N. Albemarle St., Arlington, Va. 22207 (E-20)
DOCTOR, NORMAN, B.S., 3814 Littleton St., Wheaton, Md. 20906 (F-13)
DOETSCH, RAYMOND N., Ph.D., Microbiology Dept., Univ. of Maryland, College Park, Md. 20742 (F-16)
DOFT, FLOYD S., Ph.D., 6416 Garnett Drive, Kenwood, Chevy Chase, Md. 20015 (E-4, 6, 19)
DONNERT, HERMANN J., Ph.D., RFD 4, Box 136, Terra Heights, Manhattan, Kans. 66502 (F)
DOSS, MILDRED A., 109 Park Valley, Silver Spring, Md. 20910 (F-15)
DOUGLAS, CHARLES A., Section 221.12, Natl. Bureau of Standards, Washington, D.C. 20234 (F-1, 6, 32)
DOUGLAS, THOMAS B., Ph.D., 3031 Sedgwick St., N.W., Washington, D.C. 20008 (F-4)
DRAEGER, R. HAROLD, M.D., 1201 N. 4th St., Tucson, Ariz. 85705 (E-32)
DRECHSLER, CHARLES, Ph.D., 6915 Oakridge Rd., University Park (Hyattsville), Md. 20782 (E-6, 10)
DRUMMETER, LOUIS F., Jr., Code 6420, U.S. Naval Res. Lab., Washington, D.C. 20390 (F)
DU PONT, JOHN ELEUTHERE, Newton Square, Pennsylvania 19073 (M)
DUPRE, ELSIE, Mrs., Code 6553, Optical Sci. Div., Naval Res. Lab., Washington, D.C. 20390 (F-32)
DUERKSEN, J.A., 3134 Monroe St., N.E., Washington, D.C. 20018 (E-1, 6)
DUNKUM, WILLIAM W., 256 Burgess Ave., Alexandria, Va. 22305 (F)
DUNNING, K.L., Ph.D., Code 6670, Naval Research Lab., Washington, D.C. 20390 (F-1)
DUPONT, JEAN R., M.D., 818 Moore St., Sikeston, Mo. 63801 (F-19)
DURIE, EDYTHE G., 5011 Harna Dr., Alexandria, Va. 22310 (M)
DURST, RICHARD A., Ph.D., Chemistry Bldg., Rm. A219, National Bureau of Standards, Washington, D.C. 20234 (F-4)

E

ECKHARDT, E.A., 840 12th St., Oakmont, Allegheny County, Pa. 15139 (E-1)
ECKLIN, JOHN W., 5100 8th Rd., S., 508, Arlington, Va. 22204 (M)
EDDY, BERNICE E., Ph.D., Div. Biologic Standards, National Institutes of Health, Bethesda, Md. 20014 (F-6, 16, 19)
EDDY, NATHAN B., M.D., 7055 Wilson Lane, Bethesda, Md. 20034 (F-4, 6, 19)
EDERER, DAVID L., Far U V Physics Section, Rm. A251, Bldg. 221, National Bureau of Standards, Washington, D.C. 20234 (F-32)
EDMUNDS, LAFE R., Ph.D., 6003 Leewood Dr., Alexandria, Va. 22310 (F-5)
EGOLF, DONALD R., 3600 Cambridge Court, Upper Marlboro, Md. 20870 (F-10)
EISENHART, CHURCHILL, Ph.D., Met A-123, National Bureau of Standards, Washington, D.C. 20234 (F-1, 30)
EL-BISI, HAMED M., Ph.D. 1017 Aponi Rd., Vienna, Va. 22180 (M-16)
ELBOURN, ROBERT D., 8221 Hamilton Spring Ct., Bethesda, Md. 20034 (F-1, 13)
ELLINGER, GEORGE A., 739 Kelly Dr., York, Pa. 17404 (E-6)
ELLIOTT, F.E., 7507 Grange Hall Dr., Oxon Hill, Md. 20022 (F)
EMERSON, K.C., Ph.D., 2704 No. Kensington St., Arlington, Va. 22207 (F-3, 5)
EMERSON, W.B., 415 Aspen St., N.W., Washington, D.C. 20012 (E)
ENNIS, W.B., Jr., 4011 College Heights Dr., Hyattsville, Md. 20782 (F)
ESTERMANN, I., Dept. of Physics, Technion, Haifa, Israel (E-1)
ETZEL, HOWARD W., 7304 River Hill Rd., Washington, D.C. 20021 (F)
EWERS, JOHN C., 4432 26th Road, North, Arlington, Va. 22207 (F-2)

F

FAHEY, JOSEPH J., U.S. Geological Survey, Washington, D.C. 20242 (E-4, 6, 7)
FALLON, ROBERT, 8251 Toll House Rd., Annandale, Va. 22003 (F)

FARR, MARION M., Miss, 515 Thayer Ave., Silver Spring, Md. 20910 (F-15)

FARROW, RICHARD P., National Canners Assn., 1133 20th St., N.W., Washington, D.C. 20036 (F-4, 6, 27)

FAULKNER, JOSEPH A., 1007 Sligo Creek Pky., Takoma Park, Md. 20012 (F-6)

FAUST, GEORGE T., Ph.D., 9907 Capitol View Ave., Silver Spring, Md. 20910 (F-7, 31)

FAUST, WILLIAM R., Ph.D., 5907 Walnut St., Temple Hills, Md. 20031 (F-1, 6)

FEARN, JAMES E., Ph.D., A367 Chem., Organic Chemistry Section, National Bureau of Standards, Washington, D.C. 20234 (F-4)

FELSENFELD, OSCAR, Tulane Research Center, Covington, La. 70433 (F-6)

FELSHER, MURRAY, Sr. Staff Geologist, Off. Techn. Anal. Enforcement, EPA, Washington, D.C. 20460 (M-1, 7)

FERGUSON, ROBERT E., 6307 Tone Dr., Washington, D.C. 20034 (F-4)

FERRELL, RICHARD A., Ph.D., Dept. of Physics, University of Maryland, College Park, Md. 20742 (F-6, 31)

FIELD, WILLIAM D., Dept. Entomology, Smithsonian Institution, Washington, D.C. 20560 (F-5)

FINLEY, HAROLD E., Head, Dept. of Zoology, Howard University, Washington, D.C. 20001 (F-3)

FIVAZ, ALFRED E., 804 Dale Drive, Silver Spring, Md. 20910 (E-11)

FLETCHER, DONALD G., Natl. Bureau of Standards, Rm. A102, Bldg. 231—IND, Washington, D.C. 20234 (M-4)

FLETCHER, HEWITT G., Jr., Box 217, Sandy Spring, Md. 20860 (F)

FLINT, EINAR P., U.S. Bureau of Mines, 4513 Interior Bldg., Washington, D.C. 20240 (F-4, 20, 28, 36)

FLORIN, ROLAND E., Ph.D., Polymer Chemistry Section, B-328 Poly, National Bureau of Standards, Washington, D.C. 20234 (F-4)

FLYNN, DANIEL R., 17500 Ira Court, Derwood, Md. 20855 (F)

FLYNN, JOSEPH H., Ph.D., 5309 Iroquios Rd., Washington, D.C. 20016 (F-4)

FOCKLER, H. H., MSLS, 10710 Lorain Ave., Silver Spring, Md. 20014 (M)

FONER, S. N., Applied Physics Lab., The Johns Hopkins University, Silver Spring, Md. 20910 (F-1)

FOOTE, RICHARD H., Sc.D., 8807 Victoria Road, Springfield, Va. 22151 (F-5, 6)

FORD, W. KENT, Jr., Dept. of Terrestrial Magnetism, Carnegie Institution of Washington, 5241 Broad Branch Rd., N.W., Washington, D.C. 20015 (F)

FORZIATI, ALPHONSE F., Ph.D., 9812 Dameron Dr., Silver Spring, Md. 20902 (F-1, 3, 21, 29)

FORZIATI, FLORENCE H., Ph.D. 9812 Dameron Dr., Silver Spring, Md. 20902 (F)

FOSTER, AUREL O., 4613 Drexel Rd., College Park, Md. 20740 (F-15, 24)

FOURNIER, ROBERT O., 108 Paloma Rd., Portola Valley, Calif. 94025 (F-6, 7)

FOURT, LYMAN, 5510 Johnson Ave., Bethesda, Md. 20034 (F)

FOWELLS, H. A., Ph.D., 10217 Green Forest, Silver Spring, Md. 20903 (F-11)

FOWLER, EUGENE, U.S. Atomic Energy Comm., Washington, D.C. 20545 (M-26)

FOX, DAVID W., The Johns Hopkins Univ., Applied Physics Lab., Silver Spring, Md. 20910 (F)

FOX, ROBERT B., Naval Res. Lab., Code 6120, Washington, D.C. 20390 (F-4, 6)

FRAME, ELIZABETH G., Ph.D., 7711 Radnor Rd., Bethesda, Md. 20034 (F)

FRANKLIN, PHILIP J., 5907 Massachusetts Ave. Extended, Washington, D.C. 20016 (F-4, 13)

FRANZ, GERALD J., M.S., 9638 Culver St., Kensington, Md. 20795 (M-6, 25)

FREDERIKSE, H. P. R., Ph.D., 9625 Dewmar Lane, Kensington, Md. 20795 (F)

FREEMAN, ANDREW F., 5012 N. 33rd St., Arlington, Va. 22207 (M)

FRENKIEL, FRANCOIS N., Applied Math. Lab., Naval Ship Res. & Develop. Ctr., Washington, D.C. 20034 (F-1, 22, 23)

FRIEDMAN, LEO, Ph.D., Director, Div. of Toxicology (BF-150), Bureau of Science, Food & Drug Admin., H.E.W., Washington, D.C. 20204 (F-4, 19)

FRIESS, S. L., Ph.D., Environmental Biosciences Dept., Naval Med. Res. Inst. NNMC, Bethesda, Md. 20014 (F-4)

FRUSH, HARRIET L., 4912 New Hampshire Ave., N.W., Apt. 104, Washington, D. C. 20011 (F-4, 6)

FULLMER, IRVIN H., Warwick Towers, Apt. 1003, 1131 University Blvd. W., Silver Spring, Md. 20902 (E-1, 6, 14)

FULTON, ROBERT A., 530 Merrie Dr., Vorvallis, Oregon 97330 (E-4, 5)

FURUKAWA, GEORGE T., National Bureau of Standards, Washington, D.C. 20234 (F-1, 4, 6)

FUSILLO, MATTHEW H., VA Hospital, 50 Irving St., N.W., Washington, D.C. 20422 (M-6, 16)

G

GAFAFER, WILLIAM M., 133 Cunningham Dr., New Smyrna Beach, Fla. 32069 (E)

GAGE, WILLIAM, Ph.D., 2146 Florida Ave., N.W., Washington, D.C. 20008 (F-2)

GALLER, SIDNEY, 6242 Woodcrest Ave., Baltimore, Md. 21209 (F-6)

GALLOWAY, RAYMOND A., Dept. of Botany, University of Maryland, College Park, Md. 20742 (F-10, 33)

GALTSOFF, PAUL S., Ph.D., P.O. Box 167, Woods Hole, Mass. 20543 (E-3)

GALVIN, CYRIL J., Jr., 2915 Tennyson St., N.W., Washington, D.C. 20015 (F-7, 18, 30)

GANT, JAMES O., Jr., 1835 Eye St., N.W., Suite 201, Washington, D.C. 20006 (M)

GARDNER, IRVINE C., Ph.D., 9531 E. Stanhope Rd., Rock Creek Hills, Kensington, Md. 20795 (E-1, 6, 32)

GARNER, C. L., The Garfield, 5410 Connecticut Ave., N.W., Washington, D.C. 20015 (E-1, 4, 12, 17, 18)

GARVIN, DAVID, Ph.D., 4000 Tunlaw Rd., N.W., Apt. 323, Washington, D.C. 20007 (F-4)

GAUM, CARL H., 9609 Carriage Rd., Kensington, Md. 20795 (F-18)

GEIL, GLENN W., 123 S. Adelpha Cir., Enid, Okla. 73701 (F)

GEORGE, BOYD W., Ph.D., P.O. Box 2484, College Sta., Pullman, Washington 99163 (M)

GHAFFARI, ABOLGHASSEM, Ph.D., D.Sc., Fac. Sciences, Univ. of Teheron, Shahreza, Teheron, Iran (F)

GIBSON, JOHN E., Box 96, Gibson, N.C. 28343 (E)

GIBSON, KASSON S., 4817 Cumberland St., Chevy Chase, Md. 20015 (E)

GINTHER, ROBERT J., Code 6060, U.S. Naval Research Lab., Washington, D.C. 20390 (F-28, 29)

GISH, OLIVER H., 7107 S. Indian River Dr., Fort Pierce, Fla. 33450 (E-1, 6)

GLASGOW, A. R., Jr., Ph.D., 4116 Hamilton St., Hyattsville, Md. 20781 (F-4, 6)

GLASSER, ROBERT G., Ph.D., 2812 Abilene Dr., Chevy Chase, Md. 20015 (F)

GLICKSMAN, MARTIN E., 2223 Hindle Lane, Bowie, Md. 20715 (F-20)

GODFREY, THEODORE B., 7508 Old Chester Rd., Bethesda, Md. 20034 (E)

GOLDBERG, MICHAEL, 5823 Potomac Ave., N.W., Washington, D.C. 20016 (F-1)

GOLDMAN, ALAN J., Applied Mathematics Div., Inst. for Basic Standards, Natl. Bureau of Standards, Washington, D.C. 20234 (F)

GOLDSTEIN, GORDON D., 9520 Saybrook Ave., Silver Spring, Md. 20901 (M)

GOLUMBIC, CALVIN, ARS, USDA, Rm. 637 Fed. Center Bg., Hyattsville, Md. 20782 (F)

GONET, FRANK, 4007 N. Woodstock St., Arlington, Va. 22207 (F-4)

GOODE, ROBERT J., B.S., Strength of Metals Br., Code 6380, Metallurgy Div., U.S.N.R.L., Washington, D.C. 20390 (F-6,20,36)

GOODMAN, RALPH, 6600 Melody Lane, Bethesda, Md. 20034 (F)

GORDON, CHARLES L., 5512 Charles St., Bethesda, Md. 20014 (F-1, 4, 6)

GORDON, NATHAN, 1121 Univ. Blvd. Apt. 205, Silver Spring, Md. 20902 (F-4)

GORDON, RUTH E., Ph.D., Inst. of Microbiology, Rutgers Univ., New Brunswick, N.J. 008903 (F-16)

GRAF, JOHN E., 2035 Parkside Dr., N.W., Washington, D.C. 20012 (F-3, 5, 6)

GRASSL, CARL O., Sugar Plant Field Station, P.O. Box 156, Canal Point, Fla. 33438 (F)

GRAY, ALFRED, Dept. Math., Univ. of Maryland, College Park, Md. 20742 (F)

GRAY, IRVING, Georgetown Univ., Washington, D.C. 20007 (F)

GREENBERG, LEON, Ph.D., 6209 Poindexter Lane, Rockville, Md. 20852 (F)

GREENBERG, O. W., Dept. Phys. & Astron., Univ. of Maryland, College Park, Md. 20742 (F)

GREENOUGH, M. L., M.S., Rm. A109 Poly, National Bureau of Standards, Washington, D.C. 20234 (F)

GREENSPAN, MARTIN, 12 Granville Dr., Silver Spring, Md. 20902 (F-1, 25)

GRIFFITHS, NORMAN H. C., 3100 20th St., N.E., Washington, D.C. 20018 (F-21)

GRISAMORE, NELSON T., 9536 E. Bexhill Dr., Kensington, Md. 20795 (F)

GROSSLING, BERNARDO F., U.S. Geological Survey, Rm. 5216, GSA Bg., Washington, D.C. 20242 (F-7)

GUARINO, P. A., 6714 Montrose Rd., Rockville, Md. 20852 (F-13)

GURNEY, ASHLEY B., Ph.D., Systematic Entomology Lab., USDA, c/o U.S. National Museum, Washington, D.C. 20560 (F-3, 5, 6)

H

HACSKAYLO, EDWARD, Ph.D., Plant Industry Station, USDA, Beltsville, Md. 20705 (F-6, 10, 11, 33)

HAENNI, EDWARD O., Ph.D., Div. Chem. & Phys., BF-140, FDA, Washington, D.C. 20204 (F-4)

HAINES, KENNETH A., ARS, USDA, Federal Center Blg., Hyattsville, Md. 20781 (F-5)

HAKALA, REINO W., Ph.D., 2817 N.W. 21st St., Oklahoma City, Okla. 73107 (F)

HALL, E. RAYMOND, Museum of Natural History, Univ. of Kansas, Lawrence, Kans. 66044 (F)

HALL, R. CLIFFORD, M.F., 316 Mansion Drive, Alexandria, Va. 22302 (E-11)

HALL, STANLEY A., Agric. Res. Center (East), USDA, Beltsville, Md. 20705 (F-24)

HALL, WAYNE C., 1755 Ivy Oak Square, Reston, Va. 22070

HALLER, H.L., 4407 38th St., N.W., Washington, D.C. 20016 (E-4, 5, 6, 24)

HALLER, WOLFGANG, Ph.D., National Bureau of Standards, Washington, D.C. 20234 (F)

HALSTEAD, BRUCE W., World Life Research Institute, 23000 Grand Terrace, Colton, Calif. 92324 (F-6, 19)

HAMBLETON, EDSON J., 5140 Worthington Dr., Washington, D.C. 20016 (E-3, 5, 6)

HAMER, WALTER J., 3028 Dogwood St., N.W., Washington, D.C. 20015 (F-6, 13, 19)

HAMILTON, C.E. MIKE, Federal Power Comm., 441 G St., N.W., Washington, D.C. 20426 (M-7, 36)

HAMMERSCHMIDT, W.W., Ph.D., 7818 Holmes Run Dr., Falls Church, Va. 22042 (M)
HAMMOND, H. DAVID, Ph.D., 14 Chappel St., Brockport, N.Y. 14420 (M-10)
HAMPP, EDWARD G., D.D.S., National Institutes of Health, Bethesda, Md. 20014 (F-21)
HANCOCK, JUDITH M., Biol. Dept., St. Joseph's College, North Windham, Me. 04062 (M)
HAND, CADET H., Jr., Bodega Marine Lab., Bodega Bay, Calif. 94923 (F-6)
HANSEN, LOUIS S., D.D.S., School of Dentistry, San Francisco Med. Center, University of California, San Francisco, Calif. 94122 (F-21)
HANSEN, MORRIS H., M.A., Westat Research, Inc., 11600 Nebel St., Rockville, Md. 20852 (F-34)
HARDENBURG, ROBERT EARLE, Ph.D., Plant Industry Station, U.S. Dept. of Agriculture, Beltsville, Md. 20705 (F-6)
HARRINGTON, FRANCIS D., 4612 N. 2nd Rd., Arlington, Va. 22203 (M)
HARRINGTON, M.C., Ph.D., Physics Directorate (NPP), Air Force Off. Sci. Res., 1400 Wilson Blvd., Arlington, Va. 22209 (F-1, 13, 22, 31, 32)
HARRIS, MILTON, Ph.D., 3300 Whitehaven St., N.W., Suite 500, Washington, D.C. 20007 (F)
HARRIS, ROBERT H., Ph.D., 12915 Travilah Rd., Rockville, Md. 20850 (M)
HARRIS, THOMAS H., Office of Pesticides, Public Health Service, HEW, Washington, D.C. 20201 (F)
HARRISON, W.N., 3734 Windom Pl., N.W., Washington, D.C. 20016 (F-1)
HARTLEY, JANET W., Ph.D., National Inst. of Allergy & Infectious Diseases, National Institutes of Health, Bethesda, Md. 20014 (F)
HARTMANN, GREGORY K., 10701 Keswick St., Garrett Park, Md. 20766 (F-1, 25)
HARTZLER, MARY P., 3326 Hartwell Ct., Falls Church, Va. 22042 (M-6)
HASKINS, C.P., Ph.D., 2100 M St., N.W., Suite 600, Washington, D.C. 20037 (F)
HASS, GEORG H., 7728 Lee Avenue, Alexandria, Va. 22308 (F)
HAUPTMAN, HERBERT, Ph.D., Medical Foundation of Buffalo, 73 High St., Buffalo, N.Y. 14203 (F-1)
HAZELTON, L.W., Ph.D., Hazelton Labs., 9200 Leesburg Pike, Vienna, Va. 22180 (F-4)
HEINRICH, KURT F., 804 Blossom Dr., Woodley Gardens, Rockville, Md. 20850 (F)
HEINZE, P.H., Ph.D., Horticultural Crops Research, USDA, ARS, MQ., Rm. 803 F.C.B., Hyattsville, Md. 20782 (F-4, 6, 10)
HELLER, ISIDORE, Dept. of Mathematics, Catholic University, Washington, D.C. 20017 (F)
HENDERSON, E.P., Div. of Meteorites, U.S. National Museum, Washington, D.C. 20560 (E)
HENDERSON, MALCOLM C., Ph.D., 2699 Shasta Rd., Berkeley, Calif. 94708 (F-1)
HENNEBERRY, THOMAS J., 2608 Shenandale Dr., Silver Spring, Md. 20904 (F-5, 24)
HERMACH, FRANCIS L., 2415 Eccleston St., Silver Spring, Md. 20902 (F-13, 35)
HERMAN, ROBERT, Theoretical Physics Dept., General Motors Research Lab., 12 Mi & Mound Rds., Warren, Mich. 48091 (F-1)
HERSCHMAN, HARRY K., 4701 Willard Ave., Chevy Chase, Md. 20015 (F-20)
HERSEY, MAYO D., M.A., Div. of Engineering, Brown University, Providence, R.I. 02912 (E-1)
HERZFELD, KARL F., Dept. of Physics, Catholic University, Washington, D.C. 20017 (F-1)
HERZFELD, REGINA F., Ph.D., Dept. of Anthropology, Catholic University, Washington, D.C. 20017 (F-1, 2)
HESS, WALTER C., 3607 Chesapeake St., N.W., Washington, D.C. 20008 (E-4, 6, 19, 21)
HEWSTON, ELIZABETH M., Felicity Cove, Shady Side, Md. 20867 (F)
HEYDEN, FR. FRANCIS, Manila Observatory, American Embassy, APO San Francisco, Calif. 96528 (F-32)
HIATT, CASPAR W., Ph.D., Univ. of Texas Medical School, San Antonio, Texas 78229 (F)
HICKLEY, THOMAS J., 626 Binnacle Dr., Naples, Fla. 33940 (F-13)
HICKOX, GEORGE H., Ph.D., 9310 Allwood Ct., Alexandria, Va. 22309 (F-6, 14, 18)
HICKS, V., Ph.D., 4000 Sunset Blvd., Minneapolis, Minn. 55416 (F)
HILDEBRAND, EARL M., 11092 Timberline Dr., Sun City, Ariz. 85351 (E)
HILL, FREEMAN K., 12408 Hall's Shop Rd., Fulton, Md. 20759 (F-1, 6, 22)
HILSENRATH, JOSEPH, 9603 Brunett Ave., Silver Spring, Md. 20901 (F-1)
HILTON, JAMES L., Ph.D., Plant Industry Station, USDA, ARS, Beltsville, Md. 20705 (F-33)
HINMAN, WILBUR S., Jr., Marlborough Point, P.O. Box 56, Brooke, Va. 22430 (F-13)
HOBBS, ROBERT B., 7715 Old Chester Rd., Bethesda, Md. 20034 (F-4)
HOERING, THOMAS C., Carnegie Inst. of Washington, Geophysical Lab., 2801 Upton St., N.W., Washington, D.C. 20008 (F-4, 7)
HOFFMANN, C.H., Ph.D., 6906 40th Ave., University Park, Hyattsville, Md. 20782 (F-5, 11, 24)
HOGE, HAROLD J., Ph.D., Head, Thermodyn. Lab. Prd., U.S. Army Natick Labs., Natick, Mass. 01760 (F-1)
HOLLIES, NORMAN R.S., Gillette Research Institute, 1413 Research Blvd., Rockville, Md. 20850 (F-4)
HOLLINSHEAD, ARIEL C., Ph.D., Lab. for Virus & Cancer Research, Dept. of Medicine, 2300 K St., N.W., Washington, D.C. 20037 (F-16, 19)
HOLMGREN, HARRY D., Ph.D., P.O. Box 391, College Park, Md. 20740 (F-1)
HOLSHOUSER, WILLIAM L., Bureau of Aviation Safety, Natl. Trans. Safety Board, Washington, D.C. 20591 (F-6, 20)

HONIG, JOHN G., Office Chief of Staff, Army, The Pentagon, Washington, D.C. 20310 (F-1, 4, 34)

HOOD, KENNETH J., 2000 Huntington Ave., #1118, Alexandria, Va. 22303 (M-33)

HOOKER, MISS MARJORIE, U.S. Geological Survey, Washington, D.C. 20242 (F-7)

HOOVER, JOHN I., 5313 Briley Place, Washington, D.C. 20016 (F-1, 6)

HOOVER, THOMAS B., Ph.D., Southeast Water Lab., Athens, Ga. 30601 (F-29)

HOPKINS, STEPHEN, M.Ed., Trash Masters Corp., 2135 Wisconsin Ave., N.W., Washington, D.C. 20007 (F)

HOPP, HENRY, Ph.D., 7003 Wells Parkway, Hyattsville, Md. 20782 (F-11)

HORNSTEIN, IRWIN, 5920 Bryn Mawr Rd., College Park, Md. 20740 (F-4, 27)

HOROWITZ, E., Deputy Director, Institute for Materials Res., National Bureau of Standards, Washington, D.C. 20234 (F)

HORTON, BILLY M., 3238 Rodman St., N.W., Washington, D.C. 20008 (F-1, 13)

HOUGH, FLOYD W., C.E., Woodstock, Virginia 22664 (E-17, 18)

HOWE, PAUL E., 3601 Connecticut Ave., N.W., Washington, D.C. 20008 (E3, 4, 6, 8, 19)

HUBBARD, DONALD, 4807 Chevy Chase Dr., Chevy Chase, Md. 20015 (F-4, 6, 32)

HUBERT, LESTER F., 4704 Mangum Rd., College Park, Md. 20740 (F-23)

HUDSON, COLIN M., Ph.D., Chief Scientist, U.S. Army Weapons Command, Rock Island, Ill. 61201 (F-22)

HUGH, RUDOLPH, Ph.D., George Washington Univ. Sch. of Med., Dept. of Microbiology, 1339 H St., N.W., Washington, D.C. 20005 (F-16, 19)

HUNDLEY, JAMES M., American Heart Association, 44 E. 23rd St., New York, N.Y. 10010 (F)

HUNTER, RICHARD S., 9529 Lee Highway, Fairfax, Va. 22030 (F-27, 32)

HUNTER, WILLIAM R., Code 7143, U.S. Naval Research Lab., Washington, D.C. 20390 (F-1, 6, 32)

HUNTOON, R.D., Ph.D., 13904 Blair Stone Lane, Wheaton, Md. 20906 (F-1, 13)

HUTCHINS, LEE M., Cacao Ctr., Institute of Agriculture, Turrialba, Costa Rica (E-10, 11)

HUTTON, GEORGE L., 6304 Kirby Road, Bethesda, Md. 20034 (F-5, 6)

I

INSLEY, HERBERT, Ph.D., 5219 Farrington Rd., Washington, D.C. 20016 (F-1, 7)

IRVING, GEORGE W., Jr., Ph.D., 4836 Langdrum Lane, Chevy Chase, Md. 20015 (F-4, 27)

IRWIN, GEORGE R., Ph.D., 7306 Edmonston Rd., College Park, Md. 20740 (F-1, 6)

ISBELL, H.S., 4704 Blagden Ave., N.W., Washington, D.C. 20011 (F-4)

J

JACKSON, H.H.T., Ph.D., 122 Pincecrest Rd., Durham, N.C. (E-3)

JACOBS, WOODROW C., Ph.D., 6309 Bradley Blvd., Bethesda, Md. 20034 (F-23)

JACOBSON, MARTIN, U.S. Dept. of Agriculture, Agric. Research Center, Beltsville, Md. 20705 (F-4, 24)

JACOX, MARILYN E., Ph.D., National Bureau of Standards Washington, D.C. 20234 (F-4)

JAMES, L.H., The James Laboratories, 189 W. Madison St., Chicago, Ill. 60602 (F)

JAMES, MAURICE T., Ph.D., Dept of Entomology, Washington State University, Pullman, Washington 99163 (E-5)

JANI, LORRAINE L., 2733 Ontario Rd., N.W., Washington, D.C. 20009 (M)

JAY, GEORGE E., Jr., Ph.D., National Cancer Inst., Bethesda, Md. 20014 (F-6)

JEN, C.K., Applied Physics Lab., 8621 Georgia Ave., Silver Spring, Md. 20910 (F)

JENKINS, ANNA E., Route 3, Walton, N.Y. 13856 (E-3, 6, 10)

JESSUP, R.S., 7001 W. Greenvale Pkwy., Chevy Chase, Md. 20015 (F-1, 6)

JOHANNESEN, ROLF B., National Bureau of Standards, Washington, D.C. 20234 (F-4)

JOHNSON, DANIEL P., 9222 Columbia Blvd., Silver Spring, Md. 20910 (F-1)

JOHNSON, KEITH C., 4422 Davenport St., N.W., Washington, D.C. 20016 (F)

JOHNSON, PHYLLIS T., Ph.D., Nat. Marine Fisheries Serv., Oxford Lab., Oxford, Md. 21654 (F-5, 6)

JOHNSON, WILBUR V., Apt. 627, 4000 Massachusetts Ave., N.W., Washington, D.C. 20016 (M-1, 4, 31)

JOHNSTON, FRANCIS E., 307 W. Montgomery Ave., Rockville, Md. 20850 (E-1)

JONES, HENRY A., Desert Seed Co., Inc., Box 181, El Centro, Calif. 92243 (F)

JORDAN, GARY BLAKE, 7185 So. Birch Way, Littleton, Colo. 80122 (M-13)

JUDD, NEIL M., Georgian Towers, Apt. 120-C, 8715 First Ave., Silver Spring, Md. 20910 (E)

JUDSON, LEWIS V., Ph.D., 314 Main St., Cumberland Center, Maine 04021 (E-1, 6)

K

KAISER, HANS E., 433 South West Dr., Silver Spring, Md. 20901 (M-6)

KARLE, ISABELLA, Code 6030, U.S. Naval Res. Lab., Washington, D.C. 20390 (F)

KARLE, JEROME, Code 6030, U.S. Naval Research Lab., Washington, D.C. 20390 (F-1, 4)

KARR, PHILIP R., 5507 Calle de Arboles, Torrance, Calif. 90505 (F-13)

KARRER, ANNIE M.H., Port Republic, Md. 20676 (E)

KARRER, S., Port Republic, Md. 20676 (F-1, 4, 6, 31, 32)

KAUFMAN, H.P., Box 1135, Fedhaven, Fla. 33854 (F-12)

KEARNEY, PHILIP C., Ph.D., 13021 Blairmore St., Beltsville, Md. 20705 (F-4)

KEGELES, GERSON, RFD 2, Stafford Springs, Conn. 06076 (F)

KENNARD, RALPH B., Ph.D., 3017 Military Rd., N.W., Washington, D.C. 20015 (E-1, 6, 31, 32)

KENNEDY, E.R., Ph.D., Biology Department, Catholic University, Washington, D.C. 20017 (F-16)

KESSLER, KARL G., Ph.D., Atomic Physics Division, National Bureau of Standards, Washington, D.C. 20234 (F-1, 6, 32)

KEULEGAN, GARBIS H., 215 Buena Vista Dr., Vicksburg, Miss. 39180 (F-1, 6)

KING, PETER, 1120 Cameron Rd., Alexandria, Va. 22308 (F-1, 4, 6)

KINNEY, J.P., Hartwick, Otsego County, N.Y. 13348 (E-11)

KLEBANOFF, PHILIP S., Aerodynamics Sect., National Bureau of Standards, Washington, D.C. 20234 (F-1, 22)

KLINGSBERG, CYRUS, Natl. Academy of Sciences, 2101 Constitution Ave., Washington, D.C. 20418 (F-28)

KLUTE, CHARLES H., Apt. 118, 4545 Connecticut Ave., N.W., Washington, D.C. 20008 (F-1, 4)

KNAPP, DAVID C., 4855 Ricava Dr., Boulder, Colo. 80303 (F)

KNIPLING, EDWARD F., Ph.D., Sc.D., Science Advisor, ARS-OA, USDA, Room 205, Nat. Agr. Library, Beltsville, Md. 20705 (F-5)

KNIPLING, PHOEBE H., Ph.D., 2623 N. Military Rd., Arlington, Va. 22207 (F)

KNOBLOCK, EDWARD C., 12002 Greenleaf Ave., Rockville, Md. 20854 (F-4, 19)

KNOPF, ELEANORA B., Ph.D., Sch. of Earth Sciences, Stanford Univ., Stanford, Calif. 94305 (E)

KNOWLTON, KATHRYN, Apt. 837, 2122 Massachusetts Ave., N.W., Washington, D.C. 20008 (F-4, 19)

KNOX, ARTHUR S., M.A., M.Ed., U.S. Geological Survey, Washington, D.C. 20006 (M-6, 7)

KOHLER, HANS W., 607 Owl Way, Bird Key, Sarasota, Fla. 33577 (F-6, 13, 31)

KOHLER, MAX A., NOAA Office of Hydrology, Natl. Weather Serv., Silver Spring, Md. 20910 (F-18, 23)

KRAUSS, ROBERT W., Dept. Botany, Univ. of Maryland, College Park, Md. (F)

KRUGER, JEROME, Ph.D., Rm B254, Materials Bldg., Natl. Bur. of Standards, Washington, D.C. 20234 (F-4, 29)

KULLBACK, SOLOMON, Statistics Dept., George Washington Univ., Washington, D.C. 20006 (F-13)

KULLERUD, GUNNAR, Sc.D., Head, Dept. Geosciences, Purdue Univ., Lafayette, Ind. 47907 (F-6)

KURTZ, FLOYD E., 8005 Custer Rd., Bethesda, Md. 20014 (F-4)

KURZWEG, HERMAN H., 731 Quaint Acres Dr., Silver Spring, Md. 20904 (F-1, 22)

KUSHNER, LAWRENCE M., Ph.D., Dept. Dr., Natl. Bur. of Standards, Washington, D.C. 20234 (F-36)

L

LADO, ROBERT, Ph.D., Georgetown Univ., Washington, D.C. 20007 (F)

LAKI, KOLOMAN, Ph.D., Bldg. 4, Natl. Inst. of Health, Bethesda, Md. 20014 (F)

LAKIN, HUBERT W., U.S. Geological Survey, Bldg. 25, Denver Fed. Ctr., Denver, Colo. 80201 (F)

LAMANNA, CARL, Ph.D., 3812 37th St., N., Arlington, Va. 22207 (F-16, 19)

LAMBERTON, BERENICE, Georgetown Univ. Observ., Washington, D.C. 20007 (M)

LANDER, JAMES F., Nat. Earthquake Info. Center, NOAA, ERL, R101S, Boulder, Colo. 80302 (F)

LANDIS, PAUL E., 6304 Landon Lane, Bethesda, Md. 20034 (F-6)

LANDSBERG, H. E., 5116 Yorkville Rd., Temple Hills, Md. 20031 (F-1, 23)

LANG, WALTER B., M.S., Kennedy-Warren, Washington, D.C. 20008 (E–4, 6, 7, 36)

LANG, MARTHA E.C., Kennedy-Warren, Washington, D.C. 20008 (F-6, 7)

LANGFORD, GEORGE S., Ph.D., 4606 Hartwick Rd., College Park, Md. 20740 (F-5, 24)

LAPHAM, EVAN G., 5340 Cortez Ct., Cape Coral, Fla. 33904 (E)

LASHOF, THEODORE W., 10125 Ashburton Lane, Bethesda, Md. 20034 (F)

LASTER, HOWARD J., Ph.D., Dept. of Physics & Astron., Univ. of Maryland, College Park, Md. 10742 (F-1, 31)

LATTA, RANDALL, 2122 California St., N.W., Washington, D.C. 20008 (E-5)

LAYMAN, JOHN, Ed.D., Science Teaching Center, Univ. Maryland, College Park, Md. 20742 (M)

LE CLERG, ERWIN L., 14620 Deerhurst Terrace, Silver Srping, Md. 20906 (E)

LEE, RICHARD H., RD 2, Box 143E, Lewes, Delaware 19958 (E)

LEINER, ALAN L., Hopinson House, 602 Washington Square So., Philadelphia, Pa. 19106 (F)

LEJINS, PETER P., Univ. of Maryland, Dept. of Sociology, College Park, Md. 20742 (F-10)

LENTZ, PAUL LEWIS, 5 Orange Ct., Greenbelt, Md. 20770 (F-6, 10)

LEOPOLD, LUNA B., Room 3203, 95 A Bldg., Washington, D.C. 20242 (F)

LEVERTON, RUTH M., Ph.D., Office of Administrator, ARS, USDA, Washington, D.C. 20250 (F)

LEVIN, ERNEST M., 7716 Sebago Rd., Bethesda, Md. 20034 (F-4, 28)

LEVY, SAMUEL, 2279 Preisman Dr., Schenectady, N.Y. 12309 (F)

LEWIS, KEITH H., Ph.D., 1701 No. Kent, Apt. 1006, Arlington, Va. 22209 (M)

LEY, HERBERT L., Jr., M.D., P.O. Box 34434, Bethesda, Md. 20034 (F-6, 8, 16)

LI, HUI-LIN, The Morris Arboretum, Chestnut Hill, Philadelphia, Pa. 19118 (F)

LIDDEL, URNER, 4600 Connecticut Ave., N.W., Apt. 617, Washington, D.C. 20008 (E-1)

LIEBERMAN, MORRIS, 107 Delford Ave., Silver Spring, Md. 20904 (F-4, 6, 33)

LINDQUIST, ARTHUR W., Rte. 1, Bridgeport, Kans. 67424 (E-6)

LINDSEY, IRVING, M.A., 202 E. Alexandria Ave., Alexandria, Va. 22301 (E)

LING, LEE, Food & Agri. Organ. of U.N., Viale Delle, Terme Di Caracalla, Rome, Italy (F)

LINK, CONRAD B., Dept. of Horticulture, Univ. of Maryland, College Park, Md. 20742 (F-6, 10)

LINNENBOM, VICTOR J., Ph.D., Code 8300, Naval Res. Lab., Washington, D.C. 20390 (F-4)

LIST, ROBERT J., 1123 Hammond Pkwy., Alexandria, Va. 22302 (F-23)

LITTLE, ELBERT L., Jr., Ph.D., U.S. Forest Service, Washington, D.C. 20250 (F-10, 11)

LLOYD, DANIEL BOONE, 5604 Overlea Rd., Sumner, Washington, D.C. 20016 (F-6)

LOCKARD, J. DAVID, Ph.D., Botany Dept., Univ. of Maryland, College Park, Md. 20742 (M-33)

LOCKHART, LUTHER B., Ph.D., 6820 Wheatley Ct., Falls Church, Va. 22042 (F-4)

LONG, AUSTIN, 2715 E. Helen St., Tucson, Ariz. 85716 (F)

LORING, BLAKE M., Sc.D., 8104 Carey Branch Dr., Oxon Hill, Md. 20022 (F-20, 36)

LUSTIG, ERNEST, Ph.D., FDA, HEW, BF-145, Washington, D.C. 20204 (F-4)

LYMAN, JOHN, Ph.D., 404 Clayton Rd., Chapel Hill, N.C. 27514 (F-23)

LYNCH, MRS. THOMAS J., 4960 Butterworth Pl., N.W., Washington, D.C. 20016 (M)

M

MA, TE-HSIU, Dept. of Biological Science, Western Illinois Univ., Macomb, Ill. 61455 (F-3)

MAC DONALD, TORRENCE H., 622 Chain Bridge Rd., McLean, Va. 22101 (M)

MADDEN, ROBERT P., A251 Physics Bldg., Natl. Bureau of Standards, Washington, D.C. 20034 (F-32)

MAENGWYN-DAVIES, G.D., Ph.D., 2909 34th St., N.W., Washington, D.C. 20008 (F-4, 6, 19)

MAGIN, GEORGE B., Jr., 7412 Ridgewood Ave., Chevy Chase, Md. 20015 (F-6, 7, 26)

MAHAN, A.I., 10 Millgrove Gardens, Ednor, Md. 20904 (F-1)

MAIENTHAL, MILLARD, 10116 Bevern Lane, Potomac, Md. 20854 (F-4)

MALONEY, CLIFFORD J., Bureau of Biologics, FDA, Bethesda, Md. 20014 (F)

MANDEL, H. GEORGE, Ph.D., Dept. of Pharmacology, George Washington Univ. Sch. of Med., 1339 H St., N.W., Washington, D.C. 20005 (F-4, 19)

MANDEL, JOHN, A345 Chemistry Bg., Natl. Bur. of Standards, Washington, D.C. 20234 (F-1)

MANNING, JOHN R., Metal Physics Section, Natl. Bur. of Standards, Washington, D.C. 20234 (F-20)

MARCUS, MARVIN, Ph.D., Dept. Mathematics, Univ. of California, Santa Barbara, Calif. 93106 (F-6)

MARGOSHES, MARVIN, Ph.D., 69 Midland Ave., Tarrytown, N.Y. 10591 (F)

MARSHALL, LOUISE H., Div. Med. Sci., Room 351 NAS-NRC, 2101 Constitution Ave., Washington, D.C. 20418 (F)

MARSHALL, WADE H., 4209 Everett St., Kensington, Md. 20795 (F-1)

MARTIN, BRUCE D., P.O. Box 234, Leonardtown, Md. 20650 (F-7)

MARTIN, JOHN H., 124 N.W. 7th St., Apt. 303, Corvallis, Oregon 97330 (E-6)

MARTIN, ROBERT H., 2257 N. Nottingham St., Arlington, Va. 22205 (M-23)

MARTON, L., Ph.D., Editorial Office, 4515 Linnean Ave., N.W., Washington, D.C. 20008 (E-1, 13)

MARVIN, ROBERT S., Natl. Bur. of Standards, A537 Admin., Washington, D.C. 20234 (F-1, 4, 6)

MARYOTT, ARTHUR A., Natl. Bur. of Standards, Washington, D.C. 20234 (F-4, 6)

MARZKE, OSCAR T., Westchester Dr., Pittsburgh, Pa. 15215 (F-14, 20)

MASON, HENRY LEA, Sc.D., 7008 Meadow Lane, Chevy Chase, Md. 20015 (F-1, 6, 14, 35)

MASSEY, JOE T., Ph.D., 10111 Parkwood Dr., Bethesda, Md. 20014 (F)

MATHERS, ALEX P., 320A Mansion Dr., Alexandria, Va. 22302 (F-4)

MATLACK, MARION, Ph.D., 2700 N. 25th St., Arlington, Va. 22207 (E)

MAUSS, BESSE D., Rural Rt. 1, New Oxford, Pa. 17350 (F)

MAXWELL, LOUIS R., Ph.D., 3506 Leland St., Chevy Chase, Md. 20015 (F)

MAY, DONALD C., Jr., Ph.D., 5931 Oakdale Rd., McLean, Va. 22101 (F)

MAY, IRVING, U.S. Geological Survey, Washington, D.C. 20242 (F-4, 7)

MAYER, CORNELL H., 1209 Villamay Blvd., Alexandria, Va. 22307 (F-1, 6, 13)

MAYOR, JOHN R., A.A.A.S., 1515 Massachusetts Ave., N.W., Washington, D.C. 20005 (F)

MAZUR, JACOB, Natl. Bureau of Standards, Washington, D.C. 20234 (F-6)

MC BRIDE, GORDON W., Ch.E., 100 Park Ave., Suite 2209, New York, N.Y. 10017 (F)

MC CAMY, CALVIN S., All Angels Hill Rd., Wappingers Falls, N.Y. 12590 (F-32)

MC CLELLAN, WILBUR D., Ph.D., Agr. Res. Center (West), USDA, Beltsville, Md. 20705 (F-6, 10)

MC CLURE, FRANK T., 810 Copley Lane, R.F.D. 1, Silver Spring, Md. 20904 (F-1, 4)

MC CULLOUGH, JAMES M., Ph.D., 6209 Apache St., Springfield, Va. 22150 (M)

MC CULLOUGH, N.B., Ph.D., M.D., Dept. of Microbiology & Public Health, Michigan State Univ., East Lansing, Mich. 48823 (F-6, 8)

MC ELHINNEY, JOHN, Ph.D., 11601 Stephen Rd., Silver Spring, Md. 20904 (F-1)

MC GRATH, JAMES R., Ph.D., 5900 Madawaska Rd., Washington, D.C. 20016 (M-25)

MC GUNIGAL, THOMAS E., J.D., 13013 Ingleside Dr., Beltsville, Md. 20705 (F-1, 13)

MC INTOSH, ALLEN, 4606 Clemson Rd., College Park, Md. 20740 (E-6, 15)

MC KEE, S. A., 5431 Lincoln St., Bethesda, Md. 20034 (F)

MC KELVEY, VINCENT E., Ph.D., 6601 Broxburn Dr., Bethesda, Md. 20034 (F-7)

MC KENZIE, LAWSON M., 5311 Westpath Way, Washington, D.C. 20016 (F-1)

MC KIBBEN, EUGENE G., Ph.D., 4226 Longfellow St., Hyattsville, Md. 20781 (F-12)

MC KINNEY, HAROLD H., 1620 N. Edgewood St., Arlington, Va. 22201 (E-6, 10, 16, 33)

MC KOWN, BARRETT L., M.S., 3580 So. River Terr., Edgewater, Md. 21037 (M-6)

MC MILLEN, J. HOWARD, Ph.D., 4200 Stanford St., Chevy Chase, Md. 20015 (E)

MC MURDIE, HOWARD F., Natl. Bur. of Standards, Washington, D.C. 20234 (F-28)

MC NESBY, JAMES R., Natl. Bur. of Standards 223.53, Washington, D.C. 20234 (F)

MC PHEE, HUGH C., 3450 Toledo Terrace, Atp. 425, Hyattsville, Md. 20782 (E-6)

MC PHERSON, ARCHIBALD T., Ph.D., 4005 Cleveland St., Kensington, Md. 20795 (F-1, 4, 6, 27)

MEADE, BUFORD K., NOAA–National Ocean Survey, Washington Science Ctr., Rockville, Md. 20852 (F-17)

MEARS, FLORENCE, Ph.D., 8004 Hampden Lane, Bethesda, Md. 20014 (F)

MEARS, THOMAS W., B.S., 2809 Hathaway Terrace, Wheaton, Md. 20906 (F-1, 4, 6)

MEBS, RUSSELL W., Ph.D., 6620 32nd St., N., Arlington, Va. 22213 (F-12, 20)

MEINKE, W. WAYNE, Ph.D., Analytical Chemistry Div., Natl. Bur. of Standards, Washington, D.C. 20234 (F-4)

MELMED, ALLAN J., 732 Tiffany Court, Gaithersburg, Md. 20760 (F)

MENDLOWITZ, HAROLD, 708 Lamberton Dr., Silver Spring, Md. 20902 (F)

MENIS, OSCAR, Analytical Chem. Div., Natl. Bureau of Standards, Washington, D.C. 20234 (F)

MERRIAM, CARROLL F., Prospect Harbor, Maine 04669 (F-6)

MEYERHOFF, HOWARD A., 3625 S. Florence Pl., Tulsa, Okla. 74105 (F-7)

MEYERSON, MELVIN R., Ph.D., Rm. A349, Bldg. 224, National Bureau of Standars, Washington, D.C. 20234 (F-20)

MEYKAR, OREST A., P.E., 200 E. Luray Ave., Alexandria, Va. 22301 (M-13, 14)

MEYROWITZ, ROBERT, 555 Thayer Ave., Apt. 209, Silver Spring, Md. 20910 (F-4)

MICHAELIS, ROBERT E., National Bureau of Standards, Chemistry Bldg., Rm. B330, Washington, D.C. 20234 (F-20)

MICKEY, WENDELL V., 1965 KOHLER Dr., Boulder, Colo. 80303 (F)

MIDDLETON, H. E., 430 E. Packwood, Apt. H-108, Maitland, Fla. 32751 (E)

MIDER, G. BURROUGHS, M.D., Exec. Off., Amer. Soc. Exper. Path. & Univ. Assoc. Res. & Educ. Pathol., 9650 Rockville Pike, Bethesda, Mr. 20014 (F)

MILLAR, DAVID B., NMRI, NNMC, Environmental Biosciences Dept., Physical Biochemistry Div., Washington, D.C. 20014 (F)

MILLER, CARL F., 18 W. Windsor Ave., Alexandria, Va. 22301 (E-/0

MILLER, CLEM O., Ph.D., 6343 Nicholson St., Falls Church, Va. 22044 (F-4, 6)

MILLER, J. CHARLES, 10600 Eastbaurne Ave., Apt. 7, W. Los Angles, Calif. 90024 (E-7)

MILLER, PAUL R., Ph.D., Fort Valley State College, Box 889, Ft. Valley, Ga. 31030 (F-10)

MILLER, RALPH L., Ph.D. 5215 Abington Rd., Washington, D.C. 20016 (F-7)

MILLER, ROMAN R., 1232 Pinecrest Circle, Silver Spring, Md. 20910 (F-4, 6, 28)

MILLIGAN, DOLPHUS E., Ph.D., National Bureau of Standards, Washington, D.C. 20234 (F-4)

MILLIKEN, LEWIS T., SSL Res. Inst., 43-20, NHTSA, 400 7th St., S.W., Washington, D.C. 20590 (M-1, 4, 7)

MILTON, CHARLES, Dept. of Geology, George Washington Univ., Washington, D.C. 20006 (F-7)

MITCHELL, J. MURRAY, Jr., Ph.D., 1106 Dogwood Dr., McLean, Va. 22101 (F-6, 23)

MITCHELL, JOHN W., 9007 Flower Ave., Silver Spring, Md. 20901 (F)

MITTLEMAN, DON, 80 Parkwood Lane, Oberlin, Ohio 44074 (F)

MIZELL, LOUIS R., 108 Sharon Lane, Greenlawn, N.Y. 11740 (F)

MOEZIE, FATEMEH TAYMOORIAN, 5432 N. 24th St., Arlington, Va. 22205 (M)

MOHLER, FRED L., Ph.D., 2853 Brandywine St., N.W., Washington, D.C. 20008 (E-1)
MOLLARI, MARIO, 4527 45th St., N.W., Washington, D.C. 20016 (E-3, 5, 15)
MOLLER, RAYMOND W., Ph.D., Catholic Univ. of America, Washington, D.C. 20017 (F)
MOORE, GEORGE A., Ph.D., Natl. Bur. of Standards 312.03, Washington, D.C. 20234 (F-6, 20, 29, 36)
MOORE, HARVEY C., Dept. of Anthropology, American Univ., Washington, D.C. 20016 (F-2)
MORAN, FREDERICK A., 7711 Kipling Pkwy., Washington, D.C. 20028 (M-23)
MORRIS, J.A., 23-E Ridge Rd., Greenbelt, Md. 20770 (M-6, 15, 16)
MORRIS, JOSEPH BURTON, Chemistry Dept. Howard Univ., Washington, D.C. 20001 (F)
MORRIS, KELSO B., Howard Univ., Washington, D.C. 20001 (F-4)
MORRISS, DONALD J., 102 Baldwin Ct., Pt. Charlotte, Fla. 33950 (E-11)
MORTON, JOHN D., M.A., 10217 Forest Ave., Fairfax, Va. 22030 (F-16, 23)
MOSHMAN, JACK, LEASCO, Inc., 4033 Rugby Ave., Bethesda, Md. 20014 (M-34)
MOSTOFI, F.K., M.D., Armed Forces Inst. of Pathology, Washington, D.C. 20305
MUEHLHAUSE, C.O., Ph.D., 9105 Seven Locks Rd., Bethesda, Md. 20034 (F-1, 26)
MUELLER, H.J., 4801 Kenmore Ave., Alexandria, Va. 22304 (F)
MUESEBECK, CARL F.W., U.S. Natl. Museum, Washington, D.C. 20560 (E-3, 5)
MURDOCH, WALLACE P., Ph.D., Rt. 2, Gettysburg, Pa. 17325 (F-5)
MURPHY, LEONARD M., Seismology Div., U.S. Nat. Ocean Surv., Rockville, Md. 20852 (F)
MURRAY, WILLIAM S., 1281 Bartonshire Way, Potomac Woods, Rockville, Md. 20854 (F-5)
MYERS, ALFRED T., USGS Geochemistry & Petr., Denver Federal Ctr., Denver, Colo. 80225 (F-4, 6)
MYERS, RALPH D., Physics Dept., Univ. of Maryland, College Park, Md. 20740 (F-1)
MYERS, WILLIAM H., Natl. Oceanographic Data Ctr., Washington, D.C. 20390 (M)

N

NAESER, CHARLES R., Ph.D., 6654 Van Winkle Dr., Falls Church, Va. 22044 (F-4, 7)
NAMIAS, JEROME, Sc.D., 2251 Sverdrup Hall, Scripps Institution of Oceonography, La Jolla, Calif. 92037 (F-23)
NELSON, R.H., 7309 Finns Lane, Lanham, Md. 20801 (E-5, 6, 24)
NEPOMUCENE, SR. St. JOHN, Villa Jolie, Valley Rd., Stevenson, Md. 21153 (E-4)
NEUENDORFFER, J.A., 911 Allison St., Alexandria, Va. 22302 (F-6, 34)
NEUSCHEL, SHERMAN K., U.S. Geological Survey, Washington, D.C. 20242 (F-7)
NEWMAN, MORRIS, Natl. Bur. of Standards, Washington, D.C. 20234 (F)
NEWMAN, SANFORD B., Ph.D., Room A1000 Administration Bldg., Natl. Bur. of Standards, Washington, D.C. 20234 (F)
NEWTON, CLARENCE J., Ph.D., 1504 S. 2nd Ave., Edinburg, Texas 78539 (E)
NICKERSON, DOROTHY, 2039 New Hampshire Ave., Washington, D.C. 20009 (E-6, 32)
NIKIFOROFF, C.C., 4309 Van Buren St., University Park, Hyattsville, Md. 20782 (E)
NIRENBERG, MARSHALL W., 7001 Orkney Pkwy., Bethesda, Md. 20034 (F-4)
NOFFSINGER, TERRELL L., Spec. Weather Serv. Br., NOAA/NWS, Gramax Bldg., Silver Spring, Md. 20910 (F-23)
NOLLA, J.A.B., Ph.D., Apartado 820, Mayaguez, Puerto Rico 00708 (F-6)
NORRIS, KARL H., 11204 Montgomery Rd., Beltsville, Md. 20705 (F-27)
NOYES, HOWARD E., 4807 Aspen Hill Rd., Rockville, Md. 20853 (F-16, 19)

O

O'BRIEN, JOHN A., Ph.D., Dept. of Biology, Catholic Univ. of America, Washington, D.C. 20017 (F-10)
O'HERN, ELIZABETH M., Ph.D., 633 G St., S.W., Washington, D.C. 20024 (M-16)
O'KEEFE, JOHN A., Code 640, Goddard Space Flight Ctr., Greenbelt, Md. 20771 (F-1)
OBOURN, ELLSWORTH S., Ph.D., 2100 S. Ocean Dr., Apt. 2CD, Ft. Lauderdale, Fla. 33316 (E-1, 6)
OEHSER, PAUL H., 9012 Old Dominion Dr., McLean, Va. 22101 (F-1, 3, 9, 30)
OKABE, HIDEO, Ph.D., A243, 222, Natl. Bur. of Standards, Washington, D.C. 20234 (F-4)
OLIPHANT, MALCOLM W., Ph.D., Hawaii Loa Coll., P.O. Box 764, Kaneohe, Oahu, Haw. 96744 (F)
OLSEN, HAROLD W., Br. of Engr. Geol., U.S. Geological Survey, 345 Middlefield Rd., Menlo Park, Calif. 94025 (M)
OLSON, JOSEPH C., Ph.D., BF-210, Food & Drug Admin., 200 C St., N.W., Washington, D.C. 20204 (M-16, 27)
OLTJEN, ROBERT R., 3514 Susquehanna Dr., Beltsville, Md. 20705 (F)
ORDWAY, FRED, Ph.D., 5205 Elsmere Ave., Bethesda, Md. 20014 (F-4, 6, 20, 28)
ORLIN, HYMAN, NOAA-NOS, Rockville, Md. 20852 (F-17)
OSER, HANS J., 8810 Quiet Stream Ct., Potomac, Md. 20852 (F-6)
OSGOOD, WILLIAM R., Ph.D., 2756 Macomb St., N.W., Washington, D.C. 20008 (E-14, 18)
OSWALD, ELIZABETH J., Genetic Toxicology Br., FDA, 200 C. St. N.W., Washington, D.C. 20204 (F-16)

OWENS, JAMES P., M.A. 14528 Bauer Dr., Rockville, Md. 20853 (F-7)

P

PACK, DONALD H., 1826 Opalacka Dr., McLean, Va. 22101 (F-23)

PAFFENBARGER, GEORGE C., D.D.S., ADA Res. Div., Natl. Bur. of Standards, Washington, D.C. 20234 (F-21)

PAGE, BENJAMIN L., 1340 Locust Rd., Washington, D.C. 20012 (E-1, 6)

PAGE, CHESTER H., 15400 Layhill Rd., Silver Spring, Md. 20906 (F-1, 6, 13)

PAGE, R.M., 10222 Berkshire Rd., Bloomington, Minn. 55437 (F-13)

PARK, J. HOWARD, 3614 59th Ave., S.W., Seattle, Washington 98116 (F-13)

PARKER, KENNETH W., 6014 Kirby Rd., Bethesda, Md. 20034 (E-3, 10, 11)

PARMAN, GEORGE K., c/o UNIDO, P.O. Box 837, A-1011, Vienna, Austria (F-27)

PARR, L.W., 302 Scientists Cliffs, Port Republic, Md. 20676 (E-16, 19)

PARRY, H. DEAN, NOAA-National Weather Service, Gramax Bldg., 8060 13th St., Silver Spring, Md. 20910 (F-13, 23, 35)

PASSER, MOSES, Ph.D., 6647 32nd Pl., N.W., Washington, D.C. 20015 (F)

PATTERSON, GLENN W., 8916 2nd St., Lanham, Md. 20801 (F-4, 33)

PATTERSON, WILBUR I., Ph.D., Blakely Island, Washington 98222 (F)

PAYNE, L.E., Dept. Math., Cornell Univ., Ithaca, N.Y. 14850 (F)

PEISER, H. STEFFEN, 638 Blossom Dr., Rockville, Md. 20850 (F-1, 4, 28)

PELCZAR, MICHAEL J., Jr., Vice-Pres. for Grad. Studies & Research, Center of Adult Education, Univ. of Maryland, College Park, Md. 20742 (F)

PELL, WILLIAM H., National Science Fndn. 1800 G St., N.W., Washington, D.C. 20550 (F-6, 14)

PERROS, THEODORE P., Ph.D., Dept. of Chemistry, George Washington Univ., Washington, D.C. 20006 (F-1, 4)

PHAIR, GEORGE, Ph.D., 14700 River Rd., Potomac, Md. 20854 (F-7)

PHILLIPS, MRS. M. LINDEMAN, Union Farm, Mount Vernon, Va. 22121 (F-1, 13, 25)

PIKL, JOSEF, 211 Dickinson Rd., Glassboro, N.J. 08028 (E)

PITTMAN, MARGARET, Ph.D., 3133 Connecticut Ave., N.W., Washington, D.C. 20008 (E)

PLOTKIN, HENRY H., 1801 Briggs Rd., Silver Spring, Md. 20906 (F-1)

POLACHEK, HARRY, 12000 Old Georgetown Rd., Rockville, Md. 20852 (E)

POMMER, ALFRED M., 3117 Fayette Rd., Kensington, Md. 20795 (F-4, 7, 19, 35)

POOS, F.W., 3225 N. Albemarle St., Arlington, Va. 22207 (E-5, 6, 26)

POPENOE, WILSON, Antigua, Guatemala, Central America (E-3, 11)

PRESLEY, JOHN T., 3811 Courtney Circle, Bryan, Texas 77801 (E)

PRO, MAYNARD J., 7904 Falstaff Rd., McLean, Va. 22101 (F-26)

PRYOR, C. NICHOLS, Ph.D., Naval Ord. Lab., White Oak, Silver Spring, Md. 20910 (F)

PUTNINS, PAUL H., 10809 Georgia Ave., Apt. 202, Wheaton, Md. 20902 (F-6, 23)

R

RABINOW, JACOB, I.A.T., Nat. Bureau of Standards, Washington, D.C. 20234 (F)

RADER, CHARLES A., 15807 Sherwood Ave., Laurel, Md. 20810 (F-4)

RADO, GEORGE T., Ph.D., 818 Carrie Court, McLean, Va. 22101 (F-1)

RAINWATER, H. IVAN, Plant Protection and Quarantine Programs, APHIS, Fed. Center Bg., Hyattsville, Md. 20782 (E5, 6, 24)

RALL, DAVID P., Director, National Institute of Envir. Health Sciences, P.O. Box 11233, Research Triangle, Raleigh, N.C. 27709 (F-6, 19)

RAMBERG, WALTER, Stone Hall, Cuba Rd., Cockysville, Md. 21030 (E-1)

RAPPLEYE, HOWARD S., 6712 4th St., N.W., Washington, D.C. 20012 (E-1, 6, 12, 17, 18)

RAUSCH, ROBERT, Arctic Health Res. Center, U.S. Public Health Service, Fairbanks, Alaska 99701 (F-3, 15)

RAVITSKY, CHARLES, M.S., 1808 Metzerott Rd., Adelphi, Md. 20783 (F-32)

READING, O.S., 6 N. Howells Point Rd., Bellport Suffolk County, New York, N.Y. 11713 (E-1)

REAM, DONALD F., Halavallagata 9, Reykjavik, Iceland (F)

RECHCIGL, MILOSLAV, Jr., 1703 Mark Lane, Rockville, Md. 20852 (F-4, 19)

REED, WILLIAM D., 3609 Military Rd., N.W., Washington, D.C. 20015 (F-5, 6)

REEVE, WILKINS, 4708 Harvard Rd., College Park, Md. 20740 (F-4)

REEVES, ROBERT G., Ph.D., 12524 W. Virginia Ave., Denver, Colo. 80228 (F-7, 14)

REGGIA, FRANK, 6207 Kirby Rd., Bethesda, Md. 20034 (F-6, 13)

REHDER, HARALD A., U.S. National Museum of Nat. Hist., Washington, D.C. 20560 (F-3, 6)

REICHELDERFER, F.W., 3031 Sedgwick St., N.W., Washington, D.C. 20008 (F-1, 6, 22, 23)

REINHART, FRANK W., 9918 Sutherland Rd., Silver Spring, Md. 20901 (F-4, 6)

REINHART, FRED M., P.O. Box 591, Oak View, Calif. 93022 (F-20)

REINING, PRISCILLA, 3601 Rittenhouse St., N.W., Washington, D.C. 20015 (F-2)

REITEMEIER, R.F., 7563 Spring Lake Dr., Bethesda, Md. 20034 (F)

REYNOLDS, ORR E., 2134 LeRoy Place, N.W., Washington, D.C. 20008 (F)

RHODES, IDA, 6676 Georgia Ave., N.W., Washington, D.C. 20012 (F)

RICE, DONALD A., 1518 East West Highway, Silver Spring, Md. 20910 (F)

RICE, FREDERICK A.H., 8005 Carita Court, Bethesda, Md. 20034 (F-4, 6, 19)

RICKER, P.L., 623 Town House Motor Hotel, San Angelo, Texas 76901 (E)

RINEHART, JOHN S., 756 Sixth St., Boulder, Colo. 80302 (F-6, 20)

RIOCH, DAVID McK., M.D., 2429 Linden Lane, Silver Spring, Md. 20910 (F-3, 8)

RITT, P.E., Ph.D., GTE Laboratories, Inc., 40 Sylvan Rd., Waltham, Mass. 02154 (F)

RITTS, ROY E., Jr., Dept. of Microbiology, Mayo Clinic, Rochester, Minn. 55901 (F)

RIVELLO, ROBERT M., Dept. of Aerospace Engng., Univ. of Maryland, College Park, Md. 20740 (F-14, 22)

RIVLIN, RONALD S., Lehigh University, Bethlehem, Pa. 18015 (F)

ROBBINS, MARY LOUISE, Ph.D., George Washington Univ. Sch. of Med., 1339 H St., N.W., Washington, D.C. 20005 (F-6, 16, 19)

ROBERTS, ELLIOT B., 4500 Wetherill Rd., Washington, D.C. 20016 (E-1, 18)

ROBERTS, RICHARD B., Ph.D., Dept. Terrestrial Mag., 5241 Broad Branch Rd., N.W., Washington, D.C. 20015 (F)

ROBERTS, RICHARD C., 5170 Phantom Court, Columbia, Md. 21044 (F-6)

ROBERTSON, A.F., Ph.D., 4228 Butterworth Pl., N.W., Washington, D.C. 20016 (F)

ROBERTSON, RANDAL M., Ph.D., 1404 Highland Circle, S.E., Blacksburg, Va. 24060 (F-1, 6)

ROCK, GEORGE D., Ph.D., The Kennedy Warren, 3133 Conn. Ave., N.W., Washington, D.C. 20008 (E)

RODNEY, WILLIAM S., 8112 Whites Ford Way, Rockville, Md. 20854 (F-1, 32)

RODRIGUEZ, RAUL, 3533 Martha Custis Drive, Alexandria, VA. 22302 (F-17)

ROGERS, L.A., Patten, Maine 04765 (E-16)

ROLLER, PAUL S., 825 Colorado Bldg., 1341 G St., N.W., Washington, D.C. 20005 (E)

ROMNEY, CARL F., 4105 Sulgrave Dr., Alexandria, Va. 22309 (F-7)

ROSADO, JOHN A., 1709 Great FAlls St., McLean, Va. 22101 (F)

ROSENBLATT, DAVID, 2939 Van Ness St., N.W., Apt. 702, Washington, D.C. 2008 (F-1)

ROSENBLATT, JOAN R., 2939 Van Ness St., N.W., Apt. 702, Washington, D.C. 20008 (F-1)

ROSENSTOCK, HENRY M., 10117 Ashburton Lane, Bethesda, Md. 20034 (F)

ROSENTHAL, SANFORD, M., Bldg. 4, Rm. 122, National Insts. of Health, Bethesda, Md. 20014 (E)

ROSS, SHERMAN, National Research Council, 2101 Constitution Ave., N.W., Washington, D.C. 20418 (F)

ROSSINI, FREDERICK D., Dept. Chemistry, Rice Univ., Houston, Tex. 77001 (F-1)

ROTH, FRANK L., M.Sc., Box 441, Nogales Star Rt., Amado, Ariz. 85640 (E-6)

ROTH, ROBERT S., Solid State Chem. Sect., National Bureau of Standards, Washington, D.C. 20234 (F)

ROTKIN, ISRAEL, 11504 Regnid Dr., Wheaton, Md. 20902 (F-1, 13, 34)

RUBIN, MORTON J., M.Sc., Bldg. 5, NOAA, 6010 Executive Bldg., Rockville, Md. 20852 (F-23)

RUBIN, VERA C., Ph.D., 3308 McKinley St., N.W., Washington, D.C. 20015 (F)

RUPP, N.W., D.D.S., American Dental Assoc., Research Division, National Bureau of Standards, Washington, D.C. 20234 (F-21)

RUSSELL, LOUISE M. Bg-A, Agr. Res. Center, (West), USDA, Beltsville, Md. 20705 (F-5)

RYALL, A. LLOYD, Route 2, Box 216, Las Cruces, N. Mex. 88001 (E-6, 10, 27)

RYERSON, KNOWLES A., M.S., Dean Emeritus, 15 Arlmonte Dr., Berkeley, Calif. 94707 (E-6)

S

SAALFIELD, FRED E., Naval Res. Lab., Code 6110, Washington, D.C. 20390 (F-4)

SAENZ, ALBERT W., Nuclear Sciences Div., Naval Research Laboratory, Washington, D.C. 20390 (F)

SAILER, R.I., Ph.D., Bg-A, Agr. Res. Center (West), USDA, Beltsville, Md. 20705 (F-5, 24)

SALISBURY, LLOYD L., 10138 Crestwood Rd., Kensington, Md. 20795 (M)

SAN ANTONIO, JAMES P., Agr. Res. Center (West), USDA, Beltsville, Md. 20705 (M)

SANDERSON, JOHN A., Ph.D., 303 High St., Alexandria, Va. 22203 (F-1, 32)

SANDOZ, GEORGE, Ph.D., Office of Naval Research, Chicago Office, 536 Clark St., Chicago, Ill. 60605 (F-6, 20)

SARVELLA, PATRICIA A., Ph.D., 4513 Romlon St., Apt. 302, Beltsville, Md. 20705 (F-6)

SASMOR, ROBERT M., 12 Old Mamaroneck Rd., White Plains, N.Y. 10605 (F)

SAULMON, E.E., 202 North Edgewood St., Arlington, Va. 22201 (M)

SAVILLE, THORNDIKE, Jr., M.S., 5601 Albia Rd., Washington, D.C. 20016 (F-6, 18)

SAYLOR, CHARLES P., 1001 Riggs Rd., Adelphi, Md. 20783 (F-1, 4, 32)

SCHAFFER, ROBERT, Chemistry A 367, Nat. Bur. Standards, Washington, D.C. 20234 (F)

SCHAMP, HOMER W., Jr., 521 Overdale Rd., Baltimore, Md. 21229 (F-1)

SCHECHTER, MILTON S., 10909 Hannes Court, Silver Spring, Md. 20901 (F-4, 5, 24)

SCHEER, MILTON D., 811 N. Belgrade Rd., Silver Spring, Md. 20902 (F-1, 4)

SCHINDLER, ALBERT I., Sc.D., Code 6330, U.S. Naval Res. Lab., Washington, D.C. 20390 (F-1)

SCHMID, HELLMUT, 20740 Warfield Court, Gaithersburg, Md. 20760 (F-6, 17)

SCHMIDT, CLAUDE H., MRRL, ARS, USDA, State University Sta., Fargo, No. Dak. 58102 (F-5)

SCHMITT, WALDO L., Ph.D., U.S. National Museum, Washington, D.C. 20560 (E-3)

SCHNEIDER, SIDNEY, 239 N. Granada St., Arlington, Va. 22203 (M)

SCHOEN, LOUIS J., 8605 Springdell Pl., Chevy Chase, Md. 20015 (F)

SCHOENEMAN, ROBERT LEE, 217 Sachem Drive, Forest Heights, Washington, D.C. 20021 (F)

SCHOOLEY, ALLEN H., 6113 Cloud Dr., Springfield, Va. 22150 (F-6, 13, 31)

SCHOOLEY, JAMES F., 13700 Darnestown Rd., Gaithersburg, Md. 20760 (F-6)

SCHOONOVER, IRL C., National Bureau of Standards, Washington, D.C. 20234 (F-1, 4)

SCHRECKER, ANTHONY W., Ph.D., National Institutes of Health, Bethesda, Md. 20014 (F-4)

SCHUBAUER, G.B., Ph.D.,, 5609 Gloster Rd., Washington, D.C. 20016 (F-22)

SCHUBERT, Leo, Ph.D., The American Univ., Washington, D.C. 20016 (F-1, 4, 30)

SCHULMAN, JAMES H., 2284 Dunster Lane, Rockville, Md. 20854 (F)

SCHULTZ, E. S., 2 Martins Lane, Benwyn, Pa. 19312 (E-6)

SCHWARTZ, ANTHONY M., Ph.D., Gillette Research Inst., 1413 Research Blvd., Rockville, Md. 20850 (F-4)

SCHWARTZ, BENJAMIN, Ph.D., 888 Montgomery St., Brooklyn, N.Y. 11213 (E)

SCHWERDTFEGER, WILLIAM J., B.S., 9200 Fowler Lane, Lanham, Md. 20801 (F-13)

SCOFIELD, FRANCIS, 2403 Eye St., N.W., Washington, D.C. 20037 (M-4, 32)

SCOTT, DAVID B., D.D.S., Dean, Case Western Reserve Univ., Sch. of Dentistry, 2123 Abington Rd., Cleveland, Ohio 44106 (F-21)

SCRIBNER, BOURDON F., National Bureau of Standards, Washington, D.C. 20234 (F-4, 32)

SEABORG, GLENN T., Ph.D., Lawrence Berkeley Lab., Univ. of California, Berkeley, Calif. 94720 (F)

SEEGER, RAYMOND J., Ph.D., 4507 Wetherill Rd., Washington, D.C. 20016 (E-1, 30, 31)

SEITZ, FREDERICK, Rockefeller University, New York, N.Y. 10021 (F-36)

SERVICE, JERRY H., Ph.D., Cascade Manor, 65 W. 30th Ave., Eugene, Oreg. 97405 (E)

SETZLER, FRANK M., Sc.D., 950 E. Shore Dr., Culver, Ind. 46511 (E-2, 3, 6)

SHAFRIN, ELAINE G., M.S., Apt. N-702, 800 4th St., S.W., Washington, D.C. 20024 (F-4)

SHALOWITZ, A.L., 1520 Kalmia Rd., N.W., Washington, D.C. 20012 (E-17)

SHANAHAN, A. J., 7217 Churchill Rd., McLean, Va. 22101 (F-16)

SHAPIRA, NORMAN, 86 Oakwood Dr., Dunkirk, Md. 20754 (M)

SHAPIRO, GUSTAVE, 3704 Munsey St., Silver Spring, Md. 20906 (F)

SHAPIRO, MAURICE M., Ph.D., U.S. Naval Research Lab., Code 7020, Washington, D.C. 20390 (F-1)

SHELTON, EMMA, National Cancer Institute, Bethesda, Md. 20014 (F)

SHEPARD, HAROLD H., Ph.D., 2701 S. June St., Arlington, Va. 22202 (F-5, 24)

SHERESHEFSKY, J. LEON, Ph.D., 9023 Jones Mill Rd., Chevy Chase, Md. 20015 (E)

SHERLIN, GROVER C., 4024 Hamilton St., Hyattsville, Md. 20781 (F-1, 6, 13, 31)

SHIELDS, WILLIAM ROY, A.M.S.S., Natl. Bur. of Standards, Physics Bldg., Rm. A25, Washington, D.C. 20234 (F)

SHMUKLER, LEON, 151 Lorraine Dr., Berkeley Heights, N.J. 07922 (F)

SHOTLAND, EDWIN, 418 E. Indian Spring Dr., Silver Spring, Md. 20901 (M-1)

SHROPSHIRE, WALTER A., Ph.D., Radiation Bio. Lab., 12441 Parklawn Dr., Rockville, Md. 20852 (F-6, 10, 33)

SIEGLER, EDOUARD HORACE, Ph.D., 201 Tulip Ave., Takoma Park, Md. 20012 (E-5, 24)

SILBERSCHMIDT, KARL M., Instituto Biologico, Caixa Postal 7119, Sao Paulo, Brazil (F)

SILVER, DAVID M., Ph.D., Applied Physics Lab., Johns Hopkins Univ., Silver Spring, Md. 20910 (M-4, 6)

SILVERMAN, SHIRLEIGH, Academic Liaison, Natl. Bur. of Standards, Washington, D.C. 20234 (F-1)

SIMMONS, JOHN A., Rm. A157, Bldg. 223, Natl. Bureau of Standards, Washington, D.C. 20234 (F-1)

SIMMONS, LANSING G., 4425 Dittmar Rd., N., Arlington, Va. 22207 (F-18)

SIMHA, ROBERT, Case Western Reserve Univ., Cleveland, Ohio 44106 (F)

SITTERLY, BANCROFT W., Ph.D., 3711 Brandywine St., N.W., Washington, D.C. 20016 (E-1, 31, 32)

SLACK, LEWIS, 106 Garden Rd. Scarsdale, N.Y. 10583 (F)

SLADEK, JAROMIL V., 2940 28th St., N.W., Washington, D.C. 20008 (F-4)

SLAWSKY, MILTON M., 8803 Lanier Dr., Silver Spring, Md. 20910 (F-6, 12, 22, 31)

SLAWSKY, ZAKA I., Naval Ordnance Lab., White Oak, Silver Spring, Md. 20910 (F)

SLOCUM, GLENN G., 4204 Dresden St., Kensington, Md. 20795 (E-16, 27)

SMITH, BLANCHARD DRAKE, M.S., 2509 Ryegate Lane, Alexandria, Va. 22308 (F-6, 13)

SMITH, EDGAR R., Box 52, Lottsburg, Va. 22511 (E-4)
SMITH, FLOYD F., Ph.D., 9022 Fairview Rd., Silver Spring, Md. 20910 (F-5, 24)
SMITH, FRANCIS A., Ph.D., 1023 55th Ave., South, St. Petersburg, Fla. 33705 (E-6)
SMITH, HENRY LEE, Jr., Ph.D., 112 Depew Ave., Buffalo, N.Y. 14214 (F-2)
SMITH, JACK C., 3708 Manor Rd., Apt. 3, Chevy Chase, Md. 20015 (F)
SMITH, NATHAN R., 322 S. Washington Dr., St. Armands Key, Sarasota, Fla. 33577 (E-6, 10, 16)
SMITH, PAUL A., 4714 26th St., N., Arlington, Va. 22207 (F-6, 7, 18, 22)
SMITH, ROBERT C., Jr., 4200 Peachtree Pl., Alexandria, Va. 22304 (F-4, 22)
SMITH, SIDNEY T., D. Eng., 5811 Sunderland Court, Alexandria, Va. 22310 (F-1, 13, 32)
SMITH, WILLIE, Natl. Insts. of Health, Bethesda, Md. 20014 (F-19)
SNAVELY, BENJAMIN L., 721 Springloch Rd., Silver Spring, Md. 20904 (F-25, 31, 32)
SNAY, HANS G., 17613 Treelawn Dr., Ashton, Md. 20702 (F-6, 25)
SOKOLOVE, FRANK L., 2311 S. Dinwiddie St., Arlington, Va. 22206 (M)
SOLLNER, KARL, Lab. of Physical Bio., Natl. Insts. of Health, Bethesda, Md. 20014 (f-4, 29)
SOLOMON, EDWIN M., 11550 Lockwood Dr., Silver Spring, Md. 20904 (M)
SOMMER, HELMUT, 9502 Hollins Ct., Bethesda, Md. 20034 (F-1, 13)
SONN, MARTIN, Ph.D., Ed.D., 5 Watson Dr., Portsmouth, R.I. 02871 (F)
SORROWS, H.E., 8820 Maxwell Dr., Potomac, Md. 20854 (F)
SPALDING, DONALD H., Ph.D., 17500 S.W. 89th Ct., Miami, Fla. 33157 (F-6, 10)
SPECHT, HEINZ, Ph.D., 4429 Franklin St., Kensington, Md. 20795 (F-1, 6)
SPENCER, LEWIS V., Box 206, Gaithersburg, Md. 20760 (F)
SPERLING, FREDERICK, 1131 University Blvd., W., L1122, Silver Spring, Md. 20902 (F-19)
SPICER, H. CECIL, 2174 Louisa Drive, Belleair Beach, Florida 33534 (E-7)
SPIES, JOSEPH R., 507 N. Monroe St., Arlington, Va. 22201 (F-4)
SPOONER, CHARLES S., Jr., M.F., 346 Springvale Rd., Great Falls, Va. 22066 (F)
SPRAGUE, G.F., 10206 Green Forest Dr., Silver Spring, Md. 20903 (F)
ST GEORGE, R.A., 3305 Powder Mill Rd., Adelphi Station, Hyattsville, Md. 20783 (F-3, 5, 11, 24)
STADTMAN, E.R., Bldg., 3, Rm. 108, Natl. Institutes of Health, Bethesda, Md. 20014 (F)
STAIR, RALPH, P.O. Box 310, Newburg, Oreg. 97132 (E-6)
STAKMAN, E.C., Univ. of Minnesota, Inst. of Agric., St. Paul, Minn. 55101 (E)
STAUSS, HENRY E., Ph.D., 8005 Washington Ave., Alexandria, Va. 22308 (F-20)
STEARN, JOSEPH L., 6950 Oregon Ave., N.W., Washington, D.C. 20015 (F)
STEELE, LENDELL E., 7624 Highland St., Springfield, Va. 22150 (F-20, 26)
STEERE, RUSSELL L., Ph.D., 6207 Carrollton Ter., Hyattsville, Md. 20781 (F-6, 10)
STEGUN, IRENE A., Natl. Bur. of Standards, Washington, D.C. 20234 (F)
STEINER, ROBERT F., 2609 Turf Valley Rd., Ellicott City, Md. 21043 (F-4)
STEINHARDT, JACINTO, Ph.D., Georgetown Univ., Washington, D.C. 20007 (F-4)
STEPHENS, ROBERT E., Ph.D., 4301 39th St., N.W., Washington, D.C. 20016 (F-1, 32)
STERN, KURT H., Ph.D., Naval Res. Lab., Code 6160, Washington, D.C. 20390 (F-4, 29, 30)
STERN, WILLIAM L., Dept. Botany, Univ. of Maryland, College Park, Md. 20742 (F-10)
STEVENS, HENRY, 5116 Brookview Dr., Washington, D.C. 20016 (E)
STEVENS, RUSSELL B., Ph.D., Div. of Biology & Agric. N.R.C., 2101 Constitution Ave., Washington, D.C. 20418 (F-10)
STEVENSON, JOHN A., 4113 Emery Pl., N.W., Washington, D.C. 20016 (E-6, 10)
STEWART, I.E., 4000 Tunlaw Rd., N.W., Washington, D.C. 20007 (F)
STEWART, T. DALE, M.D., 1191 Crest Lane, McLean, Va. 22101 (F-2)
STIEBELING, HAZEL K., 4000 Cathedral Ave., Washington, D.C. 20016 (E)
STIEF, LOUIS J., Ph.D., Code 691, NASA Goddard Space Flight Ctr., Greenbelt, Md. 20771 (F-4)
STIEHLER, ROBERT D., Ph.D., Natl. Bur. of Standards, Washington, D.C. 20234 (F-1, 4, 6, 14)
STILL, JOSEPH W., M.D., 1146 E. Garvey, West Covina, Calif. 91790 (F)
STILLER, BERTRAM, 3210 Wisconsin Ave., N.W., Apt. 501, Washington, D.C. 20016 (F-1)
STIMSON, H.F., 2920 Brandywine St., N.W., Washington, D.C. 20008 (E-1, 6)
STIRLING, MATHEW W., 3311 Rowland Pl., N.W., Washington, D.C. 20008 (F-2, 6)
STRAUB, HAROLD W., Ph.D., 7008 Richard Dr., Bethesda, Md. 20034 (F-32)
STRAUSS, SIMON W., Ph.D., 4506 Cadell Pl., Camp Springs, Md. 20031 (F-4)
STUART, NEIL W., 1341 Chilton Dr., Silver Spring, Md. 20904 (F-10)
SULZBACHER, WILLIAM L., 8527 Clarkson Dr., Fulton, Md. 20759 (F-16, 27)
SWEENEY, WILLIAM T., 8411 Buckland Mill Rd., Gainesville, Va. 22065 (F-16, 21)
SWICK, CLARENCE H., 5514 Brenner St., Capitol Heights, Md. 20027 (F-1, 6, 12)
SWINGLE, CHARLES F., Ph.D., Pauma Valley, Calif. 92061 (E)

SYKES, ALAN O., 304 Mashie Dr., S.E., Vienna, Va. 22180 (M-25)

SYSKI, RYSZARD, Ph.D., Dept. of Mathematics, Univ. of Maryland, College Park, Md. 20742 (F)

T

TALBERT, PRESTON T., Dept. of Chemistry, Howard Univ., Washington, D.C. 20001 (F-4)

TALBOTT, F. LEO, R.D. #4, Bethlehem, Pa. 8015 (F-1, 6, 31)

TASAKI, ICHIJI, M.D., Ph.D., Res. Branch Natl. Insts. of Mental Health, Bethesda, Md. 20014 (F)

TATE, DOUGLAS R., B.A., 11415 Farmland Dr., Rockville, Md. 20852 (F-1)

TAUSSKY, OLGA, California Inst. of Technology, Pasadena, Calif. 91109 (E)

TAYLOR, ALBERT L., 3913 Wyoming Ave., Tampa, Fla. 33616 (E-15)

TAYLOR, JOHN K., Chemistry Bldg., Rm. B-326, Natl. Bur. of Standards, Washington, D.C. 20234 (F-4, 29)

TAYLOR, LAURISTON S., 7407 Denton Rd., Bethesda, Md. 20014 (E)

TAYLOR, MODDIE D., Ph.D., 4560 Argyle Terrace, N.W., Washington, D.C. 20011 (F-4)

TCHEN, CHAN-MOU, City College of New York, Mechanical Engr. Dept., New York, N.Y. 10031 (F)

TEAL, GORDON K., Ph.D., 5222 Park Lane, Dallas, Tex. 75220. (F-6, 13, 29)

TEELE, RAY P., 3713 Jenifer St., N.W., Washington, D.C. 20015 (F-1, 6, 32)

TEPPER, MORRIS, 107 Bluff Terrace, Silver Spring, Md. 20902 (F-22, 23)

THAYER, T.P., Ph.D., U.S. Geological Surv., Washington, D.C. 20242 (F-7)

THEUS, RICHARD B., 8612 Van Buren Dr., Oxon Hill, Md. 20022 (F)

THOM, H.C.S., Cons. Engr., 14310 Bauer Dr., Rockville, Md. 20853 (F-20)

THOMAS, H. REX, Ph.D., 3907 Beechwood Rd., Hyattsville, Md. 20782 (F-10)

THOMAS, JAMES L., 13900 Glen Mill Rd., Rockville, Md. 20850 (F)

THOMPSON, JACK C., 281 Casitas Bulevar, Los Gatos, Calif. 95030 (F)

THURMAN, ERNESTINE B., Louisiana State Univ., 1542 Tulane Ave., New Orleans, La. 70118 (F)

TIDBALL, CHARLES S., Physiology Dept., George Washington Univ., 1339 H St., N.W., Washington, D.C. 20005 (F-8)

TILDEN, EVELYN B., Ph.D., Apt. 1006, 55 West Chestnut St., Chicago, Ill. 60610 (E-6)

TITUS, HARRY W., 7 Lakeview Ave., Andover, N.J. 07821 (E-6)

TODD, MARGARET RUTH, Miss, U.S. Natl. Museum, Washington, D.C. 20560 (F-7)

TOLHURST, GILBERT, Ph.D., 7 Red Fox Lane, Amherst, Mass. 01002 (F)

TOLL, JOHN S., Pres., State Univ. of New York, Stony Brook, L.I., N.Y. 11790 (F)

TORGESEN, JOHN L., Natl. Bur of Standards, Materials Bldg. B-354, Washington, D.C. 20234 (F-4, 6)

TORIO, J.C., 226 Cedar Lane, Apt. 84, Vienna, Va. 22180 (M-4)

TORRESON, OSCAR W., 4317 Maple Ave., Bethesda, Md. 20014 (E-6)

TOUSEY, RICHARD, Ph.D., Code 1740, Naval Res. Lab., Washington, D.C. 20390 (F-1, 32)

TRAUB, ROBERT, Ph.D., 5702 Bradley Blvd., Bethesda, Md. 20014 (F-5)

TREADWELL, CARELTON R., Ph.D., Dept. of Biochemistry, George Washington Univ., H St., N.W., Washington, D.C. 20005 (F-19)

TROMBA, F.G., VSR, ARS, Agric. Res. Ctr., Beltsville, Md. 20705 (f-15)

TRUEBLOOD, MRS. CHARLES K., 7100 Armat Dr., Bethesda, Md. 20014 (F-19)

TRUBUL, THEODORE S., Sc.D., 11711 River Dr., Lorton, Va. 22079 (M-14, 34)

TRYON, MAX, 6008 Namakagan Rd., Washington, D.C. 20016 (F-4, 6)

TULANE, VICTOR J. Assistant President, Livingstone Coll., Salisbury, N.C. 28144 (F)

TUNELL, GEORGE, Ph.D., Dept. of Geol. Sci., Univ. of California, Santa Barbara, Calif. 93106 (E-7)

TURNER, JAMES H., 11902 Falkirk Dr., Potomac, Md. 20853 (F-15)

U

UHLANER, J.E., Ph.D., U.S. Army Behavior and Systems Res. Lab., Rosslyn Commonwealth Bldg., 1300 Wilson Blvd., Arlington, Va. 22209 (F)

USDIN, EARL, 2924 N. Oxford St., Arlington, Va. 22207 (F-4, 19)

V

VACHER, HERBERT C., 2317 Huidekoper Pl., N.W., Washington, D.C. 20007 (E)

VAN EVERA, R.W., 901 No. Kensington St., Arlington, Va. 22205 (F)

VAN TUYL, ANDREW H., Ph.D., 1000 W. Nolcrest Dr., Silver Spring, Md. 20903 (F-1, 6, 22)

VEITCH, FLETCHER P., Jr., Ph.D., Dept. of Chemistry, Univ. of Maryland, College Park, Md. 20742 (F-4)

VERDIER, PETER H., 8827 McGregor Dr., Chevy Chase, Md. 20015 (F)

VERNICK, SANFORD H., 3501 John Marshall Dr., Arlington, Va. 22207 (M)
VESTINE, E. H., 901 Hartzell St., Pacific Palisades, Calif. 90272 (F)
VIGUE, KENNETH J., Dir., Internatl. Projects, ITT Corp., ITT Bldg., 1707 L St., N.W., Washington, D. C.20036 (M-13, 31)
VINTI, JOHN P., Sc.D., M.I.T. Measurement Systems Lab., 70 Vassar St., Cambridge, Mass.
VISCO, EUGENE P., B.S., Geomet. Inc., 50 Monroe St., Rockville, Md. 20850 (M-1, 34)
VON BRAND, THEODOR C., Ph.D., 8606 Hempstead Ave., Bethesda, Md. 20034 (E-15)
VON HIPPEL, ARTHUR, 265 Glen Rd., Weston, Mass. 02193 (E)

W

WACHTMAN, J.B., Jr., Ph.D., B306 Matls. Bldg., Natl. Bur. of Standards, Washington, D.C. 20234 (F-1, 6, 28)
WAGMAN, DONALD D., 7104 Wilson Lane, Bethesda, Md. 20034 (F-4)
WAGONER, ANN, Miss, 1508 34th St., N.W., Washington, D.C. 20007 (M)
WALKER, E. H., Ph.D. 7413 Holly Ave., Takoma Park, Md. 20012 (E-10)
WALKER, RAYMOND F., Ph.D., 670 Shawnee Dr., Franklin Lakes, N.J. 07417 (F-6, 28)
WALTER, DEAN I., Code 6370, Naval Res. Lab., Washington, D.C. 20390 (F-4, 6)
WALTHER, CARL H., 1337 27th St., N.W., Washington, D.C. 20007 (F-6, 18)
WALTON, W.W., Sr., 1705 Edgewater Pkwy., Silver Spring, Md. 20903 (F-4)
WARD, HENRY P., Ph.D., 2713 17th St., N.E., Washington, D.C. 20018 (E-4, 6)
WARGA, MARY E., Optical Society of America, 2100 Pennsylvania Ave., N.W., Washington, D.C. 20037 (F-1, 4, 6, 32)
WARING, JOHN A., 8502 Flower Ave., Takoma Park, Md. 20012 (M-30)
WATERMAN, PETER, 25 Brandywine St., S.W., Washington, D.C. 20032 (F-6)
WATSON, BERNARD B., Ph.D., Res. Analysis Corp., McLean, Va. 22101 (F-6, 31)
WEAVER, DE FORREST E., M.S., Geological Survey, Washington Bldg., Rm. 110, 1011 Arlington Blvd., Arlington, Va. 22209 (E-4)
WEAVER, E.R., 6815 Connecticut Ave., Chevy Chase, Md. 20015 (E-4, 6)
WEBER, EUGENE W., B.C.E., 2700 Virginia Ave., N.W., Washington, D.C. 20037 (F-6, 12, 17, 18)
WEBER, ROBERT S., 1825 Martha Ave., Harlingen, Tex. 78550 (M)
WEIDA, FRANK, 19 Scientists Cliff, Port Republic, Calvert County, Md. 20676 (E-1)
WEIDLEIN, E.R., Weidacres, P.O. Box 445, Rector, Pa. 15677 (E)
WEIHE, WERNER K., 2103 Basset St., Alexandria, Va. 22308 (F-32)
WEINBERG, HAROLD P., B.S., 1507 Sanford Rd., Silver Spring, Md. 20902 (F-20)
WEINTRAUB, ROBERT L., 305 Fleming Ave., Frederick, Md. 21701 (F-4, 10, 16, 33)
WEIR, CHARLES E., Rt. 3, Box 260B, San Louis Obispo, Calif. 93401 (F)
WEISS, FRANCIS JOSEPH, Ph.D., Sc.D., 6121 Montrose Rd., Rockville, Md. 20852 (E-1, 4, 6, 10, 16, 26, 27, 33)
WEISS, RICHARD A., 3609 N. Delaware St., Arlington, Va. 22207 (F-6, 13)
WEISSBERG, SAMUEL, 14 Granville Dr., Silver Spring, Md. 20901 (F-1, 4)
WEISSLER, ALFRED, Ph.D., 5510 Uppingham St., Chevy Chase, Md. 20015 (F-1, 4, 25)
WELLMAN, FREDERICK L., Dept. of Plant Pathology, North Carolina State Univ., Raleigh, N.C. 27607 (E)
WENSCH, GLEN W., Esworthy Rd., Rt. 2, Germantown, Md. 20767 (F-6, 20, 26)
WEST, WALTER S., U.S. Geological Survey, Wisconsin State Univ., Rountree Hall, Platteville, Wis. 53818 (M-7, 14)
WEST, WILLIAM L., Dept. of Pharmacology, Howard Univ., Washington, D.C. 20001 (M-19, 26)
WESTERHAUT, GART, Ph.D., Astronomy Program, Space Sciences Bg., Univ. of Maryland, College Park, Md. 20742 (F)
WETMORE, ALEXANDER, Ph.D., Smithsonian Inst., Washington, D.C. 20560 (F-3, 6)
WEXLER, ARNOLD, Phys. B 356, Natl. Bur. of Standards, Washington, D.C. 20234 (F-1, 35)
WHEELER, WILLIS H., 3171 N. Quincy St., Arlington, Va. 22207 (E-6, 10)
WHERRY, EDGAR T., Ph.D., Dept. Botany, Univ. of Pennsylvania, Philadelphia, Pa. 19104 (E)
WHITE, CHARLES E., Ph.D., 4405 Beechwood Rd., Hyattsville, Md. 207 2 (E-4)
WHITE, HOWARD J., Jr., 8028 Park Overlook Dr., Bethesda, Md. 20034 (F-4)
WHITE, JOHN A., Physics Dept., American Univ., Washington, D.C. 20016 (M-1)
WHITE, ORLAND E., Sc.D., 1708 Jefferson Park Ave., Charlottesville, Va. 22903 (E)
WHITE, ROBERT M., NOAA, U.S. Dept. Commerce, Washington, D.C. 20230 (F)
WHITELOCK, LELAND D., B.S.E.E., 5614 Greentree Rd., Bethesda, Md. 20034 (F-13)
WHITMAN, MERRILL J., 3300 Old Lee Highway, Fairfax, Va. 22030 (F-26)
WHITTAKER, COLIN W., Ph.D., 1705 Lanier Pl., N.W. Washington, D.C. 20009 (E-4)
WHITTEN, CHARLES A., 9606 Sutherland Rd., Silver Spring, Md. 20901 (F-1, 6)
WICHERS, EDWARD, Ph.D., 9601 Kingston Rd., Kensington, Md. 20795 (E-4)
WILDHACK, W.A., 415 N. Oxford St., Arlington, Va. 22203 (F-1, 6, 22, 31, 35)
WILHELM, PETER G., 6710 Elroy Pl., Oxon Hill, Md. 20021 (F)

WILLIAMS, DONALD H., 4112 Everett St., Kensington, Md. 20795 (M-27)

WILSON, BRUCE L., 20 N. Leonora Ave., Apt. 204, Tucson, Ariz. 85711 (F-1, 6)

WILSON, WILLIAM K., M.S., 1401 Kurtz Rd., McLean, Va. 22101 (F-4)

WINKLER, WILLIAM R., 1001 Rockville Pike, Apt. 1033, Rockville, Md. 20852 (F-23, 37)

WINSTON, JAY S., Ph.D., 3106 Woodhollow Dr., Chevy Chase, Md. 20015 (F-6, 23)

WINT, CECIL, 7 St. Andrew Park, Kingston 10, Jamaica, W.I. (F)

WISE, GILBERT H., 8805 Oxweel Lane, Laurel, Md. 20810 (M-6)

WITHINGTON, C.F., 3411 Ashley Terr., N.W., Washington, D.C. 20008 (F-7)

WITTLER, RUTH G., Ph.D., Dept. of Bacterial Diseases, Walter Reed Army Inst. of Res., Washington, D.C. 20012 (F-16)

WOLFF, EDWARD A., 1021 Cresthaven Dr., Silver Spring, Md. 20903 (F-6, 13, 22, 23)

WOLFLE, DAEL, Graduate School of Public Affairs, University of Washington, Seattle, Washington 98195 (F)

WOLFRAM, LESZEK J., Gillette Res. Inst., 1413 Research Blvd., Rockville, Md. 20850 (F)

WOLICKI, E.A., Nuclear Sciences Div., Code 6601, U.S. Naval Res. Lab., Washington, D.C. 20390 (F)

WOMACK, MADELYN, 11511 Highview Ave., Silver Spring, Md. 20902 (F-4, 19)

WOOD, LAWRENCE A., Ph.D., Natl. Bur. of Standards, Washington, D.C. 20234 (F-1, 4)

WOOD, MARSHALL K., M.P.A., 2909 Brandywine St., N.W., Washington, D.C. 20008 (F)

WOOD, REUBEN E., 3120 N. Pershing Dr., Arlington, Va. 22201 (F-4, 29)

WOODS, MARK W., Natl. Cancer Inst., Bethesda, Md. 20014 (F-10, 19)

WORKMAN, WILLIAM G., M.D., 5221 42nd St., N.W., Washington, D.C. 20015 (E-6, 8)

WRENCH, CONSTANCE P., 10230 Democracy Lane, Potomac, Md. 20854 (M-6)

WRENCH, JOHN W., Jr., 10230 Democracy Lane, Potomac, Md. 20854 (F-6)

WULP, OLIVER R., Noyes Lab. of Chem. Phys., Calif. Inst. of Tech., Pasadena, Calif. 91108 (E)

WYMAN, LEROY W., Ch. E., 134 Island View Dr., Cape St. John, Annapolis, Md. 21401 (F-6, 20, 36)

Y

YAO, AUGUSTINE Y.M., Ph.D., 4434 Brocton Rd., Oxon Hill, Md. 20022 (M-23)

YAPLEE, BENJAMIN S., 6104 Westland Dr., Hyattsville, Md. 20782 (F-13)

YOCUM, L. EDWIN, 1257 Drew St., Apt. 2, Clearwater, Fla. 33515 (E-10, 33)

YODER, HATTEN S., Jr., Geophysical Lab., 2801 Upton St., N.W., Washington, D.C. 20008 (F-4, 7)

YOLKEN, H.T., Rm. B314, Natl. Bur. of Standards, Washington, D.C. 20234 (F-29)

YOUNG, BOBBY G., Dept. of Microbiology, Univ. of Maryland, College Park, Md. 20742 (M)

YOUNG, CLINTON J.T., M.S., 300 Rucker Pl., Alexandria, Va. 22301 (M-32)

YOUNG, DAVID A., Jr., PH.D., 612 Buck Jones Rd., Raleigh, N.C. 27606 (F-5)

YOUNG, M. WHARTON, 3230 Park Pl., Washington, D.C. 20010 (F)

YUILL, J.S., M.S., 4307-A Hartwick Rd., College Park, Md. 20740 (E-5, 6, 24)

Z

ZELENY, LAWRENCE, Ph.D., 4312 Van Buren St., University Park, Hyattsville, Md. 20782 (E)

ZEN, E-AN, U.S. Geological Survey, Washington, D.C. 20242 (F-7)

ZIES, EMANUEL G., 3803 Blackthorne St., Chevy Chase, Md. 20015 (E-4, 6, 7)

ZOCH, RICHMOND T., 12612 Craft Lane, Bowie, Md. 20715 (F)

ZWANZIG, ROBERT W., Inst. for Fluid Dyn. & Applied Math., Univ. of Maryland, College Park, Md. 20740 (F-1, 6)

ZWEMER, RAYMUND L., 5008 Benton Ave., Bethesda, Md. 20014 (E)

NOTES

JOURNAL OF THE WASHINGTON ACADEMY OF SCIENCES

Instructions to Contributors

General

Type manuscripts on white bond paper either 8½ by 11 or 8 by 10½ inches. Double space all lines, including those in abstracts, tables, legends, quoted matter, acknowledgments, and references cited. Number pages consecutively. Place your name and complete address in the upper right hand corner of the title page.

Title, Author, and Affiliation

Page 1 of your manuscript should contain only this information and your name and address. Choose a concise but complete and meaningful title. In research papers concerning biological subjects, include an indication of the order and family of the taxa discussed. Academic degrees will not normally be included unless the author so specifies. If possible, combine your affiliation and mailing address (including Zip) so that readers can write to you directly.

Abstract

Type on a separate sheet at the end of the manuscript. Make the abstract intelligible without reference to the text of the paper. Write an informative digest of the significant content and conclusions, not a mere description. Generally, the abstract should not exceed 3% of the text.

Footnotes

Use footnotes as sparingly as possible. Number text footnotes consecutively with Arabic numerals and type them on a separate sheet of paper at the end of the manuscript. Type table footnotes, if any, below each pertinent table on the same page.

Illustrations and Legends

The quality of all original illustrations must be high enough to facilitate good offset reproduction. They should have ample margins and be drawn on heavy stock or fastened to stiff cardboard to prevent bending. They should be proportioned to column (1 x 3) or page (2 x 3) type-dimensions, leaving space for legend material. Photographs should have a glossy finish. They reproduce best when the contrast is fairly high. Identify each illustration with number and author in light pencil marks on the reverse side. Submit all illustrations separately – please do not glue or clip them to the pages of the manuscript.

Do not type or write legends directly on the illustrations. Type legends on a separate sheet or sheets at the end of the manuscript. Indicate where you want illustrations to appear in the printed paper by writing the figure numbers lightly in the text margins, and be sure that each figure is properly referenced in the text itself. Original "art" will be returned only at the author's request and expense.

Tables

Include tables only when the same information cannot be presented economically in the text, or when a table presents the data in a more meaningful way. Consider preparing extremely complicated tabular matter in a form suitable for direct reproduction as an illustration. In such cases, the use of the typewriter is not recommended.

References to Literature

Limit references within the text and in synonymies to author and year (and page if needed). In a "Reference Cited" section, list alphabetically by senior author only those papers you have included in the text. Likewise, be sure all the text references are listed. Type the "References Cited" section on a separate sheet after the last page of text. Abbreviations should follow the *USA Standard for Periodical Title Abbreviations*, Z39.5-1963.

Submission of Manuscripts

Send completed manuscripts and supporting material to the Academy office (see address inside front cover) in care of the Editor. Authors will be requested to read Xerox "proofs" and invited to submit reprint orders prior to publication.

Reprints – Prices for reprints may be obtained on request.

Washington Academy of Sciences
Room 29, 9650 Rockville Pike (Bethesda)
Washington, D.C. 20014
Return Requested with Form 3579

2nd Class Postage
Paid at
Washington, D.C.

VOLUME 62
Number 4
DECEMBER, 1972

Journal of the WASHINGTON ACADEMY OF SCIENCES

Issued Quarterly
at Washington, D.C.

Directory Issue

CONTENTS

Features:

HAROLD E. BAMFORD, JR: A Concept for Applying Computer Technology to the Publication of Scientific Journals ... 306
CHARLES MILTON: Note on a Drawing by M.C. Escher ... 315

Profile:

E.E. SAULMON: Scientific and Regulatory Aspects of Venezuelan Equine Encephalitis ... 317

Research Reports:

H.E. LANDSBERG: Noise Increase in an Urbanizing Area ... 329
JOHN A. FLUNO: Grooming in *Polistes exclamans* (Viereck), a Forerunner of Communications in Social Hymenoptera ... 332

Academy Affairs:

Board of Managers Meeting Notes ... 334
Announcement ... 337
The Philosophical Society of Washington: By-Laws, Officers, and Committees, 1 October 1972 ... 339

Washington Academy of Sciences

Founded in 1898

ACADEMY OFFICE

9650 Rockville Pike (Bethesda)
Washington, D. C. 20014
Telephone (301) 530-1402

The Journal

This journal, the official organ of the Washington Academy of Sciences, publishes historical articles, critical reviews, and scholarly scientific articles; proceedings of meetings of the Academy and its Board of Managers; and other items of interest to Academy members. The *Journal* appears four times a year (March, June, September, and December) – the September issue contains a directory of the Academy membership.

Subscription Rates

Members, fellows, and patrons in good standing receive the *Journal* without charge. Subscriptions are available on a calendar year basis only, payable in advance. Payment must be made in U.S. currency at the following rates:

U.S. and Canada	$10.00
Foreign	11.00
Single Copy Price	3.00

Back Issues

Obtainable from the Academy office (address at bottom of opposite column): **Proceedings:** Vols. 1-13 (1898-1910) **Index:** To Vols. 1-13 of the *Proceedings* and Vols. 1-40 of the *Journal* **Journal:** Back issues, volumes, and sets (Vols. 1-62, 1911-1972) and all current issues.

Claims for Missing Numbers

Claims will not be allowed if received more than 60 days after date of mailing plus time normally required for postal delivery and claim. No claims will be allowed because of failure to notify the Academy of a change in address.

Changes of Address

Address changes should be sent promptly to the Academy office. Such notification should show both old and new addresses and zip number.

Published quarterly in March, June, September, and December of each year by the Washington Academy of Sciences, 9650 Rockville Pike, Washington, D.C. Second class postage paid at Washington, D.C.

DELEGATES TO THE WASHINGTON ACADEMY OF SCIENCES, REPRESENTING THE LOCAL AFFILIATED SOCIETIES

Philosophical Society of Washington	Edward Beasley
Anthropological Society of Washington	Jean K. Boek
Biological Society of Washington	Delegate not appointed
Chemical Society of Washington	Harvey Alter
Entomological Society of Washington	Reece I. Sailer
National Geographic Society	Alexander Wetmore
Geological Society of Washington	Charles Milton
Medical Society of the District of Columbia	Delegate not appointed
Columbia Historical Society	Paul H. Oehser
Botanical Society of Washington	Conrad B. Link
Society of American Foresters	Robert Callaham
Washington Society of Engineers	George Abraham
Institute of Electrical and Electronics Engineers	Leland D. Whitelock
American Society of Mechanical Engineers	William G. Allen
Helminthological Society of Washington	Aurel O. Foster
American Society for Microbiology	Lewis Affronti
Society of American Military Engineers	H.P. Demuth
American Society of Civil Engineers	Carl H. Gaum
Society for Experimental Biology and Medicine	Carlton Treadwell
American Society for Metals	Glen W. Wensch
International Association for Dental Research	Norman H.C. Griffiths
American Institute of Aeronautics and Astronautics	Robert J. Burger
American Meteorological Society	Harold A. Steiner
Insecticide Society of Washington	H. Ivan Rainwater
Acoustical Society of America	Alfred Weissler
American Nuclear Society	Delegate not appointed
Institute of Food Technologists	Lowrie M. Beacham
American Ceramic Society	J.J. Diamond
Electrochemical Society	Stanley D. James
Washington History of Science Club	Delegate not appointed
American Association of Physics Teachers	Bernard B. Watson
Optical Society of America	Elsie F. DuPré
American Society of Plant Physiologists	Walter Shropshire
Washington Operations Research Council	John G. Honig
Instrument Society of America	Delegate not appointed
American Institute of Mining, Metallurgical and Petroleum Engineers	Delegate not appointed
National Capitol Astronomers	John A. Eisele
Mathematical Society of America	Daniel B. Lloyd

Delegates continue in office until new selections are made by the respective societies.

FEATURES

A Concept for Applying Computer Technology to the Publication of Scientific Journals[1]

Harold E. Bamford, Jr.[2]

Office of Science Information Service, National Science Foundation, Washington, D.C. 20550

ABSTRACT

c Although computer technology has been introduced into every other phase of scientific communication, relatively little use has yet been made of it in primary dissemination—perhaps because of the limited operational scale of the typical journal. An editorial processing center (EPC) is conceived as a mechanism for combining small publishing operations to achieve a scale great enough for significant computerization while leaving each editor in full command of his own publication. The EPC's computer assists authors, editors, and referees to perform their essential, intellectual functions by relieving them of non-essential, programmable functions. Its final output is a magnetic tape for use in photocomposition. The EPC concept is presented by tracing the path of a single manuscript from preparation to publication. The costs and benefits of an EPC are then assessed, and a number of questions are raised for further study.

The past 5 or 6 years have witnessed the introduction of computer technology into nearly every phase of scientific communication. One compelling factor behind this trend is the promise of operational economies. In abstracting and indexing, for example, there is a real danger that without computerization, some services will be forced into a self-defeating spiral of rising prices, increasing delays, and declining quality.

Another factor is equally valid, if somewhat less urgent. Through computer technology it is possible to improve established information services and introduce novel ones. Expanded coverage of existing knowledge, increased speed in propagating new information and retrieving old, better screening of the relevant from the irrelevant, more effective presentation—in these ways we can hope to enhance the productivity of the scientists, educators, and technologists who use the information services. And user productivity is, after all, the name of the game we are playing. Scientific communication has no other payoff.

The electronic digital computer was conceived as an instrument for scientists to use in the analysis of their data. From data analysis to retrieval of the data to be analyzed is no great step, and banks of empirical data to be searched are beginning to appear in many fields. At the same time, computer-accessible files of bibliographic references are making possible information services which were altogether out of reach

[1] Based on a paper presented at the Sixteenth Conference of the Council of Biology Editors, Rochester, Minnesota, May 15-16, 1972.

[2] The views expressed in this paper are those of the author and do not necessarily reflect those of the National Science Foundation.

only a few years ago. Usually these files are by-products of the computerized production of abstracts and indexes.

Secondary processors are achieving significant economies through their use of computers to derive a variety of printed products from a single input keyboarding. Further economies would be possible if secondary processing could be based on a by-product of primary publication, just as bibliographic searches are now based on computer-accessible files created in the course of secondary processing.

But relatively little use of the computer has been made in primary dissemination. Computer-controlled photocomposition is beginning to compete with conventional typesetting, and subscription fulfillment has been computerized successfully by some of the larger societies. They could use the same computers to assist editors and writers, as popular magazines and the daily press have done; but none of them appears to have tried it.

The main obstacle to computerization of journal publication is probably the limited scale of operations involved. Although the significant life sciences literature to be published in 1972 may fill more than half-a-million pages, it will appear in upwards of 1,000 journals in many different countries. An obvious solution is to combine some of these separate operations so as to achieve a scale which would make significant computerization worthwhile. But how can this be done without sacrificing editorial control of the journals?

Before suggesting an answer to this question, it may be well to make explicit some of the assumptions on which the answer will rest. Any concept for applying computer technology to the publication of scientific journals must presume some model of the publication process as it exists today. Let us distinguish 5 functions:

- Preparation and refinement
- Channeling
- Evaluation
- Typesetting and correction
- Printing and distribution

The initial preparation of a manuscript is indisputably the author's responsibility, although he is expected to seek the counsel of his colleagues prior to submitting it to a journal. Most of its subsequent refinement is also accomplished by the author, but under the more or less pointed guidance of the editor. A final stage of refinement, known variously as copy editing, subediting, or redaction, may be carried out by the editor himself or by specialists under his supervision.

By selecting the journal to which his manuscript is submitted, the author takes the initiative in channeling his message to its ultimate readers. The editor must concur in the author's selection of a communication channel, of course; and he may refer the manuscript to another journal. In such a case the author would have to concur in the editor's channel selection.

Once a manuscript has been submitted, its evaluation is wholly in the hands of the editor. Inevitably, he relies on his colleagues for assistance; but the responsibility is undivided. At any point in the evaluation process he may reject the manuscript, call for its refinement, or seek advice on its merit.

If he chooses not to exercise any of these options, the manuscript is ready to be set in type by a printer, who then provides galley proofs for final correction by author and editor.

That done, an issue of the journal is produced and distributed to subscribers.

Probably not less than 3, and quite possibly more than 15, months have elapsed since the manuscript was submitted. And the first copy will have cost somewhere between \$25 and \$95/1,000 words to produce, depending on the publishing scale, processing efficiency, and standard of quality involved, and on the extent to which editorial services are donated.

Such is the model behind the concept which will now be presented. As Fig. 1 indicates, the concept involves authors, editors, referees, and printers essentially no different from those assumed in the model. But inserted in their midst are one or more things called "editorial processing centers", or "EPCs".

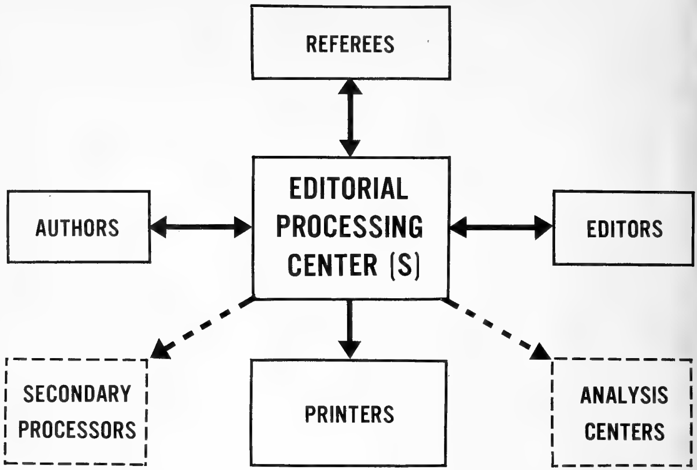


Fig. 1. The concept schematized.

As a manuscript moves from preparation to publication, there are many processing steps which can be economically delegated to a computer, provided the scale of operations is great enough. An EPC is a device for combining operations to achieve such a scale. Its computer assists authors, editors, and referees to perform their essential, intellectual functions by relieving them of non-essential, programmable functions. Its final output is a magnetic tape for use by a printer in photocomposition.

The EPC may be an independent entity, either proprietary or not for profit; or it may be established within the framework of an existing institution. Some of the economic aspects are considered below, but first let us trace the path of a single manuscript from preparation to publication to see how an EPC might work. As we proceed, please bear in mind that what is being presented is a concept. A great many details would have to be worked out in order to arrive at a finished system design.

To begin, the author has his manuscript typed on special form sheets with a typewriter approved for its typeface, adjustment, and other factors affecting its ability to make impressions which can be read by optical character recognition, or OCR, equipment. The form sheets, which can be distributed through campus bookstores, are also intended to facilitate OCR scanning. They have ruled margins and spaces for title, authors, abstract, references, footnotes, page numbers, etc. When the manuscript has been typed to the author's satisfaction, he marks it for the attention of the editor of his chosen journal and mails it to the editorial processing center (Fig. 2). At the EPC a mail clerk enters the manuscript into a computer system by means of an OCR scanner. No special skill is required for this process, which is termed "recording" The special form sheets assure reliable scanning and enable the computer to "tag" the various components of the manuscript for suitable processing. Housekeeping functions are carried out automatically. These would include the assignment of a control number to the

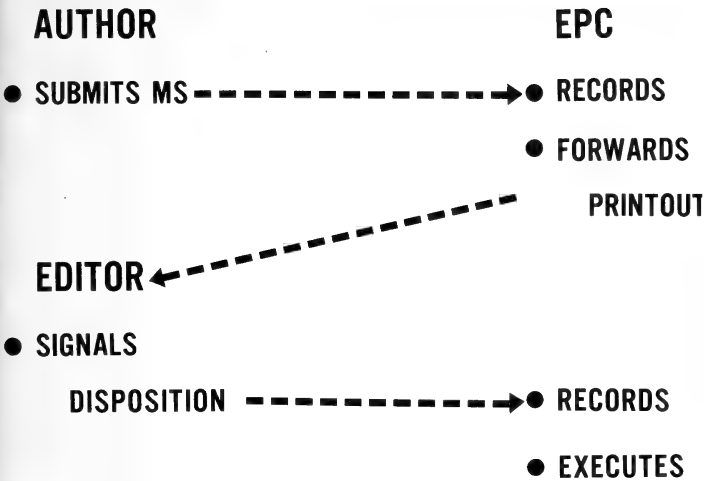


Fig. 2. Submission and screening of manuscript.

manuscript and the acknowledgement of its receipt by a postal card to the author.

Once the manuscript has been satisfactorily recorded it is simply discarded. A computer printout in a form optimized for editorial use is automatically prepared and mailed to the editor. This is followed by a tracer if the editor does not respond within a reasonable period of time.

The editor examines the printout and transmits his decision to the EPC, where a telephone clerk records his instructions by means of an on-line keyboard. The computer system immediately displays the clerk's input on a cathode-ray tube, and the clerk reads it back to the editor. If the editor is satisfied that his signal has been correctly recorded, he discards his printout, and the computer system proceeds to execute his instructions.

For the purpose of illustration, let us suppose that the editor has a choice of 4 processing sequences. After stating his name and the manuscript's control number:

- he can say "reject". This is enough to initiate an automatic sequence in which the computer's files are purged and a notice of rejection is mailed to the author.
- he may wish to refer the manuscript to the editor of another journal. In such a case he can identify that journal by its CODEN or its International Standard Serial Number, and the computer system will simply forward a printout to the indicated editor.
- a single word is sufficient to initiate an accept sequence, as described below.
- but let us assume that the editor wants to have the manuscript reviewed by experts in 1 or more specialties. He can indicate those specialties by identifying codes, which he can look up in a manual. Of course, if he wants to designate 1 or more referees by name he is free to do that as well.

In fact, provision can easily be made for him to insert free-language remarks into the

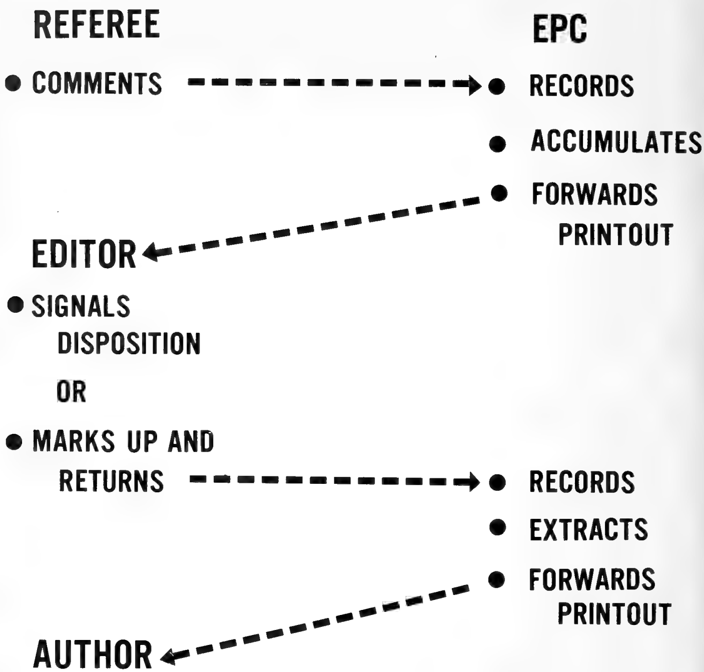


Fig. 3. Review and evaluation of manuscript.

record in connection with any of these options.

The EPC maintains a register of qualified specialists who are willing to serve as referees. The computer system selects names from that register in accordance with the editor's specifications. Other factors may be considered as well, such as a potential referee's past performance and current review assignments, any potential conflicts of interest, and the journal's editorial policies respecting the number and qualifications of its referees.

Printouts of the manuscript are automatically mailed to the selected referees, together with any instructions required by editorial policy. If any of the selected individuals declines to serve, a substitute is automatically selected. And if any of the selected individuals fails to respond within a reasonable time, the EPC follows up automatically.

Each referee reviews the printout which he received from the EPC (Fig. 3) and has his comments typed on standard form sheets with an approved typewriter. These he forwards to the EPC, where a mail clerk records them with an OCR scanner in the same fashion as a manuscript and discards them. Comments are accumulated by the computer system until all the referees have responded, at which time the entire file is automatically printed out and forwarded to the editor.

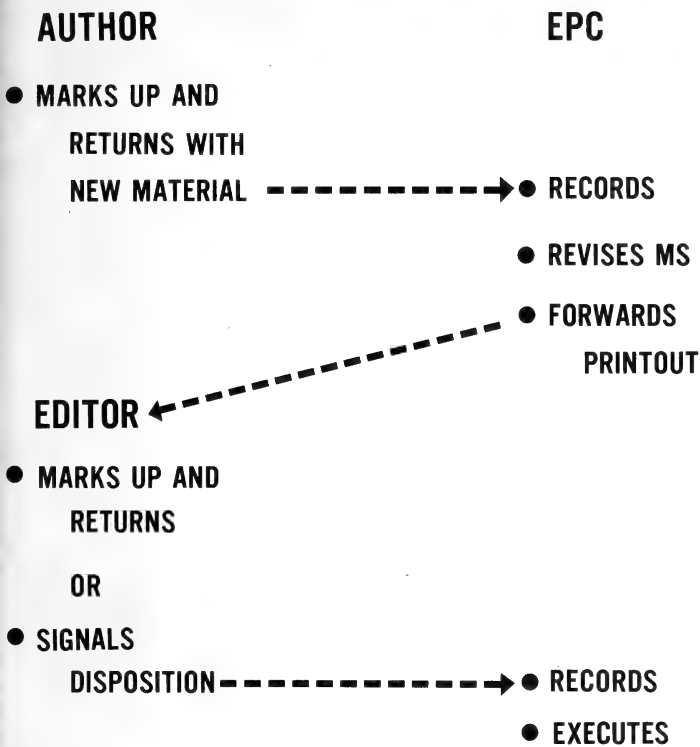


Fig. 4. Refinement of manuscript.

Again, follow-up is automatic if it becomes necessary.

The editor examines this new printout, which includes the manuscript and all of the referees' comments. Having done so, he may telephone the EPC and exercise any of his original 4 options: to reject, refer to another journal, accept for publication, or send the manuscript out for additional review.

Alternatively, he may mark portions of the referees' comments to be extracted and sent to the author. In this case, he mails the marked-up printout to the EPC, where a mail clerk records the markings by on-line keyboard. The manuscript is then printed out, along with the editor's extracts from the referees' comments, and forwarded to the author.

The author examines his printout (Fig. 4), has new material typed on special form sheets with an approved typewriter, marks the printout to indicate deletions and the points at which new material is to be inserted, and mails the package to the EPC.

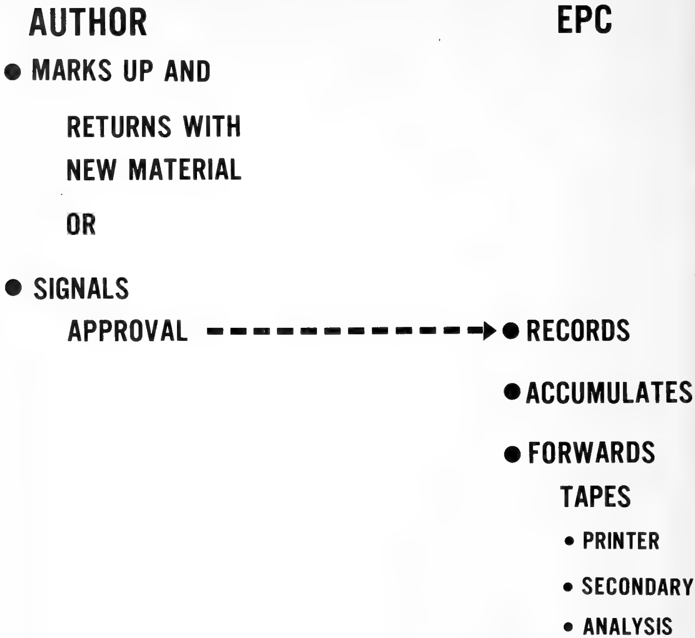


Fig. 5. Author's review of edited manuscript.

Note that there is no need to retype any part of the original manuscript, which is still in the computer system's file.

At the EPC a mail clerk records the new material by OCR scanner and the author's markings by on-line keyboard. The original manuscript is than automatically revised to incorporate the author's changes, and a printout of the complete file is mailed to the editor.

Following his examination of this new printout, which consists of the revised manuscript and all of the referees' comments, the editor can mark it up again and can send it back to the author for further refinement, or he can exercise any of his original 4 options. Let us suppose that this time he signals the EPC to accept the manuscript for publication.

The "accept" sequence begins with programmed copy editing, in which the EPC's computer system adjusts the fine detail of the approved manuscript in accordance with the journal's detailed editorial rules and standards. A printout of the edited manuscript is then sent to the author for his approval prior to publication.

If the author takes exception to any of the editorial adjustments he can mark up the printout and recycle it (Fig. 5). Otherwise he telephones the EPC and indicates his approval.

His signal recorded by on-line keyboard, the manuscript is accumulated with other manuscripts until press time, when it is transferred to a computer tape and forwarded to the printer. Copies of the tape may also be sent to abstracting and indexing services and to information analysis centers.

There you have it: a concept for combining small publication operations to achieve a scale great enough for worthwhile computerization while leaving each editor in full command of his own publication. It is just a technical concept, of course. No attempt has been made to deal with the political/organizational arrangements for implementing it. Forgetting such things for the moment, let us add up the benefits and costs suggested by the technical concept.

Consider first the immediate operating economies. Publishing costs should be less with no galley proofs to correct and no need to have manuscripts re-keyboarded by a compositor. And labor costs should decrease markedly with the computerization of filing, acknowledgement, follow-up, and other routine correspondence, not to mention referee selection, manuscript revision, and copy editing. However, to the extent that labor is donated by authors, reviewers, editors, or their institutions, the savings will not show up on the publishers' books.

The effectiveness of communication could gain in several respects. Speed of publication can only benefit from computer processing, which is not only fast but eliminates the need to check for and correct human errors. Standardization and quality control could readily be implemented at the subeditorial level. And the quality of exposition and even of the scientific content could be raised through the systematic use of referees which the EPC would make possible.

Implementation of an EPC would create a base for further development. A participating journal would gain a considerable measure of flexibility to vary the form of its product in an effort to increase the value of that product to its users. Looking further ahead, it would be only a minor variation on the EPC concept to link the editors to the central computer by on-line console. The variation could be extended by easy steps to the referees, to the authors, and finally to the readers.

This is not at all fantastic. Let me quote from a 1970 report by the Council on Biological Sciences Information:

> . . . we can probably look to a time when an author will compose his "manuscript" [at a computer terminal] and transmit it . . . over the network to the editor, who will transmit it similarly to the reviewers. When he receives the reviewers' comments, the author will revise his text, using a computer program to make insertions and deletions. When the revised version is approved, the editor will "publish" it instantaneously by releasing it to the network with a notation signaling its approval by a specific review group. The network will automatically feed the work to [abstracting and indexing services] where it will be indexed and classified, perhaps in hundreds of different ways for different users, for alerting and retrieval purposes.

Such a scheme is not likely to be implemented in a single leap, but stepwise it may not be hard to realize.

Getting back to the more immediate benefits of the EPC, some of these would be realized not by the primary publishers themselves but by abstracting and indexing services and by data analysis centers. Computers can be used to advantage in secondary processing and for data compilation if the cost of input is not too great. With the primary literature already in machine-readable form, input costs would be quite modest.

On the other side of the ledger are the costs of developing and operating the EPC. The development costs will not be very large if the various technologies are as advanced as we are led to believe. The real challenge will be to organize for the exploitation of those technologies. A great deal of time and effort will have to be invested, but the dollar investment is likely to be small relative to the continuing cost of operation.

The costs of the plant, labor, and materials needed to operate an EPC, on the other hand, are not likely to be small, even allowing for the economies anticipated. For some scale of operations and for some package of functions those economies should be great enough to make participation clearly preferable to independent operation. But careful studies are needed to provide a basis for workable arrangements.

Numerous questions can be raised. For

example,

- are today's publication practices as amenable to computerization as in the model, or has the non-routine component been underestimated?
- is the technology of optical character recognition ready for this application?
- how far are we from programmed copy editing?
- is automatic referee selection a feasible idea?

It may be asked whether this concept of an editorial processing center addresses the whole range of editorial activities. Of course it does not. For one example, the handling of pictorial, graphic, and tabular material submitted with the manuscript is totally neglected. One may also challenge the benefits credited to the EPC:

- would it really effect significant reductions in labor and publishing costs?
- would it actually reduce publication lag?
- could it truly be used to raise the quality of publication?

This description of an EPC has been fairly concrete, but for each specific feature indicated there are equally concrete alternatives. For example, the submission of manuscripts on magnetic tape would probably be feasible and might be preferable to the use of optical character recognition. More important, the whole complex of functions attributed to the EPC is only one package among many possibilities. The computer has been used as fully as possible simply to show the full potential of the EPC concept. But there has been no detailed analysis, and as a practical matter it might be desirable to start with a more austere package and add on functions as successive configurations were proved out.

The level of investment required for a minimum package and for each of a series of add-ons would have to be determined. Equally necessary would be good, firm estimates of the net operating costs of each configuration. Such estimates would have to be made over a range of operating levels reflecting the participation of different numbers of publishers with different input volumes. The key to organizing a workable system would be the determination of a breakeven point for each functional package considered—i.e., the particular operating level at which the net operating costs would equal the present dollar outlays for comparable functions.

But even with full planning information there would remain a question as to the community's readiness to depart from its traditional methods of publication. Conceivably the potential for improved dissemination and the advantages to analysis centers and secondary processors would induce participation at the breakeven point. More likely, the immediate economic advantages of participation would have to exceed some subjective threshold to precipitate a decision like that. The answers to these questions can be found through objective analysis of factual data, but only if the scientific community accepts the responsibility for putting together and implementing a workable package of functions will anything come of them.

Note on a Drawing by M. C. Escher

Charles Milton

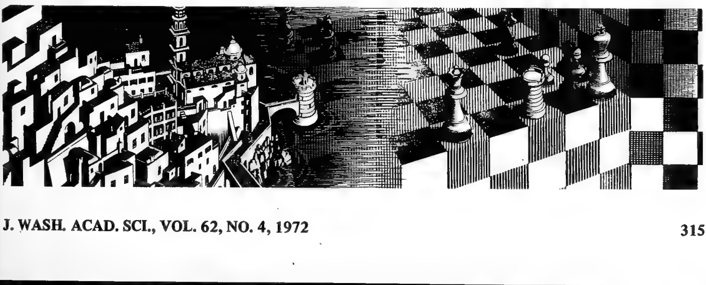
Research Professor, Department of Geology,
George Washington University, Washington, D.C. 20006

ABSTRACT

M.C. Escher's "Metamorphose" illustrates this exceptional artist's unique ability to communicate with scientists.

Many have noted and deplored the communications gap separating the worlds of the scientists and humanists. Some scientists, indeed physicists and mathematicians especially, do have artistic, often, musical avocations; but rare is it to find an artist having any strong interest or concern with scientific study. One can recall a few, of the greatest; da Vinci, Rembrandt, and in our times Eakins, who studied human anatomy as a basis for their art. But M.C. Escher (1898-1972) was the first great artist to deeply and systematically concern himself with fundamental philosophical problems confronting human intelligence, so that his art became the expression of profound and rigorous abstract reasoning. In so doing, Escher has succeeded in communicating with scientists to an amazing degree, historically unique, as attested by some 70 technical books and articles in which his work had appeared as frontispiece or other illustrations, or as the theme of scientific discussion up to 1970.[1] A few of these are: H.M. Coxeter, *Introduction to Geometry*, New York and London, 1969; P. Terpstra and L.W. Codd, *Crystallometry*, London, 1961; C.H. MacGillavry, *Symmetry Aspects of M.C. Escher's Periodic Drawings*, Utrecht, 1965.

But the list extends far beyond the mathematical disciplines, into works on nuclear physics, solid state reactions, chemical evolution, interstellar communication, optical illusions and related psychological phenomena, decision making theory, teaching methods, x-ray diffraction, opthalmology; even, as the cover piece for a United States Park Service brochure[2] describing the Everglades National Park: a geometrical array of swimming fish transformed into an identical array of flying waterfowl—a symbolic formulation of the ecological unity of the Florida water-land as scientifically precise as it is aesthetically charming. It is this combination of intellectual depth with draftsmanship of a strangely haunting beauty, that characterizes



Escher's work.

This note however concerns itself with a single minuscule item of Escher's creativity: the depiction of a chess game in one of his drawings, *Metamorphose* (in English, Metamorphosis). One sees a reverie, in which idea follows idea by a psychological process of "free association" with each theme deriving from the preceding, and in turn determining that which follows. One of these themes is a chess game. In Escher's words "...The blocks give rise to a city on the sea shore. The tower standing in the water is at the same time a piece in the game of chess; the board for this game, with its light and dark squares, leads back once more to the letters of the word 'Metamorphose'.[3]

For the significance of this chess game, with its relatedness to the profoundly philosophic spirit implicit in all of Escher's work, I am indebted to my friend Mr. David Fleischer, a chess scholar. It may be noted, by the way, that the chess pieces of this game are plain conventional Staunton design, far from the ostentatiously gaudy pieces usually shown by commercial artists in advertisements, in positions invariably absurd and meaningless.

Escher has placed his pieces so that the game depicted has a deep—one might say—a tragic symbolism. Mr. Fleischer observes (written communication, 1971):

> "...This is the 'smothered mate', commonly known as 'Philidor's Legacy.' It goes back as far as 1496, being first published by one Lucena. Usually the white rook is at K1, there is no black bishop, and the queen is somewhere on the KN1-QR7 diagonal. Then Black plays 1 N-B7ch; 2K-N1, N-R6 dbl ch; 3K-R1 (if K-B1, Q-B7 mate), Q-N8ch: 4 RXQ, N-B7 mate."

Thus the white king is doomed, inescapably; and it is his own rook who in attempting to defend him from the hostile queen, blocks his only possible escape from the advancing black knight who will give the fatal blow.

This theme of inevitable doom appears again in "Predestination", where "an aggressive voracious fish and a shy vulnerable bird are the actors in this drama; such contrasting traits of character lead inevitably to the denouement ... a black, devilish fish and a white bird, all innocence, but sad to say, irrevocably doomed to destruction ..."[4] In "Encounter",[5] the theme is again the fore-ordained meeting of white and black figures, of good and evil, though here there is a note of acceptance, or, at least, resignation. And in "Circle Limit IV Heaven and Hell"[6] we see once more the ineluctable interrelatedness of white and black, of angels and devils, of good and evil, oppressively clear and frightening in our midst, but as our vision expands to the limits of our consciousness and understanding, diminishing and ultimately vanishing into incomprehensible nothingness.

References and Acknowledgment

[1]J.L. Locher, Editor, The World of M.C. Escher, New York, 1971, pp. 55-56. Mr. C.V.S. Roosevelt, Washington, D.C., who had kindly permitted reproduction of the illustration (copyright) from his private collection informs me that the actual number of such publications is now far greater. In a letter (Oct. 22, 1972) he refers to some 200 titles, in English, Dutch, French, German, Swedish, Italian, Danish, Russian, Polish, Hungarian, etc.

[2]Interpretative Folder for the Everglades National Park, Florida, 1966, U.S. Gov. Printing Office.

[3]The Graphic Work of M.C. Escher, London and New York, 1961, p. 16. This woodcut, Metamorphose, with Escher's work up to that time, was the subject of a remarkable review by G.H.'s Gravesande (1940), *M.C. Escher and his Experiments: an Exceptional Graphic Artist*; De Vrije Bladen, The Hague; translated into English by Maarten C. Bolle; published and copyrighted by C.V.S. Roosevelt.

[4]ibid. p. 17.

[5]ibid, p. 16.

[6]ibid, p. 23.

Scientific and Regulatory Aspects of Venezuelan Equine Encephalitis[1]

E.E. Saulmon

Deputy Administrator, Veterinary Services, APHIS, Washington, D.C. 20250.

ABSTRACT

Recognized mosquito-borne, viral encephalomyelitis in the United States consists of Western (WEE), Eastern (EEE), Venezuelan (VEE), St. Louis (SLE), and California (CE) strains. WEE, EEE, and VEE cause clinical disease problems in equines. Horses are dead-end hosts for WEE and EEE but are amplifying hosts for VEE. Thus, the latter is of greater public health significance. Laboratory support is required for differential diagnosis of the three diseases. Equines are considered primary sentinels for the detection of epizootics of VEE.

VEE swept across Mexico, in less than 1 year, killing in excess of 10,000 horses. Epidemic VEE entered the United States from Mexico in June 1971, and appears to have established itself in the small mammal populations of Texas. Numerous mosquito species in the United States are capable of transmitting VEE. The disease was brought under control using aerial pesticide spraying, quarantine, and vaccination of horses. The epidemic virus of VEE has been isolated from animals in 25 Texas counties. It has not been found outside Texas.

Equine encephalitis has been with us for a considerable time. An epizootic of what was probably viral encephalitis of horses occurred on Long Island, New York, in 1828 and again in 1836 and more than 500 horses died. In 1882 and 1897, horses in Texas died in numbers described as "by the thousands." In 1912, a disease called Horse Plague caused losses estimated at 35,000 in Nebraska, Kansas, Colorado, Oklahoma, and Missouri. In the 1930's, equine encephalitis was regarded as the most important disease affecting horses in the United States. During the 1930's, much additional information was developed in regard to the encephalitides of Equidae. The eastern type (EEE) and the western type (WEE) of equine encephalitis were found to be caused by filterable viruses, and in South America a virus (VEE) was found to be causing a similar encephalitis of horses.

Early clinical signs of encephalomyelitis in horses include marked depression and high fever. Other signs include incoordination, circling, mystagmus, drooping lower lip, and dehydration. The disease may be acute or subacute and may result in prostration and death, or incomplete or complete recovery. In an outbreak situation many infected horses may not show clinical evidence of the disease.

WEE virus was isolated from horses in California in 1930. Human cases were first described in 1932 and the virus first isolated

[1]A speech presented at the February 17, 1972 meeting of the Washington Academy of Sciences.

from man in 1938. The virus of WEE was isolated from mosquitoes in 1941. WEE is found primarily in western and midwestern states and also in western Canada where it has extended to as far north as the south part of Hudson Bay. The disease has also been reported in some southeastern states of this country and WEE virus has been recovered from birds and mosquitoes in northeastern United States. WEE probably also exists in South America in Argentina, Peru and Chile. *Culex tarsalis* mosquitoes (which feed on birds, horses, and man) are considered the primary vector of WEE with wild birds a primary reservoir. Domestic birds can also become infected and WEE virus has also been isolated from squirrels and garter snakes. Significant outbreaks of WEE occur in man as well as horses, both horse and man can be considered dead-end hosts of the virus. The case-mortality rate in horses is about 50%.

EEE virus was isolated in 1933 following investigation of equine encephalitis in New Jersey, Virginia, Delaware, and Maryland. The virus was isolated from humans, pigeons and pheasants in 1938. EEE virus has been found in Canada, eastern and southern United States, and along the gulf coast area extending through Mexico and Central America, and northern and eastern South America as far south as Argentina. Islands in the Caribbean have been involved. The epizootiology of EEE includes a sylvan cycle involving fresh-water swamp mosquitoes and swamp-dwelling birds. The virus can thus cycle over a long period of time until the opportunity is presented for it to "spill over" to other birds and to other mosquitoes which attack horse and man. Horse and man are considered, as with WEE, for practical purposes, to be dead-end hosts. EEE virus causes significant disease outbreaks in horses but fewer cases in man than does WEE. In pheasant flocks direct bird-to-bird transmission has been found.

St. Louis encephalitis (SLE) was recognized in the early 1930's and since has been an important largely urban and sometimes rural mosquito-borne human disease of the continental United States, northern Mexico and the Caribbean. The virus can cycle between mosquitoes and wild birds with man as incidental dead-end host. SLE is not important as a disease of horses nor are they or other mammals, including man, believed to perpetuate the disease. Horses do develop serological SLE titers.

California encephalitis virus (CE) was first isolated from mosquitoes in California in the early 1940's and since has been found in widely separated states. Small wild mammals (perhaps rabbits and squirrels) and mosquito vectors probably maintain the virus in nature. Horses are not an important factor insofar as CEV is concerned.

When one recalls that there are more than 200 recognized arboviruses, I suppose it is only natural that this array can create rather difficult and sometimes bewildering problems. The few just mentioned are those which may come to the attention of scientists in this country. The encephalitides are important diseases of horses and man and from both an economic and public health standpoint are cause for considerable concern to the livestock owners, the general public, and to public health, research and regulatory scientists.

Venezuelan Equine Encephalomyelitis (VEE)

VEE was first noted in horses in Colombia in 1935 and in Venezuela in 1936. The virus was first isolated from an equine brain in Venezuela and identified in 1939. VEE appeared as epizootics from time to time in these countries and was later reported in Trinidad, Ecuador, British Guiana, French Guiana, Surinam, Brazil, Curacao, West Indies, Peru, and Panama. The disease has been observed to cause significant outbreaks in humans since 1944. In 1961 and 1962, a severe outbreak of the disease occurred in humans in Colombia, northwest Venezuela (32,000 cases were reported with at least 190 fatalities) and in Panama where several hundred people became infected. In Ecuador, 31,000 human cases with 250-400 deaths were reported in 1969.

VEE Virus

Like other arboviruses of Group A, VEE is a relatively small (40-70 mu) RNA virus. It

Fig. 1.–Colt with VEE symptoms, Brownsville, Tex.

is not readily inactivated by formalin and can be preserved by lyphilization or in 50% buffered glycerol at -70°C. It can be readily recovered from blood and nasopharyngeal washings if collected during the acute phases of the disease and for longer periods of time from other tissues (e.g., bone marrow, spleen, liver, lung, kidney, thymus, adrenal, heart, lymph nodes). The virus has been isolated from the nasal, eye and mouth secretions and from the urine and from milk of infected mares. VEE virus can be inactivated by propylene glycol, glycolic acid, thioglycolic acid, thiourea, and methyl thioglycolate.

This agent is notorious for its ability to infect laboratory personnel working with the virus, usually by inhalation of airborne material. No chemical has been shown to have significant activity, in vivo, against VEE virus, thus specific chemotherapy is not available at present. This also explains the desirability for a vaccine as was developed by the Army in their TC-83 vaccine for protection of high-risk personnel.

Horses affected with VEE may die of either a fulminating systemic disease or a typical encephalitis. It is not possible to distinguish clinically among the diseases referred to as WEE, EEE, and VEE. Histologic changes furnish only presumptive evidence. Unfortunately, a veterinarian is often called to examine a suspect case after obvious clinical signs are present and viremia is decreasing and antibody levels for serological tests have not yet peaked.

We must depend upon the laboratory for serological and virus isolation work in order to determine which virus is involved.

Three serological tests are used routinely. Listed in the order of their specificity they are:

1. (SN) Virus-Serum Neutralization Test: Neutralizing antibodies often appear within a few hours after infection and may persist throughout the animal's life.

2. (CF) Complement-Fixation Test: At higher antibody levels the CF test is apparently quite specific for VEE.

3. (HI) Hemagglutination Inhibition Test: Using the HI test, a relatively high degree of cross reactivity between VEE and other virus has been observed. Antibodies detected by HI appear somewhat later and probably persist throughout the host's life.

Significant SN, CF, and HI antibodies may develop as early as six days after virus inoculation. Virus isolations may be made by using a variety of laboratory animals including mice, rats, guinea pigs, hamsters, and monkeys. Embryonated hens' eggs readily become infected and die in 15-48 hours.

Chicken embryo, fetal guinea pig heart, baby hamster or bone marrow cells can also be used as tissue culture systems. A practical commonly used laboratory procedure is to inoculate suckling mice with tissues from the suspect case (blood, serum, spleen, brain).

If mice are killed, a crude complement fixation antigen is made from the mouse brain. If the CF test is positive for VEE, the mouse brain is inoculated into guinea pigs or adult mice. If these are killed, this is taken as evidence that epidemic VEE virus is present. If they do not die, this is evidence that either vaccine virus or an endemic strain of VEE is involved. The agent may be further identified by means of the kinetic HI test.

VEE in Man

The incubation period in man is considered to be short, ranging from 2-5 days; the onset is usually very sudden. Symptoms may include severe headache, fever lasting from 1-4 days, malaise, chills, nausea or vomiting, and myalgia. Severe encephalitis or generalized systemic illness may occur, and in rare instances, tremors, diplopia, and lethargy. Symptoms persist 3-5 days in mild cases and as long as 8 days in more serious attacks. A prompt and apparently complete recovery usually takes place. Fatalities generally involve children less than 15 years of age.

VEE Distribution in Wild Mammals and Birds

Isolation of VEE virus from wild mammals includes those from monkeys, fox, spiny rat, forest spiny pocket mouse, terrestrial rice rat, short-tailed cane mouse, cotton rats, opossums, and from certain species of wild birds. Bats appear experimentally to be excellent hosts for the VEE agent. Significant viral titers persisted for at least 26 days and low titers for at least 90 days. The infection is apparently not lethal to the bats.

The VEE virus differs from EEE and WEE viruses in that it seems to multiply better in mammals than in birds. However, VEE virus has been isolated from a number of naturally infected pigeons, chickens, sandwich tern, green heron, groove-billed ani, little blue heron, black-cowled oriole, gray-capped flycatcher, social flycatcher, keel-billed toucan, scarlet-rumped tanager, and clay-colored robin. The 10 last-named species of birds were caught in Panama, although several of these migrate to North America.

English sparrow-mosquito-English sparrow transmission was demonstrated experimentally. Virus levels were usually quite low in all birds inoculated or subjected to mosquito bites, and the birds did not show clinical signs or encephalitis. One species of striated herons with rather low viremias were able to infect feeding mosquitoes. Chicks less than one month old were fatally susceptible to experimental infection; those older than one month produced antibodies but no clinical signs or viremia.

VEE Distribution in Domestic Animals

VEE virus has been isolated from naturally infected horses, mules, and donkeys. Neutralizing and HI antibodies of significant titers have been found in sera from dogs, goats, swine, sheep, and cattle. Of dogs experimentally inoculated with VEE, some died of the infection. Contact transmission from infected to noninfected dogs was demonstrated.

Epizootiology of VEE

The epizootiology of VEE seems to include a sylvan cycle utilizing mosquitoes and wild rodents such as the cotton rat. A large number of species of mammals and birds develop antibodies to VEE virus and virus can be isolated from many of these. Many different species of mosquitoes can be vectors of the disease; however, depending on geographical and climatical factors, and the strain of VEE virus involved. Some species are more efficient vectors than others. Although the mosquito has not been proven to transmit the virus transovarally, the virus multiplies considerably in the mosquito, which can remain infected for life.

Viremia in the horse persists only for a few days. However, it can reach such high levels as to infect nearly all appropriate species of mosquitoes which feed upon it. Contrary to the other viral encephalitides we are concerned with, the horse serves as a very important amplifying host, thus is extremely important from a public health standpoint. One often hears the expression, perhaps an oversimplification, that if you don't have sick horses you don't have an epidemic in humans. However, man can also develop a rather high viremia. Although direct transmission from horse to horse has been experimentally proved, it is unlikely that this plays a significant part in the natural spread of the disease.

In order to understand the encephalitides of man and animals, it is essential that we develop the best possible information on the viral agents involved, which vectors and which host animals are instrumental in maintaining the disease in endemic or sylvatic form, and those hosts necessary for the development of epidemics. It is necessary to determine virus-vector-host relationships, which vectors are potentially the most efficient as well as which animals are capable of infecting them. Many warm or cold-blooded animals are susceptible to mosquito-borne infection, but only certain ones develop sufficient levels of viremia to infect mosquitoes with minimal infection thresholds.

To be an effective carrier or reservoir of infection, the host must be not only susceptible to infection but must also develop and circulate a threshold level of virus sufficient to infect the vector. Some hosts circulate less virus and are able to infect only some species of mosquitoes while others circulate more virus and can infect less efficient mosquito vectors. If the host animal develops too low a viremia to infect mosquitoes, it is considered a blind or dead-end host.

The selective feeding habits of mosquitoes must also be considered. Vectors which feed predominantly on birds, although heavily infected, may not be a hazard for mammals. A similar situation exists for vectors which feed predominantly on only certain species of mammals.

Epidemics are dependent upon the efficiency of the host species and the vector species to propagate the virus and whether both exist in sufficient numbers. The level of viral activity depends not only upon the type of virus present but also on the subtype involved. These vary in their ability to infect hosts and vectors. A certain subtype may, for example, require a certain species of mosquito to maintain viral activity. However, if sufficiently high viral activity is involved other mosquitoes and additional reservoir animals could contribute to additional viral activity. Biologically, broader host and vector spectrums increase the spread and survival probabilities of arbovirus diseases. Although mosquitoes are believed to be the only important vectors of VEE, there have been observations which suggest that others should be investigated.

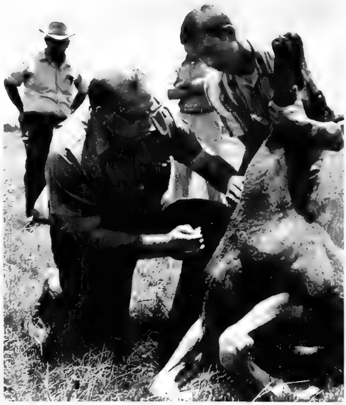


Fig. 2.—Blood sample being taken from colt, Brownsville, Tex. Samples were sent to laboratories at Denver and at Atlanta to be tested for VEE.

In the United States, in southern Florida, during the years 1963 through 1969, 99 isolations of VEE virus (an endemic strain) were made from 5 species of mosquitoes and from cotton rats. Public health officials have also reported naturally-occurring cases in humans in Florida. These were shown by serology, not by virus isolation. The strain in Florida has not caused clinical disease in horses.

Epizootic strains of VEE classified as IA have been isolated from Colombia and Venezuela, IC in Venezuela, and IB (the one which reached Texas) has also been found in Peru, Ecuador, Central America, Mexico, and perhaps Argentina. Fortunately, the TC-83 type vaccine offers protection against all of these. Endemic strains include ID in Colombia and Panama, IE on east coast of Central America and Mexico, II Florida (only), and III and IV in Brazil. The kinetic HI test has been used to differentiate these isolates.

VEE in Mexico

Epizootic VEE had not been reported north of Panama until mid-1969 when the disease occurred in El Salvador and also invaded Guatemala, Honduras, and Nicaragua. The disease further extended into southern Mexico and into Costa Rica. As VEE progressed into Central American countries and on into Mexico, extensive use was made of the U.S. Army TC-83 vaccine in an attempt to protect individual horses and by creating an immune barrier of vaccinated animals.

Although the vaccine proved to be very effective in protecting vaccinated animals, the virus was able to breach the "immune barriers" created to contain it. A number of factors could, of course, have weakened such barriers. The most obvious possibilities are that too many animals did not receive the vaccine, in some cases the vaccine may not have been carefully cared for, or perhaps the mass vaccination program did not begin soon enough or include a large enough geographical area.

It is difficult to know just when epidemic and/or endemic VEE virus first entered Mexico. Neutralizing bodies were found there in 1962. VEE virus was isolated in the State of Veracruz in 1963. In 1966, the disease was reported as affecting some 1,000 horses (with a 30% mortality) in northern Veracruz and southern Tamaulipas states.

In August 1969, an epizootic of equine encephalitis began in the State of Chiapas adjacent to Guatemala. Approximately 300 horses died from December 1969 to February 1970. Vector control measures were undertaken in some areas. The outbreak subsided in March.

The disease again appeared in June 1970 in the same general area and an active vaccination program began in August with close to 500,000 horses being vaccinated in Chiapas, Oaxaca, and Veracruz states. The mortality rate in sick animals was about 80% with 7,000 horses reported as having died out of a population of 300,000. Deaths stopped about 7 days following vaccination; however, by the middle of September the disease had penetrated the vaccination belts to reach north of the Port of Veracruz on the Gulf area by October 1970 and north of Acapulco on the Pacific side of Mexico by November. It was estimated that during 1970, 10,000 horses died in the States of Chiapas, Oaxaca, Veracruz, Guerrero, and Michoacan. It is not known whether human deaths occurred. In April 1971, VEE manifested itself again in southern Veracruz.

During FY 1971, nearly 1 million doses of TC-83 vaccine were made available to Mexico, the most recent being in May 1971 when the 200,000 doses were sent to Mexico in anticipation of a cooperative program to vaccinate a buffer zone in Mexico along the gulf coast between Tampico, Mexico, and Brownsville, Texas. Application of the vaccine in this zone was subsidized by the United States Department of Agriculture.

However, by June, epidemic VEE virus had reached the Texas-Mexico border at Brownsville, Texas. Although initially the disease advanced mainly along the gulf coastal and other areas of lower altitude in Mexico, outbreaks also appeared inland in areas of lower rainfall in the high plains. The disease continued to advance north and west toward El Paso, Texas, and northward through the Pacific coastal and inland areas of Mexico, and continues to appear at various locations in Mexico in animals that were missed when the vaccination brigades were in the area.

Buffer zones of vaccination in Mexico also failed to hold the disease, and it advanced from southern Mexico in June 1970 to the Texas border in June 1971, a distance of 1,000 miles in a year. It spread into the United States in the last week of June.

Mexico plans to vaccinate all of her nearly 9 million Equidae. The task is near completion. It is difficult to obtain accurate morbidity and mortality rates. Up to 25,000 deaths of horses probably occurred in Mexico. There may have been up to 12,000 human cases with an unknown, probably very low, mortality rate.

Control of Venezuelan Equine Encephalomyelitis in the United States

This past summer's outbreak of Venezuelan equine encephalomyelitis was the number one agricultural news story of 1971 in the United States. The virus spread from Mexico into southern Texas, killed several hundred horses, and hospitalized approximately 100 people. On July 16, 1971, the U.S. Secretary of Agriculture declared the existence of a "national emergency threatening the entire horse industry." The Secretary did not have the authority to declare the emergency until the disease was confirmed in this country. This confirmation was reported on July 9, 1971.

The fight against VEE was a Herculean task. More than 4,000 practicing veterinarians, federal and State scientists and inspectors, private aerial pesticide application operators, military personnel, and chemical industry officials were battling the disease at the height of the federal-State cooperative VEE control program.

Three principal weapons were used to bring VEE under control: quarantines to prevent the movement of non-vaccinated horses from infected areas; vaccination to develop an immune horse population; and aerial pesticide spraying to reduce mosquito vector populations. Use of these weapons required massive planning and coordination.

Fig. 3.—VEE victim. This horse had wandered across the Mexican-U.S. border, was caught and held in quarantine pen, where it died.

Quarantines

Federal quarantines on all Equidae were applied to Texas on July 13, 1971, to Louisiana, Arkansas, Oklahoma, and New Mexico on July 19; and to Mississippi on August 2. Horses moving from any State under federal quarantine were required to have a veterinary health inspection and certificate and a VEE vaccination more than 14 days prior to movement. Individual states also placed restrictions on horses brought into the State, and persons wishing to move horses were advised to contact State Animal Health officials of the State concerned.

Federal quarantines were removed from New Mexico, Oklahoma, and Arkansas on September 10, 1971; from Mississippi on November 9, 1971; and from Louisiana on January 17, 1972.

Vaccination

The U.S. Department of Agriculture furnished TC-83 VEE vaccine for horses in the states of Texas, New Mexico, Oklahoma, Arkansas, Louisiana, California, Arizona, Mississippi, Alabama, Georgia, Florida, Kentucky, Tennessee, North Carolina, South Carolina, Virginia, Maryland, Delaware, and New Jersey. The Department also paid for the administration of the vaccine by veterinary practitioners in these States. More than 2.8 million horses have been vaccinated since the vaccination program began in June 1971. This broad experience with the vaccine to date indicates that it is both effective and safe for use in horses and other Equidae even though originally it was designed for use in man (people at high risk). VEE vaccine offers horses protection against VEE virus but not against eastern or western encephalomyelitis. However, vaccines have been available against these diseases for a number of years.

This organized vaccination program was not extended to other States, as they were considered to be in a lesser risk category.

However, since August 25, 1971, a licensed commercial VEE vaccine has been available in all States in which State Animal Health officials authorize its use.

Vector Control Program

Although epidemic VEE was moving rapidly northward through Mexico on rather broad fronts, it was observed that greatest disease pressures were generally along the Gulf coast area and extending inland along major water courses and in areas of lower altitudes. The vector control program in the United States was designed to reduce vector populations in more critical areas, provide time for vaccinating the horse population, and give vaccinated animals time to develop immunity. The area considered most critical was an area extending up the Rio Grande River and up the Gulf coast from Brownsville, Texas. When it was known that the disease was present in a larger area, the vector control program was extended to an area stretching from Falcon Dam, Texas, to Lake Charles, Louisiana. Unfortunately, we were unable to arrange with the government of Mexico for U.S. planes to apply the pesticide on the Mexico side of the border.

A detailed mosquito control plan outlining all aspects of the proposed treatment program was drawn up by the vector control staff of the task force sent into Texas to combat the outbreak. Cooperating federal and State agencies, the governors of Texas and Louisiana, and the President's Council on Environmental Quality reviewed and approved the plan before spraying got underway. This clearance included approval of the use of malathion, a chemical that is one of the safest insecticides in use today. Malathion residues break down a few days after application, and the formulation is relatively harmless to humans, livestock, and other warm-blooded animals. Later the Council approved the use of Dibrom, which is also nonpersistent and low in toxicity to warm-blooded animals.

Meanwhile, the Public Health Service dispatched mosquito surveillance teams to Texas because of the danger to humans who might be bitten by infected mosquitoes. The teams set up light traps throughout the southern portion of the State and began surveying mosquito species and populations. By early July, the Center for Disease Control of PHS had determined that adult mosquito counts were high enough to justify aerial spraying. Information from vector surveys enabled the vector control staff to (1) keep track of mosquito populations and buildups, (2) pinpoint areas where spraying was needed to control mosquitoes, and (3) measure the effectiveness of chemical applications.

Fig. 4.–Aerial spraying for mosquitoes in Houston area–part of vector control effort in the VEE program.

Spraying began on July 10 and when completed on August 13, 9.6 million acres had been sprayed. Local mosquito abatement agencies added another 3.1 million acres making a total of 12.7 million acres sprayed once or twice. Supplemental funding was arranged for 5 county mosquito abatement units along the coastal area of Texas.

Seven major aerial applicators received contracts. The type of aircraft to be used was restricted, for reasons of economy, speed, and proper application of the chemical, to multi-engine planes with swath widths of at least 750 ft and airspeeds of not less than 175 mph. A single DC-3 can do the work of 8-10 single-engine spray planes. An air-ground communications network was set up connecting spray aircraft with their bases and emergency task force headquarters in Houston. Positions of all planes and acreage were plotted on a master control map in the headquarters.

As the program progressed, responsibility for compiling and evaluating survey information passed from the Public Health Service to USDA's leadership. The new mosquito survey team sent into the field was symbolic of the cooperative nature of the VEE control program, with entomologists from USDA, DOD, Texas A&M University, HEW's Center for Disease Control, and from Louisiana State University.

More than 200 federal, State, county and military personnel participated in the VEE mosquito control program. This included USDA pilots who were important factors in maintaining high spraying safety and accuracy. The pilots' daily duties included checking swath widths, making certain that only acreage scheduled for treatment was sprayed, and performing tests to maintain proper aircraft calibration and droplet size and coverage. To further insure environmental protection, pesticide monitoring teams regularly sampled water, sediment, and aquatic organisms from 19 sites throughout the area.

Cooperation received from the Chevron Chemical Company and American Cyanamid (makers of Dibrom and malathion respectively) were also important to the success of the mosquito control program. The production and movement of Dibrom and malathion were increased in coordination with program needs. In addition, both companies sent teams of experts to Texas to aid in monitoring chemical usage and safety precautions.

The VEE mosquito control program ended after 90% of the horses in the infected area and the buffer zone beyond had been vaccinated. During the program's 35 days of operation, most species of adult mosquito populations in the control area were reduced to near zero.

The low toxicity of the insecticides used,

Fig. 5.—Ground fogging for mosquitoes, Atlanta, Ga.

fine atomization and low application rates—3 oz/a for malathion and ¾ oz/a for Dibrom—enabled the task force to achieve mosquito control without endangering local ecologies. All aircraft were inspected in advance of spraying to determine that the correct nozzle sizes were used and that no leaks would cause droplet sizes in excess of those recommended. Close surveillance was maintained by USDA pilots in chase planes to assure adequate performance by spray aircraft. The insecticide flow rate was monitored in the air. Dye cards and glass slides on the ground were exposed to the spray to assure correct droplet size and dispersion.

Environmental Protection Agency personnel collected samples of water, aquatic organisms, sediment, and fish, and otherwise monitored the possible environmental effects of the spray program. Beekeepers were advised in advance to take suitable precautions.

Survey teams reported excellent control of adult *Aedes sollicitans*, *A. taeniorhynchus*, and *Psorophora confinnis*. Except where ground fogging equipment was used to spray barns and sheds, adult Anopheles were not controlled.

The role of the federal and State governments was to stop the epidemic and to minimize the number of human and equine cases rather than eradicate the disease. The control program was successful in this respect. Isolations of epidemic VEE virus were limited to south Texas and to 74 horses and 88 humans in 26 counties. No humans are known to have died from the disease.

Any discussion of the control program must necessarily make special note of the splendid cooperation that was given to the U.S. Department of Agriculture by the Department of Defense, the Department of Health, Education and Welfare, various State agencies, and a vast number of individuals. This assistance was invaluable in conducting the campaign.

Surveillance

The epidemic strain of Venezuelan equine encephalomyelitis (VEE) virus was isolated only from the southern part of Texas in

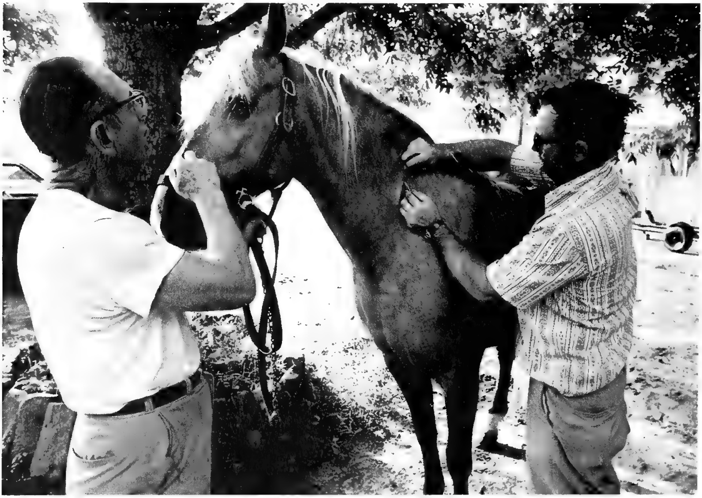


Fig. 6.—VEE vaccination program, Atlanta, Ga.

1971. It is believed that further spread of the virus in the U.S. equine population was prevented by establishing a massive barrier of vaccinated horses, and the vector control measures.

The most important part of VEE surveillance is the prompt reporting and investigation of all suspected encephalitis cases in horses or other Equidae in the entire United States. Prompt laboratory diagnostic results must be obtained from all suspicious cases to effectively control the disease. Samples from these animals will be tested for virus isolation and serum antibody to VEE, EEE, and WEE. However, it cannot be assumed that further viral spread did not or will not occur. Further, there is no information on how far the disease may have spread in those species of animals which may harbor the virus without visible evidence of disease such as small mammals.

A surveillance system is being established to further determine the area of VEE viral activity and to establish an early warning alert system regarding the spread of this disease. A primary surveillance zone has been established across the southern United States. This zone consists of a band that varies in width from 150-300 mi wide north of the United States-Mexico border, crosses through mid Texas in an east-west direction and lies north of the Gulf coast of Louisiana and Mississippi and the Alabama-Georgia-Florida borders.

In the primary surveillance zone, serum samples for antibody detection will be collected from the following animals known to be capable of developing VEE antibodies: dogs, foxes, coyotes, opossums, raccoons, deer, and other wildlife native to the area. Horses in the area will be of limited value for this purpose since most horses have been vaccinated against VEE. Hamsters and rabbits may be used as sentinel animals when necessary to provide adequate surveillance in certain strategic locations, such as in the Mississippi, Sabine, and Pecos River valleys.

To assist in this surveillance, Veterinary Services of the Animal and Plant Health Inspection Service, United States Department of Agriculture, in addition to their own personnel, is seeking assistance from other agencies. The Department of Defense will cooperate in disease and vector monitoring systems on their military bases. Also, a large number of predatory control personnel in Texas, New Mexico, Arizona, and California will assist in the surveillance. The Southeastern Cooperative Wildlife Disease Study (a study group coordinated at the University of Georgia) will participate in the surveillance in the southeastern part of the United States. In return, USDA will notify these cooperating agencies of the laboratory results for Venezuelan, eastern, and western equine encephalomyelitis.

Fig. 7.—All horses vaccinated for VEE were identified.

Summary

In the summer of 1971, VEE was brought under control using 3 principal weapons: quarantine and vaccination of horses and other equidae, and aerial pesticidal spraying for vector control.

In more than 1,500 U.S. investigations of horses suspected of having encephalitis, the epidemic virus of VEE has been isolated from animals only in 26 south Texas counties.

The Herculean task of stopping the northward spread of VEE in the United States was accomplished only through the cooperative effort of many individuals and agencies.

A surveillance system has been established to detect any new outbreaks or other spread of VEE.

Noise Increase in an Ubanizing Area

H.E. Landsberg

Institute for Fluid Dynamics and Applied Mathematics, University of Maryland, College Park 20742

ABSTRACT

Measurements in a large wooded area and in a small shopping center at Columbia, Md. showed a significant difference in sound levels attributed solely to human activity.

Urbanization increases noise levels. Nature has her own sounds: the rustling of leaves, the murmuring brook, the pounding of the surf, the song of the birds. Occasionally these have their own crescendos: the howling gales, the crashing thunder. But, by and large, in our regions nature is usually quiet. Man has intruded with noisier and noisier activities as his numbers per unit area grow. Noise has in recent years been somewhat redundantly designated as a pollutant.

Within the framework of an investigation of changes in the local atmospheric environment, caused by urbanization, casual observations of sound levels were also made. The locale has been the growing town of Columbia, Maryland, a so-called planned community. Located in the Washington-Baltimore corridor, it has grown from about 200 inhabitants in a rural farm setting in 1967 to about 17,000 in 1972.

The micrometeorological changes have already been profound. They have been reported on as they occurred (Landsberg, 1970; Landsberg and Maisel, 1972) and remain under continuing surveillance. The sound measurements were made coincidental to a series of mobile micrometeorological surveys. These were traverses through the area of the new town from the rural edges through various sectors which are in various stages of urbanization. It became immediately obvious that there was a notable increase in sound level as the areas of dense settlement were approached.

This led to an experiment in which greater statistical detail on the sound levels was sought. On 2 meteorologically similar days 2 selected sites were placed under surveillance. In each case sound was continuously recorded for 6 hours, from 8:30 a.m. to 14:30 p.m. One site was a large wooded area in a sector of the town not yet urbanized. The day of the survey, to minimize influence of outside sound sources, was Sunday. A traffic artery of the settlement was, however, within hearing distance. The second site was a small shopping center in one of the residential villages of the town. It has a supermarket, small stores and a sizeable parking lot. Data were collected on a weekday.

The sound levels were evaluated every minute, which was about as detailed as the resolution of the equipment permitted. This yielded a sample of 360 readings at each site.

[1]Contribution No. 58, Graduate Program in Meteorology.

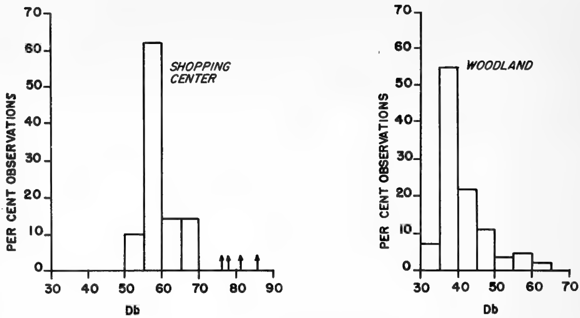


Fig. 1.–Frequency distribution of noise levels, by 5-db intervals, in Columbia, Md. area. Left shows daytime values in urbanized sector on moderately busy day. Right shows daytime condition in a sector of undeveloped woodland, representative of conditions prior to urbanization of area.

This should be a representative sample of the 2 settings.

These surveys did, indeed, result in 2 notably different samples of sound levels. These sites are undoubtedly representative of the "undisturbed" environment of the area and of one moderately affected by urban activities. The samples support only in greater detail what had also been established on some 50 mobile micrometeorological surveys from 1969-1971. On these instantaneous sound was measured at 18 fixed points in the townsite and a few casual measurements on a farm 3 mi to the west. These measurements, which will be referred to below, are entirely consistent with the hypothesis that the differences between the 2 survey sites are caused by the absence of human activity at the first and their presence at the second.

Fig. 1 shows the frequency distributions of sound levels by 5-db intervals. For the shopping center only a 5-hr interval was used in this graph during hours maximum activity. For the other hour, prior to much activity, a different pattern was prevalent, to be referred to again later. As is readily notable from the histograms, the frequency distributions are fairly compact with strong modes. In the woodland this mode is at the 35-40 db level, a very quiet environment. In the shopping center the principal level was 55-60 db, considered to be an intrusive noise level. At the shopping center the level never sank below 50 db. In the early morning before much activity in the center the mode of the frequency distribution is between 50 and 55 db.

The distribution in the woodland is very skewed, with some quite high levels recorded. These occasional loud noises were caused extraneously by automobiles on the neighboring thoroughfare and aircraft passing overhead. In the shopping center histogram some arrows mark occasional peak noises of 70-80 db caused by jet aircraft in the take-off and landing patterns of Friendship International Airport (14 miles east of Columbia), a facility perhaps a bit too close for a "planned" community.

The highest noises in these surveys, as well as during the mobile observations over a 3-yr interval, were screaming sirens of emergency vehicles and the clanging of trash disposal trucks. These reached the 80-85 db level. All noises resulting from the ephemeral activities of construction, such as bulldozing, earth-tamping and steelwork were eliminated from the data. They, too, reached high levels in the 70 and 80 db class. However, they cannot be considered as permanent parts of the community life. Present levels of sound during daytime in Columbia, as revealed by the mobile surveys, yield the following average outdoor values: open residential areas 56 db, dense housing areas 61 db, business districts 66 db. Most of these noise levels are created by automobile traffic. At night these values are reduced by 5 to 8 db, on an average.

During the early days of construction there was a chance to measure the sound reduction by trees. A row of townhouses had been built and occupied. It was screened by a 75-m-wide belt of deciduous trees, 15 m high, without underbrush. On the other side was a highway with moderate traffic. At the edge of the highway, during daytime hours sound levels of 70 db prevailed but in the backyard of the shielded houses the sound was reduced to a 58-db average. This gives a shielding value of 5 db/30 m of shelterbelt. Other work has shown that 6-8 db/30 m reduction can be achieved by trees and shrubbery, judiciously planted (Leonard, 1971; Cooke and Haverbeke, 1971). The Columbia shelterbelt has now made way to more housing and the sound levels in the whole section have risen. This is, of course, the result of a blend of noises from the highway and those internally produced.

Although our project was not designed to make a systematic noise survey, the data obtained are likely to be representative of areas in the process of urbanization. The result of an approximate 30-db increase in noise level for an essentially residential community is not encouraging. It also indicates the need for considerably more imaginative land planning and use of vegetation in new communities than heretofore.

Acknowledgments

The help of Miss D.W. Galvin and Mr. T.N. Maisel in the survey work is greatly appreciated. The support of our work by NSF (Atmospheric Science Section) through Grant GA-29304X is gratefully acknowledged.

References Cited

Cook, D.I., and Haverbeke, D.F. v, 1971: Trees and shrubs for noise abatement; Trees and Forests in an Urbanizing Environment, Univ. of Mass. Coop. Ext. Serv. Monogr., pp. 39-41.

Landsberg, H.E., 1970. Climatic consequences of urbanization; J. Wash. Acad. Sci. 60: 82-87.

Landsberg, H.E., and Maisel, T.N., 1972. Micrometeorological observations in an area of urban growth; Boundary-Layer Meteorology 2: 365-370.

Leonard, R.E., 1971. Effects of trees and forests in noise abatement; Trees and Forests in an Urbanizing Environment, Univ. of Mass Coop. Ext. Serv. Monogr., pp. 35-38.

Grooming in Polistes exclamans (Viereck), a Forerunner of Communications in Social Hymenoptera

John A. Fluno[1]

Entomology Research Division, Agr. Res. Serv., USDA, Beltsville, Md. 20705

ABSTRACT

The behavior pattern in a nest of *Polistes exclamans* (Viereck) is described, and colony development before and afterwards is recorded. Similarity of this behavior to the dance of the honeybee suggests that this behavior may be a forerunner to communicative dancing as found in the honeybee.

In July 1971, I was fortunate enough to observe a behavior pattern in a nest of *Polistes exclamans* (Viereck) not unlike communicative dancing on the comb of the honey bee, *Apis mellifera* L. The events observed and colony development before and after the event are herein described.

In the vicinity of Silver Spring, Maryland, some *P. exclamans* come out of hibernation as early as February 7, but most probably do not survive, although I saw one queen out of hibernation on February 18, 1971. Thus the queen that built the nest over the east door of the North Building, Plant Industry Station at Beltsville, Md., probably left hibernation some time in March or early April. I first noted the nest May 14; it was on a cornice over the upper righthand corner, about 45 inches above the actual swinging door (which swings inward). The nest contained 4 cells; by May 27, it had 15 cells. On June 8, there were 20 cells, and two of these were capped, indication of prepupae or pupae within. The queen spent quite a bit of time June 8 near the capped cells. Then, between 1:15 p.m. EDST and 2:05 p.m., the first worker emerged. By July 13, at least 8 workers and the queen were present; by July 20, there were at least 11 workers.

During the week of July 13 to July 20, on five different occasions, one or more of the wasps performed a "waggle dance" similar to that commonly performed by honey bees. For the record, my notes on those occasions are given here in their entirety:

"*July 13*—At 7:55 a.m., EDST, 8 on nest. At 9:05 a.m., 6 on cells, 1 behind nest, all fairly quiet. At 11:50 a.m., 8 or 9 on nest, very active. As I watched, 1 arrived, apparently carrying no meat. She performed a "waggle dance" like a honey bee, oriented towards 1 o'clock [6 o'clock was toward the building]. She repeated the "dance" twice more, circling each time to the same initial position and then preened or groomed herself. So far as I could tell, the dance drew no attention from her sister wasps.

"*July 15*—At 8:05 a.m. EDST, 6 very active on nest. At 11:33 a.m., as I stepped out to observe, 1 wasp was doing a waggle dance towards 7 o'clock—I think she was the queen. The others paid no attention and she

[1]Mr. Fluno retired from ARS June 30, 1972. His present address is 1234 Lakeview Drive, Winter Park, Florida 32789.

did not groom herself afterwards. Is this plea for grooming a forerunner to communication as it occurs in honey bees? At this time, I counted 7 wasps on the nest. At 4:50 p.m., I could see only 5 on the nest. Were all but the queen and 4 workers out foraging for food?

"*July 16*—At 8:06 a.m. EDST, at least 7 on nest. At 10:37 a.m., when I first looked, 1 finished a waggle dance and then groomed herself. At 5:33 p.m., 8 on nest and 1 behind. Two were grooming themselves and 1 did a waggle dance towards 9 o'clock and then went behind the nest."

"*July 20*—At 8:45 a.m. EDST, at least 12 on nest; at 11:32 a.m., while I was attempting to count, 1 arrived with meat. The meat was divided and just about every wasp (now 10 of them) promptly took a head-down position in a cell, obviously feeding larvae and doubtless getting fed in return. Several then performed the waggle dance in several different directions. Some then began preening or grooming themselves. At 5:03 p.m., I counted only 6 on the nest; this is obviously now a thriving, successful colony, with as many as 6 away from the nest at a time, hunting food or paper-making materials."

At this time, the nest was about 3 inches in diameter. It had a ring of 19 capped cells placed a bit offcenter. The ring was as narrow as 1 cell wide in places but several cells wide in other places. That there were larvae in the cells inside as well as outside the ring was evidenced by the activities of the workers in parceling out meat brought to the nest.

I was out of town between July 23 and August 30 and thus could not observe the nest during this period. By September 1, the nest was about 6 inches in diameter. There were at least 25 wasps on the nest, and a major emergence on September 7 at least doubled the number of wasps in the colony. From then until mating and dispersal began on October 13, there appeared to be no room for waggle dancing. It would appear that observance of the dancing behavior is dependent upon relatively small numbers of wasps on the nest so room is available for the activity. Yet I suspect the colony must be a successful one. It is possible that caring for the sexual brood may play a role in triggering the behavior. I made many observations before July 13 without seeing any indications of the dance. Fortunately, the nest was within a few feet of my office, and observation was not time-consuming, so I did not hesitate to dash out to look at the nest from time to time, often as many as four times a day.

Time of day did not seem to be a factor. Waggle dances were observed at 10:37 a.m. (July 16), 11:32 a.m. (July 20), 11:33 a.m. (July 15), and 11:50 a.m. (July 13), but also at 5:33 p.m. (July 16).

I saw no evidence that any direction-giving was accomplished by the dancing behavior, but grooming almost always occurred. The activity of dancing in a predatory hymenopteran was totally unexpected. However, this kind of behavior has been reported by others. Esch (1971) described the waggle dance in *Polistes versicolor vulgaris* Bequaert and reported a sound-burst at the turning point of the dance. Eberhard (1969) reported waggle dancing in *Polistes fuscatus* (Fabricius).

The opinions of the two authors concerning the significance of the dance do not agree. Esch feels it may be part of a defensive behavior, but Eberhard calls it an expression of dominance by the queen or another female that ranks high in the nest hierarchy.

Regardless of the true meaning or function of the waggle dance, if any, its similarity to the dance of the honey bee suggests that the behavior may be a forerunner to communicative dancing in the socially more fully evolved honey bee.

References Cited

Eberhard, M.J.W. 1969. The social biology of polistine wasps. Museum of Zoology, U. of Mich., Misc. Pub. No. 140, 101 pp.

Esch, H. 1971. Wagging movements in the wasp *Polistes versicolor vulgaris* Bequaert [Hymenoptera, Vespidae]. Zeit. Vergleich. Physiol. 72: 221-25.

BOARD OF MANAGERS MEETING NOTES
April, 1972

The 619th meeting of the Board of Managers of the Washington Academy of Sciences was called to order at 8:07 p.m. on April 13, 1972 by President Robbins in the Conference of the Lee Building at FASEB.

Announcements.–Since the minutes of the 618th meeting had been mailed to members of the Board prior to the meeting, Dr. Robbins invited comments or corrections. It was requested that the attendance record be corrected to show that S.B. Detwiler, Jr. was present. After due consideration the minutes were declared to be accepted as corrected.

Dr. Robbins introduced Dr. Edward E. Beasley, the new delegate from the Philosophical Society of Washington (elected to follow in Feb. 10, 1972); and Dr. Edward Hacskaylo, who would later report the findings of the special committee that studied the JBSE.

Two letters received recently by Dr. Robbins were instrumental in her decision to move the location of the Annual Meeting from the Cosmos Club to the George Washington University Club. The letters voiced objection to the refusal of the Cosmos Club to admit women as members. Her sympathetic action was in keeping with her plan to speak on the problems of Women in Science in her address as the retiring president of the Washington Academy of Sciences. The meeting date will be the third Wednesday instead of the third Thursday of May.

Two meetings were announced. The 33rd Annual Conference of the Chemurgic Council would be held in the Statler Hilton Hotel on May 11 and 12, 1972. The annual Teacher Recognition and Awards Dinner of the JBSE would be held on May 15th. Dr. Sarvella updated the announcement to state that the dinner would probably be held at the Broadmoor Csikos Restaurant.

Upon arrival of Mr. William A. Deiss from the Smithsonian Institution, further business was delayed that he might speak. Mr. Deiss had previously requested permission from Dr. Robbins to discuss with the Board of Managers, the desire of the Smithsonian to become the custodian of the archives of the Washington Academy of Sciences. He provided each board member with a copy of a Smithsonian publication entitled "A Guide to Archives." The archives are located in the main building and can handle 4,000 cubic feet of records. 1500 cubic feet are now in service. The archives at the Smithsonian may be broadly grouped as official records of the Smithsonian and as the manuscript collection. The archives of the Philosophical Society of Washington are now held by the Smithsonian.

Mr. Deiss indicated that of particular interest to historians or scholars would be the financial records and both published and unpublished manuscripts. He explained that a complete set of the Academy Journals would have interest to scholars mainly to fill in gaps of history where certain of the desired records and manuscripts were missing. He explained further that the Smithsonian Library had the Journal and the Proceedings of the Washington Academy of Sciences.

Mr. Detwiler recalled several interesting facts. He could provide a complete set of the Journal and Proceedings prior to 1950. He remembered that Dr. Heinz Specht when secretary had compiled voluminous, detailed minutes of each meeting. He also recalled that before the move from 1530 P Street, N.W. to Bethesda, Dr. Malcolm Henderson had gone through the files and discarded heavily. Dr. Robbins thought that some past officers and Committee Chairmen might have some records that no longer exist in the Academy office files.

Dr. Deiss emphasized that archivists

generally have a different point of view about such records than do the scientists; therefore he would like for the Smithsonian to see all of the records before any are discarded. He extended an invitation for members of WAS to visit the archives during Monday through Friday, between the hours of 8:45 a.m. and 5:15 p.m. Other times are possible under special arrangements. He suggested that a call for appointment be made to 381-5355.

Dr. Honig moved that the "proposal to place our past documents and papers into the custody of the Smithsonian archives be accepted in principal." There followed a second by Mr. Detwiler and a voice vote of approval.

Treasurer.—Treasurer Honig had good news on the financial state of the Academy. Since his last report an amount of $5000 had been received as dividends from investments. Also a grant in support of Symposium II had been received from EPA. Although the account books are practically balanced at the moment; there still exists the state of deficit spending where we are dependent on the receipt of next year's dues to meet bills for the rest of the fiscal year. Dr. Honig urged Miss Ostaggi to send out follow-up letters for the collection of this year's dues.

Ad Hoc Committee on the JBSE.—Dr. Hacskaylo was invited to give his report at this time in view of the lateness of the hour and in view of the number of committee reports yet to be heard. Dr. Hacskaylo stated that the committee had met on five occasions since late December in order to accomplish the following assignment:

1) to make a thorough study of the relationship between the Joint Board and the parent organizations.
2) to recommend to the parent organizations whether the relationship should be continued or not.
3) if the recommendation is that the relationship be maintained, to establish a set of rules that clearly indicate the role of the parent organizations on the one hand and of the Joint Board on the other in all of their relationships with each other. These rules will then be the basis for rewritten By-laws of the Joint Board.

The report as submitted represented the opinion of the majority of the committee. There is a possibility of a minority report. It appears to be unanimous in the committee that the activities of the JBSE and its relations with the parent organizations had been reviewed thoroughly. Also there was unanimous agreement that there is a continuing need for an organization or board such as the Joint Board. The report gave recommendations on the number of members that constitute the JBSE, the selections of members of the board and the term of office, and the rotation of chairmen between appointees of the two parent organizations. Regarding relations between the JBSE and the Parent organizations, the committee pointed out need for improved communications, need for adequate financial support, need for restructuring of the by-laws, and the need for a continuing review of the JBSE programs to increase their effectiveness.

Although Dr. Hacskaylo responded to numerous questions during the presentation of the report, the Board of Managers indicated a desire to study the recommendations and make decisions on another occasion. A motion by Dr. Honig and a second by Dr. Forziati was approved by voice vote to receive the report as presented, with expression of gratitude for the diligent work of the *ad hoc* committee.

Membership.—A first reading of the nominations for fellowship was given at the February 10, 1972 meeting. Following a second reading at this meeting, and upon a motion by Mr. Detwiler and a second by Dr. Sarvella and a voice vote of approval, Dr. James S. Albus, Mr. Alfred F. Campagnone, and Dr. Melvin Reich were accepted as Fellows of the Washington Academy of Sciences.

Information about nine additional candidates was submitted by mail to the Board of Managers by Chairman Landis in a memorandum dated March 29, 1972. A second reading was given by Dr. Robbins with the explanation that these candidates were now eligible for final consideration. In this group were Dr. Anton M. Allen, Dr. Stuart A. Aaronson, Dr. Ronald Fayer, Dr. Andrew M. Lewis, Jr., Dr. Robert R. Oltjen, Dr. Robert H. Purcell, Dr. Theron S. Rumsey, Dr. David R. Smith, and Dr. Sidney Teitler. A voice note of approval followed a motion to that effect by Dr. Sarvella and a second by Mr. Detwiler.

In a memorandum from Chairman Landis, Mr. Paul H. Oehser (already a fellow) was identified as the new delegate from the Columbia Historical Society. Pertinent information about two additional nominees for fellowship was read by Dr. Robbins for the first time.

Policy and Planning.—Dr. Retsigle, President Elect of the District of Columbia Institute of Chemists, has requested information leading to an application for affiliation.

Ways and Means.—Dr. Honig inquired of Dr. Robbins as to the existence of an auditing Committee. One will be appointed promptly.

Meetings.—At the April meeting, Dr. Walter Boek will talk about the National Graduate University.

Awards for Scientific Achievement.—Chairman Dickson was congratulated for the success of the Awards meeting. He inquired about awards in other disciplines being made next year, and was given guidance that the committee had considerable latitude in proposing special awards.

Grants-in-Aid.—Dr. Sarvella's report involved a plan to award the available AAAS grant for this year to secondary school students, unaware of the fact that an amount of $360 had already been paid out to the Summer Research Participation Program at American University. She proposed to contact AAAS and then keep the awards within the budget.

Public Information.—Chairman Noyes stated that he had compiled a list of 30 organizations that probably would be interested in announcing in their newsletters about the existence of publications on Symposium I and on Symposium II. He proposed to write to each organization and he also asked for permission to place an ad in the magazine "Science." Dr. Sarvella and Dr. Forziati initiated a motion to authorize the committee to place an advertisement in "Science" at a suitable price. Motion carried.

Tellers.—Chairman Detwiler noted that President-Elect Cook will move into the President's position at the annual meeting in May. For the other position there were two or more candidates on the ballot this year for the first time. The votes were distributed as follows:

President-Elect	Grover C. Sherlin	200
Secretary	Kurt H. Stern	209
Treasurer	Nelson W. Rupp	172
Richard P. Farrow		125
Jean Boek		111
John G. Honig		145
Managers at Large	Selected by the Hare system were Leland A. DePue and Elizabeth Oswald for three-year terms. In addition Raymond J. Seegar was selected to complete the post vacated when Father Heyden moved to the Phillipines.	

On Ballot II the Maryland, District of Columbia-Virginia Section of the Mathematical Association of America was voted into affiliation, 320 to 4.

On Ballot III, Amendment of the By-laws were approved by a vote of 307 to 10. In the future the Nominating Committee is directed to qualify at least two candidates for each elective position on the Ballot.

Special AAAS Committee.—Dr. Cook explained that there were two interlinked matters that he was concerned with on this committee. For one thing, there is a proposal that students be secured either through the efforts of the FBSE or the WJAS to serve as ushers at the Sheraton Park and the Shoreham Hotels during the AAAS meetings in Washington, D.C. December 26-30, 1972.

The second thing concerns the subject for Symposium III. Dr. Cook believes that four other meetings in Washington, in a time span of three months, on the aspects of Noise Pollution will satiate all interest in Noise Symposiums for a while. Other possible topics proposed were Solid Waste Disposal, Food Additives, and Pandemic Gonorrhea. Other topics may be proposed, looking toward possible sources of financial support.

The meeting adjourned at 10:47 p.m.—*Grover C. Sherlin,* Secretary

---

ANNOUNCEMENT

Due to the lateness of the present issue, and to the fact that the Society is undergoing a change in printers, the March 1973 issue will present a somewhat expanded "Academy Affairs" section containing news that could not be included here.—*Ed.*

BY-LAWS OF
THE PHILOSOPHICAL SOCIETY OF WASHINGTON

(Adopted by the Society, November 24, 1917; as amended December 4, 1920, May 21, 1932, December 3, 1938 and April 14, 1972.)

Article I. THE OFFICERS OF THE SOCIETY, THEIR ELECTION AND DUTIES

Section 1. The elective officers of the Society shall be a President, First and Second Vice-Presidents, a Corresponding Secretary, a Recording Secretary, a Treasurer and four members-at-large of the General Committee. These officers, together with the latest two living ex-Presidents of the Society and the Chairmen of the Program and Membership Committees, shall constitute the board of management of the Society, to be called the General Committee. The elective officers shall be chosen by ballot at or previous to the Annual Meeting of the Society, shall start their terms of office at the close of this Annual Meeting and hold office until the close of the Annual Meeting in the year in which their successors are elected. Any vacancy occurring among the officers shall be filled by the General Committee until the next Annual Meeting, when such vacancy shall be filled by the Society. No member of the Society shall hold any one office for more than two years in succession.

Section 2. The President, First and Second Vice-Presidents and Treasurer shall be elected annually, and shall serve for one year. The Corresponding Secretary, the Recording Secretary and the members-at-large of the General Committee shall serve for two years. The Chairmen of the Program and Membership Committees shall be elected by the General Committee not later than the last meeting in February and shall hold office for one year beginning June 1. Other members of these committees shall be elected by the General Committee not later than the first meeting in May and shall hold office for the year starting June 1.

Section 3. The President shall preside at meetings of the Society and of the General Committee, and shall applint all committees not otherwise provided for. In the case of the absence of the President his duties shall devolve upon the officers of the Society in the following order:

1. First Vice-President.
2. Second Vice-President.
3. Corresponding Secretary.
4. Recording Secretary.
5. Treasurer.

Section 4. The Corresponding Secretary shall conduct the general correspondence, keep the minutes of the General Committee, keep the register of members showing dates of their election, transfers, resignations, deaths, etc., and make an annual report jointly with the Recording Secretary.

Section 5. The Recording Secretary shall keep the minutes of the Society, and shall be in charge of the publication of scientific papers and abstracts.

Section 6. The Treasurer, or in his absence or inability to act, the Acting-Treasurer provided for in Article I, Sec. 7, shall, under the direction of the General Committee, have charge of the funds and investments of the Society, shall keep a correct copy of the register of members of the Society, shall make collections and disbursements, and shall render an annual report. His accounts shall be audited annually by an appointed Committee of the Society not members of the General Committee.

Section 7. The General Committee shall have power to designate any one of its members except the President, a Vice-President or a Secretary, as Acting-Treasurer to serve during the absence of the Treasurer or his inability to act.

Section 8. Not later than ten weeks before the Annual Meeting the President shall appoint a Committee on Elections consisting of three members who are former Presidents. The Committee shall serve as a nominating committee and shall have charge of the Annual Election of Officers.

Article II. THE GENERAL COMMITTEE

Section 1. The General Committee shall have the control and management of the affairs, property and funds of the Society. Five members shall be a quorum for the transaction of business, but not fewer than four affirmative votes shall be necessary for any financial action. It shall adopt by-laws for the establishment and government of standing committees, for the nomination and election of new members, for the dues of members and for such other matters not covered herein as may be necessary to carry out the objects of the Society.

Section 2. The General Committee shall make, or cause to be made, rules and specifications for the conduct of nominations and elections.

Article III. MEETINGS OF THE SOCIETY

Section 1. Regular meetings of the Society for the consideration and discussion of scientific subjects shall be held on alternate Fridays from October to May, inclusive, unless the General Committee shall otherwise direct. Special meetings of the Society may be called by the General Committee.

Section 2. The first regular meeting in January shall be set apart for the address of the retiring President.

Section 3. The last regular meeting in December shall be the Annual Meeting for the presentation of annual reports, and, if necessary, the completion of the election of officers.

Section 4. The meetings of the Society shall be held at such place and hour as the General Committee shall designate.

Article IV. ANNUAL MEETING

Section 1. At the Annual Meeting of the Society the order of proceeding shall be as follows:

1. Reading of minutes of last Annual Meeting.
2. Report of Treasurer.
3. Report of Auditing Committee.
4. Report of Secretaries.
5. Report of Committee on Elections.
6. Election of Officers not already decided.
7. Business presented by General Committee.
8. Discussion of Society policies and recommendations to the General Committee.
9. Reading of rough minutes of the meeting.

Article V. AMENDMENTS

Amendments of the foregoing By-laws shall only be made by a two-thirds vote of those members of the Society present at a regular meeting, after notice of the proposed change shall have been mailed to each member at least two weeks previously.

THE PHILOSOPHICAL SOCIETY OF WASHINGTON
Officers and Committees
1 Oct 1972

President
Edward E. Beasley

Vice Presidents
Bradley F. Bennett
Ralph P. Hudson

Corresponding Secretary
Robert J. Rubin (1971-73)

Recording Secretary
James J. Krebs (1970-72)

Treasurer
George E. Hudson

Members-at-Large
Earl Callen (1970-72)
Herbert Jehle (1970-72)
Harold Glaser (1971-73)
Heber J. R. Stevenson (1971-73)

Past Presidents on the General Committee
Langdon T. Crane, Jr.
Herbert Hauptman

Membership Chairman
Bernard E. Drimmer (1972-73)

Program Chairman
Dirse W. Sallet (1972-73)

Joseph Henry Lecture Committee (for May 1973)
Ralph P. Hudson, Chairman
Julian Eisenstein
Paul H. E. Meijer

Committee on Elections (for December 1972)
John A. O'Keefe, Chairman
Langdon T. Crane, Jr.
Louis R. Maxwell

JOURNAL OF THE WASHINGTON ACADEMY OF SCIENCES

Instructions to Contributors

General

Type manuscripts on white bond paper either 8½ by 11 or 8 by 10½ inches. Double space all lines, including those in abstracts, tables, legends, quoted matter, acknowledgments, and references cited. Number pages consecutively. Place your name and complete address in the upper right hand corner of the title page.

Title, Author, and Affiliation

Page 1 of your manuscript should contain only this information and your name and address. Choose a concise but complete and meaningful title. In research papers concerning biological subjects, include an indication of the order and family of the taxa discussed. Academic degrees will not normally be included unless the author so specifies. If possible, combine your affiliation and mailing address (including Zip) so that readers can write to you directly.

Abstract

Type on a separate sheet at the end of the manuscript. Make the abstract intelligible without reference to the text of the paper. Write an informative digest of the significant content and conclusions, not a mere description. Generally, the abstract should not exceed 3% of the text.

Footnotes

Use footnotes as sparingly as possible. Number text footnotes consecutively with Arabic numerals and type them on a separate sheet of paper at the end of the manuscript. Type table footnotes, if any, below each pertinent table on the same page.

Illustrations and Legends

The quality of all original illustrations must be high enough to facilitate good offset reproduction. They should have ample margins and be drawn on heavy stock or fastened to stiff cardboard to prevent bending. They should be proportioned to column (1 x 3) or page (2 x 3) type-dimensions, leaving space for legend material. Photographs should have a glossy finish. They reproduce best when the contrast is fairly high. Identify each illustration with number and author in light pencil marks on the reverse side. Submit all illustrations separately – please do not glue or clip them to the pages of the manuscript.

Do not type or write legends directly on the illustrations. Type legends on a separate sheet or sheets at the end of the manuscript. Indicate where you want illustrations to appear in the printed paper by writing the figure numbers lightly in the text margins, and be sure that each figure is properly referenced in the text itself. Original "art" will be returned only at the author's request and expense.

Tables

Include tables only when the same information cannot be presented economically in the text, or when a table presents the data in a more meaningful way. Consider preparing extremely complicated tabular matter in a form suitable for direct reproduction as an illustration. In such cases, the use of the typewriter is not recommended.

References to Literature

Limit references within the text and in synonymies to author and year (and page if needed). In a "Reference Cited" section, list alphabetically by senior author only those papers you have included in the text. Likewise, be sure all the text references are listed. Type the "References Cited" section on a separate sheet after the last page of text. Abbreviations should follow the *USA Standard for Periodical Title Abbreviations*, Z39.5-1963.

Submission of Manuscripts

Send completed manuscripts and supporting material to the Academy office (see address inside front cover) in care of the Editor. Authors will be requested to read Xerox "proofs" and invited to submit reprint orders prior to publication.

Reprints - Prices for reprints may be obtained on request.

Washington Academy of Sciences
Room 29, 9650 Rockville Pike (Bethesda)
Washington, D.C. 20014
Return Requested with Form 3579

2nd Class Postage
Paid at
Washington, D.C.

VOLUME 63
Number 1
MARCH, 1973

Journal of the WASHINGTON ACADEMY OF SCIENCES

Issued Quarterly
at Washington, D.C.

Directory Issue

CONTENTS

Features:

FRED SCHULMAN: Technology and Our Standard of Living 2

WALTER E. BOEK: Institutional Stability and Innovation in Higher Education 11

LEE J. SHERVIS and R. D. SHENEFELT: Poor Access to *Apanteles* Species Literature Through Titles, Abstracts, and Automatically Extracted Species Names as Keywords 22

Research Reports:

BARNARD D. BURKS: North American Species of *Calosota* Curtis (Hymenoptera: Eupelmidae) 26

Academy Affairs:

Scientists in the News 32

Obituaries
- Wade H. Marshall 35
- Walter D. Sutcliffe 36

Notice 25

Washington Academy of Sciences

Founded in 1898

ACADEMY OFFICE

9650 Rockville Pike (Bethesda)
Washington, D. C. 20014
Telephone (301) 530-1402

The Journal

This journal, the official organ of the Washington Academy of Sciences, publishes historical articles, critical reviews, and scholarly scientific articles; proceedings of meetings of the Academy and its Board of Managers; and other items of interest to Academy members. The *Journal* appears four times a year (March, June, September, and December) – the September issue contains a directory of the Academy membership.

Subscription Rates

Members, fellows, and patrons in good standing receive the *Journal* without charge. Subscriptions are available on a calendar year basis only, payable in advance. Payment must be made in U.S. currency at the following rates:

U.S. and Canada	$10.00
Foreign	11.00
Single Copy Price	3.00

Back Issues

Obtainable from the Academy office (address at bottom of opposite column): **Proceedings:** Vols. 1-13 (1898-1910) **Index:** To Vols. 1-13 of the *Proceedings* and Vols. 1-40 of the *Journal* **Journal:** Back issues, volumes, and sets (Vols. 1-62, 1911-1972) and all current issues.

Claims for Missing Numbers

Claims will not be allowed if received more than 60 days after date of mailing plus time normally required for postal delivery and claim. No claims will be allowed because of failure to notify the Academy of a change in address.

Changes of Address

Address changes should be sent promptly to the Academy office. Such notification should show both old and new addresses and zip number.

Published quarterly in March, June, September, and December of each year by the Washington Academy of Sciences, 9650 Rockville Pike, Washington, D.C. Second class postage paid at Washington, D.C.

DELEGATES TO THE WASHINGTON ACADEMY OF SCIENCES, REPRESENTING THE LOCAL AFFILIATED SOCIETIES

Philosophical Society of Washington	Edward Beasley
Anthropological Society of Washington	Jean K. Boek
Biological Society of Washington	Delegate not appointed
Chemical Society of Washington	Harvey Alter
Entomological Society of Washington	Reece I. Sailer
National Geographic Society	Alexander Wetmore
Geological Society of Washington	Charles Milton
Medical Society of the District of Columbia	Delegate not appointed
Columbia Historical Society	Paul H. Oehser
Botanical Society of Washington	Conrad B. Link
Society of American Foresters	Robert Callaham
Washington Society of Engineers	George Abraham
Institute of Electrical and Electronics Engineers	Leland D. Whitelock
American Society of Mechanical Engineers	William G. Allen
Helminthological Society of Washington	Aurel O. Foster
American Society for Microbiology	Lewis Affronti
Society of American Military Engineers	H.P. Demuth
American Society of Civil Engineers	Carl H. Gaum
Society for Experimental Biology and Medicine	Carlton Treadwell
American Society for Metals	Glen W. Wensch
International Association for Dental Research	Norman H.C. Griffiths
American Institute of Aeronautics and Astronautics	Robert J. Burger
American Meteorological Society	Harold A. Steiner
Insecticide Society of Washington	H. Ivan Rainwater
Acoustical Society of America	Alfred Weissler
American Nuclear Society	Delegate not appointed
Institute of Food Technologists	Lowrie M. Beacham
American Ceramic Society	J.J. Diamond
Electrochemical Society	Stanley D. James
Washington History of Science Club	Delegate not appointed
American Association of Physics Teachers	Bernard B. Watson
Optical Society of America	Elsie F. DuPré
American Society of Plant Physiologists	Walter Shropshire
Washington Operations Research Council	John G. Honig
Instrument Society of America	Delegate not appointed
American Institute of Mining, Metallurgical and Petroleum Engineers	Delegate not appointed
National Capitol Astronomers	John A. Eisele
Mathematical Society of America	Daniel B. Lloyd
Philosophical Society of Washington	Bradley F. Bennett
Chemical Society of Washington	Alfred Weissler
Entomological Society of Washington	William E. Bickley

Delegates continue in office until new selections are made by the respective societies.

FEATURES

Technology and Our Standard of Living

Fred Schulman

U.S. Atomic Energy Commission, National Aeronautics and Space Administration, Washington, D.C. 20546

ABSTRACT

A general picture is given of the dynamic position of research and technology in the complex ebb and flow of this country's economic health which supports our high standard of living. It is the power from nuclear energy which almost alone can sustain the American standard of living for the foreseeable future under conditions as they are emerging here and abroad. The precarious nature of our present energy resources makes it important that the current downward trend in real national investment in research and technology be reversed.

I am delighted to be here this evening to give you my impressions of how technology affects our lives and our standard of living. Since this is a very complex and provoking subject, obviously, there will be many differing thoughts on the subject, and I hope to give you in the next few minutes a point of view which perhaps may not be often expressed. I will therefore say at the beginning of my talk that the opinions I will express are my own personal opinions and not those of either the Atomic Energy Commission or the National Aeronautics and Space Administration.

At the outset, let me say that we are now in the midst of a revolution, fully as far reaching in our daily lives as was the great American Political Revolution of the 18th Century and the Industrial Revolution of the 19th Century. This 20th Century revolution is the Scientific Revolution. Because we are in the midst of this revolution, we are not often able to see where it is taking us, but that it is enriching our lives as well as posing problems common to all revolutions, such as rapid change, is obvious. Competing for primacy and threatening to supplant it are the subdivisions now gaining attention such as the energy revolution and the social revolution, with the outcome still in doubt. The warriors in this revolution are you and I. It is often said that more than three-fourths of all the scientists who have lived since creation are still alive today. Therefore, it is not surprising that the products which account for about one-half of the profits of many large companies such as duPont, did not even exist as recently as twenty years ago. The result of all this activity and research is a national growth rate and GNP far above the average of that obtained earlier in this century as I shall show.

What has all this to do with the stan-

[1]Presented at a joint meeting of the IEEE Nuclear Sciences Group and the Washington Academy of Sciences, Cosmos Club, Washington, D.C. January 18, 1973

dard of living? We see around us growing unemployment, particularly of highly trained technical people at unprecedented levels for this country. We see an energy crisis growing with shortages already evident, with cost of fuels for home and industry rising at such a high rate that the U.S. economy, which is based on the wasteful use of abundant cheap energy, is becoming threatened. How long do you think that prices of oil can continue to rise 16% in three years, or coal 40%, or natural gas 300% in three years, as reported by the American Chemical Society without shutting down considerable portions of our industry. What do the lessons of history tell us? First, you may be surprised that this is really not the first time there has been such high levels of technology unemployment. Let me go back for a moment to the Renaissance of the early 15th Century. The highest standard of living and highest degree of culture was attained by the Italian city-states, Florence, Venice, Genoa, etc. The Italians living in this area were really the "spacemen" of that day, if we define space technology as the highest technology of the period. This was due to the leading activities of the Renaissance Italians in shipbuilding, instrumentation, navigation, astronomy, mathematics, etc. This advanced technology was required because they carried on a very lucrative trade with the East, which in turn sustained their advanced culture. In 1453, when the Turks captured Constantinople and thereby cut the trade routes, there was no longer any need for employment of the Renaissance "spacemen." Within a generation or two, the unemployed "spacemen" had been dispersed to the undeveloped countries of the time, such as England, France, and Spain, with the results that we all enjoy today. *And,* as you know, the city-states of Italy disappeared from the leadership of history.

The United States was and may still be the leading technological society of our day. It still enjoys the highest per capita standard of living in the world. Cheap energy does most of our work and sustains our transportation system. Our rate of technology investment has continuously increased during this century until 1965, when for the first time the rate of investment in research and development began to decline and is still declining. We sometimes forget that there is a definite relationship between standard of living and productive investment. Thus, Professor Edward Shapiro of the University of Detroit has written that without technological innovation, investment will languish and without the necessary rate of investment, the private enterprise economy will stagnate. According to the United Nations, the five countries with the highest per capital GNP in 1970 were the United States, Kuwait, Sweden, Canada, and Switzerland, with per capita incomes ranging from \$3,670 in the United States to \$2,310 in Switzerland. All of these countries have enjoyed considerable research and development with the exception of Kuwait which does, however, enjoy a fantastic oil income and investment. It might be interesting to note that Kuwait consumes even more energy per capita then does the U.S., its consumption amounting to 11,905 kg coal equivalent per capita to 10,331 kg for the U.S. The countries with the lowest per capita national product are Burundi, Somalia, Upper Volta, and Ethiopia with per capita GNP of only \$50 to \$60 per year. I needn't mention, I think, that none of these countries has much technology. Recently, Prof. David White, of MIT in a speech in New York in the ASME Forum on the Energy Crisis, indicated that this trend is continuing.

It is interesting to note that since 1910 the population of this country has increased 122%, while the real gross national product has increased 600% so that living standards have risen steadily despite the huge increase in population. The per capita income during this period rose from approximately \$1200 to \$3500 per year. But, and this is the important point, we are currently on a plateau, and there is no real growth in per capita national product. If there is no growth in the national product per person, how are we going to pay for better schools and better health and social needs? How are we going to provide the energy needed to make the U.S. comfortable and productive from fast-dwindling cheap sources without a high order of new technology? Since we are traveling together through the present, and don't yet have the benefit of hindsight, it is difficult to say with certainty whether the decline in technology investment in the United States which commenced in 1965 was really the start of most of the problems facing us today. Since the United States enjoys high wages, it obviously requires jobs which can produce sufficient real wealth to support those wages. Furthermore, new industries must be created to absorb the approximately one million new workers who enter the labor force each year.

How can we do this without discovering new products and processes which are the direct result of research and development? How will nuclear breeders and fusion or solar energy progress from promise to fact? I frankly feel the answer is more research and development, not less. I will return in a moment to nuclear energy and the energy crisis. But now let me pursue the relationship of technology with more direct everyday concerns of living standards. The dollar is under severe pressure from abroad. Inflation is very difficult to reduce. Advanced technology can help to solve both these problems. Let us see how technology relates to the strength of the dollar. Since 1964, net exports of U.S. goods and services have fallen from a surplus of $8.5 billion to the first deficit of the century last year. Furthermore, the largest American exports, except for food, have been the high technology products of research and development such as electronic and aerospace products, chemicals and drugs and machinery. If our know-how in this area becomes further eroded, you probably can expect to see a further weakening in our export position and, hence, a continual erosion in the international value of our currency. Thus the Smithsonian currency agreements, reached after last years devaluation of the dollar, are already under great pressure and the price of gold in dollars has risen to more than $60 from $40 in only one year making further erosion in the value of the dollar quite likely. It is significant, I think, that, in 1970 the percentage of goods manufactured abroad reached the unprecedented percentage of 56% of imports and last year this trend continued, reaching 67.6%, or more than two thirds of all imports into the U.S. In other words, it is becoming cheaper to produce most products abroad and import them to the United States than to manufacture them here. Were it not for new atomic energy and aerospace products, this state of affairs would be even worse. This tendency can be reduced by the discovery of new products with high technology content. In fact, *continuity of discovery* is probably a new requirement for U.S. economic health, since modern communications and faster transfer of technology abroad has reduced the economic advantage to the innovator nation to about only 7-10 years as compared to an average of more than thirty years before World War II. The President has recognized the importance of technology in these areas. In addition to numerous moves to strengthen U.S. technology, he has set up a special task force to look at technology opportunities aimed at the effective employment of the vast technical and scientific talent which are unused today. Let me give you just a brief background for this. Federal expenditures for R&D in the Physical Sciences rose from $600M in 1960 to $1,705M in 1965 and has since declined to $1,131M in 1968. Similarly, R&D in the Engineering Sciences increased from $690M to $1,576M, and then has declined slightly over the same period. During those same years, the level of research performed by industry rose nearly 40% from 1960 to 1965, and then increased by less than 20% to 1968. The rate of industrial research is still declining. This is the situation which confronts the country, and the threat to our living standards should be clearly recognized.

It is interesting to review the period of high technology investment spurred by the space program during the years 1960 to 1965 with the periods immediately preceding and following this period. During the decade 1950 to 1960 the per capita GNP grew very slowly. It was almost flat, rising from about $2500 to $2700, while from 1960 through 1966 it grew from $2700 to more than $3400. If it were able to continue at that rate, the per capita GNP would have reached more than $4,000 today. This would have produced a real increase in GNP of more than $100 billion. Think what this extra $100 billion could do to meet the needs of the nation. Since federal income is approximately 18.6% of GNP, there would have been an extra $18.6 billion available to meet pressing housing and other social needs even without raising taxes. It is also important, I think, to recognize that the current budget for the federal government already includes more than $60 billion for income security and $25 billion for health and education. I think it is obvious that the elimination of the federal investment in space technology amounting to about $3 billion would hardly have a significant effect in providing additional

	1970	1975	1980	1985
Total Domestic Energy Consumption	67,827	83,481	102,581	124,942
Total Projected Domestic Supply				
Oil	21,048	22,789	24,323	23,405
Gas	22,388	20,430	18,030	14,960
Coal	13,062	15,554	18,284	21,388
Hydropower	2,677	2,840	3,033	3,118
Nuclear	240	3,340	9,490	21,500
Geothermal	7	120	343	514
Synthetic Oil	-	-	-	197
Synthetic Gas	-	380	570	940
Total Domestic Supply	59,422	65,453	74,073	86,022
Shortage Indicated	8,405	18,028	28,508	38,920
Projected Imports and Other Means for Supplying Fuels to Make Up for Shortage				
Imported Oil	7,455	15,284	22,163	29,997
Imported Gas	950	1,610	3,880	6,280
Additional Coal Production	-	756	1,643	1,762
Additional Residual Fuel Imports	-	378	822	881
Total	8,405	18,028	28,508	38,920

(1) U.S. Energy Outlook Volume Two - National Petroleum Council Nov. 1971

Fig. 1.—Total future U.S. energy requirements. Units in trillion BTU.

money for these other programs, but it could have a devastating effect if reductions in space technology are continued and are followed by similar reductions in other technology areas such as pharmaceutical, chemical, nuclear and electronic research, as I have already outlined.

Up to this point in this talk I have given a general picture of the dynamic position of research and technology in the complex ebb and flow of this country's economic health which supports our high standard of living and I have given some examples of the space program in this picture. Now let me turn to the specific effects of atomic energy.

It really is fortunate that decades ago a few farsighted individuals laid the foundations for what is now the atomic power industry. It is the power from nuclear energy which almost alone can sustain the American standard of living for the forseeable future under conditions as they are emerging both here and abroad. It is important to realize that total energy consumptions increased by 50% in the decade 1960-70 (from 44.6 to 67.8 quadrillion BTUs). Total future U.S. energy requirements have been estimated by the National Petroleum Council as 83.5×10^{15} BTU in 1975, growing at 4.2% per year to 125×10^{15} BTU in 1985. This is shown in fig. 1.

The energy crisis may perhaps be put in perspective by the following findings made by the 1971 report to the Secretary of Interior by his advisory National Petroleum Council: These are tabulated as fig. 2

1. NPC estimates U.S. energy consumption growth at 4.2% annually during 1971-85 with electric utility consumption rising at 6.7% per year. This is roughly 4 to 7 times the population growth estimated by the Bureau of the Census.

2. Oil imports will rise to 57% of oil consumption and 25% of total energy use in 1985.

3. Natural gas imports which now amount to 4% of gas supplies will rise to more than 28% in 1985.

4. Coal production will rise to 1,071 million tons in 1985 from 590 million tons in 1970 if SO_2 can be commercially controlled.

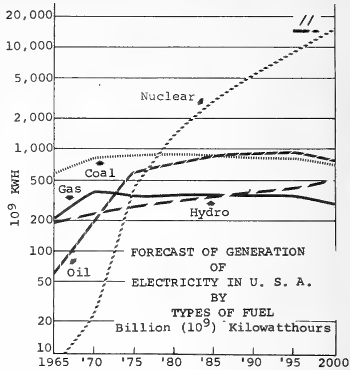


Fig. 2.—Summary of the report of the Secretary of Interior's advisory National Petroleum Council.

5. Nuclear power will rise from 23 billion kwhr in 1970 to 2,068 billion kwhr in 1985 or about 48% of electricity supply.

6. Energy sources other than oil, gas, coal and nuclear will not exceed 3% of need by 1985.

7. Huge capital costs of about $375 billion will be necessary in the period 1971-85 to make available the above energy resources. Remember that this estimate compares with only 67.8 x 10^{15} BTU consumed in 1970. But in 1975 the U.S. will be able to supply only 65.5 x 10^{15} BTU and only 86.0 x 10^{15} BTU in 1985 leaving deficits of 18 and 39 x 10^{15} BTU, respectively. During this period nuclear power grows from 0.2 to 21.5 x 10^{15} BTU, which is a growth rate of 100 times the 1970 output.

By the end of the century, nuclear power is expected to provide about 50% of the nations' needs for energy. But there is a note of caution that I must introduce here. Delays have developed in the nuclear power field for a variety of technical, mechanical, environmental and regulatory reasons which together have resulted both in a shortage of curbarrels of oil per day to the U.S. even if we could pay for it. Of course huge new seaports and terminals would have to be built to accommodate these ships in an ecologically satisfactory manner. We also would need to build new oil refining capacity at 2½ times the rate of the last decade if we are to reach the 10 million barrels new capacity required in 1985 and we are already behind schedule. Such delays will probably result in gasoline shortages which will reach the man in the street in the form of higher gasoline prices, restrictions on use, or both.

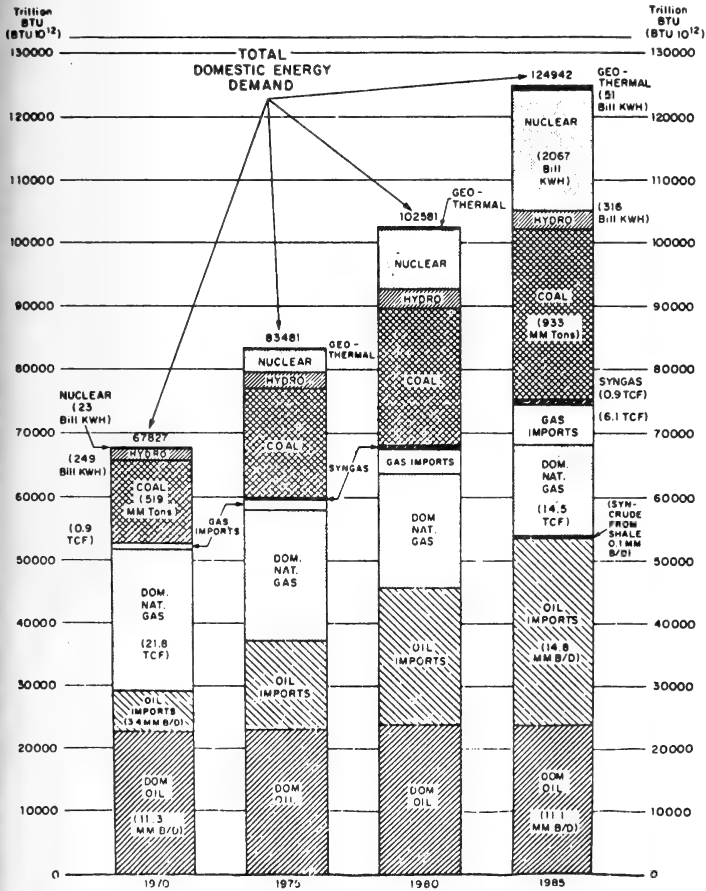


Fig. 4.—Proved U.S. fuel reserves.

rently available energy and in a projected need to import the deficit at a significant cost to the country. For example, only 25% of the 1972 projected nuclear plants are in service today. The others are in various stages of approval, construction or check-out. The shortfall is significant when one realizes that to make up the expected 1975 and 1985 deficits, the U.S. will have to import from overseas nearly 40% of its oil in 1975 and more than half its oil in 1985 and will import nearly 30% of its gas requirements by 1985. These supply sources are shown graphically in fig. 2 and fig. 3. As you know the U.S.S.R. has recently offered to deliver 2 billion cu. ft/day to the east coast of the U.S. Soviet gas reserves have been estimated by academician V.S. Emelyanov as 1,860 billion cu m. An investment amounting to billions of dollars will be needed to produce and ship this gas.

Nuclear plant delays have an immediate cost impact to the consumers affected. For example, the Wisconsin Public Service Commission was recently requested to approve a 5.7% rate increase to compensate the utility for increased

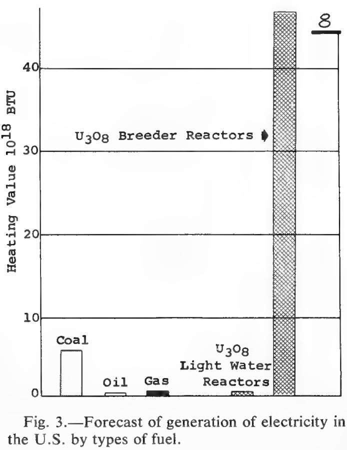


Fig. 3.—Forecast of generation of electricity in the U.S. by types of fuel.

electric energy costs due to one to two years delay in approval and construction of two nuclear power plants, and the three-year delay in availability of Indian Point-2 is increasing costs to a similar, equivalent, rate increase.

Obviously, nuclear technology is an important, though often misunderstood, factor in both the near-term and long-term solution to energy, unemployment and balance of trade problems. First; by selling nuclear fuel services and reactors abroad, it is contributing to strengthening the value of the dollar by reducing the balance of payments deficit. Second: by providing electrical and process energy, it is reducing the need for foreign oil, with all the attendant political, diplomatic and financial strains which such reliance implies. Third; by helping to maintain an adequate supply to energy in this country, brownouts, black-outs and shut-down of industry can be avoided.

Mr. Gerard C. Gambs, Vice-President of the management engineering firm of Ford, Bacon, David Inc. of New York has estimated that a delay of only 10,000 MWe requires the importation of 100,000,000 barrels of oil per year. Since, Mr. Gambs does not believe it feasible to import the huge amounts of oil and gas that may be needed, he forsees a cessation of industrial plant expansion and rationing of fuels. The difficulty of importing such fuels can be seen from the President's Economic Report of January 1972, in which a balance of payments deficit of $23.4 billions was recorded for 1971. Fuel imports can easily double this deficit before 1985 as Deputy Assistant Secretary of Commerce Stanley Nehmer said recently at an international conference and I'm sure economists will surely propose measures to prevent this from happening. Such measures are bound to have considerable effect on the lives of all of us. For example, in order to provide the energy expected to be used in this country in 1985, just twelve years away, at least 350 huge supertankers of a quarter million dead weight tons would have to be built during 1971-85 to carry the 14.8 million

Furthermore we would need to build 120 Liquid-Natural-Gas-Tankers of 790,000 barrels capacity in the period 1971-85 to haul the 4 billion cu. ft./day of liquified natural gas that must be imported in 1985 to supplement dwindling domestic supplies. Large liquefaction storage and gasification plants will obviously be needed to handle this large amount of liquified natural gas.

How can technology help? I have already described in general terms, the relationships of research and development activity to the general well being. In the nuclear technology area, efficiency in energy use and generation from fission reactors can assist in the immediate years ahead. Beyond this, there is the prospect of breeder reactors multiplying nuclear fuel reserves at reasonable prices (≤ $15/ lb. U_3O_8) by more than a factor of 100 (to 33.6Q) as seen in fig. 4. Note that Mr. Gambs raises this estimate to more than 45Q. For comparison 1Q is equivalent to 173 billion barrels of oil or 970 billion cubic feet of natural gas. Geothermal and solar sources can contribute large amounts of energy if the needed technology is created. There is also the prospect of doubling available natural gas reserves by controlled nuclear explosions in tight gas formations when the technology finds both technical and public acceptance as suggested by Prof. Edward Teller of the University of California. Finally in the long term, there is the prospect of nuclear fusion with almost limitless energy possibilities, if the scientific and engineering problems can be solved. The AEC fusion research program has been making good progress in recent years and a five-phase program leading to a demonstration fusion reactor power plant of from 500 to 2,000 Mwt

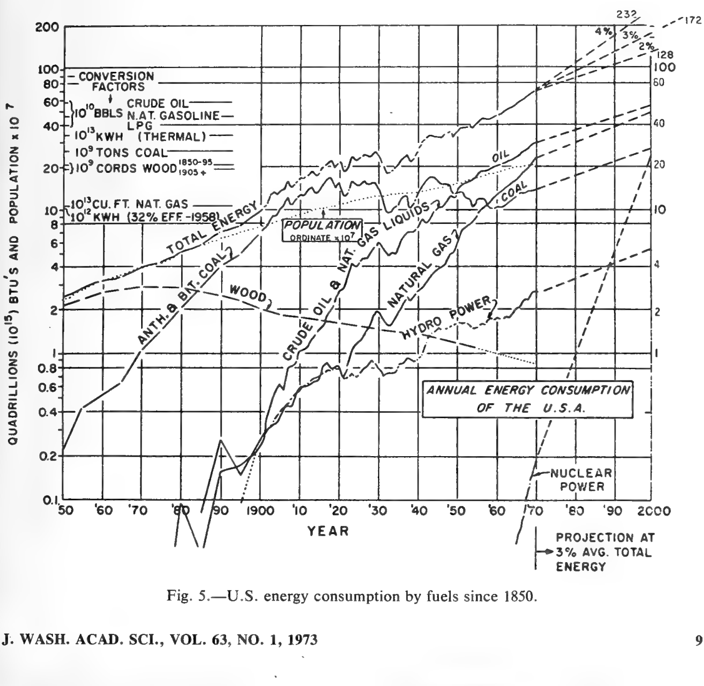


Fig. 5.—U.S. energy consumption by fuels since 1850.

continuous output in the year 2000 has been outlined by the Office of Science and Technology. The U.S. Social goal of a continuing rise in the standard of living for more and more of its citizens, including winning the war on poverty, will require an increase in the per capita consumption of energy and so will attempts to improve the quality of life through environmental control. It has been estimated that these goals alone can add 66% to the current per capita energy consumption (Chase National Bank). Fig. 5 shows the historical use and sources of energy in the U.S. since 1850 and projects future energy needs for the American standard of living. The precarious nature of our energy resources is clearly indicated. Note the role projected for nuclear energy. With confidence in the future and hope that the current environmental, technical and economic problems can be solved. American utilities in 1972 ordered a record 39 nuclear electric generating power plants totalling 42,000 megawatts. If we are to do all things I mentioned to provide the technology for future energy sources and thus help to provide a decent standard of living in the future, it is important that the current downward trend in real national investment in research and technology be reversed. Fortunately, there are signs that this indeed will occur.

The data I have used in this talk are derived from the President's Economic Reports of 1971 and 1972, Statistical Abstracts of the United States for 1970 and 1972, and from material presented at the Federal Executive Institute and ASME forum on the Energy Crisis, Nov. 1972 and other sources. In summary, I have touched on only a few of the highlights of the many inter-relations between technology and our standard of living. I think you see that they not only are quite complex, but also that it is important for each of us to try to understand them as best we can so that as informed citizens, we can participate in the drama of the scientific revolution and help make it socially rewarding by reaching the goals desired by all of us.

Institutional Stability and Innovation in Higher Education[1]

Walter E. Boek

President, National Graduate University, Washington, D.C.

ABSTRACT

Starting with the essence of greatness in a university, i.e. the quality of relationships among teacher-knowledge-student and environment, some antecedents of the modern university model are presented. Mentioned are early influences from preliterate, Sumerian, Greek, Athenian, and Roman societies as well as religions such as Judaism, Christianity and Mohammedanism. Also discussed is the transference of European practices to American such as the right of a university to govern itself and to organize into faculties. Models are cited such as the Academy of Plato, monastery colleges, guild universities, the American college quadrangle, the University of Virginia plan, land grant colleges, "the great universities," and National Graduate University.

The substance of a university is actually quite simple. It amounts to a teacher and a student in an appropriate scholarly atmosphere where knowledge can be fostered and transferred from one to the other, the greatness of a university being dependent on the type and quality of the relationship among these: teacher-knowledge-student-environment.

In this paper, I will give 1) a brief accounting of some antecedents of our modern university model; 2) a diagrammatic, somewhat historical, presentation of relationships among determinant variables, and 3) some strengths and weaknesses in a few current innovations in the model including what is being done at National Graduate University

Antecedents

It is a unique characteristic of humans that from the nearly two million years since the key mutations occurred permitting separation from other animals, adjustments to environmental variations have largely been in the cultural sphere rather than the genetic one. Thus, when an understanding of institutions of higher education, a most significant invention, it sought, it is important to be cognizant of their social evolution.

Formal education is not the invention of literate societies, for organized training of youth, with graduation ceremonies or "rites of passage" which give personal recognition of standards met and a public announcement of their changed role as a result of the training, were common in preliterate societies. Hence, such influences, along with those of the Sumerian schools with their clay practice tablets, undoubtedly were present when the Greeks began to develop their methods. And it is in such cultures that foundations were laid for education as we know it today in the Western world.

Citizenship and rule in the Greek city state were dependent upon two things —you had to come from the right family and you had to be properly educated in political, military and religious thinking. Early in Athens a schooling schedule had been developed whereby the boy from 7 to 16 went to a private teacher known as a grammatist to learn writing, reading, and counting, to a citharist for music and to a palestra for physical education. Teaching was by rote, with a slave known as a pedagog employed to drill the students on their lessons. The state supervised the education, and if a father did not pay for his son's schooling, the son was excused from having to support him in old age.

From 16 to 18, the Athenian youth was

[1]After-dinner presentation at the June 20, 1972 meeting of the Washington Academy of Sciences.

in a state gymnasium, learning the laws, religious rites, dances, songs, and physical fitness exercises. At 18, the father presented his son as a candidate for citizenship, his long hair was cut and he pledged to "transmit my fatherland, not only not less, but greater and better, than it was transmitted to me . . ." At 20 he became a citizen-elect, or ephebus, and trained to be a soldier, with an examination at the end of his next year. From 21 to 22 he was a soldier on the frontier, after which he took another examination.

Later in Greece this pattern changed to having the years 16 through 20 devoted to much more intellectual pursuits, although still oriented to political affairs, with the Sophists as teachers, following their dictum, "man is the measure of all things." By 350 B.C. Greek school education had been differentiated into the three divisions so familiar to us today: *primary* education with a grammatist from age 7 or 8 to 13, who taught reading, writing, arithmetic and chanting; *secondary* education from 13 to 16 with geometry, drawing, and music, again with a grammatist; and *higher* or *university* education for those beyond 16.

Critical in this Greek educational scheme were Socrates, with his interest in developing not only knowledge of particular facts, but also a right judgment, or *sophia,* as to what is true and good; Plato who formed an Academy in 386 B.C., which was a union of teachers and students, both men and women, who possessed in common a chapel, library, lecture and living rooms, where philosophy, math and science were of concern; and Aristotle who taught in the Lyceum in 355 B.C.

After Greece was taken over by Philip of Macedonia and his son, Alexander, and later annexed by Rome, the Athens Assembly was allowed to continue in operation. It created professorships under its supervision in what came to be known as the University of Athens which functioned for about 400 years until closed by the Roman Christian Emperor in 529 A.D. During this time also, the University of Alexandria developed a library, with perhaps as many as 700,000 manuscripts, along with a museum or Temple to the nine muses where men of letters carried on investigations supported by the royalty. In this manner was Greek science, literature and philosophy preserved for 10 centuries.

In spite of destruction of this library and conquest of Greece, the Romans did not annihilate either the Greek intellectual or his educational system. Instead, Greek teachers flowed into Italy where they first taught in Greek until finally changing to Latin in primary and secondary schools and schools of rhetoric. From these, students went east to Greek universities such as Athens and Rhodes. By 70 A.D., they could also attend the University of Rome which seemed to have been established by the Emperor Vespasiano in the Temple of Peace. At the same time Greek and Roman systems flourished, the Hebrews had scribes or scripture scholars who taught the law. In 64 A.D., Joshua ben Gamalo ordered establishment of an elementary school in each village.

As it gained acceptance, Christianity initially concentrated on laws and psalmody of the church. Monasteries starting about 330 A.D. produced a religious scholasticism with rules such as those of Benedict who required eight hours of labor and two hours of reading each day. A novice had this status from 12 to 18. Later during the dark ages, monastaries preserved learning of the past that was compatible with Christian ideology.

Thus up to this time, literature and philosophy were contributed to the educational system primarily by the Greeks, administration and the law by the Romans, moral responsibility by the Hebrews, and a distribution system by the ubiquitous Christians.

By the eighth century, in Northern England, the Cathedral of York had a large library containing most of the Latin authors and textbooks then extant. When Alcium, a student from York, joined Charlemagne's court, Charlemagne in 787 issued a proclamation in which he encouraged establishment of schools as well as education in the thinking of the church.

In Europe between the ninth and the sixteenth centuries until the end of the age of chivalry, education for a privileged boy was up to the age of 7 or 8 at home, from 7 to 14 serving as a page to a lady while learning to read and write, from 14 to 21 as a squire or personal servant of the lord, and at 20 perhaps becoming a knight after swearing an oath to defend the church. By 1150 the church exercised central supervision of the training of all teachers in the diocese through issuance of licenses to teach. The seven liberal arts of the Middle Ages became grammar, rhetoric, dialectic (logic), arithmetic, geometry, astronomy and music, which emerged as another persistent influence on educational developments.

The Mohammedans had also developed a center of learning at Baghdad. Learned Greeks and Jews taught in their schools, and they had a university with a library and an observatory. The Eastern learning of Greece and the Mohammedans was carried to Spain through the many universities found there by the Arabians.

In the 13th century, the guild system was adopted in north central Europe by teachers and students who received charters from the Pope or kings granting them special privileges. One was that of *Cassatio,* or the right to stop lectures and go on a strike as a means of enforcing a redress of grievances against either town or church authority. Through this came into being the rights of a university to govern itself, to defend itself against encroachment of its freedom to teach and study, to discipline members of its guild, to examine, and to grant the license to teach.

These universities were primarily places for apprentices in the arts to be developed into journeymen and masters who were certified after a public presentation and test which served as their rite of passage. Masters were organized into faculties by the teaching subjects of arts, law, medicine and theology. With the invention of paper brought to Europe by the Arabs and the printing of the first book in 1456 by the Germans, the use of textbooks became possible, freeing teaching from some of the rote learning necessary before.

Moving now to Luther and Calvin, we find that Luther admonished the towns, once they were free of Rome, to spend money for schools. In 1559 the German state of Wurtemberg set up a state system of schools, with elementary ones for both boys and girls, followed by Latin schools, and then by the colleges or universities of the state. The Calvinists demanding religious and civic education of all, had their synods make appropriations for universities, with municipalities paying for lower level education.

During the Counter Reformation, Jesuits established colleges with dormitories, classrooms, dining halls and playgrounds, and at one time, apparently, had 200,000 students in them.

Coming out of this middle European background, the pilgrims in America required towns to have grammar schools to perpetuate their religion. In 1636 the General Court of the Massachusetts Bay Company founded Harvard College to produce an educated ministry. In this new institution, medieval theological instruction was combined with the arts under the sole teaching of President Master Dunster for the first fifty years.

In contrast to New England, adherents of the National Church who came to Virginia felt that education was no business of the state. Later, in 1819 a significant decision made by the Supreme Court preserved the sanctity and independence of the university by deciding that Dartmouth's Charter was a contract and that a legislature could not infringe on it by making that college into a state institution.

With this historical sketch as background, I turn to the teacher-knowledge-student-environment equation and proceed with a diagrammatic analysis.

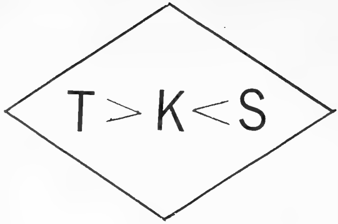


Fig. 1.—Teacher-Knowledge-Student Relationships

Relationships Among Determinant Variables

The story-teller who reiterates the history of the tribe and its moral fiber to the youth is illustrated by (fig. 1) as would be Socrates and his students.

As teaching aids were developed which enhanced learning and instruction, a slightly more complicated situation existed with the teacher and his tools and the student with his. The wampum belt of the Iroquois Indians is an example of a teaching aid. The Onondaga historian-keeper of the belt taught a youth in his family the historical and political significance of designs on it. This ensured perpetuation of individual tribal traditions along with the history and rules of the League of the Iroquois, which was an effective United Nations organization in a preliterate society lasting more than 400 years.

This straight-forward, teacher-student relationship as an educational model varied as larger groups of youth were trained in many societies, including Greece, by separating them from their families and housing them together. It was with Plato's Academy that the model began to take a more modern shape, as in fig. 2, in that the chapel, library, lecture rooms and living rooms were clustered together. The attractant was knowledge which brought students to the teacher; the focus of knowledge centered around religion, which in turn helped to preserve fundamental human experience in regulating relationships to the environment and to other people.

A further elaboration of this was the monastic colleges, in which walls were built as diagramed in fig. 3. Required here was the senior friar as the administrator, but he still taught, and teachers and students were not unduly separated. Again, center of attention was on knowledge, especially its use to reach God.

The European guild universities were similar in that their members, teachers and students segregated themselves from the townspeople, obtaining special rights and privileges still reserved today in our educational institutions. To a considerable extent, this separation is necessary, of course, because the townspeople or non-academics are concerned with day-to-day affairs of acquiring a livelihood

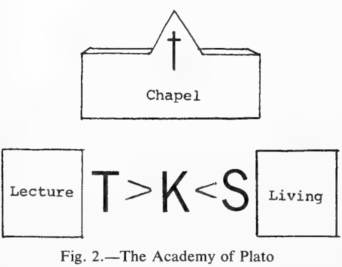


Fig. 2.—The Academy of Plato

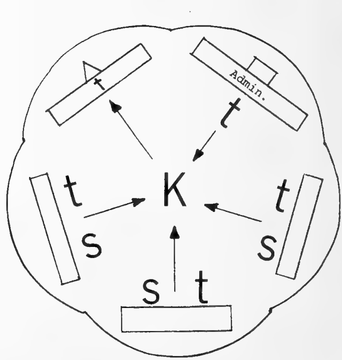


Fig. 3.—Monastic Colleges

while the scholar has to be interested in the past, present and future. However, the scholar's livelihood must also come from somewhere. Contributions or fees directly from students has seldom been adequate. For this reason, patrons in the form of wealthy individuals, the religious entity, rulers, or the government have supplied the means by which teachers and students could have the time to bring together, store and use knowledge to produce more knowledge. For their part, monks attempted to be self sufficient through agricultural and craft production.

To some extent the European universities did have a role beyond their walls due to their responsibilities for training teachers for the lower schools. Their independence of teaching and action, however, was restricted by their necessity to have a positive attitude toward the state or church or both. When German philosophy came to proclaim its famous doctrine of Academic Freedom, *Lernfreiheit* and *Lehrfreiheit,* for example, it imposed upon itself the following ground rules:

> "It is necessary to place one restriction, if not upon the thinker, at least upon the teacher appointed by the State and supported by the public funds: he must assume a positive attitude toward the State."[2]

While the focus was on knowledge and the student, as depicted in fig. 4, the guild as did the monastery tended to encourage the seeking of solutions to problems by sitting around discoursing rather than bothering to look at the phenomenon itself.

Oxford was one of the guild universities which went through a critical period in 1408 and 1410 when students and young masters rose, defied Archbishop Arundel, forced their own chancellor to resign, and actually fortified the campus. In this fashion ended the intellectual history of medieval Oxford.

During the 15th century, universities began to lose their independence. After

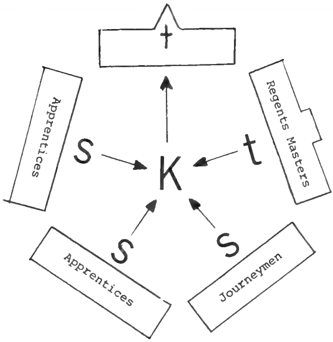


Fig. 4.—The Guild Universities

1629, Bishop Laud enriched Oxford with benefactions, adorned it with buildings and at the same time assumed that it would be an institution of orthodoxy; decorous, disciplined and correct. To insure this, he required a detailed weekly report of discipline and doctrine.[3]

With the initiation in America of Harvard, William and Mary, and other colleges, European patterns were followed, eventuating in a number of buildings placed around the familiar quadrangle (fig. 5). Studies stemmed from the Greek and Latin works and the seven liberal arts of the Middle Ages (again grammar, rhetoric, philosophy, mathematics, geometry, astronomy, and religion). Separate faculties were also established as colleges within the universities.

Visionary Thomas Jefferson varied this somewhat in his blue-print for the University of Virginia. His early design (fig. 6) called for students to be domiciled near their teachers, with rules of behavior set by the university. The significant change was that in educating for the new nation, Jefferson went beyond the classics because he wanted students to study such subjects as agriculture as well as

---

[2]Friedrick Paulsen. The German Universities and University Study. Hildefheim, Germany. Olms. Reprinted 1966. (First Printing 1902 in Berlin by A. Asher and Company).

[3]In his *A Brief History of Education,* Ellwood P. Cubberley summarized much of the literature on early educational developments (New York. Houghton Mifflin Co. 1922. Pp. 4-62 plus index).

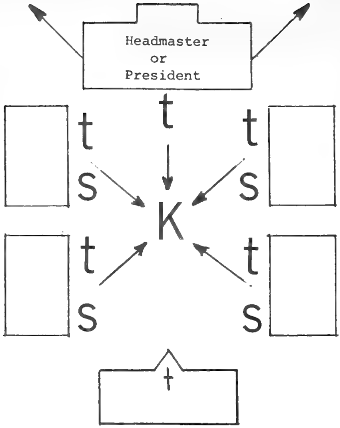


Fig. 5.—American University Quadrangle

Latin. The relation between the community of scholars and society was a simple one for him: the autonomous academic community would be a leader in an open-ended decentralized democracy. At the University of Virginia there was to be no taking of attendance and no grading. Moreover, Jefferson believed that a man was not qualified as a professor knowing nothing but his own profession; rather he should be well-educated in the sciences generally. To have a community of faculty, he felt it was necessary to have teachers not entrenched in their private thoughts and specialist ambitions. He conceived of professionals talking to one another. His was to be a general university, like Bologna or Padua, in being professionally oriented, where a youth would say, "Show me how," and find a teacher who would show him, and also be like Paris or Oxford in its notion of a unitary faculty where a thinker professed a truth he knew and a fascinated youth latched onto him to ask, "what" and "why".

Perhaps the most far-reaching alteration in character of higher education came with the land grant colleges set up over 100 years ago. Designed to serve the rural nation, their teachers, scholars and students devoted themselves to the study of farming from the viewpoint of agronomy, plant science, engineering, animal husbandry and social relations.

The interest of agriculture, industry and government in universities, which has been fostered since then, has resulted in quite a different model which began to look like fig. 7. Knowledge per se and students were no longer the only interest of professors. Rather, instructors had to be concerned about producing knowledge that could be utilized by non-

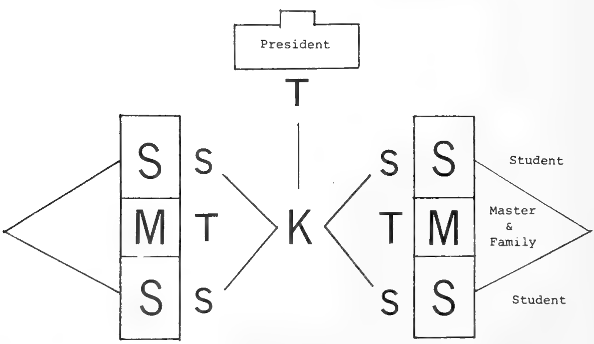


Fig. 6.—University of Virginia Concept

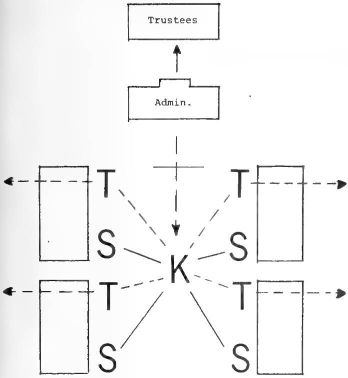


Fig. 7.—Land Grant College Influence

university members, and they extended themselves eventually with the agriculture and home economic agents they trained.

The regents or board of trustees became outside the once academic community. Actually, the original regents were the teaching masters who ruled the guilds. When separate faculties came into being, regents became non-teachers who still controlled the universities. After a while, they were no longer within the institutions, but still were in charge. At present, we have state-wide boards who govern multi-universities and who have made substantive incursions into institutional autonomy. Some have additionally been given authority over private universities as well as those owned by the government.

We now have reached a state where fig. 8 may be the university model. The student and teaching have become relatively unimportant while relations with industry and government represent the goal for the college administrator and faculty. Association with them furnish prestige and money, while students are shunted off on less important junior faculty or apprentices. The signs on doors of faculty "available by appointment only" during a few hours of the week are a clear indication of the disinterest in students. Teaching and learning require personal relationships, and if professors will not provide this, students will create their own separate social system for this purpose with their own standards.

The intense concentration of federal funds—five billion dollars or more from about 40 federal agencies going to 2,100 institutions—has tended to give a high priority and influence to the training of technicians and to the implementation of knowledge that can serve the government and society. Concerning this, Senator Mark Hatfield has asked, "But in this entire process, where do the priorities fall —upon obtaining research grants, serving the federal government, and contributing to the corporate economy or upon really enriching the human lives of the students at the university?"

"Having public relations outside the university become more important than having relations within the university? Is our mistake that we have not realized that the questions of values, the personal dimension of the student's life, and his search for identity and self-expression will inevitably be affected by the environment of his college and university?"

The late Paul Goodman, commenting on the uniformity among our colleges, noted that a great number have faculty members who are creative and learned and can teach what they want. Yet, he asks, if anyone can name 10 out of the 3,000 that strongly stand for anything peculiar to themselves—peculiarly wise, radical or even peculiarly dangerous, stupid or licentious. How can there be so many self-governing communities, he wonders, yet so much conformity to the national norm?[4]

"Not only is one campus more and more like the next, but increasing numbers of campuses are parts of larger systems," wrote the nine authors of the *Report on Higher Education* prepared

[4]Paul Goodman. *Compulsory Mis-education and The Community of Scholars*. N.Y. Vintage Books, 1962, p. 171.

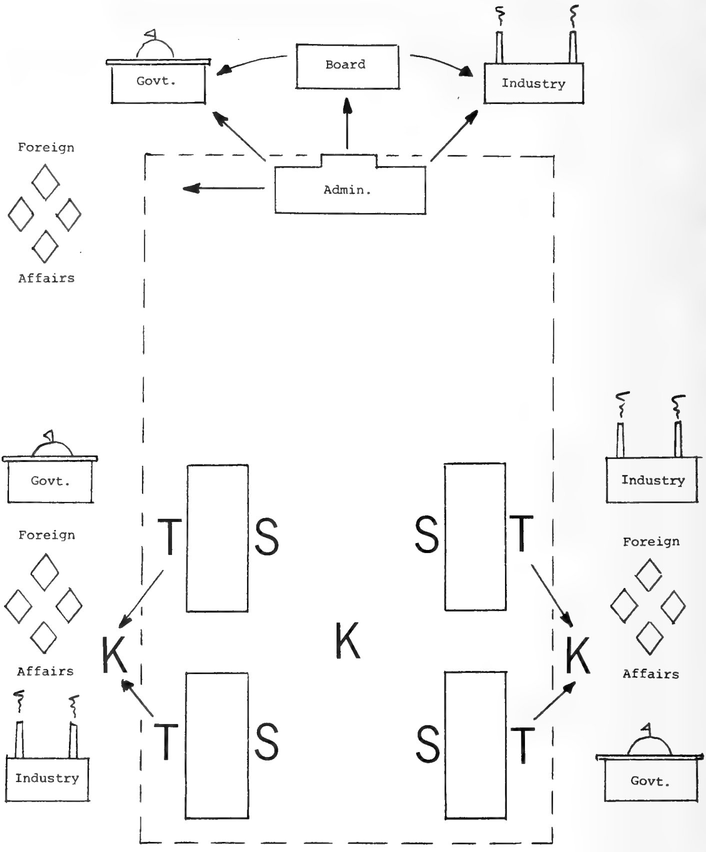


Fig. 8.—The Great Universities

for the Secretary of Health, Education, and Welfare in March, 1971. As the only institutions capable of expanding rapidly enough to meet the postwar demand, public multi-campus systems have grown rapidly, until today they dominate higher education. Without quite realizing it, the states have built bureaucracies that threaten the viability and autonomy of the individual campus.[5]

During the last few years a number of new models for higher education have been advanced. One of these is the free university organized primarily by students and the younger teachers. In a way,

[5]Frank Newman (Chairman) and others. *Report on Higher Education.* March 1971. Washington, D.C. Office of Education, United States Department of Health, Education and Welfare, p. ix.

it strives to create the Socrates-student relationship wherein free discussion reigns. It fails dismally because teachers and students do not have enough knowledge to exchange without adding to it and refreshing it with laboratory research of their own or others. It is well and good to have soap box orations and discussions in Picadilly or Union Square but boring and unendurable for the scholar.

Another much-touted alteration is one which eliminates the formal teacher. The administration sets standards for the diploma, devises examinations and awards them with little direct contact with candidates. One would suspect that such an administration could also decide the proportion of the people in each population segment who should have each advanced degree and then give out that number with little concern for academic achievement.

The Skinnerian operant conditioning model, if applied to higher education, would have our colleges become teaching machines. In it the learner would be reduced to a primitive organism who would produce a low-grade behavioral response.

The free university, the administrative university or the teaching machine university, separately or in combinations are dramatic reactions that have come about to meet the external as well as internal pressures of the politician, the government official, the liberal educator, and the unindoctrinated student. There are also many other very academically and socially healthy and productive educational innovations which receive far less public attention like the joining together of MIT and Harvard in the environmental science field or the adjustments being made within colleges to make education more valid in our time.

Pressures on the equilibrium of our universities are both internal and external. The external ones—government, industry, agriculture, labor and some parts of education—now are asking for 1) training of more doers rather than researchers to meet the shortage of well-trained professionals who can act on the basis of research; 2) inclusion of non-academic experience as part of the qualifying requirements for graduation; 3) the admission of heretofore unqualified students and, furthermore, the graduation of them; and 4) the conducting of problem-oriented research.

Internally, there are three main sources of pressure: First, students demanding more relevance to the outside world, more competence in their teachers, and a better relationship both in quantity and quality with them. (Some of the "relevance" pressure comes from individuals who do not understand that registering in a university involves entering the subordinate student role to learn what that institution offers. This became a serious problem when the university's normal selection and rejection procedures are interferred with.) Second, administrators concerned with management and budgets whose orientation thus tends to be away from the teacher-knowledge-student core of the university. Some teachers have also accepted this mentality, as illustrated by fig. 8 presented earlier. Third, the internal force still emanating from the significant proportion of faculty members who continually exert pressure to maintain the fundamental qualities of the true university where knowledge can be pursued by both faculty and students in a permissive environment. If this were not so, higher education would be in a tragic decline.

National Graduate University Model

The National Graduate University vision is one such attempt to assist students in achieving satisfactory professional status as scientists or practitioners in education, administration, or the social sphere. The teacher-knowledge-student environment equasion is being strengthened by gleaning from the past and present those methods of learning and teaching which characterize the real university and then protecting them by constructing a model that will work today. In this task we are indebted to hundreds of scholars who have con-

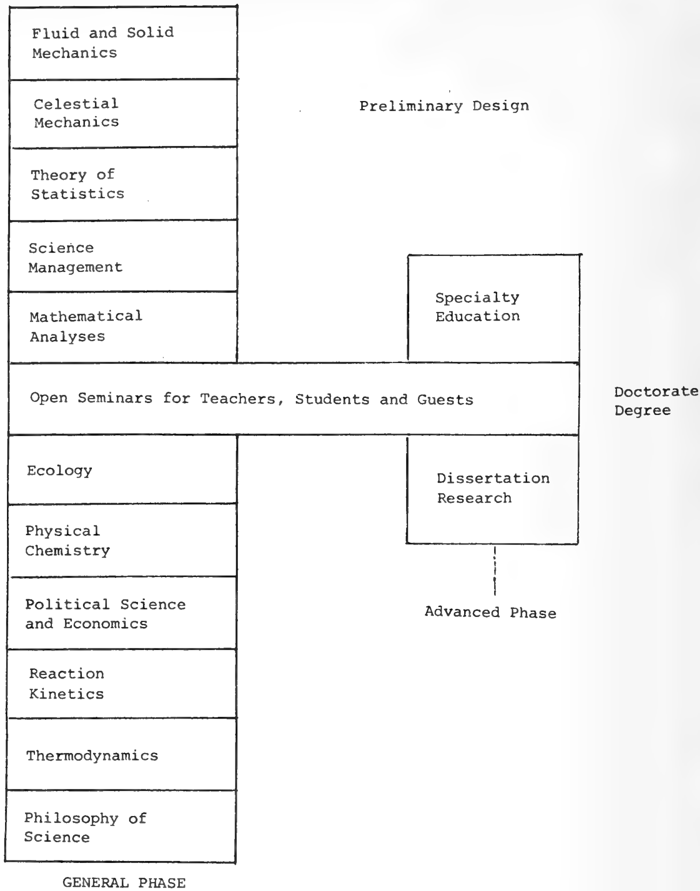


Fig. 9.—Environmental Science College Preliminary Design.

tributed their thinking to our curricula development.

Just as the Greek, medieval and European guild universities were related to issues of the day so our Colleges are to modern society. The first two, just getting underway are Human Service and Management, with Natural Resources soon to follow. We also expect to have Developmental Planning; Behavioral Science, and Environmental Science colleges established before many years pass.

The plan within each college is to insure that students have a broad foundation of knowledge through study in a series of what Dr. Hatton S. Yoder, Jr., Waldo E. Smith, Dr. Richard A. Prindle and others called "core areas of study." Later Drs. Raymond J. Seeger, Carl F. Hawver, George W. Irving, Jr., and their fellow curriculum-development committee members labeled these "general phase fields," as is indicated in fig. 9.

Upon satisfactory completion of these general fields or core areas, the advanced phase is entered, with concentrated attention given to the more specific interests of students. For completion of the doctorate degree, practical experience in a research laboratory or human service or management position, depending on the College the student is enrolled in, is requisite as is a dissertation.

Lecture courses are not given. We agree with the philosophy that expounding is not teaching. The teacher is to provide the model of scholarship, to stimulate students in learning and to provide the means by which it may be enhanced. Students meet with the professor in small groups, usually for a minimum of three hours twice each week. A carefully prepared syllabus with adequate references is utilized to guide their reading between sessions.

Since learning, which exceeds the primary transfer of uncontested knowledge, i.e., that with which the learner already agrees, is greatly enhanced by significant people in the learner's world, the instructor has two major responsibilities: the first is to make himself one of the significant people in the student's world and the second is to make the students important to one another. For this, he must have the type of ego that thrives upon open discussion in which it is permissible for mature students to ask for substantiation of generalizations and to add results of reliable research they have discovered. Rather than just being concerned about his own status and role, the instructor guides students in building constructive relationships with one another as an essential step in the learning process.

The length of study for a student or group of students is dependent upon beginning competency, intensity of work and progress. Academic credits for courses are not given except for transfer purposes. Examinations are the means to determine whether or not the standards have been met by students. Three people are involved in the examination preparation and evaluation, which are on a pass-or-fail basis. One of these is the instructor and one is a person qualified in that field from outside of the University. The third is usually another faculty member.

We feel that this National Graduate University model respects the extra-university world at the same time it preserves the integrity of the university. It recognizes individual competencies and interests, yet maintains high academic standards. The maximum interaction among students and faculty encourages scholarly efforts and makes it possible for teachers to impart values as well as facts.

I appreciate this opportunity of being able to offer these ideas here this evening and invite your guidance and assistance in our undertaking.

Poor access to Apanteles[1] species literature through titles, abstracts and automatically extracted species anmes as keywords[2]

Lee J. Shervis and R. D. Shenefelt[3]

Department of Entomology, University of Wisconsin, Madison 53706

ABSTRACT

A collection of 183 documents on 3 species of *Apanteles* was examined for 1) frequency of the species names in titles, 2) frequency of the species names in published abstracts, and 3) variations in spelling of the species names in the original texts. These species were mentioned in 0-3% of the titles and in 0-29% of 97 published abstracts, suggesting the need for greater depth of analysis of the literature. Numerous variations in spelling of the genus, species and author components of the species names were encountered in the full texts, creating a special problem in the use of wholly automatic full text processing and searching.

Titles and abstracts, no matter how carefully written, cannot convey the entire content of a long or complex document. An information retrieval system which indexes only titles or abstracts, therefore, omits access to information which does not comprise a large percentage of the full document. Automatic full text processing techniques, such as those discussed by Wilson (1966) have been suggested as a solution to this problem. This technology involves the mechanical conversion of the printed or microfilmed page to machine readable form, automatic extraction of keywords from full documents and automatic retrieval of information from the resulting files through keywords selected by the user.

A cursory examination of Braconidae literature showed that information on a given species, in spite of its absolute length, frequently comprised too small a proportion of a complete text to be treated in an abstract. It was also noticed that the scientific names of the species were frequently misspelled in the literature, presenting an apparent obstacle to efficient retrieval through automatic full text processing and searching. The purpose of this study was to obtain quantitative data on the above problems, using a selected portion of Braconidae literature as the working base. The study was part of preliminary work toward the construction of a prototype Braconidae information retrieval system.

Methods

A collection of 183 documents[4] on 3 species of *Apanteles* was examined for 1) frequency of the species names in titles, 2) frequency of the species names in published abstracts, and 3) variations in spelling of the species names in the original texts. The species studied were *Apanteles melanoscelus* (Ratzeburg) 1844, *A. porthetriae* Muesebeck 1928, and *A. ocneriae* Ivanov 1899, all parasites of the gypsy moth, *Porthetria dispar* (L.). 167 of the documents dealt with *melanoscelus*, 38 with *porthetriae* and 14 with *ocneriae*. Twenty-seven of the documents contained information on 2 or all of these species.

[1]Hymenoptera: Braconidae

[2]Research supported by the College of Agricultural and Life Sciences, University of Wisconsin, Madison, and by means of a cooperative agreement between the College and the Agricultural Research Service, USDA.

[3]Specialist and professor, respectively.

[4]The bibliography will be published in the June, 1973 issue of this *Journal*.

The documents consisted of journal articles, U.S. federal, U.S. state and foreign government publications, conference proceedings and technical books (catalogs, manuals, textbooks, etc.) in 12 languages. Species information from a document ranged in length from a single sentence or footnote to over 30 pages. The documents themselves were from 1-2 pages to 1400 pages in length.

The Review of Applied Entomology (Series A: Agricultural) was used to obtain abstracts of these documents. It was selected as the best single source for our subject matter because of its extensive and early (1913-present) coverage of the world literature. Abstracts for 97 of our documents were obtained, located through the author index. The documents pertaining to *melanoscelus, porthetriae* and *ocneriae* were represented by 93, 16 and 3 abstracts, respectively. The number of abstracts obtained did not reflect the relative coverage of *RAE;* some of the 183 documents were published before 1913, others were men-

Table 1.—Variations in spelling of scientific names—*A. melanoscelus, A. porthetriae, A. ocneriae.*

I. *Apanteles melanoscelus* (Ratzeburg) 1844 (167 documents)			
Genus variations:	A	*Author variations:*	(blank)
	Ap		Latr
	Apantales		Ratz
	Apanteles		Ratzb
			Ratzbg
Species variations:	m		Ratzeberg
	malanoscelus		Ratzeburg
	melanocelis		Rbg
	melanocelus		Ritg
	melanocephalus		Rtz
	melanoscelis		Rtzb
	melanoscellus		Rtzbg
	melanoscelus		
	melanoschelus		
	melanoseclis		
	melinosus		
II. *Apanteles porthetriae* Muesebeck 1928 (38 documents)			
Genus variations:	A	*Author variations:*	(blank)
	Apanteles		L
			Mues
Species variations:	portehtriae		Muesb
	portethriae		Muesebeck
	portheriae		Mus
	porthertiae		Nees
	porthetria		new species
	porthetriae		
	porthretiae		
	porttetriae		
III. *Apanteles ocneriae* Ivanov 1899 (14 documents)			
Genus variations:	A	*Author variations:*	Iv
	Ap		Ivan
	Apanteles		Ivanov
			Ivanow
Species variations:	ochneriae		Iw
	ocneria		Iwanov
	ocneriae		lv
			Stanov
			Svan
			Svanow
			Tw

tioned by title only, a few were missed because of publishing time lag, and one year's volume was not available.

Results

Titles. — Only 4 of the 167 documents containing information on *A. melanoscelus* (3%) mentioned this species in the title. None of the *A. porthetriae* or *A. ocneriae* documents contained the species names in the titles.

Abstracts.—The species was mentioned in 27 of the 93 abstracts of *A. melanoscelus* documents, in 2 of 16 for *A. porthetriae* and in none of 3 for *A. ocneriae*, or 29%, 12.5% and 0%, respectively. The percentage probably would not have improved had a complete set of abstracts been available, since most of the documents mentioned only by title were long works in which the species information was relatively brief.

The low frequency of the species names in titles and abstracts suggested the need for greater depth of analysis of the literature to achieve thorough access to species-level information.

Spelling of Species Names.—The misspelling of words in original documents is seldom mentioned as an important problem in automatic full text processing, and it probably isn't for normal words. Our sample collection, however, revealed a rather significant variety of spellings of the names of the 3 *Apanteles* species. These variant spellings apparently were due to 1) alternate interpretations of the Latin grammar rules in the International Code of Zoological Nomenclature, 2) inconsistent abbreviations of the genus and/or author components, 3) the failure of authors to adequately verify spellings prior to publication, and 4) typographical errors.

The spellings encountered are listed in Table 1. Synonyms were not recorded, nor were variations in punctuation and capitalization, e.g. "?Apanteles melanoscelus", "L'Apanteles melanoscelus", "A. Por-thetriae", "(Ratz)".

The accepted spellings "melanoscelus", "porthetriae" and "ocneriae" failed to occur at least once in 13%, 19%, and 21% of the respective documents.

The combination of the correctly spelled species term plus the most common stem for the author component ("Ratz--", "Mues--", "Ivan--") failed to occur in 36%, 24% and 64% of the respective documents.

Conclusions and Discussion

The occurrence of spelling variations in technical entomological literature creates a special problem worth noting, in spite of the fact that automatic full text processing is perhaps not a viable alternative for efficiently handling the existing literature. The recent "Wigington Report" (1972) states that technical problems still exist in converting the printed page to machine readable form without keyboarding its content. One such problem is the high error rate of present optical character recognition equipment when multiple font recognition is required.[5] A more fundamental problem, however, is the well known one of inherently poor recall-precision levels.

It isn't our intention to dismiss any possible alternative that may ultimately aid in coping with the information problem, or parts of it, but we thought it desirable to point out some of the problems of particular importance in handling the existing literature of the 1½ million described species of insects.

A manual literature processing technique has been developed (Shervis et al., 1972) which offers the potential for virtually complete recall of published species information with acceptable levels of noise. It is hoped that this technique will eventually prove useful in handling portions of the existing body of entomological literature.

Acknowledgment

Our appreciation is expressed to Dr. Richard H. Foote for reading the manu-

[5] It was tempting to illustrate the remarkable variety of fonts encountered in our collection; in one document (Crossman, 1922) the species name alone occurred in 12 different fonts.

script and for many suggestions regarding the research.

References Cited

Crossman, S. S. 1922. *Apanteles melanoscelus*, an imported parasite of the gipsy moth. U.S. Dep. Agr. [Dep.] Bull. 1028: 1-25.

Shervis, L. J., R. D. Shenefelt, and R. H. Foote. 1972. Species-level analysis of biological literature for storage and retrieval. BioScience 22: 651-655.

[Wigington Report] National Academy of Sciences. Computer Science and Engineering Board. Information Systems Panel. 1972. Libraries and information technology; a national system challenge. Washington, D.C., Nat. Acad. Sci. xi + 84p.

Wilson, R. A. 1966. Optical page reading devices. New York, Reinhold. ix + 197p.

NOTICE

1973 Programs

John Wesley Powell Auditorium
Cosmos Club, 2170 Florida Ave., N.W., Washington, D.C.

8:00 P.M. Public Welcome

April 19

Dr. Max V. Matthews Acoustical and Behavioral Research Center, Bell Telephone Laboratories

Computer Music and Other Unusual Computer Applications

This subject will intrigue those who are interested in using computers for functions other than performing arithmetic operations very rapidly or handling masses of data. The speaker will demonstrate how useful a computer could be to a composer, for instance, if he had a program available which took his score and produced a tape on which the composition has been "performed" by the computer and which he can play on his tape recorder. In addition, he will discuss one or more of the other unusual uses to which he has been putting computers, such as an aid to composing music, and for typesetting.

May 17

Dr. Richard K. Cook President, Washington Academy of Sciences

Annual Dinner Meeting

For information contact:

Washington Academy of Sciences Office
9650 Rockville Pike (Bethesda), Washington, D.C. 20014
Telephone:530-1402

PARKING: Available at the Cosmos Club, on the street, and at the Fairfax Hotel across from the Cosmos Club (2121 Massachusetts Ave.)

RESEARCH REPORT

North American Species of Calosota *Curtis (Hymenoptera: Eupelmidae)*

Barnard D. Burks

Systematic Entomology Laboratory, ARS, USDA, c/o U. S. National Museum, Washington, D. C. 20560

ABSTRACT

A revision of the North American species of the eupelmid genus *Calosota* is presented. A key, illustrations, and descriptions of the 2 known *(C. longiventris, C. metallica)* and 3 new *(C. pseudotsugae, C. kentra, C. montana)* species are included. Most of the species of *Calosota* for which hosts are known parasitize wood-boring Coleoptera.

The species of *Calosota* have a distinctive appearance, with the pronotum greatly reduced, the mesoscutum and praescutum fused into a semi-quadrate sclerome that shows hardly any traces of the notaulices, the axillae greatly reduced and widely separated, and the body elongate and slender, resembling in habitus many of the genera of the Cleonymini of the Pteromalidae. *Calosota* species do not look, a first glance, like eupelmids.

Yet *Calosota* is an eupelmid genus. The mid coxae are attached in such a way that they can be rotated either anteriorly or posteriorly, the mid tibia has a saltatorial apical spur, the basal mid tarsal segments are enlarged and bear ventral spines or teeth, the mesopleuron lacks a femoral furrow, and the prepectus is enlarged and projects over the anterior margin of the mesepisternum.

Bouček (1958, p. 354) has proposed a subfamily Calosotinae in the Eupelmidae for *Calosota* and a few allied genera. Bolivar y Pieltain (1923, 1929) has twice revised the Spanish species of *Calosota,* and Hedqvist (1963, p. 138) has recharacterized the genus. *Calosota* occurs in all faunal regions and is especially well represented in the Oriental region. Most of the species of *Calosota* for which hosts are known parasitize wood-boring Coleoptera.

Up to now, 2 species of *Calosota* have been known for North America. In this paper I describe 3 more and give a key and descriptions for the separation of all the North American species. I undertook the revision of this interesting little genus when Mr. M. A. Deyrup of Washington State submitted a series of an undescribed species for which he needed a name.

Genus **Calosota** Curtis

Calosota Curtis, 1836, Brit. Ent. 13: 596.—Ruschka, 1920, Verh. Zool.—Bot. Ges. 70: 248.—Gahan and Fagan, 1923, U.S. Natl. Mus. Bul. 124: 26.—Bolivar y Pieltain, 1923, Rev. Fitopat. 1: 62.—Bolivar y Pieltain, 1929, Eos 5: 123.—Peck *in* Muesebeck et al., 1951, U. S. Dept. Agr. Monog. 2: 508.—Nikolskaya, 1952, Opred. Fauna S.S.S.R. 44: 480.—Heqvist, 1956, Ent. Tidskr. 77: 96.—Bouček *in* Kratochvíl, 1957, Klíč Zvířeny ČSR 2: 244.—Hedqvist, 1963, Studia Forest. Suec. 11: 139.—Nikolskaya, 1963, Keys Fauna U.S.S.R.

44: 493 (Eng. transl.).—Bouček, 1964, Ent. Soc. Canada Mem. 34: 60 (Eng. transl.).—De Santis, 1967, Buenos Aires Com. Inv. Cient., Cat. Him. Arg., Ser. Par., p. 172.

Type-species.—Calosota vernalis Curtis. Orig. desig.

Calosoter Walker, 1837, Ent. Mag. 4: 358.—Ashmead, 1896, Proc. Ent. Soc. Wash. 4: 7, 10.—Dalla Torre, 1898, Cat. Hym. 5: 270.—Ashmead, 1904, Carnegie Mus. Mem. 1: 288, 290.—Schmiedeknecht, 1909, Gen. Ins., fasc. 97: 172, 174, 184.—Gahan, 1922, Proc. U.S. Natl. Mus. 61 (24): 16.—Risbec, 1952, Mem. Inst. Sci. Madagascar, ser. E, 2: 61, 132.

Type-species.—Calosoter vernalis Walker. Desig. by Westwood, 1840.

Generic description.—Eyes large, pubescent; antennae inserted at or slightly below level of ventral margins of compound eyes; malar furrow present; margins of clypeus indistinct; anterior ocellus located outside scrobe cavity; surface within scrobe cavity mostly or entirely shining and smooth, rest of frons sculptured; face and ventral half of parascrobal spaces pubescent; antenna lacking true ring segments, but first funicular segment shorter than second, being 2/5 to 4/5 as long as second segment, 8 funicular segments present. Pronotum reduced in size, scarcely visible from dorsal aspect, laterally with a more or less distinct femoral furrow; notaulices absent or faintly indicated anteriorly; axillae small and widely separated; mid coxae attached so as to rotate either anteriorly or posteriorly, mid tibia with an apical, saltatorial spur, mid tarsus with basal segments thickened and bearing ventral teeth or spines in 2 parallel, longitudinal rows; hind tibia with 2 apical spurs, mesopleuron without femoral furrow; forewing with basal cell completely setose, speculum present or absent. Propodeum in female extremely short on meson, posterior margin almost or quite in contact with anterior margin, in male propodeum slightly longer on meson; propodeal spiracles large and round. Gaster of female long and slender, with apical tergum acuminate, ovipositor often projecting; basal 2 to 5 gastral terga in female with posterior margins emarginate on meson, male usually with only first tergum emarginate.

Calosota pseudotsugae, new species

This species differs from all other North American species in having a longitudinal speculum in the forewing below the base of the marginal vein, fig. 1; other species either lack a speculum or have it lying parallel to the basal vein (path of obsolete vein Rs).

Female.—Length 3.0–4.0 mm. Head with metallic bronzy luster, shading to green on meson below antennal sockets; antennal scape yellow at base, black with faint metallic green luster apically, pedicel and flagellum black; mesoscutum blue-green, praescutum bronze color; scutellum black with very faint metallic green luster; propodeum blue-green; gaster black, faintly iridescent laterally; wings hyaline, veins tan; coxae dark blue-green, anterior femora and tibiae black with bases and apices yellow, mid and hind femora and tibiae tan, all tarsi tan. All pubescence silvery.

Antennae inserted at level of ventral margins of compound eyes; basal funicular segments slender and elongate, apical ones relatively shorter and broader but not quadrate, pedicel 3 times as long as first funicular segment, second to sixth funiculars equal in length and each twice as long as first, seventh and eight equal in length and each 7/8 as long as sixth, club as long as apical 3 funiculars, first club segment 2/5 length of club; width of malar space 1/2 as great as height of compound eye; ocellocular line 1/6 as long as postocellar line.

Entire thoracic dorsum with slightly irregular, netlike sculpture, this formed of minute, raised lines, netlike figures slightly larger on meson than

North American Species of *Calosota* Curtis
Key to Females

1. Forewing with a longitudinal speculum below base of marginal vein, fig. 1 .... *pseudotsugae,* new species
   Forewing either lacking a speculum or having one parallel to basal vein (path of obsolete vein Rs), fig. 3 2
2. Scutellum not flat, but roundly elevated in posterior half, its surface sculpture closely set, slightly irregular, longitudinal carinulae; head and body mostly bright metallic blue or blue-green .... *metallica* Gahan
   Scutellum flattened, its surface sculpture netlike; head and body black or black with dark metallic green, bronze, or lavender luster 3
3. Gaster elongate and acuminate, 5 times as long as thorax, and with seventh gastral tergum much longer than sixth .... *longiventris* Ashmead
   Gaster shorter, not over 2-½ times as long as thorax, and with seventh tergum equal to or shorter than sixth 4
4. Forewing shaded with tan; thorax black, without metallic luster; forewing without speculum .... *kentra,* new species
   Forewing hyaline; thorax dorsally with metallic blue in longitudinal lateral and median stripes a pair of submedian bronze colored stripes lying between the blue ones; forewing with speculum, fig. 3 .... *montana,* new species

elsewhere; prepectus with similar sculpture; mesopleuron with minute, netlike sculpture anteriorly, sculpture becoming fainter posteriorly, this posterior sculpture a plexus of minute, closely-set, lineolate engraved lines; forewing with marginal vein twice as long as stigmal, 1 2/5 times as long as postmarginal; a longitudinal speculum present below base of marginal vein, fig. 1; scutellum flattened.

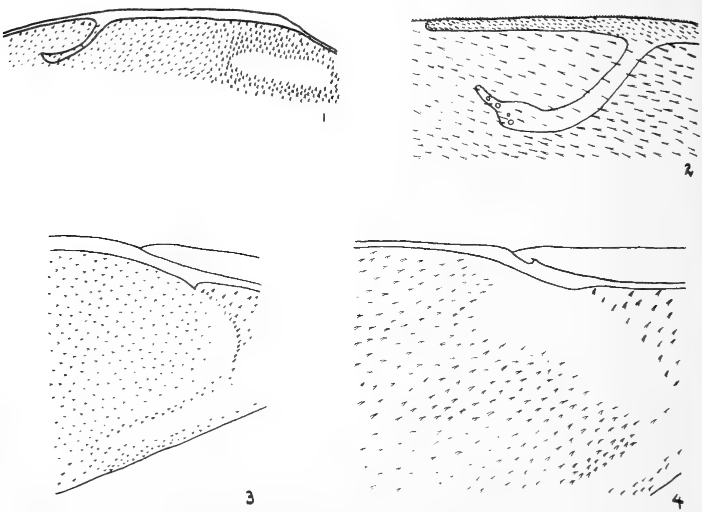
Propodeum with a median smooth area as wide as scutellum, this smooth area containing 2 or 3 strong, longitudinal carinae on each side of meson, rest of propodeal surface minutely shagreened; posterior margin of propodeum a low lamina on meson, carinate elsewhere, posterior and anterior propodeal margins just in contact at meson; each spiracle situated in a depression that is completely surrounded by a low ridge. Gaster slender, acuminate, 2 1/2 times as long as thorax; sixth and seventh gastral terga equal in length; ovipositor slightly exserted.

Male.—Length 4.0 mm. Color as in female, except that propodeum is entirely black. Antennae with scape broader than in female, pedicel twice as long as first funicular, second to sixth funiculars equal in length and each as long as pedicel, seventh and eighth each 7/8 as long as sixth, club as long as sixth and seventh combined; propodeum with entire surface shagreened and as long on meson as postscutellum; a shield-shaped figure on meson of propodeum formed by a pair of parenthesis-shaped, longitudinal carinae, numerous irregular, longitudinal carinulae in this shield-shaped area; gaster 1 3/4 times as long as thorax.

Type-locality.—Maytown, Thurston Co., Washington.

Type.—U. S. N. M. Catalog No. 72481.

Described from 5 female, 1 male specimens. Holotype female, allotype male, and 4 female paratypes, Maytown, Washington, reared April 6 -12, 1972, from material of downed *Pseudotsuga menziesii* that also yielded specimens of the beetle *Pseudohylesinus nebulosus* (LeConte), Hymenoptera *Spathius sequoiae* Ashmead, *Heydenia unica* Cook and Davis, *Cecidostiba thomsoni* Crawford, *Eurytoma tomici* Ashmead and *E. cleri* Ashmead, and the dipteron *Medetera aldrichii* Wheeler. The rearing was done by M. A. Deyrup.



Figs. 1-4 Portions of forewings of species of *Calosota*. 1, *pseudotsugae*, n. sp., showing longitudinal speculum below base of marginal vein; 2, *kentra*, n. sp., stigmal vein; 3, *montana*, n. sp., showing narrow speculum parallel to basal vein; 4, *metallica* (Gahan), showing large speculum.

Biological relationships.—This species probably is a primary parasite of the scolytid beetle *Pseudohylesinus nebulosus* (LeConte).

Calosota metallica (Gahan)

Calosoter metallicus Gahan, 1922, Proc. U.S. Natl. Mus. 61(24): 16, ♀, ♂.

Calosota metallica (Gahan) Packard, 1928, U.S. Dept. Agr. Tech. Bul. 81: 14.—Gahan, 1933, U. S. Dept. Agr. Misc. Pub. 174: 58.—Knowlton and Janes, 1933, Utah Agr. Expt. Sta. Bul. 243: 12.—Rockwood and Reeher, 1933, U. S. Dept. Agr. Tech. Bul. 361: 18.—Phillips and Poos, 1937, U. S. Dept. Agr. Farmers Bul. 1323: 8—Knowlton and Harmston, 1939, Proc. Utah Acad. Sci. 16: 62.— Chamberlin, 1941, U.S. Dept. Agr. Tech. Bul. 784: 39.—Peck *in* Muesebeck et al., 1951, U. S. Dept. Agr. Monog. 2: 508.—Nikolskaya, 1952, Opred. Fauna S.S.S.R. 44: 483—Phillips and Poos, 1953, U.S. Dept. Agr. Farmers Bul. 1323 (rev.): 5.—Nikolskaya, 1963, Keys Fauna U.S.S.R. 44: 497 (Eng. transl.).

This species differs from all other Nearctic ones of this genus in being almost entirely bright metallic blue or blue-green, in having the scutellum elevated rather than flat and having longitudinal, lineolate sculpture, and in lacking the double row of minute teeth on the ventral side of the midtarsal segments (in *metallica* these teeth are replaced by short spines). The female gaster of this species is also only moderately lengthened and is scarcely acuminate apically. It may be desirable to place *metallica* in some genus other than *Calosota*.

Female.—Length 2.5 – 4.0 mm. Head and body bright metallic blue or blue-green with iridescent green or purple luster on pleura; antennal scape metallic blue, pedicel green, flagellum dark brown or black; coxae metallic blue or lavender, femora and tibiae pale tan or yellow at bases and apices, middle parts blue or blue-green, tarsi tan with apical segment of each brown; wings hyaline with yellow veins. All pubescence silvery.

Antennae inserted very slightly below level of ventral margins of compound eyes; basal funicular segments slightly longer than wide, apical ones wider than long, pedicel 4 times as long as first funicular, second funicular twice as long as first, third to fifth equal in length and each 1 1/4 times as long as second, sixth and seventh equal in length and each 9/10 as long as fifth, eighth 4/5 as long as fifth, club 3 times as long as fifth, first club segment 1/2 as long as club; width of malar space 3/5 as great as height of compound eye; ocellocular line 1/7 as long as postocellar line.

Mesoscutum and praescutum with minute, net-like sculpture, scutellum with this sculpture so modified as to form closely set, longitudinal striae; scutellum not flat but very slightly depressed on meson in basal half, posterior half with surface slightly elevated and rounded; prepectus with sculpture similar to scutum; mesopleuron almost smooth, but with faint coriaceous sculpture, the lines of this sculpture transverse in anterior half, becoming longitudinal in posterior half; forewing with stigmal and postmarginal veins usually equal in length (postmarginal sometimes slightly the longer), marginal vein 4 times as long as stigmal, a relatively broad speculum along basal vein, fig. 4; mid tarsus with spines rather than teeth on ventral surface; apical spur of mid tibia relatively weak.

Propodeum almost smooth, with faint alutaceous sculpture; propodeal spiracles not set in depressions. Gaster subflattened dorsally, as wide as thorax, and twice as long as thorax; basal 2 terga emarginate on meson of posterior margin; seventh tergum 2/3 as long as sixth; ovipositor slightly exserted.

Male.—Length 2.0–3.0 mm. Color and sculpture as in female; first funicular segment 1/4 as long as pedicel, second funicular 2 1/2 times as long as first, third to eighth equal in length and each 1 1/5 times as long as second; club almost 3 times as long as eighth funicular, first club segment 1/3 as long as club; width of malar space 1/3 as great as height of compound eye; ocellocular line 1/9 as long as postocellar line. Length of propodeum on meson 2/3 as great as length of postscutellum; gaster shaped as in female, but only 1 1/4 times as long as thorax.

Type-locality.—San Miguel, California.

Type.—U. S. N. M. Catalog No. 24988.

Distribution.—Idaho, Utah, Wash., Oreg., Calif.

Biological relationships.—Associated with grasses, attacking various hosts in the stems. This has been reared as a primary parasite of several species of *Harmolita* and, as a secondary parasite, from *Ditropinotus aureoviridis* Crawford and *Eurytoma parva* Phillips, these 2 being primary parasites of *Harmolita*. It also has been reared as a primary parasite of *Mayetiola destructor* (Say).

Calosota longiventris (Ashmead)

Calosoter longiventris Ashmead, 1896, Proc. Ent. Soc. Wash. 4: 12, ♀, ♂.—Dalla Torre, 1898, Cat. Hym. 5: 270.—Schmiedeknecht, 1909, Gen. Ins., fasc. 97: 185.

Calosota longiventris (Ashmead) Peck *in* Muesebeck et al., 1951, U. S. Dept. Agr. Monog.

2: 508.—Peck, 1963, Canad. Ent. Suppl. 30: 474.—Burks *in* Krombein and Burks, 1967, U.S. Dept. Agr. Monog. 2, Suppl. 2: 245.

This species differs from all other North American species of *Calosota* in having the seventh gastral tergum of the female so greatly lengthened that it is 4 times as long as the sixth tergum.

Female.—(Redescribed from the single fragmentary lectotype specimen.) Length 6.0 mm. Head, thorax and propodeum black with faint metallic green luster, gaster black; antennal scape black with faint metallic bronze luster, pedicel and flagellum black; coxae black with very faint bronze luster, femora and tibiae dark brown, tarsi slightly lighter; wings hyaline, veins brown. Pubescence silvery.

Antennae inserted slightly below level of ventral margins of compound eyes; pedicel and funicular segments elongate, pedicel 5/6 as long as the combined first and second funiculars, first funicular 1/2 as long as second, second to fourth equal in length, fifth and sixth each 5/6 as long as fourth (apical parts of antenna missing); width of malar space 1/2 as great as height of compound eye; ocellocular line 1/4 as long as postocellar line.

Entire dorsum of thorax with minute, slightly irregular, netlike sculpture, this formed by minute raised lines; median, longitudinal band on praescutum slightly depressed and having surface sculpture a little coarser than elsewhere on dorsum; prepectus sculptured as is mesoscutum; mesopleuron with faint, longitudinal, semi-lineolate sculpture; forewing with marginal vein 3 times as long as stigmal, postmarginal 1 1/3 times as long as stigmal; speculum absent; scutellum flattened.

Propodeum faintly sculptured, almost smooth; posterior margin of propodeum slightly elevated as a low lamina, this touching anterior margin on meson; spiracles of propodeum not in depressions. Gaster elongate, slender, 5 times as long as thorax; seventh tergum greatly lengthened, 4 times as long as sixth tergum; ovipositor projecting from a distance 1/6 as great as length of seventh tergum.

Male.—Length 3.0 – 4.0 mm. Head black with faint brassy luster; thorax black, faintly metallic green laterally; propodeum shining black, gaster black with faint iridescent luster; antenna stouter than in female, scape widened apically and funicular segments thicker and shorter than in female; pedicel twice as long as first funicular, second 1 2/5 times as long as first, second to fifth equal in length, sixth 7/8 as long as fifth, seventh and eighth equal in length and each 5/6 as long as sixth, club as long as 3 apical funiculars; width of malar space 2/5 as great as height of compound eye; ocellocular line 1/6 as long as postocellar line; gaster 2 1/3 times as thorax.

Type-locality.—Santa Cruz Mountains, California.

Types.—Lectotype female, U. S. N. M. Catalog No. 3463. Specimen labeled, "Sta. Cruz Mts. Cal., Calosoter longiventris Ashm. ♀." Present designation of lectotype. There also are 2 male paralectotype specimens in the collection, 1 labeled as is the type, the other labeled, "Argus Mts. May 91 K."

Distribution.—Idaho, Calif.

Biological relationships.—Unknown.

Calosota kentra, new species

This species agrees with *longiventris* Ashmead in that it has a long, slender gaster with an exserted ovipositor, but they may be separated by the fact that this species has shaded wings, the seventh gastral tergum is only as long as the sixth, and the stigma of the forewing is enlarged and has a long, slender uncus, fig. 2.

Female.—Length 4.0 mm. Head black, with faint iridescent blue luster on face and at eye margins, scrobe cavity lavender; thorax black with faint metallic blue luster at apices of scutellum and postscutellum, and at posterior margin of mesepisternum; propodeum dark metallic blue; gaster black with basal tergum metallic blue; antennal scape dark blue-green, pedicel and flagellum black; coxae dark metallic blue; femora and tibiae black, shading to tan at apices, tarsi tan with apical segment of each dark brown; wing veins light brown, forewing shaded with tan on disc below marginal vein and around stigmal vein; hindwing hyaline. All pubescence silvery.

Antennae inserted slightly below level of ventral margins of compound eyes; antenna with all funicular segments elongate, first funicular segment 1/2 as long as second, the second to fourth funiculars equal in length, fifth 9/10 as long as fourth, sixth 9/10 as long as fifth, seventh slightly shorter than sixth, eighth slightly shorter than seventh, club twice as long as second funicular, first club segment 1/2 as long as club; width of malar space 2/3 as great as height of compound eye; ocellocular line 1/3 as long as postocellar line.

Entire thoracic dorsum with slightly irregular, minute, netlike sculpture, this formed by minute raised lines; prepectus with similar sculpture; mesopleuron faintly sculptured, amost smooth; forewing with marginal vein twice as long as postmarginal and 1 3/5 times as long as stigmal, the stigma enlarged and with a long, slender uncus, fig. 2; speculum absent; scutellum flattened.

Propodeum with surface shagreened, posterior margin carinate, this margin in contact with anterior margin on meson, numerous short carinae extending anteriorly from posterior margin in lateral areas of propodeum. Gaster slender, twice as long as thorax; seventh gastral tergum as long as sixth; ovipositor exserted for a distance 1/2 as great as length of sixth tergum.

Male.—Unknown.

Type-locality.—Albany, New Hampshire.

Type.—U. S. N. M. Catalog No.

2, 1958, by W. J. Morse.

Biological relationships.—Unknown.

Cecidostiba montana, new species

This species greatly resembles the European species *vernalis* Curtis in having the frons iridescent blue-violet shading to green on the vertex, the thoracic dorsum has alternating longitudinal blue and greenish bronze stripes, the propodeum is blue-violet, and the hind tibiae are entirely brown in contrast with the anterior and mid tibiae, which are mostly black with faint metallic green luster, the apices tan. They differ in that the sixth and seventh gastral terga are equal in length in *vernalis,* but the sixth is longer than the seventh in this species.

Female.—Length 4.5 mm. Head metallic blue-violet, shading to green on vertex; dorsum of thorax with a blue longitudinal stripe at each lateral margin and on meson, with 2 metallic greenish bronze stripes between the blue ones; thoracic pleuron and sternum blue-violet; coxae dark blue-violet, femora black with faint green luster, apices tan, anterior and mid tibiae the same color, hind tibiae uniformly dark brown, all tarsi pale tan with apical segment of each darker; wings hyaline, veins brown; propodeum blue-violet; gaster black with blue luster ventrally. All pubescence silvery.

Antennae inserted slightly below level of ventral margins of compound eyes; basal funicular segments of antenna elongate, apical ones semi-quadrate, pedicel 1 1/4 times as long as first funicular segment, second and third funiculars each as long as pedicel, fourth 9/10 as long as third, fifth 9/10 as long as fourth, sixth and seventh each 4/5 as long as fourth, eighth 2/3 as long as fourth, club twice as long as pedicel, basal club segment not quite 1/2 as long as club; width of malar space 3/8 as great as height of compound eye; ocellocular line 1/4 as long as postocellar line.

Entire thoracic dorsum with slightly irregular, minute, netlike sculpture, this formed by minute raised lines; prepectus with similar sculpture; mesopleuron with similar sculpture in anterior half, posterior half with much fainter and finer reticulate surface sculpture; forewing with marginal vein 1 2/3 times as long as postmarginal and 2 1/2 times as long as stigmal; a narrow speculum along basal vein; scutellum flattened.

Propodeum with surface shagreened, posterior margin strongly carinate, this margin not quite touching anterior margin on meson; a pair of longitudinal, submedian carinae present just behind lateral margins of scutellum; numerous short, stout carinulae extending anteriorly from posterior margin in lateral areas of propodeum; each propodeal spiracle situated in a depression that is surrounded laterally and posteriorly by a low ridge. Gaster 2 1/2 times as long as thorax; basal 5 gastral terga medianly emarginate on posterior margin; sixth tergum 1 1/7 times as long as seventh.

Male.—Length 3.5 mm. Head black with very faint metallic green luster on ventral half, faintly iridescent bronze-green on vertex; thorax black with faint metallic blue luster on dorsal meson and on pleura; gaster black with faint iridescence laterally; legs and wings colored as in female; antennal pedicel 2 1/2 times as long as first funicular segment, second funicular 2 1/4 times as long as first, third and fourth each as long as second, fifth 7/8 as long as fourth, sixth to eighth equal in length and each 2/3 as long as fourth, club as long as apical 3 funiculars, first club segment 1/3 as long as club; width of malar space 2/3 as great as height of compound eye; ocellocular line 1/6 as long as postocellar line; gaster 1 1/2 times as long as thorax.

Type-locality.—Rock Creek, Granite Co., Montana.

Type.—U. S. N. M. catalog no. 72483.

Described from 1 female, 1 male specimens. Type female, Rock Creek, Montana, reared Feb. 11, 1969, from unidentified gall on *Pinus contorta,* by J. G. Bringuel under his accession no. 1602; allotype male, same data, but reared Feb. 10, 1969, under accession no. 1601.

Biological relationships.—Essentially unknown; may parasitize some gall maker on pine.

References Cited

Bolivar y Pieltain, C. 1923. Especies españolas de *Calosota* Curt. Rev. de Fitopat. 1: 62-69.

————. 1929. Estudio monografico de las especies españolas del genero *Calosota* (Hym. Chalc.). Eos 5: 123-142.

Bouček, Z. 1958. Eine Cleonyminen-studie . . . eingeschlossen einige Eupelmidae (Hym. Chalcidoidea). Acta Ent. Musei Nat. Pragae 32: 353-386.

Hedqvist, K.-J. 1963. Die Feinde der Borkenkäfer in Schweden, I. Erzwespen (Chalcidoidea). Studia Forest. Suec. 11, 176 pp.

SCIENTISTS IN THE NEWS

Contributions in this section of your Journal are earnestly solicited. They should be typed double-spaced and sent to the Editor two months preceding the issue for which they are intended.

BATTELLE LABORATORIES

Bernard K. Dennis has been named Chief, Information Systems Research, for Battelle's Columbus Laboratories. He is in charge of the research organization's Washington, D.C., information operations.

Before joining Battelle-Columbus in 1964, Dennis developed and managed one of industry's first computer-based technical information systems. This system has been in operation since 1957, supplying information to more than 2,000 engineers and scientists.

At Battelle, his research has involved the design, development, and evaluation of information systems. He is the author of a number of technical papers on the subject.

Dennis received his B.S. from the University of Cincinnati, where he specialized in mathematics and physical sciences. His master's was granted by the same institution. His professional affiliations include the American Association for the Advancement of Science, American Ordnance Association, American Society for Information Science, Armed Forces Communications and Electronics Association, Operations Research Society of America, and Special Libraries Association. He was recently named a Fellow by the Washington, D.C., Academy of Sciences.

DEPARTMENT OF AGRICULTURE

Martin Jacobson, Leader of the Biologically Active Natural Products Laboratory, AEQI, has isolated from the female gypsy moth, identified, and prepared synthetically a compound capable of inhibiting the growth of a human tumor system, Walker intramuscular carcinosarcoma 256, in rats. The work was carried out in cooperation with the natural products program of the National Cancer Institute, National Institutes of Health, Bethesda, Maryland. The characterization of this compound, of a type never before shown to have antitumor activity, provides a valuable lead for preparing related compounds possibly possessing higher activity in this and other tumor systems.

Henry T. Skinner, director of the National Arboretum, has retired after 20 years of dedicated service in building the institution into one of national and international prominence. This was announced at a reception this afternoon at the arboretum honoring Skinner.

Skinner's primary interests have long been devoted to the development of research and the educational aspects of the National Arboretum. During this period many educational features have been added to the institution.

Some of the noteworthy features are the Fern Valley Trail which was developed by the National Capital Area Federation of Garden Clubs, the Touch-and-See Nature Trail for the blind, the Fred Lee Memorial Garden of late flowering azaleas, the Gotelli Collection of 1,500 naturally dwarf conifers (needled evergreens), as well as the large collection of flowering crabapples (over 200 varieties), the collection of daylilies, peonies (which includes many of the Saunders hybrid tree peonies), some 200 boxwoods, 750 species and varieties of holly, 60 varieties of flowering cherries, 150 species and cultivars of magnolias, and many more fine collections of plants.

When one adds these to the famous azalea and rhododendron collections, the year around value of the Arboretum to the public becomes evident. An illustration of this flowering season is the display in November of the fall flowering Sasanqua camellias.

The spring flowering season starts with the azaleas and dogwoods followed by the Camellia japonica, flowering crabapples, flowering cherries, peonies, daylilies and many others. The home gardener studies these collections to see which would be best suited to his garden and the general public enjoys the beauty and arrangement of the plants in this 415-acre arboretum.

The staff of technical experts in the arboretum conduct a continuous breeding program on woody plants. It has so far released to commercial propagators a number of hardy large flowered hibiscus, crape myrtle, magnolias, hollies, viburnums and firethorn. Many are particularly interested in the hardy firethorn Mojave recently released which is noted, in addition to its hardiness, for its resistance to fire blight and scab.

Other research work includes the study and propagation of desirable shade trees. This project involves the production of new desirable kinds and how to propagate them. These projects on woody plants are a necessary part of the work of an arboretum since they involve many years' work by highly skilled experts.

Skinner's education began at the Wisley School of the Royal Horticultural Society (England) and continued at Cornell University and the University of Pennsylvania. He was curator of the Morris Arboretum in Philadelphia before his appointment as director of the National Arboretum in 1952.

Because of his work, Skinner has received many awards and citations for his services to horticulture which include the Jackson Dawson Medal of the Massachusetts Horticultural Society for research contributions in plant propagation, the American Home Achievement Medal, the Arthur Hoyt Scott Horticultural Award for work and writings on horticultural and botanical subjects, the Gold Medal of the American Rhododendron Society for studies especially of American native azaleas, the Norman J. Colman Award of the American Association of Nurserymen for contributions in the field of horticultural research, the Superior Service Award of the U.S. Department of Agriculture, the Garden Club of America Medal of Honor for service to horticulture, the Distinguished Achievement Medal of the Pennsylvania Horticultural Society, and the American Horticultural Society's Liberty Hyde Bailey Medal for his role in building the arboretum into a place of national and international prominence in the plant world.

In addition to these activities, Dr. Skinner has been active in many professional horticultural and botanical societies. He is a Past President of the American Association of Botanical Gardens and Arboreta; Past President of the American Horticultural Society, and is a member of the Commission on Nomenclature and Registration of the International Society for Horticultural Science.

Recently he has served as a member of the executive committee of the International Society for Horticultural Science. He has been a popular speaker at many horticultural meetings. More especially, he has been a guide and counselor to many horticultural groups as well as a popular writer.

Many will miss Dr. Skinner's guidance, but will be thankful for his contributions to horticulture and for his leadership.

NATIONAL INSTITUTES OF HEALTH

Sanford M. Rosenthal, former chief of the Laboratory of Pharmacology and Toxicology, National Institute of Arthritis, Metabolism, and Digestive Diseases, has been awarded the Harvey S. Allen prize from the American Burn Association for his studies on treatment and cause of traumatic shock and burns.

Dr. Rosenthal's work has led to an increased understanding of the role of electrolyte disturbance in burns shock and to the use of large quantities of isotonic saline by mouth for its treatment.

Prior to Dr. Rosenthal's studies, intravenous infusions with plasma extenders had been considered essential for the effective treatment of burn shock.

His work is of particular value for potential use in the rapid treatment of traumatic shock and burns in mass disaster where intravenous plasma extenders and the skilled personnel to administer them are not always available.

Since his retirement in 1961, Dr. Rosenthal has been a consultant to NIAMDD Director, Dr. G. Donald Whedon.

NAVAL RESEARCH LABORATORY

George T. Rado, Head of the Naval Research Laboratory's (NRL's) Magnetism Branch here, has been elected Chairman of the Magnetism Commission of the International Union of Pure and Applied Physics (IUPAP) for a 3-year term, 1972-1975.

George T. Rado

The election was held during the Fourteenth General Assembly of IUPAP at the National Academy of Sciences here September 20 to 25.

The NRL scientist has been a member of the IUPAP Magnetism Commission since 1966 and served as its Secretary from 1969 to 1972. Included in the Commission headed by Dr. Rado are one representative each from Australia, Denmark, France, E. Germany, W. Germany, Hungary, Israel, Japan, The Netherlands, United Kingdom and the Soviet Union.

Dr. Rado has received international recognition for his research in magnetism. He won the NRL-RESA Pure Science Award in 1957, the E. O. Hulburt Science Award for 1965 and the Navy Award for Distinguished Achievement in Science in 1971.

Dr. Rado joined the NRL staff in 1945. He had attended the Massachusetts Institute of Technology from 1937 to 1943 where he received his SB, SM and PhD degrees in Physics. He has published numerous articles in professional journals and co-edited the five-volume treatise entitled, "Magnetism".

Dr. Rado, his wife Leanore and their two daughters reside at 818 Carrie Court, McLean, Va.

Lendell E. Steele, supervisory research physicist, head, Reactor Materials Branch, Metallurgy Div., Naval Research Laboratory, Washington, D.C., was recently elected chairman of Committee E-10 on Radioisotopes and Radiation Effects of the American Society for Testing and Materials.

ASTM is the world's largest source of voluntary consensus standards for materials, products, systems, and services. It is headquartered in Philadelphia, Pa., with 22,000 members throughout the world.

Committee E-10 promotes the knowledge of the use of radioisotopes in materials testing and the investigation of the changes in the properties and constitution of materials as a function of exposure to radiation.

Lendell E. Steele

A native of Kannapolis, N.C., Steele received his B.S. degree from George Washington University in 1950, and his M.A. degree from American University in 1959.

He began his professional career in 1948 as a physical science aid with the National Bureau of Standards. He was later with the U.S. Geological Survey as a scientific aid and later a chemist with the National Agricultural Research Center. Steele joined the Naval Research Laboratory in 1951 as a chemist for a short period prior to spending several years as a research and development and radiological safety officer with the U.S. Air Force. He returned to the Naval Research Laboratory as a chemist, 1953-1956; a physicist, 1956-1964; and as a research physicist, head, Reactor Materials Branch, 1964-1966. During 1967 he was a metallurgical engineer with the U.S. Atomic Energy Commission. Steele assumed his present position in 1968 with the broad program responsibility for fundamental and applied research on radiation damage phenomena and on materials for advanced nuclear power systems including thermal, fast and thermonuclear reactors. He directs the related High Level Radiation Laboratory for Naval Research Laboratory and serves as co-director of the new inter-divisional research effort called Cooperative Radiation Effects Stimulation (CORES) Program.

A member of ASTM, Steele was the first vice-chairman of Committee E-10 on Radiation Effects and Radioisotopes from 1970 to 1972 when he was elected chairman. He was a co-recipient of the 1972 Charles B. Dudley Medal for a series of papers published by ASTM on "Structure and Composition Effects on Irradiation Sensitivity of Pressure Vessel Steels and Welds."

He is also a member of the American Nuclear Society, American Society for Metals, Research Society of America, and the Washington Academy of Sciences.

Included in his honors are the Washington Academy of Sciences Award in Engineering Sciences, 1962; Research Society of America Award for Applied Science, 1964; and the American Nuclear Society Special Award for work in Neutron Damage of Materials.

Steele has authored more than 100 technical articles in his field.

OBITUARIES

Wade H. Marshall

Wade H. Marshall, 64, former National Institute of Mental Health scientist, died Nov. 4, 1972, at his home in Kensington, Md.

Dr. Marshall retired as chief of the Laboratory of Physiology in 1970 after serving with NIMH for 17 years.

He spent the major portion of his career investigating the functions and vital processes of the central nervous system.

Using electrophysiological methods, Dr. Marshall was the first to map the portion of the brain responsible for vision.

He earned his Ph.D. at the University

of Chicago in 1934 and later taught physiology at George Washington University Medical School.

Dr. Marshall then went to Johns Hopkins Medical School where he did research on brain function.

During World War II, he helped develop rocket propulsion fuels at Johns Hopkins Applied Physics Laboratory and worked with Bowen and Company on the development of a pilot assembly line for the proximity fuse.

Upon Dr. Marshall's retirement, he received an unusual honor from 40 colleagues who had been members of the laboratory he supervised.

Each contributed an original paper to *The International Journal of Neuroscience* which dedicated two issues to him.

Dr. Marshall is survived by his wife, Dr. Louise Marshall, a physiologist with the National Academy of Sciences; a son, Thomas, assistant professor of chemistry at Northern Illinois University; a daughter, Mrs. Percy Martin of Washington, D.C., and four grandchildren.

Walter D. Sutcliffe

Walter D. Sutcliffe, 80, of Forest Hill Road, Baltimore, died at Frederick Memorial Hospital. He was the husband of Edna Krum Sutcliffe and the son of the late John and Amanda Sutcliffe. He was born in West Park, New York.

He was graduated from Syracuse University in 1913 with a degree in civil engineering. He was a member of Tau Beta Pi and Sigma Beta fraternities.

He served as a hydrographic and geodetic engineer in the U.S. Coast and Geodetic Survey and worked in various parts of Alaska and the continental U.S. From 1917 to 1946 he was in charge of computation of first order base line and traverse work. Promoted to chief of the field records section he continued his work until retirement in 1954.

He served as a consultant engineer in his son's firm, D. K. Sutcliffe & Associates, Frederick. He was the author of four professional books. He was a member of the Washington Academy of Sciences, the Washington Society of Engineers, the American Congress on Surveying and Mapping, the American Museum of Natural History, the Society of American Military Engineers, the New York State Society of Washington, Philosophical Society of Washington, Syracuse University Alumni Association of Baltimore, and the Varsity Club of Syracuse University.

In 1953 he was awarded the U.S. Department of Commerce silver medal for meritorious service.

Mr. Sutcliffe was married in Poughkeepsie, N.Y., in 1915. He was a member of St. Mark's United Methodist Church, Baltimore, and served as a member of the administrative board. He also served as a troop committeeman and treasurer for the Boy Scouts.

Besides his wife, Mr. Sutcliffe is survived by one son, Draper K. Sutcliffe, Knoxville; two granddaughters, Sandra L. Sutcliffe and Susan A. Sutcliffe, Knoxville; one brother, Charles Sutcliffe, Poughkeepsie, N.Y.; one nephew and several cousins.

JOURNAL OF THE WASHINGTON ACADEMY OF SCIENCES

Instructions to Contributors

General

Type manuscripts on white bond paper either 8½ by 11 or 8 by 10½ inches. Double space all lines, including those in abstracts, tables, legends, quoted matter, acknowledgments, and references cited. Number pages consecutively. Place your name and complete address in the upper right hand corner of the title page.

Title, Author, and Affiliation

Page 1 of your manuscript should contain only this information and your name and address. Choose a concise but complete and meaningful title. In research papers concerning biological subjects, include an indication of the order and family of the taxa discussed. Academic degrees will not normally be included unless the author so specifies. If possible, combine your affiliation and mailing address (including Zip) so that readers can write to you directly.

Abstract

Type on a separate sheet at the end of the manuscript. Make the abstract intelligible without reference to the text of the paper. Write an informative digest of the significant content and conclusions, not a mere description. Generally, the abstract should not exceed 3% of the text.

Footnotes

Use footnotes as sparingly as possible. Number text footnotes consecutively with Arabic numerals and type them on a separate sheet of paper at the end of the manuscript. Type table footnotes, if any, below each pertinent table on the same page.

Illustrations and Legends

The quality of all original illustrations must be high enough to facilitate good offset reproduction. They should have ample margins and be drawn on heavy stock or fastened to stiff cardboard to prevent bending. They should be proportioned to column (1 x 3) or page (2 x 3) type-dimensions, leaving space for legend material. Photographs should have a glossy finish. They reproduce best when the contrast is fairly high. Identify each illustration with number and author in light pencil marks on the reverse side. Submit all illustrations separately – please do not glue or clip them to the pages of the manuscript.

Do not type or write legends directly on the illustrations. Type legends on a separate sheet or sheets at the end of the manuscript. Indicate where you want illustrations to appear in the printed paper by writing the figure numbers lightly in the text margins, and be sure that each figure is properly referenced in the text itself. Original "art" will be returned only at the author's request and expense.

Tables

Include tables only when the same information cannot be presented economically in the text, or when a table presents the data in a more meaningful way. Consider preparing extremely complicated tabular matter in a form suitable for direct reproduction as an illustration. In such cases, the use of the typewriter is not recommended.

References to Literature

Limit references within the text and in synonymies to author and year (and page if needed). In a "Reference Cited" section, list alphabetically by senior author only those papers you have included in the text. Likewise, be sure all the text references are listed. Type the "References Cited" section on a separate sheet after the last page of text. Abbreviations should follow the *USA Standard for Periodical Title Abbreviations*, Z39.5-1963.

Submission of Manuscripts

Send completed manuscripts and supporting material to the Academy office (see address inside front cover) in care of the Editor. Authors will be requested to read Xerox "proofs" and invited to submit reprint orders prior to publication.

Reprints – Prices for reprints may be obtained on request.

Washington Academy of Sciences
Room 29, 9650 Rockville Pike (Bethesda)
Washington, D.C. 20014
Return Requested with Form 3579

2nd Class Postage
Paid at
Washington, D.C.

Smithsonian Inst. J-WAS
Washington, D.C 20560

VOLUME 63
Number 2
JUNE, 1973

Journal of the WASHINGTON ACADEMY OF SCIENCES

Issued Quarterly
at Washington, D.C.

CONTENTS

Feature:

WILLIAM FITZHUGH: Environmental Approaches to the Prehistory of the North 39

Profile:

CLAUDE H. SCHMIDT and JOHN A. FLUNO: Brief History of Medical and Veterinary Entomology in the USDA 54

Research Reports:

LEE J. SHERVIS and R. D. SHENEFELT: A Bibliography on *Apanteles melanoscelus* (Ratzeburg), *A. porthetriae* Muesebeck and *A. ocneriae* Ivanov, Parasites of the Gypsy Moth, *Porthetria dispar* (L.) 61

PAUL M. MARSH: New Synonyms and New Combinations in North American Doryctinae (Hymenoptera; Braconidae) 69

ROBERT W. MATTHEWS and PAUL M. MARSH: *Notiospathius*, a New Neotropical Genus (Hymenoptera; Braconidae) ... 73

RICHARD E. WHITE: New North American *Euvrilletta* and *Xyletinus* With Keys to Species (Coleoptera; Anobiidae) 76

Academy Affairs:

Scientists Receive Academy's Annual Awards 82

Board of Managers Meeting Notes 85

Scientists in the News 87

Obituaries:

Nathan B. Eddy 88

Leo A. Wall 89

Letters 91

Washington Academy of Sciences

Founded in 1898

ACADEMY OFFICE

9650 Rockville Pike (Bethesda)
Washington, D.C. 20014
Telephone (301) 530-1402

The Journal

This journal, the official organ of the Washington Academy of Sciences, publishes historical articles, critical reviews, and scholarly scientific articles; proceedings of meetings of the Academy and its Board of Managers; and other items of interest to Academy members. The *Journal* appears four times a year (March, June, September, and December) – the September issue contains a directory of the Academy membership.

Subscription Rates

Members, fellows, and patrons in good standing receive the *Journal* without charge. Subscriptions are available on a calendar year basis only, payable in advance. Payment must be made in U.S. currency at the following rates:

U.S. and Canada	$10.00
Foreign	11.00
Single Copy Price	3.00

Back Issues

Obtainable from the Academy office (address at bottom of opposite column): **Proceedings:** Vols. 1-13 (1898-1910) **Index:** To Vols. 1-13 of the *Proceedings* and Vols. 1-40 of the *Journal* **Journal:** Back issues, volumes, and sets (Vols. 1-62, 1911-1972) and all current issues.

Claims for Missing Numbers

Claims will not be allowed if received more than 60 days after date of mailing plus time normally required for postal delivery and claim. No claims will be allowed because of failure to notify the Academy of a change in address.

Changes of Address

Address changes should be sent promptly to the Academy office. Such notification should show both old and new addresses and zip number.

Published quarterly in March, June, September, and December of each year by the Washington Academy of Sciences, 9650 Rockville Pike, Washington, D.C. Second class postage paid at Washington, D.C. and additional mailing offices.

DELEGATES TO THE WASHINGTON ACADEMY OF SCIENCES, REPRESENTING THE LOCAL AFFILIATED SOCIETIES

Philosophical Society of Washington	Bradley F. Bennett
Anthropological Society of Washington	Jean K. Boek
Biological Society of Washington	Delegate not appointed
Chemical Society of Washington	Alfred Weissler
Entomological Society of Washington	William E. Bickley
National Geographic Society	Alexander Wetmore
Geological Society of Washington	Charles Milton
Medical Society of the District of Columbia	Delegate not appointed
Columbia Historical Society	Paul H. Oehser
Botanical Society of Washington	Conrad B. Link
Society of American Foresters	Robert Callaham
Washington Society of Engineers	George Abraham
Institute of Electrical and Electronics Engineers	Leland D. Whitelock
American Society of Mechanical Engineers	William G. Allen
Helminthological Society of Washington	James H. Turner
American Society for Microbiology	Lewis Affronti
Society of American Military Engineers	H.P. Demuth
American Society of Civil Engineers	Carl H. Gaum
Society for Experimental Biology and Medicine	Carlton Treadwell
American Society for Metals	Glen W. Wensch
International Association for Dental Research	Norman H.C. Griffiths
American Institute of Aeronautics and Astronautics	Franklin Ross
American Meteorological Society	Delegate not appointed
Insecticide Society of Washington	H. Ivan Rainwater
Acoustical Society of America	Alfred Weissler
American Nuclear Society	Delegate not appointed
Institute of Food Technologists	William Sulzbacher
American Ceramic Society	J.J. Diamond
Electrochemical Society	Stanley D. James
Washington History of Science Club	Delegate not appointed
American Association of Physics Teachers	Bernard B. Watson
Optical Society of America	James B. Heaney
American Society of Plant Physiologists	Walter Shropshire
Washington Operations Research Council	John G. Honig
Instrument Society of America	Delegate not appointed
American Institute of Mining, Metallurgical and Petroleum Engineers	Delegate not appointed
National Capitol Astronomers	John A. Eisele
Mathematical Association of America	Daniel B. Lloyd
D.C. Institute of Chemists	Miloslav Recheigl, Jr.

Delegates continue in office until new selections are made by the respective societies.

Environmental Approaches to the Prehistory of the North

William Fitzhugh

Associate Curator of North American Archeology, Smithsonian Institution, Washington, D. C. 20560

ABSTRACT

Archeological research in the Arctic and Subarctic has expanded recently to include a wide variety of scientific disciplines including geology, ecology, and palynology. The use of these approaches is discussed in relation to an archeological project being conducted on the central Labrador coast where a 5500 year record of human occupation has been uncovered. This interesting approach to archeology has led to a better understanding of man's relationship to the North.

Serious anthropology in the Arctic began less than 100 years ago when Frans Boas made his historic visit to the Central Eskimo in 1883. Archeological investigations of Eskimo prehistory, however, did not begin until the pioneering research of Therkel Mathiassen as part of the Danish Fifth Thule expeditions in 1924. Mathiassen's work, and that of other archeologists following him, grew out of desire to link the living peoples of the Canadian and Greenland Arctic to old living sites and legends of an earlier race, called Tunnits. These sites were semisubterranean sod and earth houses with whalebone-supported roofs, and they were frequently associated with stone burial cairns. The numerous bone artifacts and debris found in these settlements indicated that unlike their descendants these earlier Eskimos were whale hunters, but otherwise they had an economy and material culture very similar to that of their ethnographic descendants. Excavation and interpretation of the early Eskimo culture, later known as Thule culture, could be accomplished by reference to the well-known historic Eskimo culture. Indeed, the archeologist's task was greatly simplified by his Eskimo digging companions, who were frequently able to name and identify the function of excavated tools—not, however, without frequent aspersion to the parochialism and backward styles of their forebears.

This ethnographic approach to Eskimo archeology persisted as the only recognized system of interpretation until a different form of prehistoric culture was discovered which preceded Thule culture and whose remains consisted mainly of minute flaked stone implements of an Old World mesolithic character. The contrast between Dorset and Thule culture

[1]From a talk presented at the March, 1973 meeting of the *Academy* in Washington, D. C.

was marked. Dorset people did not hunt whales; nor did they appear to use dog traction, covered earth houses or cairn burial. Their sites were on open, exposed locations, and the forms of their harpoons and lances were quite distinct from Thule implements. In fact, the archeologist's Eskimo companions were as puzzled as he was about the nature of this strange new mini-culture. Eskimo working with archeologist Louis Giddings in Alaska decided that the Dorset people and their Denbigh predecessors must have been a race of midgets, so small and seemingly ineffectual were their precisely flaked stone implements. Yet their face masks and skeletalized art work grippingly portrayed a psyche and world view riddled with powerful, mysterious demons and malignant spirits.

Not long after the discovery of Dorset culture archeologists uncovered the traces of a still earlier people of the Eastern Arctic. Prosaically dubbed "Pre-Dorset," this culture was clearly descended from an earlier microlithic culture in Alaska and appeared to represent the earliest Eskimo occupation of the Eastern Arctic. Their arrival in the east about 4000 years ago was equally dramatic as the later migration of Thule culture, for within a few centuries they had spread from Alaska east to northern Greenland and Labrador. While Pre-Dorset people were well adapted to the full range of arctic conditions, their economy was based on a greater degree of land hunting of caribou and muskox than were the later Eskimo cultures. In general their culture was similar to that of the Dorset people, into which Pre-Dorset evolved around 1000 B.C. without major new influence from the Western Arctic or the Canadian forests to the south. These 2 early cultures compose a single historical continuum known as the Paleo-Eskimo tradition beginning as early as 2200 B.C. and persisting until the arrival of the Thule migrants with their dogsleds and whaling harpoons around A.D. 1000. Thereafter, Dorset culture disappears with the exception of possible acculturated enclaves in Southampton Island and Hudson Strait.

The historical events and environmental conditions surrounding this cultural trilogy in the Eastern Arctic poses a great number of questions of interest to northern archaeologists. In fact, the uniqueness of cultural adaptations in the Arctic zone creates topics of general theoretical interest for anthropologists throughout the world. The focal point of the problem is, of course, the same one that has always stimulated interest in Eskimo culture, beginning with Frobisher's encounter with Baffin Island Eskimos in 1577 and which reached such a near fever-pitch following 19th century Arctic explorations of Franklin, Kane, Hall, Greeley and others—namely, what motivated man to inhabit this climatically fierce region and how did he sustain life in the face of this hardship? For the archeologist, the query went into more detail, however. The list of questions includes: What were the effects of climatic cooling and warming on northern terrestrial and marine mammals? Do population declines occur periodically which might affect human subsistence? What are the structural differences between the northern land and sea ecosystems which influence human adaptations? These more theoretical questions were followed by a host of specific problems, involving the origins of Pre-Dorset, Dorset, and Thule cultures, their distributions and variability.

Answers to these questions were not forthcoming from studies of Eskimo ethnography and mythology, which had supplied extensive detail for early reconstruction of Thule culture. The discovery of a 3000-year Paleo-Eskimo tradition was a radical new development in Eastern Arctic prehistory which required a totally new approach to archeological interpretation. Partly in response to this challenge a new type of research is being conducted in the Eastern Arctic. As a result of the more impoverished physical remains of the Paleo-Eskimo sites this work draws much of its support from techniques of the natural sciences including biology, animal behavior, oceanography, meteorology, and geology.

While not dismissing the importance of Eskimo ethnography, the new strategy emphasizes a conjunctive approach in which culture and environment are studied as interrelated variables on the assumption that human populations exist within a geographic and environmental system and that changes in the system are reflected in various aspects of a culture's adaptation. In a harsh environment, such as the Arctic, the physical restraint on cultural expression is relatively strong. The very nature of human groups, however, requires the consideration of cultural tradition and history into this scheme. A simple deterministic approach to environmental control of culture cannot be maintained. Thus the task of the archeologist is to determine the weighting of various environmental and historical factors in the explanation and cultural reconstruction of prehistory. It is this dualism between biophysical conditions and socio-cultural expression that makes the search for the reality of prehistory so elusive to archeologists. Therefore, for the purposes of this paper it will be expedient to consider only those aspects of northern prehistory in which the role of natural science is paramount. We proceed with the discussion of 6 major types of analysis which can be used to elucidate environmental relationships of some of the early Eskimo and Indian occupants of the Arctic and Subarctic.

Geological Analysis

Much of the information available to the archeologist comes through investigation of the physical environment. In order to reconstruct the prehistoric landscape of 500, 2000, or 4000 years ago, one must understand the physical and biological processes that have modified the land. In the north 2 factors—climatic change and post-glacial geographic modification—have been primarily responsible for these changes.

During the last glaciation it is estimated that an ice sheet approximately 1 mile thick developed on the Canadian Shield and the Labrador-Quebec plateau. The tremendous weight of this ice resulted in plastic deformation of the earth's crust. Following deglaciation the land "floated" back to its original position, and the highest maine terraces and lowest limit of glacial erratic boulders give some indication of the extent of glacial depression. Northeastern Hudson Bay was depressed between 500–800 ft, while in Central Labrador it varied from 600 ft on the interior to 250 ft on the coast. Farther south, in the Gulf of St. Lawrence and Upper Great Lakes, the greater thickness of ice buildup is registered by upper marine limits of nearly 1000 ft.

In areas of sandy deposits, relic beach lines and terraces provide a relative chronology of post-glacial uplift from the highest formations to the lowest, contemporary ones. By radiocarbon dating fossil shells, peat, or driftwood contained in these beachlines, it is possible to construct an absolute isostatic curve for the post-glacial period. In all areas where this has been done the curve is found to be generally logarithimic, with an initial rapid period of adjustment of up to 25–40 ft per century in the first few millenia after deglaciation and thereafter slowing to a current rate of less than 1 ft per century. Even today uplift is perceptible to Labrador fishermen who remark on the shoaling of harbors which no longer accommodate their boats as they did a generation or two earlier.

Along the sea coast uplift can be useful to the archeologist in several ways. Most immediately, the sequence of beachlines provides a relative timescale for the chronological ordering of prehistoric settlements found associated with active beaches in the past. Older sites must be confined to the upper beaches and terraces while younger sites are generally found along the more recent formations. Since most cultures occupying the maritime regions of the Subarctic and

Arctic were active seafarers, relative elevations have proven to be valuable chronological indicators, and detailed chronologies have been developed for the uplifted Arctic regions of Baltic and North Norway, Greenland, and the Eastern and Central Arctic. Unfortunately, coastal submergence has occurred in the Northern Hemisphere in the regions immediately adjacent to uplifted zones, such as in Alaska, New England, and northern Europe. This makes it difficult to relate sites on the northern beaches to contemporary cultural and chronological developments in southern coastal zones where several thousand years of prehistory lie submerged.

In the Eastern Arctic the most complete cultural sequence so far developed comes from the Igloolik area of northern Fox Basin. Here, Jorgen Meldgaard of the National Museum of Denmark has identified a series of Eskimo cultures beginning with Pre-Dorset settlers of about 2000 B.C. located on the upper beachlines. Later sites are found on successively lower beach levels, documenting the transition into Dorset culture along the 800 B.C. beaches and continuing through the arrival of Thule cultures and subsequent developments down to the present day. Since Igloolik is an area of relatively slight vertical relief, these sequential settlements are horizontally separated from each other and there is relatively little contamination of earlier settlements by those immediately following. As a result, Meldgaard feels confident in studying the evolution of tool types from house to house and believes that it is occasionally possible to identify stylistic developments within single generations, a substantial improvement over the precision of radiocarbon dating! Unfortunately, the lack of preservation of the stylistically most sensitive bone tools do not allow this approach to be applied with equal success in many other areas of the North. Other areas where geological dating has facilitated relative archeological dating include the Cape Krusenstern sequence developed by Louis Giddings in Alaska and the Hamilton Inlet chronology developed by the author for the central coast of Labrador.

Precise control of uplift information is not often available for an area in which an archeologist is working. This was the case in Hamilton Inlet when archeological work began in 1968. Therefore a major part of the continuing archeological program in this area has involved collecting geological data pertinent to archeological problems. The elevation of raised terraces and beachlines was recorded, and datable samples, such as marine shells and bones from stranded whales found associated with these fossil shorelines, were submitted for radiometric dating.

This research has resulted in 2 preliminary uplift curves (fig. 1) for the Hamilton Inlet region. Normally 1 curve would adequately describe uplift conditions for a given region. However, in Hamilton Inlet the maximum limit of marine submergence in western Lake Melville was found to be nearly 500 ft while on the outer coast the marine limit is only 250 ft. The difference appears to be a result of greater ice build-up toward the center of ice dispersal in the Labrador-Quebec interior, while the ice sheet remained thinner at the coast due to the moderating influence of the ocean. An inspection of the 2 curves reveals a dramatic difference betwee western Lake Melville and the outer coast 150 miles to the east. Terraces on the outer coast at 40–55-ft elevation were available for cultural occupation by 5500 years ago, while elevations with comparable dates in North West River now lie over 100 ft above sea level. Therefore, there is greater potential for vertical separation of archeological sites belonging to different cultural periods on the interior.

One of the most intriguing aspects of the geological investigation of Hamilton Inlet results from the reported existence of a few fossil whale skeletons north of Groswater Bay and near Cape Harrison where they are claimed to lie at elevations nearly 1000 ft above sea level. If the elevation of these whale fossils is correct they are far above the most recent postglacial marine limit, and they pose

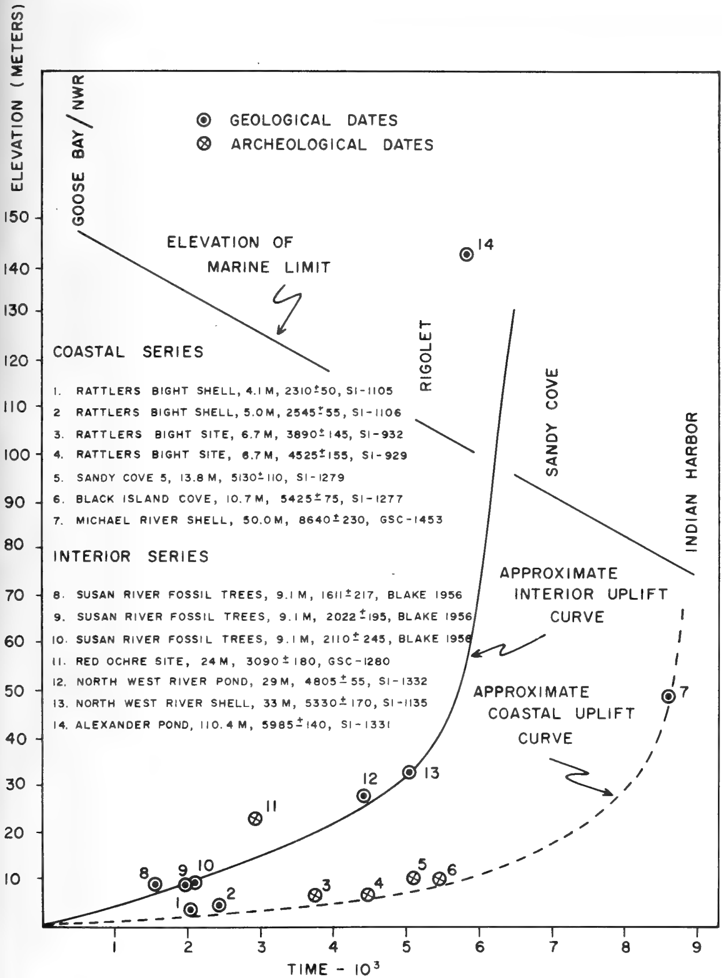


Fig. 1.—Uplift curves for the Hamilton Inlet region of Labrador. Two curves are presented: one (solid curve) for the interior Goose Bay region in western Lake Melville and another (dashed line) for the outer coastal zone. The maximum elevation of the marine limit is indicated at the top.

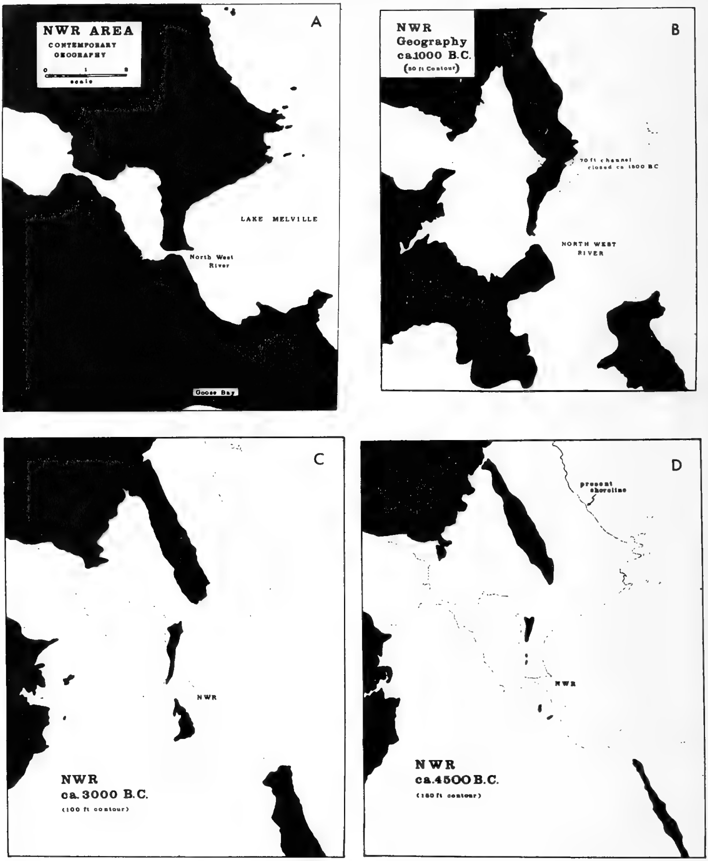


Fig. 2.—Geographic changes in the North West River region, western Lake Melville, during the past 6500 years. The most important changes in terms of human occupation took place about 3500 years ago when uplift closed the island passes along the North West River moraine and created the present exit of the Naskapi River at North West River.

a unique challenge to geological interpretation. At present our understanding of Pleistocene events in Labrador does not permit glaciation of the extent that could result in land submergence on the order of 1000 ft. Additionally, current evidence indicates that all but possibly the highest mountains of norther Labrador have been completely overridden by the ice sheet in the past glaciation. The presence of stranded whales at the reported elevation would thus require substantial revision of current geological thought, including the existence of formerly more extensive glaciation and the occurrence of nunataks (ice-free summits) during the most recent glacial maxima. Nunataks have been suggested as possibilities for the 4–5000-ft-high Torngat peaks of northern Labrador. To find them at 1000-ft elevations in central Labrador would be unique indeed.

Paleo-Geography

The uplift curve is important to the archeologist for more than relative dating of prehistoric sites. It is an important tool in paleo-geographic studies and interpretation of settlement pattern shifts through time. We have noted that landforms have changed far more significantly on the interior than they have on the coast during the early period of human occupancy of central Labrador about 4000 B.C. At this time uplift in the North West River area may have been as great as 5–10 ft per century, enough to change landforms significantly during a man's lifetime. As new land merged, old living sites were abandoned and settlements shifted to new sites with more favorable circumstances. No sites have been found dating to this period in North West River because it was at that time a small offshore island in a large marine estuary (fig. 2a). We may assume that these sites are present in the Naskapi River Valley at elevations above 150 ft. By 1500 B.C. the land had emerged enough to bring the North West River recessional moraine out of the sea near the 70-ft topographic contour (fig. 2b). At this time there were 2 exits for the Naskapi River into Lake Melville, one via the present channel and a second a few miles to the north. As uplift continued the northern channel closed (fig. 2c) and human movement between the coast and the interior for the next 3500 years became channeled through the present debauchment (fig. 2d).

Archeological data follows this geological reconstruction very closely (fig. 3). No sites have been found at North West River above the 78-ft beaches when it was an island. However, initial occupation began shortly after 1500 B.C. on the 60–70-ft terraces. As the land continued to rise the river cut down through the morainal sands, producing successively lower terraces for occupation by later Indian cultures. This process has enabled a detailed chronological sequence of cultures to be constructed for the area—this has been substantiated independently by typological and radiocarbon dating. Although the uplift on the outer coast is less and does not provide such precise vertical zonation, it is possible to use the same techniques of relative archaeological dating and geographic analysis in these areas. Here, however, there were no large rivers to provide reworked sand deposits for persistent settlement at a single locale through time. Rather, uplift changes resulted in extensive lateral displacement of archeological sites to new harbors and marine terraces as they emerged from the sea and became more desirable than those harbors with perched terraces and rock-strewn entrances.

Physical Analysis

Another type of analysis which has proven useful in archeological interpretation in central Labrador involves mineralogical and petrographic identification of lithic raw materials used in the stone tool industry of the early Indians and Eskimos. The Canadian Shield, which is the basic geological province encompassing much of northeastern Canada, is composed of granites and gneisses and other igneous and metamorphosed rocks of great age. Lacking sedimentary deposits, it is an area devoid of cherty rocks with concoidal fracture which were of main importance to man.

Central Labrador does have some remnant metamorphosed sedimentary and igneous beds which contain useful material, but the outcrops are small and localized in nature and are extremely variable in color, texture, and other prop-

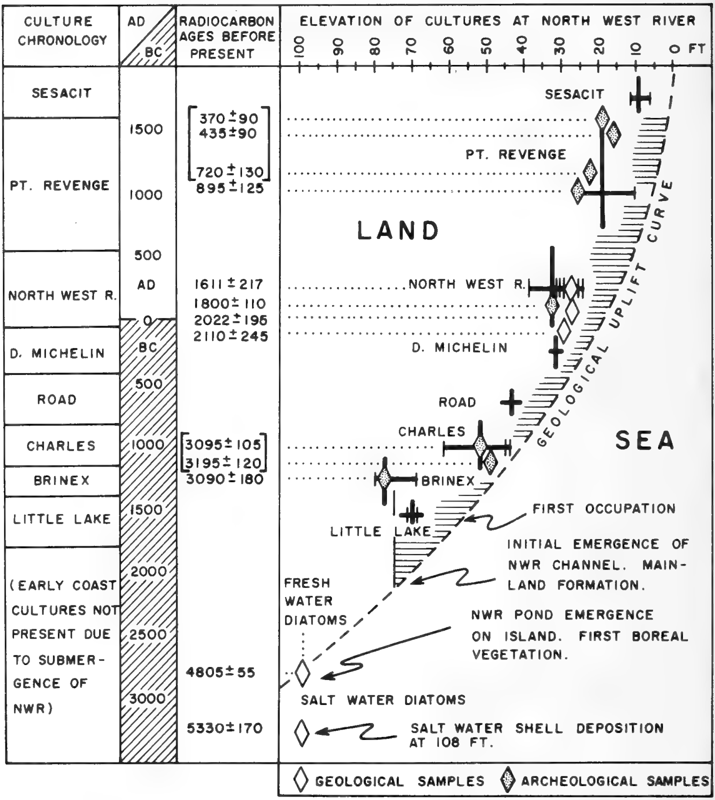


Fig. 3.—Archeological sequence at North Wester River, Labrador. This sequence represents the last 3000 years of a longer 5500-year culture history which has been defined for Hamilton Inlet. The cultural chronology at North West River clearly reflects the relationship between prehistoric sites, their elevation above sea level, and radiocarbon dates. Geological information includes fossil sea shells and salt water diatoms found in 5000-year-old uplifted sediments at approximately 100-foot elevations. More recent samples of fossil trees in the 2000-year range may indicate either fresh or salt water deposition.

erties. No single source was of domiant importance such that all prehistoric peoples used it; rather each culture seems to have found and utilized different quarries. Their choice of raw materials thus indicates a cultural preference which is replicated repeatedly in different sites belonging to a particular culture group. For instance, one group may consistently choose to use a commonly available material such as quartzite, available in the glacial and beach deposits, while a subsequent group preferred a high quality chert of a diagnostic type. A third might

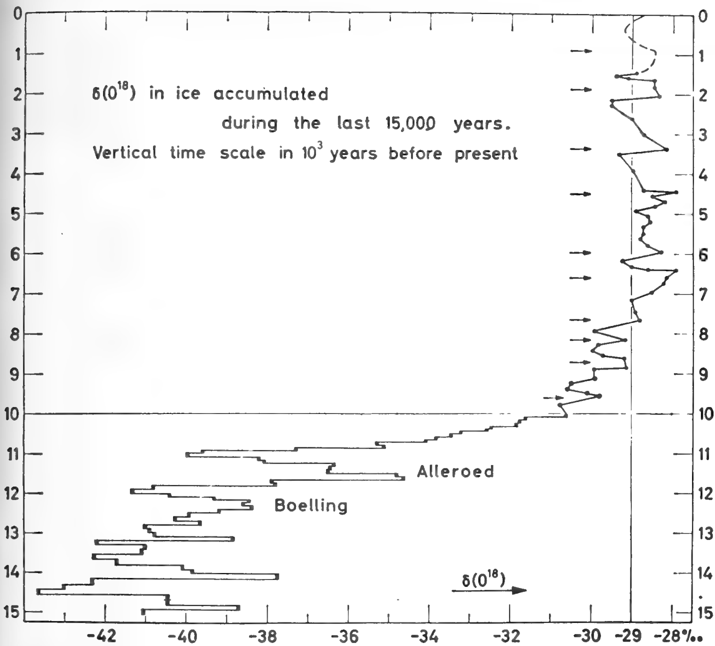


Fig. 4.—Climatic variations in the Camp Century, Greenland, ice core over the past 15,000 years, reflected by oxygen isotope variations. The data points in the upper part of the curve represent time periods of from 25 to 50 years. The step curve in the lower portion represents a continuous sequence of measured samples, each extending over approximately 100 years. (After Dansgaard, *et al.* 1969, *Science* 199(3903): fig. 4).

choose an exotic material available only from distant sources and for which extensive travel or trade must have occurred. In this way, not only are individual cultures characterized by a certain raw material complex, but the geographic origins of these materials, if they can be precisely defined, gives an indication of the extent of movement or external contacts of a particular group. For this reason archeologists in the North and elsewhere have recently become interested in vigorous scientific methods of identifying raw materials found in archeological sites.

One of the raw materials which was of special importance for interpreting cultural movements is a distinctive translucent, granular stone commonly found in coastal archeological sites and rarely found on the interior. This material, known as Ramah chert, has a geological origin in northern Labrador where it outcrops as a thin band in a sedimentary series far north of the treeline on the northern coast of Labrador, 350 mi from Hamilton Inlet.

The presence of Ramah chert in archeological sites in central Labrador and further south indicates a remarkably long-distance trade network which seems to have been most extensive in the Maritime Archaic period about 2000 B.C., a time in which points of this material were traded south as far as southern New England. That such a trade net existed along the coast but did not penetrate the interior implies a maritime orientation with good navigational capabilities, extensive contact, and cultural and probably linguistic homogeneity between the participating cultures from northern Labrador to southern Maine. The use of Ramah chert in central Labrador and its southern dispersion ceases abruptly after 1800 B.C., coincident with the disappearance of Maritime Archaic culture from the central coast of Labrador and the appearance of Pre-Dorset Eskimos in northern Labrador in the vicinity of the Ramah chert beds. Here we have an example of the importance of raw material distributions as an indicator of shifts in cultural geography. Following this early period Ramah chert is not extensively used until Indian cultures again develop a coastal adaptation following until the appearance of the Point Revenge complex begins about 500 A.D. During the intervening period Indian cultures rarely utilized the coast except for brief summer sojourns, and their activities apparently did not extend north to the Ramah beds. This is documented by the lack of coastal raw materials in their tool inventories and the absence of coastal settlements.

This type of interpretation from lithic materials can be made only if it is possible to develop exact methods of identifying lithic material from an archeological site and its purported geological parent. This has proved difficult owing to variability within rocks from one geological source location. However, a number of techniques, including X-ray diffraction and flourescence, neutron activation, electron microprobe, and various mineralogical and petrographic methods, have been used with results which range from excellent to poor, depending on the characteristics of the material and the state of the science. Research in this area is still in a developmental stage, but promising results have been obtained from neutron activation of obsidians and cherts. The best results have come from metallurgical analyses of Near Eastern metal ore bodies. In some cases, however, it appears that simple petrographic and visual studies are sufficient for accurately identifying the more distinctive materials. These techniques have proven as successful for identifying Ramah chert as preliminary neutron activation.

Environmental Models

The best source of data for reconstructing past environments often comes from archeological deposits where any material reflects human agency and cultural activities. Unfortunately, subarctic archeological sites are habitually devoid of preserved organic material of any sort due to the acidic soils of the Canadian Shield and the lack of extensive terrestrial deposits. Under these limitations the archeologist is forced to adopt a game plan which relies on secondary information sources. Using the ethnographic analogy of recent Indian and Eskimo activities and the local setting of a site, it is generally possible to determine the main purpose of a camp. One can be fairly certain that river mouth sites were fishing camps; inland camps were more likely caribou hunting stations; and sites found on exposed regions of the coast were probably seal and sea bird hunting camps. Combining this information with contemporary animal distribution one can develop a model which can be projected into the past with some assurance, providing major environmental changes have not occurred. However, even with environmental and climatic change this technique of "using the present as a key to the past" provides an archeologist with workable environmental models and hypotheses. For, if he knows the factors governing present animal distributions and the effects of climatic change on the environment, he can reasonably accurately predict the probable effects of environmental shifts on these species. Correlations can then be developed with cultural distributions to see if their shifts through time correspond with these in the natural environment.

Two examples demonstrate the use of environmental modeling in archeological research in Labrador and Hudson Bay. One of the major problems is the variability in the Indian adaptations from the central Labrador region. Here, initial Indian occupation began with the Maritime Archaic tradition with a strong coastal orientation between 5500–3800 years ago. Following this long period of cultural stability came 2000 years of cultural instability in which a number of different cultures occupied both the interior and coast, succeeding each other at approximately 500-year intervals. There is no evidence of in-place development of these groups, and they are interpreted as new introductions of people and ideas from the south. After 500 A.D. the Point Revenge culture appeared and continued to develop until historic times with a strong maritime orientation. The record thus indicated a long initial period of cultural stability within a maritime adaptation followed by a several-thousand-year period of cultural instability and replacement with only limited coastal adaptation. The last culture period is again one of stability with a maritime adaptation.

The description of culture history such as this is only the beginning of archeological interpretation. The immediate question that arose from this sequence involved an explanation of the various periods of continuity and discontinuity in the record. Was this the result of idoiosyncratic cultural events or of more general effects of environmental variables? To determine this an investigation of present day ecology of both marine and terrestrial environments was undertaken with specific reference to mammals of importance to man and the factors that govern their distribution and population structure.

Structural Ecology

The northern terrestrial environment is a relatively species-poor ecosystem characterized by a simple food chain and trophic structure. It is an unstable system subject to periodic and strong perturbation by fire and winter icing, both of which may precipitate population declines of man's basic resource, the caribou. Since caribou are herbivores adapted to lichen grazing in the boreal forest and tundra, any alteration of the lichen fields either by fire or winter glaze storms can result in population crashes or migration shifts. If these drops occur during a time when human populations are near carrying capacity, starvation is likely to occur. Ethnographic documentation provides abundant support to this cycle of events in northern Labrador and Quebec.

In terms of climatic variation, it appears that forest fires produced largely by lightning are more prevalent during warm, dry summers, while cool, damp summers have a lower pyrotechnic index. Correspondingly, cold dry winters do not present the severe icing conditions that cause caribou starvation if occasionally rainstorms strike the winter feeding grounds. Speaking only in terms of fire and icing (excluding predation), one would expect caribou herds to increase in cool climatic periods and to fall in warm periods. In fact, historical information on herd sizes gives some support to this model with caribou peaks in the cool periods around 1900 and 1960–70 and with lows in the warm period between 1915–1955. Data on caribou herds in the Central Barren Grounds and Alaska suggest similar systematic correlations.

Marine ecosystems are not subject to the same inherent instability of northern terrestrial ecosystems. The marine environment is species-rich and most animals have a broad food base. Food chains are complex and population oscillations are not great. Here, sea ice is the primary ecological determinant, and its distribution and nature affect not only the abundance of marine mammals such as seals, walrus, and whales, but more importantly, their availability to man. In particular, stormy weather may be a significant factor in the ability of a hunter to reach the game. In the marine ecosystem faunal shifts appear to occur more gradually, with less population oscillation than is characteristic for northern land mammals, and geographic shifts due to shifting climate and ice conditions are both gradual and directional. This enables the marine-oriented hunter to better predict the availability of game than is possible on the interior. Thus, cooling climates result in southern movement of arctic marine mammals down the Labrador coast coincident with a retreat of the northern forest limit. Warming conditions reverse this situation.

In short, we have presented an environmental model in which interior cultures have a potentiality for instability and periodic extinction, which is not a dominant structural component of maritime adapted cultures. Furthermore, there is a strong possibility that interior adaptations are more unstable in warm climate periods than in cool periods. However, during warm periods the coast offers a relatively diverse and stable resource base at a time when the forest limit is likely to extend further north providing shelter and firewood for Indian cultures.

Climatic and Vegetation History

It remains, then, to determine climatic events in relation to the culture history developed for Hamilton Inlet. Fig. 4 presents an oxygen isotope analysis of an ice core taken from Camp Century, Greenland. The results show a remarkably precise temperature determination for the past 15,000 years and are in agreement with temperature data based on medieval historical records and North European pollen studies. It will be seen that the peak temperature periods fall during the times of strongest cultural continuity for Indian coastal adaptations in central Labrador. Furthermore, the cold spells at 1800 B.C., 500 B.C., and 1500 A.D. correspond to southern movements of Eskimos in Labrador. These are times when one might expect southern forest shifts and Indian retreats from the coastal zones.

Similar results are seen in the analysis of pollen cores taken from the Hamilton Inlet region as part of the Smithsonian Institution's Hamilton Inlet Project. The core from Alexander Lake, near Goose Bay (fig. 5), contains a 6000-year record of post-glacial vegetation changes beginning with deglaciation around 6500 B.P. Tundra vegetation, represented by high birch, alder, willow, grass, and sedge, becomes established by 6000 B.P. and lasts until the dramatic influx of the spruce forest about 4500 B.P. Thereafter the forest composition does not register climatic events because the sample location is well within the main boreal forest limits. Charcoal counts indicate that fires have been an important part of both the tundra and boreal periods, with a major fire horizon in the tundra zone about 5500 B.P. and subsequent peak fire periods in the peak boreal period, ca. 5000–4000 B.P., followed by a drop and then gradual increase during the past 1500 years. A second pollen core (fig. 6) from Sandy Cove Pond, located on the forest-tundra boundary in outer Hamilton Inlet, is more sensitive to climatic events. It has a profile showing an initial and very brief period of tundra beginning about 5000 B.P. followed by spruce forest invasion ca. 4500 B.P. Here, however, at the forest edge, the spruce record shows considerable variation suggesting a forest maximum between 4500–3500 B.P. and declines between ca. 3500 and ca. 2000 B.P. with an intermediate cool period. The charcoal frequency reinforces the spruce curves by indicating fire peaks corresponding to the spruce maxima. Finally, the initial date of revegetation at ca. 5000 B.P. is remarkably late in this coastal core and suggests that final deglaciation of this region was far later than previously thought.

The pollen data from Hamilton Inlet provide important correlations between the cultural sequence of Indian and Eskimo settlement and adaptation types and the environmental models for caribou

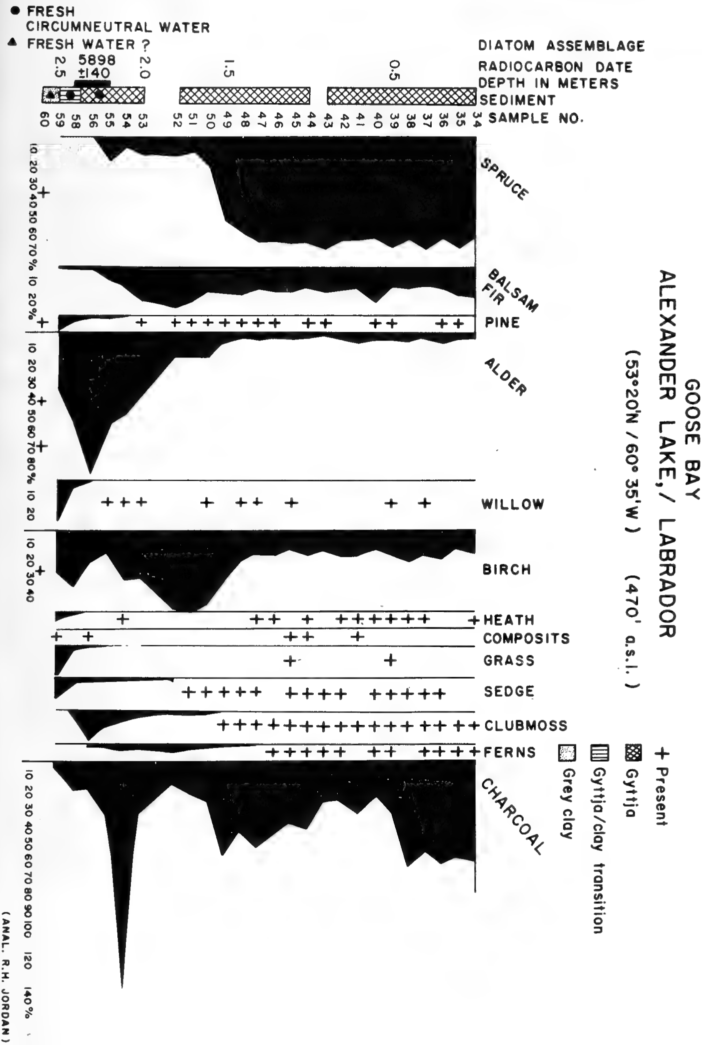


Fig. 5.—Pollen diagram from Alexander Lake, Goose Bay, Labrador, calculated as percentages of total arboreal pollen.

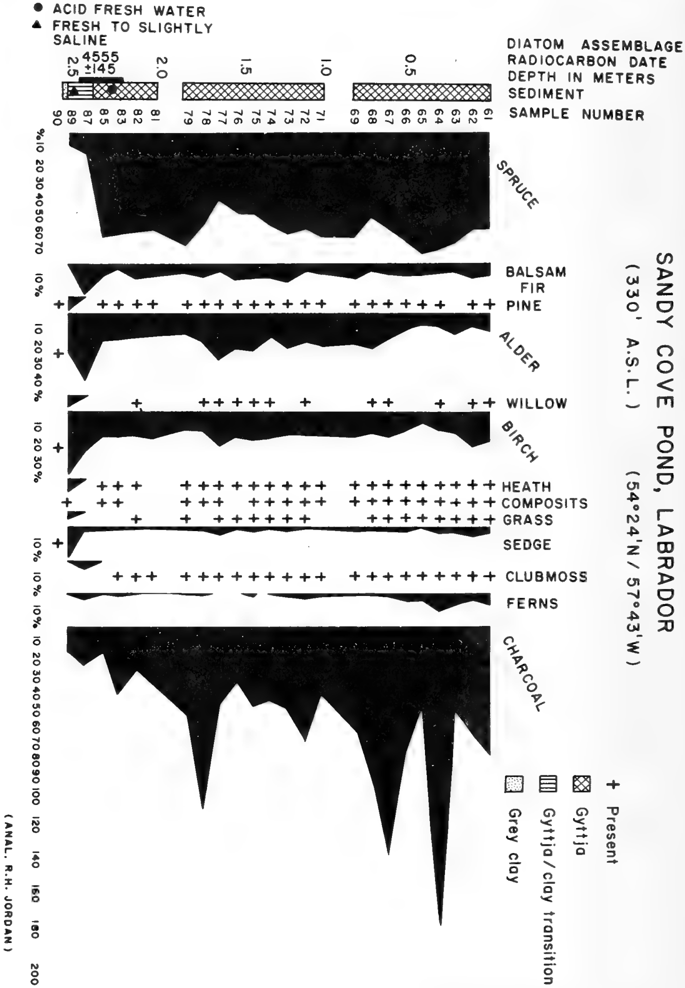


Fig. 6.—Pollen diagram from Sandy Cove Pond, Groswater Bay, Labrador, 160 mi east of Goose Bay.

ecology. First, it will be noted that ice blocked the occupation of the central Labrador interior until nearly 6000 B.P. and perhaps persisted in the coastal regions until the end of the hypsithermal at 4500 B.P. The first known occupation of this region was by Indians who arrived about the same time as the introduction of the boreal forest and spread north with the forest to its northern limit in northern Labrador. The important maritime focus of this early culture may result partially from its being a more stable adaptation during this peak period of forest fire (and inferentially, winter icing) activity, which declines during the cooler period following 3800 B.P. The intermediate period between 3800–1500 B.P. is cooler, and the forest seems to have retreated somewhat from the outher coast. Perhaps this, as well as improved hunting coditions on the interior, resulted in the limited use of the coast by Indians during this period. The appearance of Dorset Eskimo culture from northern Labrador between 2700–2300 B.P. was another important factor. Following the disappearance of Dorset culture and climatic warming beginning around 1500 B.P. Indians of the Point Revenge complex recolonized the coast and moved into northern Labrador with the northern forest expansion of the Climatic Optimum. It is at this time that Ramah chert again appears in the tool industry as it did in the northern expansion of Maritime Archaic around 4500 B.P. A final cooling period around 400 years ago coincident with the impetus for European trade, resulted in the southern expansion of Labrador Eskimo into central Labrador. This movement displaced the protohistoric Indian peoples into the interior, where they still exist today, deprived of their traditional summer coastal hunting and fishing grounds.

It would thus appear that cultural movements in central Labrador have resulted from a combination of environmental and historical conditions. There has been a strong tendency for interior Indian cultures throughout prehistory to adopt summer coastal adaptations. During warm periods these adaptations intensified and spread to the north, perhaps at the expense of Eskimo cultures. Any cooling period, however, especially if it resulted in retreat of the forest from the coast, has caused Indians to decrease use of the coast and to concentrate on interior hunting. That interior caribou hunting was insufficient for long-term cultural stability is suggested by the discontinuity of interior cultures of these cool periods. These are times when Eskimo cultures often moved south, introducing cultural and historical factors into the already complex relationships governing culture distributions and developments.

Conclusion

The foregoing discussion has presented a few of the more important scientific approaches to northern archeology. These techniques are by no means restricted to the study of arctic and subarctic archeology but have wide applicability in other areas. Archeologists are increasingly turning to these methods for information to increase the understanding of culture history and especially to investigate possible causes of culture change. In this process many other techniques are being used as well. Satellite photography is available today which permits extremely detailed environmental analyses, and in the Arctic where ice conditions are important in the distribution of animals and man they are proving extremely valuable sources of information. The development of new scientific techniques and the advancing ability of the archeologist to properly interpret the results of these analyses will continue to be a well-spring of future research in prehistory. In the future, archeology will only prosper through an increasingly integrated position between the social and natural sciences, one which mediates between the extremes of nihilistic historical particularism and mechanistic environmental causation.

PROFILE

Brief History of Medical and Veterinary Entomology in the USDA

Claude H. Schmidt and John A. Fluno[1]

North Central Region, Agricultural Research Service, USDA, Fargo, North Dakota 58102.

ABSTRACT

A chronological list of developments in medical and veterinary entomology in the last 120 years includes some of the many contributions made by U. S. Department of Agriculture entomologists and chemists that were associated with the Insects Affecting Man and Animals Research Branch.

This chronology had its genesis in 1969 when the junior author, then Assistant to the Chief of Insects Affecting Man and Animals Research Branch, visited several of the larger field laboratories. He found, to his dismay, that many of the newer employees did not have background information on what scientists in the Branch had accomplished, and he was asked numerous questions. To remedy this situation, we prepared a rough draft of some of the highlights which we thought would be interesting and informative. The manuscript was never completed because of more pressing matters. The next thing we knew the junior author was retiring and the Agricultural Research Service (ARS) was being reorganized. So it was high time to resurrect the old draft and bring it up to date.

Perhaps a few words about ARS and its past and present organization will help the reader put things in perspective. From 1953 to 1972, ARS organized and managed its research program through various Divisions and Branches. During this 19-year period, ARS grew from less than 4,000 to over 10,000 employees. It is therefore not surprising that such a tremendous growth resulted in a need to restructure the organization of ARS. Thus, as of July 1972, ARS underwent a reorganization—or more to the point, a regionalization. Divisions and Branches within ARS were replaced by Regional and Area Headquarters. For example, the senior author served for 5 years as the Chief of the Insects Affecting Man and Animals Research Branch of the Entomology Research Division and is now Area Director for ARS research for the Dakotas and Alaska. Obviously these organizational changes affect the management of research, but ARS scientists at the laboratory level continue to work on the same types of research they undertook before reorganization. Thus, those scientists who were part of

[1]Retired June 1972; present address Winter Park, Florida.

the Insects Affecting Man and Animals Research Branch continue their research under the direction of Area and Regional Headquarters.

For those scientists who belonged to the Insects Affecting Man and Animals Research Branch and the many other scientists who made or contributed to accomplishments in the field of medical and veterinary entomology, we have assembled a brief chronological history of important entomological events that occurred shortly before and during the period when Federal scientists working in these fields were part of a more or less formal organization. Of course, not all the developments listed were the exclusive discoveries of scientists of the Insects Affecting Man and Animals Research Branch, but Branch scientists played an important role, either directly or in cooperation with other scientists, in many of the events listed. Indeed, close cooperation and friendly competition among Federal and State agencies has been the order of the century.

When you look over our compendium, you will agree that the Branch was in existence during a dynamic period in medical and veterinary entomology. Moreover, ARS can be justly proud of the many contributions made by its entomologists and other scientists. These investigators have left an enviable record, and the authors feel that under the new system the research effort in this important field will be continued and even intensified. There are still many perplexing problems that need to be solved, and they will require all of our ingenuity, dedication, and cooperative effort. In the new ARS, there are mechanisms for faster decision-making at the local level to meet local problems. In addition, thanks to the National Program Staff at Beltsville, there is increased coordination at the national level between the different disciplines.

List of Events—Medical and Veterinary Entomology

1855–58	Pyrethrum first used in the United States. (Before creation of USDA in 1862.)
1862–66	During the Civil War, there were 1,585,196 cases of diarrhea and dysentery resulting in 37,794 deaths.
1881	Wire window and door screening first began to be used in U. S.
1887	Horn fly first noted in United States, near Philadelphia.
1892	L. O. Howard obtained first practical use of kerosene as mosquito larvicide.
	Role of cattle tick in transmission of Texas cattle fever discovered (Smith and Kilbourne).
1896	First recommendation to public for control of insects, ticks, and mites affecting livestock.
1897	Horn fly had spread over entire U. S., east of Rocky Mountains, to California, and Hawaii.
	Oil of citronella used as an insect repellent.
1898	House fly proved to be carrier of typhoid fever.
	Transmission of malaria by *Anopheles* mosquitoes proved (Italy).
1900	Plague discovered in U. S. (San Francisco).
	Mosquito-yellow fever relationship proved.

1901 "Swat the Fly" campaign began.

1898–1902 During the Spanish-American War, 185,056 cases and 1,500 deaths from diarrhea and dysentery. Disease caused 80% of all war deaths; as many as 600 malaria cases per 1,000 men.

1902 Mosquitoes discovered to be vectors of dengue.

1906 Ticks proved to be vectors of Rocky Mountain spotted fever. Arsenic dips developed for tick control on livestock; fever tick eradication program began; quarantine covered about 750,000 square miles.

1909 Typhus shown to be transmitted by human body lice.

Tularemia discovered in California.

First record we can find of Insects Affecting Man and Animals research. Title: "Investigations of Insects in Their Direct Relation to the Health of Man and Domestic Animals." This was the work of W. D. Hunter and F. C. Bishopp (under the direction of L. O. Howard, Chief of Bureau of Entomology) on cattle fever ticks and other ticks.

1910 First trip to northern Mexico to survey for ticks that might cross the border.

1911 Boll weevil driving Negro tenant labor away; substitute white farm labor suffering from malaria in the South.

1912 W. D. Hunter supervised tick work; he apparently became the first Chief, Insects Affecting Man and Animals, at this time.

First field station set up for screwworm control at Uvalde, Texas.

1913 Man and Animals research became part of Southern Field Crop Insect Investigations with W. D. Hunter as Chief of the new investigations.

1914 Borax found useful for fly control in manure.

Screwworm research began: "*Paralucilia macellaria* is not the only species concerned."

Hypoderma bovis found in Canada; surveys begun in the U.S. for *bovis*.

Pyrethrum-kerosene sprays began to be produced commercially for control of household pests.

Malaria control by fluctuating water levels first observed.

1915 Research on insects affecting man reported separately by Chief of Bureau for first time; same would apply to insects affecting animals; all work still under W. D. Hunter, Southern Field Crops Investigations.

1916 Carbolineum first used for control of poultry parasites.

Sodium fluoride discovered effective for poultry lice control.

Argentine ant bait developed.

USDA fly trap designed and recommended.

1918 Man and Animals research combined again; still under Hunter in Southern Field Crops Investigations.

Human body louse research began (in cooperation with National Research Council and War Department).

1919 Airplane first used for surveying mosquito-breeding areas.

During World War I, 79,537 cases of diarrhea and dysentery among troops causing 267 deaths; as many as 15 malaria cases per 1000 men.

1920 Screwworm annual loss estimated at $4,000,000.

1921 Paris Green first noted as mosquito larvicide; revolutionized malaria control.

1922 Rotenone reported effective against cattle grub and cattle lice.

1923 Benzol and pine tar first recommended for screwworm control.

1924 Airplane first used in insecticide application for disease-vector insects—Paris Green for mosquito larvae, Louisiana.

1926 Insects Affecting Man and Animals Investigations apparently first established; W. V. King headed up Man research; F. C. Bishopp Animals research.

Value of pyrethrum sprays shown in control of flies in dairies.

1927 F. C. Bishopp in charge, Insects Affecting Man and Animals, but stationed in Dallas, Texas.

1928 F. C. Bishopp moved to Washington, D. C., in charge, M&A; remained Chief of Branch (or Division) of Insects Affecting Man and Animals until November 9, 1941.

New Jersey mosquito light trap and Clear Lake gnat trap invented.

1929 Sulfur dips developed for control of lice on sheep and goats.

1930 Rocky Mountain spotted fever found in Eastern U. S.

1931 Blow fly maggots first recommended for treatment of osteomyelitis.

First recommendations (whose?) yellow electric lights as nonattractive to night-flying insects.

1933 "Screw-worm" discovered to be two species, *hominivorax* and *macellaria*.

Ditching found effective in controlling salt-marsh mosquitoes and sand flies.

Transmission of encephalitis by mosquitoes proved.

1935 Phenothiazine first tested as insecticide; used in horn fly control.

DeMeilion (South Africa) showed pyrethrum sprays in homes lowered malaria spleen rate.

Urea and allantoin, excreted by maggots, found to promote healing of wounds; can we call this first antibiotic work?

1937 E. F. Knipling proposed eradication of screwworm through sterile males.

1939 Diphenylamine found effective in wounds against screwworms.

1941 Development of aerosol bomb for mosquito control.

EQ–62 screwworm remedy developed.

E. C. Cushing became Chief, Man and Animals on retirement of F. C. Bishopp; Cushing was Chief until June 10, 1942, when he was called to active military duty, and again from November 2, 1945, until retirement on September 14, 1946.

1942 W. E. Dove became Chief, Man and Animals; Chief until October 31, 1945.

Insecticide and repellent testing for Armed Forces began at Orlando, Florida; Dimethyl phthalate, benzyl benzoate, other repellents discovered or developed.

1943 DDT developed for control of insect vectors of typhus, malaria, other vector-born diseases; shown practical for control of house flies, bed bugs, and fleas for civilian and military uses.

DDT sprays and dusts developed for control of horn flies and lice on cattle and for control of lice on other livestock.

1945 Chigger area control shown with BHC, chlordane, or toxaphene.

During World War II, 525,004 cases of diarrhea and dysentary, with 130 deaths; as many as 160 cases of overseas malaria per 1,000 men in 1943.

1946 Area control of ticks demonstrated with chlordane, DDT, and toxaphene.

E. F. Knipling became Chief, Man and Animals; remained Chief until July 1, 1953, when succeeded by A. W. Lindquist.

1947 DDT resistance in house flies discovered.

1948 Methoxychlor proved effective for control of lice, flies on cattle.

1949 Mosquitoes in some localities found to be DDT-resistant; lindane recommended as substitute.

1951 EQ-335 smear developed for screwworm control.

First automatic sprayer developed for fly control on livestock.

Insecticides found effective against imported fire ant.

First lice colony resistant to DDT established in Orlando, Florida, from lice collected in Korea.

M-1960 clothing repellent developed and used in Korea.

1953 Sugar baits proved effective in fly control.

The most effective insect repellent (deet) developed.

A. W. Lindquist became Branch Chief; held the office until retirement May 31, 1962.

1954 Screwworms eradicated from Curaçao, Dutch West Indies.

1955 First effective, safe cattle grub systemic found (ronnel, Corvallis, Oregon).

1957 Second effective, safe cattle grub systemic found (coumaphos, Kerrville, Texas).

Colony of lindane-resistant lice from West Africa established at Orlando, Florida.

1958 First recommendations for cattle grub control by systemics. Initiation of a chemosterilant screening program for both male and female sterilants.

Screwworms eradicated from Southeastern United States by the sterile male method.

1962 W. C. McDuffie became Branch Chief; held position until December 30, 1966.

Effective international collaboration program developed with World Health Organization for testing insecticides; as many as 1400 compounds tested in next 10 years.

1963 Mirex proved highly effective, selective material for the control of the imported fire ant.

1966 First large-scale use of ULV aerial technique to control mosquito vectors of St. Louis encephalitis in Dallas, Texas, by U. S. Public Health Service.

1967 C. H. Schmidt became Branch Chief July 2, 1967.

Synthetic attractant found for yellow jackets.

1968 Ground ULV shown superior to high volume thermal aerosols for mosquito control. (Gainesville, Florida.)

1969 Experiment at Sea Horse Key, Florida, demonstrated that mosquitoes can be controlled by the sterile male technique.

First report on use of sterile male technique for the control of tsetse fly on an isolated island.

1970 Use of systemic insecticides to control rodent fleas demonstrated.

1971 Venezuelan equine encephalitis epidemic in Texas conquered by ultra-low volume aerial application of insecticides and massive horse vaccination program.

Development of repellent-treated netting for bed nets, head nets, and jackets. (Gainesville, Florida.)

Evidence of house fly pheromone found, and sex pheromone in female house flies identified.

First demonstration of field effectiveness of juvenile hormone for control of the horn fly. (College Station, Texas.)

1972 Regionalization of ARS on July 1, 1972, terminated the existence of the Insects Affecting Man and Animals Research Branch and the Entomology Research Division.

A Bibliography on Apanteles melanoscelus *(Ratzeburg),* A. porthetriae *Muesebeck and* A. ocneriae *Ivanov*[1], *Parasites of the Gypsy Moth,* Porthetria dispar *(L.)*[2,3]

Lee J. Shervis and **R. D. Shenefelt**

Department of Entomology, University of Wisconsin, Madison 53706

The documents cited in this bibliography constitute an experimental file used in preliminary work toward the construction of a prototype Braconidae information retrieval system (Shervis and Shenefelt, 1973). The file was built up through intensive literature searches for each species, the goal being to find as much published information as possible on each species regardless of its originality, length, apparent accuracy or importance. A total of 183 documents is listed—167 deal with *melanoscelus*, 38 with *porthetriae* and 14 with *ocneriae*. Twenty-seven of the documents contain information on 2 or all of these species.

The titles of non-English documents are given in the language of the original full text, followed by an English translation. Parentheses ( ) indicate that an English translation of the title was present in the original document. Square brackets [ ] indicate that an English translation of the title was obtained elsewhere. For documents in Russian and Bulgarian, (Cyrillic alphabet) only an English translation of the title is given.

Where transliteration from Russian or Bulgarian was required (author names, serial titles, etc.) the Library of Congress system was used, taken from the *A.L.A. Cataloging Rules for Author and Title Entries* (1949).

Serial titles were abbreviated in accord with the *American Standard for Periodical Title Abbreviations* (1964). A list of the full titles of serials is given following the bibliography.

The page numbers given represent the full documents, not the pages containing information on the *Apanteles* species.

An asterisk (*) preceding the citation indicates that part of the bibliographic information was obtained from a secondary source, although copies of the relevant text portions were seen.

The letters "m", "p", and "o" following the citation indicate the species dealt with in the document.

[1]Hymenoptera: Braconidae

[2]Lepidoptera: Liparidae

[3]Research supported by the College of Agricultural and Life Sciences, University of Wisconsin, Madison, and by means of a cooperative agreement between the College and the Agricultural Research Service, USDA.

Bibliography

Anon. 1890. The imported gipsy moth (*Ocneria dispar* L.). Insect Life 2: 208–211. m

Aulló, M. 1925. Organización de las campañas de extinción contra plagas de *Lymantria dispar* L.

[Organization of eradication campaigns against outbreaks of *Lymantria dispar* L.] Rev. Fitopatol. 2–3: 5–12. m
Balduf, W. V. 1938. Bionomic notes on *Exartema ferriferanum* Walk. (Lepid., Olethreutidae) and its parasites (Hym: Brac., Chalc.). J. N. Y. Entomol. Soc. 46: 23–26. m
Bess, H. A. 1961. Population ecology of the gypsy moth *Porthetria dispar* L. (Lepidoptera: Lymantridae). Conn. Agr. Exp. Sta. (New Haven) Bull. 646: 1–43. m
Bischoff, H. 1927. Biologie der hymenopteren. [Biology of the Hymenoptera.] Berlin, J. Springer. vii + 598 p. m
Brammanis, L. 1957. Die forstentomologie in der Russischen zeitschrift "Lesnoje Chosjaistwo" (forstwirtschaft) jahrgang 1953–1955. [The forest entomology in the Russian journal "Lesnoe Khoziaĭstvo" (forestry) years 1953–1955.] Z. Angew. Entomol. 40: 343–370. p
———. 1963. Die forstentomologie in der Sowjetrussischen zeitschrift "Lesnoje Chosjaistwo" (forstwirtschaft) jahrgang 1958. [The forest entomology in the Soviet Russian journal "Lesnoe Khoziaĭstvo" (forestry) year 1958.] Z. Angew. Entomol. 52: 412–424. p
Brauns, A. 1964. Taschenbuch der waldinsekten. [Handbook of forest insects.] Stuttgart, G. Fischer. xiii + 817 p. m
Britton, W. E. 1935. The gypsy moth *Porthetria dispar* Linn. Conn. Agr. Exp. Sta. (New Haven) Bull. 375: 621–647. m
———. 1937. The satin moth. Conn. Agr. Exp. Sta. (New Haven) Bull. 396: 361–364. m
———. 1938. Additions to the check-list of the insects of Connecticut. Bull. Conn. State Geol. Natur. Hist. Surv. 60: 1–201. m
——— and J. T. Ashworth. 1923. Report of work in suppressing the gipsy and brown-tail moths. Season of 1921–1922. Conn. Agr. Exp. Sta. (New Haven) Bull. 247: 290–326. m
——— and J. T. Ashworth. 1925. Report of gipsy moth work. Year ending June 30, 1924. Conn. Agr. Exp. Sta. (New Haven) Bull. 265: 254–276. m
——— and J. T. Ashworth. 1931. Gipsy moth control in Connecticut in 1930. Conn. Agr. Exp. Sta. (New Haven) Bull. 327: 501–518. m
Brown, R. C. 1931. Observations on the satin moth and its natural enemies in central Europe. U.S. Dep. Agr. Circ. 176: 1–20. m
Burgess, A. F. 1915. Parasite work. Mass. State Forest. Annu. Rep. 11: 84–86. m
———. 1915. Report on the gipsy moth work in New England. U.S. Dep. Agr. [Dep.] Bull. 204: 1–32. m
———. 1916. Parasite work. Mass. State Forest. Annu. Rep. 12: 81–84. m
———. 1923. Controlling the gipsy moth and the brown-tail moth. U.S. Dep. Agr. Farmers' Bull. 1335: 1–28. m
*———. 1924. The value of natural enemies of injurious insects. Rep. Entomol. Soc. Ontario 54: 30–36. m
———. 1926. The present status of the control of the gipsy moth and the brown-tail moth by means of parasites. J. Econ. Entomol. 19: 289–293. m
———. 1930. The control of some imported tree defoliating insects. Int. Congr. Entomol. (4th, Ithaca, August 1928) Trans. p. 571–578. m
———. 1930. The gipsy moth and the brown-tail moth. U.S. Dep. Agr. Farmers' Bull. 1623: 1–33. m
——— and W. L. Baker. 1938. The gypsy and brown-tail moths and their control. U.S. Dep. Agr. Circ. 464: 1–38. m
——— and S. S. Crossman. 1927. The satin moth, a recently introduced pest. U.S. Dep. Agr. Dep. Bull. 1469: 1–22. m
——— and S. S. Crossman. 1929. Imported insect enemies of the gipsy moth and the brown-tail moth. U.S. Dep. Agr. Tech. Bull. 86: 1–148. m, p
Čapek, M. 1960. Zoznam parazitov dochovaných z hmyzich škodcov vo VÚLH v Banskej Štiavnici. I. časť-hostitelia lumčikov-Braconidae (Hymenoptera). [List of parasites bred from insect pests at VULH at Banska Stiavnica. Part I.- hosts of the Braconidae (Hymenoptera).] Vedecké Práce Výskumného Ústavu Lesného Hospodár. Banskej Štiavnici 1: 199–212. p
Ceballos, G. 1956. Catalogo de los himenópteros de España. [Catalog of the Hymenoptera of Spain.] Madrid, Inst. Españ. Entomol. 554 p. m, p
Chorbadzhiev (Tschorbadjiew), P. 1925. Beitrag zur erforschung der parasiten der schädlichen insekten in Bulgarien. [Report on studies of the parasites of destructive insects in Bulgaria.] Bŭlgarsko Entomol. Druzh. 2: 84–89. m
———(Tchorbadjieff), P. 1933. [The insect pests of fruit trees in Bulgaria.] Sofia, Min. Zemedi͡elieto i Dŭrzhavniti͡e Imoti. vii + 239 p. p
Clausen, C. P. 1956. Biological control of insect pests in the continental United States. U.S. Dep. Agr. Tech. Bull. 1139: 1–151. m
———. 1958. The biological control of insect pests in the continental United States. Int. Congr. Entomol. (10th, Montreal, August 1956) Proc. 4: 443–447. m
———. 1962. Entomophagous insects. New York, Hafner. x + 688 p. m
Collins, C. W. [1933 ?] Natural enemies of the gypsy moth, brown-tail moth and a few other pests in Massachusetts. Mass. Commissioner Conserv. State Forest. Annu. Rep. 1932: 27–31. m
———. 1934. Natural enemies of the gypsy moth, brown-tail moth, and some other forest and shade tree pests in Massachusetts. Mass. Commissioner Conserv. State Forest. Annu. Rep. 1933: 31–32. m
——— and T. H Jones. 1932. Gipsy and brown-tail moth infestations are checked by imported parasites. U.S. Dep. Agr. Yearbook Agr. 1932: 236–239. m
Craighead, F. C. 1950. Insect enemies of eastern forests. U.S. Dep. Agr. Misc. Publication 657: 1–679. m
Crossman, S. S. 1922. *Apanteles melanoscelus*, an

imported parasite of the gipsy moth. U.S. Dep. Agr. [Dep.] Bull. 1028: 1–25. m

———. 1925. Foreign travel and entomologists met while searching for enemies of the gipsy moth. J. Econ. Entomol. 18: 164–172. m

———. 1925. Two imported egg parasites of the gipsy moth, *Anastatus bifasciatus* Fonsc. and *Schedius kuvanae* Howard. J. Agr. Res. 30: 643–675. m

——— and R. T. Webber. 1924. Recent European investigations of parasites of the gipsy moth, *Porthetria dispar* L., and the brown-tail moth, *Euproctis chrysorrhoea* L. J. Econ. Entomol. 17: 67–76. m

Cushman, R. A. 1927. New species and new forms of Ichneumonidae parasitic upon the gipsy-moth parasite, *Apanteles melanoscelus* (Ratzeburg). J. Agr. Res. 34: 453–458. m

Dalla Torre, C. G. 1898. Catalogus hymenopterorum. [Hymenoptera catalog.] 4. Braconidae. Leipzig, G. Engelmann. 323 p. m

Dasch, C. E. 1971. Ichneumon-flies of America north of Mexico: 6. Subfamily Mesochorinae. Mem. Amer. Entomol. Inst. 16: 1–376. m

Davidson, R. H., and L. M. Peairs. 1966. Insect pests of farm, garden and orchard. 6th ed. New York, J. Wiley. ix + 675 p. m

DeBach, P., ed. 1964. Biological control of insect pests and weeds. New York, Reinhold. xxiv + 844 p. m

De Lépiney, J. 1930. Contribution à l'étude du complexe biologique de *Lymantria dispar*. [Contribution to the study of the biological complex of *Lymantria dispar*.] Mém. Soc. Sci. Natur. Maroc 23: 1–100. m

De Saeger, H. 1942. Les *Apanteles* hyménoptères, braconides, parasites de lépidoptères. [*Apanteles*. Hymenoptera, Braconidae, parasites of Lepidoptera.] Bull. Agr. Congo Belg. 33 (2–3): 234–288 (Reprint 1942, 56 p.) m

Diaz, B. 1923. Parásitos de *Lymantria dispar* L. *Apanteles vitripennis* Hal. [Parasites of *Lymantria dispar* L. *Apanteles vitripennis* Hal.] Rev. Fitopatol. 1: 80–82. m

Dowden, P. B. 1961. The persistence of gypsy moth parasites in heavily sprayed areas on Cape Cod, Massachusetts. J. Econ. Entomol. 54: 873–875. m

———. 1962. Parasites and predators of forest insects liberated in the United States through 1960. U.S. Dep. Agr. Agr. Handbook 226: 1–70. m, p

Duţu-Lăcătuşu, M. 1958. Contribuţii la cunoaşterea biologiei braconidelor (insecte hymenoptere). [Contributions to the knowledge of the biology of the Braconidae (Hymenoptera).] Anal. Univ. C.I. Parhon-Bucureşti. Ser. Ştiint. Natur. 19: 135–144. p

Essig, E. O. 1931. A history of entomology. New York, Macmillan. vii + 1029 p. m

***Fahringer, J.** 1936. Opuscula braconologica. [Notes on Braconidae.] Vol. 4. Palaearktische region. [Palearctic region.] Parts 1–3. Wien, F. Wagner. 256 p. m, p, o

***Felt, E. P.** *in* Atwood, G. G. 1922. The gipsy moth, an imminent menace to the forest and shade trees of the State of New York. N.Y. State Dep. Farms & Markets Agr. Bull. 148: 1–58. m

Ferrière, C. 1927. Les parasites et hyperparasites de *Lymantria dispar* au Maroc. [The parasites and hyperparasites of *Lymantria dispar* in Morocco.] Ann. Épiphyt. 13: 175–180. m

Flanders, S. E. 1963. Hyperparasitism, a mutualistic phenomenon. Can. Entomol. 95: 716–720. m

Forbush, E. H., and C. H. Fernald. 1896. The gypsy moth. *Porthetria dispar* (Linn.). Boston, Wright & Potter Printing Co. xii + 495 + c p. m

Friend, R. B. 1945. The gypsy moth in Connecticut. Trans. Conn. Acad. Arts Sci. 36: 607–629. m

Gäbler, H. 1955. Forstschutz gegen tiere. [Forest protection against animals.] Radebeul, Neumann. 368 p. m, p

Gahan, A. B. 1927. Miscellaneous descriptions of new parasitic Hymenoptera with some synonymical notes. Proc. U.S. Nat. Mus. 71 (article 4): 1–39. m

Garcia Mercet, R. *see* Mercet, R. G.

Goidanich, A. 1931. Gli insetti predatori e parassiti della *Pyrausta nubialis* Hübn. [Insect predators and parasites of *Pyrausta nubialis* Hübn.] Boll. Lab. Entomol. R. Inst. Superiore Agr. Bologna 4: 77–218. m

Graham, S. A. 1952. Forest entomology. 3rd ed. New York, McGraw-Hill. xii + 351 p. m

Györfi, J. 1939. Adatok a fürkeszdarazsak erdészeti jelentöségéhez. [Information on parasitic wasps of forest importance.] Erdészeti Kisérletek 41: 117–242. m

———. 1945. Megfigyelések a fürkészdarazsak nemzöinek táplálkozásarol. [Observations on the nutrition of the adults of hymenopterous parasites.] Erdészeti Kisérletek 45: 87–114. m

———. 1945. Ökológiai vizsgálatok a hymenopterák életéböl. [Ecological observations on the lives of the Hymenoptera.] Erdészeti Kisérletek 45: 1–70. m, p

———. 1951. Die schlupfwespen und der unterwuchs des waldes. [The parasitic wasps and the undergrowth of the woods.] Z. Angew. Entomol. 33: 32–47. m, p

Hinckley, A. D. 1972. The gypsy moth. Environment 14: 41–47. m

Howard, L. O. 1914. Report of the entomologist. U.S. Dep. Agr. Annu. Rep. 1914: 183–198. m

———. 1915. Report of the entomologist. U.S. Dep. Agr. Annu. Rep. 1915: 211–231. m

———. 1916. Report of the entomologist. U.S. Dep. Agr. Annu. Rep. 1916: 213–236. m

———. 1917. Report of the entomologist. U.S. Dep. Agr. Annu. Rep. 1917: 227–250. m

———. 1918. Report of Dr. L. O. Howard, United States entomologist. Mass. State Forest. Annu. Rep. 14: 45–46. m

———. 1918. Report of the entomologist. U.S. Dep. Agr. Annu. Rep. 1918: 233–256. m

———. 1919. Report of the entomologist. U.S. Dep. Agr. Annu. Rep. 1919: 247–273. m

———. 1920. Report of the entomologist. U.S. Dep. Agr. Annu. Rep. 1920: 307–342. m

———. 1922. A side line in the importation of insect parasites of injurious insects from one country to another. Proc. Nat. Acad. Sci. U.S.A. 8: 133–139. m

———. 1923. Report of the entomologist. U.S. Dep. Agr. Annu. Rep. 1923: 381–417. m

——— and W. F. Fiske. 1911. The importation into the United States of the parasites of the gipsy moth and the brown-tail moth. U.S. Dep. Agr. Bur. Entomol. Bull. 91: 1–344. m

Imms, A. D. 1931. Recent advances in entomology. Philadelphia, P. Blakiston. viii + 374 p. m

***Ivanov, P.** 1899 (1898). [Braconidae (cryptogasters and areolarii) of the vicinity of Koupiansk, with synoptic tables of the genera and species of these insects.] Tr. Obshchest. Estestvoispyt. Imperatorskom Khar'kovskom Univ. 33: 276–277, 311, 315–355. o

Jackson, D. J. 1928. The biology of *Dinocampus* (*Perilitus*) *rutilus* Nees, a braconid parasite of *Sitona lineata* L.-Part I. Proc. Zool. Soc. London 1928: 597–630. m

***Kirchner, L.** 1867. Catalogus hymenopterorum Europae. [Catalog of European Hymenoptera.] Vindobonae, Soc. Zoologico-Bot. 285 p. m

Komárek, J. 1937. Kritisches wort über die bedeutung der insektenparasiten der nonne. [Critical word on the significance of the insect parasites of the nun moth.] Z. Angew. Entomol. 24: 95–117. m

Krombein, K. V., and B. D. Burks. 1967. Hymenoptera of America north of Mexico; synoptic catalog. Second suppl. U.S. Dep. Agr. Agr. Monogr. 2: 1–584. m

Kurir, A. 1944. *Anastatus disparis* Ruschka, eiparasit des *Lymantria dispar* L. [*Anastatus disparis* Ruschka, egg parasite of *Lymantria dispar* L.] Z. Angew. Entomol. 30: 551–586. m

Lyle, G. T. 1916. Contributions to our knowledge of the British Braconidae. No. 3. Microgasteridae. Entomologist 49: 121–125, 160–163, 185–187, 206–208, 228–232, 251–254, 268–272. m

Maksimović, M. 1953. Neka zapažanja o krizi gradacije gubara 1950 godine u nizinskoj i planinskoj šumi. (Some observations about gradation crisis of gypsy moth in plane and mountain forests in 1950.) Zaštita Bilja 15: 12–27. m

———, P. Bjegović and L. Vasiljević. 1970. Održavanje povećane brojnosti neprijatelja gubara kao metod biološke borbe. (Maintaining the density of the gypsy moth enemies as a method of biological control.) Zaštita Bilja 107: 3–15. p

Marlatt, C. L. 1928. Report of the entomologist. U.S. Dep. Agr. [Annu. Rep. 1928]: 1–34. m

———. 1929. Report of the chief of the Bureau of Entomology. U.S. Dep. Agr. [Annu. Rep. 1929]: 1–39. m

———. 1931. Report of the chief of the Bureau of Entomology. U.S. Dep. Agr. [Annu. Rep. 1931]: 1–87. m

———. 1932. Report of the chief of the Bureau of Entomology. U.S. Dep. Agr. [Annu. Rep. 1932]: 1–38. m

———. 1933. Report of the chief of the Bureau of Entomology, 1933. U.S. Dep. Agr. [Annu. Rep. 1933]: 1–47. m

Marshall, T. A. 1885. Monograph of British Braconidae. Part I. Trans. Entomol. Soc. London 1885: 1–280. m

*———. 1901. Spécies des hyménoptères d' Europe et d' Algérie. [Hymenoptera species of Europe and Algeria.]. 5 bis: catalogue. m

Matheson, R. 1944. Entomology for introductory courses. Ithaca, N.Y., Comstock. xiv + 600 p. m

———. 1951. Entomology for introductory courses. 2nd ed. Ithaca, N.Y., Comstock. xiv + 629 p. m

McIntire, M. H. 1922. Report of the field agent, gypsy moth work. Annu. Rep. Commissioner Agr. Maine 20: 45–47. m

———. 1924. Report of field agent, gypsy moth work. Rep. Commissioner Agr. Maine 1922–1924. 21: 48–52. m

***Meĭer (Meyer), N. F.** 1927. [Parasites (Ichneumonidae and Braconidae) bred in Russia from injurious insects during 1881–1926.] Leningr. Izv. Otd. Prikladnoĭ Ėntomol. 3: 75–91. o

Mercet, R. G. 1932. Los parásitos de los insectos perjudiciales. [The parasites of the injurious insects.] Barcelona, Salvat. 151 p. m, p

Muesebeck, C. F. W. 1920. A revision of the North American species of ichneumon-flies belonging to the genus *Apanteles*. Proc. U.S. Nat. Mus. 58: 483–576. m

———. 1927. New species of chalcid flies parasitic on the gipsy-moth parasite, *Apanteles melanoscelus* (Ratzeburg). J. Agr. Res. 34: 331–333. m

———. 1928. A new European species of *Apanteles* parasitic on the gipsy moth. Proc. Entomol. Soc. Wash. 30: 8–9. p

———. 1931. *Monodontomerus aereus* Walker, both a primary and a secondary parasite of the brown-tail moth and the gipsy moth. J. Agr. Res. 43: 445–460. m

——— and S. M. Dohanian. 1927. A study in hyperparasitism, with particular reference to the parasites of *Apanteles melanoscelus* (Ratzeburg). U.S. Dep. Agr. Dep. Bull. 1487: 1–35. m

———, K. V. Krombein and H. K. Townes. 1951. Hymenoptera of America north of Mexico; synoptic catalog. U.S. Dep. Agr. Agr. Monogr. 2: 1–1420. m

Narayanan, E. S., B. R. Subba Rao, and G. A. Gangrade. 1956. The biology and rate of reproduction and the morphology of the immature stages of *Apanteles angaleti* Muesebeck. Beitr. Entomol. 6: 296–320. m

Nichols, J. O. 1962. The gypsy moth in Pennsylvania—its history and eradication. Penn. Dep. Agr. Misc. Bull. 4404: 1–82. m

***Nunberg, M.** 1925. Masowy pojaw brudnicy nieparki (*Lymantria dispar* L.) w okolicy Bochni w. r. 1924. [Mass emergence of the gypsy moth

(*Lymantria dispar* L.) in the vicinity of Bochnia in 1924.] Pol. Pismo Entomol. 4: 118–133. m

——— **and S. Wiackowski.** 1958. Meczelkowate (Braconidae, Hymenoptera) jakow pasożyty owadów leśnych. [Braconidae (Hymenoptera) as parasites of forest insects.] Folia Forest. Pol. Ser. A 1: 129–135. m

Ordóñez, R. A. *see* Riesgo Ordóñez, A.

Padiĭ, N. N. 1953. [Utilization of a biological method for controlling the gypsy moth.] Lesnoe Khoz. 6: 44–47. p

Papp, J. 1967. Results of the zoological explorations of Dr. Z. Kaszab in Mongolia. 101. Braconidae (Hymenoptera) I. Acta Zool. Acad. Sci. Hung. 13: 191–226. m

Parker, D. L. 1935. *Apanteles solitarius* (Ratzeburg), an introduced braconid parasite of the satin moth. U.S. Dep. Agr. Tech. Bull. 477: 1–17. m

Pawlowicz, J. 1936. Beobachtungen über einige in *Porthetria dispar* L., *Malacosoma neustria* L. und *Stilpnotia salicis* L. (Lep.) schmarotzende hymenopteren und dipteren. [Observations on a few Hymenoptera and Diptera parasitic on *Porthetria dispar* L., *Malacosoma neustria* L. and *Stilpnotia salicis* L. (Lep.).] Zool. Pol. 1: 99–118. m, p

Peairs, L. M. 1941. Insect pests of farm, garden, and orchard. 4th ed. New York, J. Wiley. xvii + 549 p. m

Peterson, A. 1934. A manual of entomological equipment and methods. Part I. Ann Arbor, Mich., Edwards. 21 + xiii p. + 138 plates. m, p

———. 1937. A manual of entomological equipment and methods. Part II. St. Louis, J. Swift. 334 p. m, p

———. 1953. A manual of entomological techniques. Ann Arbor, Mich., Edwards. v + 367 p. m, p

Prell, H. 1925. Über *Apanteles solitarius* Ratz. als parasit der nonnenraupen. [On *Apanteles solitarius* Ratz. as parasite of nun moth larvae.] Anz. Schädlingskunde 1: 103–105. m

Proper, A. B. 1931. *Eupteromalus nidulans,* a parasite of the brown-tail and satin moths. J. Agr. Res. 48: 37–56. m

———. 1934. Hyperparasitism in the case of some introduced lepidopterous tree defoliators. J. Agr. Res. 48: 359–376. m

***Ratzeburg, J. T. C.** 1844. Die ichneumonen der forstinsecten in forstlicher und entomologischer beziehung . . . [The Ichneumonidae of forest insects, with emphasis on forestry and entomology . . .] Vol. 1. Berlin, Nicolai. 224 p. m

*———. 1852. Die ichneumonen der forstinsecten in forstlicher und entomologischer beziehung . . . [The Ichneumonidae of forest insects, with emphasis on forestry and entomology . . .] Vol. 3. Berlin, Nicolai. 272 p. m

Reinhard, H. 1880. Beiträge zur kenntniss einiger braconiden-gattungen. [Reports on the identifications of a few braconid genera.] Deut. Entomol. Z. 24: 353–370. m

Riesgo Ordóñez, A. 1929. La fauna del Valle de los Pedroches. [The fauna of the Pedroches Valley.] Rev. Fitopatol. 4–6: 53–58. m

Romanyk, N., and A. Ruperez. 1960. Principales parasitos observados en los defoliadores de España con atencion particular de la *Lymantria dispar* L. [Observations on the principal parasites of defoliators in Spain, with particular emphasis on *Lymantria dispar* L.] Entomophaga 5: 229–236. m, p

Rondani, C. 1872. Degli insetti parassiti e delle loro vittime. [Some insect parasites and their hosts.] Bull. Soc. Entomol. Ital. 4: 41–78, 229–258, 321–342. m

———. 1873. Degli insetti nocivi e dei loro parassiti. [Destructive insects and their parasites.] Bull. Soc. Entomol. Ital. 5: 3–30, 133–165, 209–232. m

Ross, H. H. 1948. A textbook of entomology. New York, J. Wiley. ix + 532 p. m

Rudnev, D. F., and N. A. Telenga. 1958. [Biological methods to combat forest pests.] Lesnoe Khoz. 11: 37–40. p

Rudow. 1917. Die gattung *Microgaster* und ihre wirte. [The genus *Microgaster* and their hosts.] Entomol. Z. Frankfurt a. M. 31: 5–6, 10–11, 13–14, 19–20, 22–23. m

Russo, G. 1959. I principali parassiti dei lepidotteri defogliatori forestali in Italia. [Important parasites of the forest-defoliating Lepidoptera in Italy.] Boll. Lab. Entomol. Agr. Filippo Silvestri 17: 172–188. m

———. 1960. I principali parassiti dei lepidotteri defogliatori forestali in Italia. [Important parasites of the forest-defoliating Lepidoptera in Italy.] Ann. Fac. Sci. Agr. Univ. Stud. Napoli 25: 71–84. m

Ryvkin, B. V. 1957. (Peculiarities of the gipsy moth outbreaks and their causes.) Zool. Zh. 36: 1355–1358. p

Salatić, S. 1963. Rezultati ispitivanja nekih faktora efektivnosti jajnih parazita gubara. (Results of investigations of some factors of effectiveness of gypsy moth egg parasites.) Zaštita Bilja 76: 693–699 m, p

Schaffner, J. V., Jr. 1934. Introduced parasites of the brown-tail and gipsy moths reared from native hosts. Ann. Entomol. Soc. Amer. 27: 585–592. m

——— **and C. L. Griswold.** 1934. Macrolepidoptera and their parasites reared from field collections in the northeastern part of the United States. U.S. Dep. Agr. Misc. Publication 188: 1–160. m

Schedl, K. E. 1936. Der schwammspinner (*Porthetria dispar* L.) in Euroasien, Afrika und Neuengland. [The gypsy moth (*Porthetria dispar* L.) in Eurasia, Africa and New England.] Monogr. Angew. Entomol. 12: 1–242. m, p, o

Schread, J. C., W. T. Brigham, and G. R. Smith. 1942. Alternate host study of the parasites of the oriental fruit moth. Conn. Agr. Exp. Sta. (New Haven) Bull. 461: 490–502. m

Serafimović (Serafimovski), A. 1954. Ciklus razvica topolinog gubara u okolini Beograda. (A contribution to the knowledge of the development cycle of the satin moth *(Stilpnotia salicis* L.).) Zaštita Bilja 25: 18–40. m

Shapiro, V. A. 1956. [The principal parasites of the gypsy moth *(Porthetria dispar* L.) and the prospects of using them.] Zool. Zh. 35: 251–265. p

———. 1959. (The ways of stimulation of the activity of oligophagous parasites in the suppression of herds of dangerous forest pests.) Int. Conf. Insect Pathol. Biol. Contr. (1st, Praha, August 1958) Trans. p. 491–494. p

———. 1960. (Role of parasites in the decreasing of tent caterpillar population.) Tr. Vsesoiûznogo Nauchno-Issled. Inst. Zashchity Rasteniĭ 15: 71–86. m

Shchepetil'nikova (Shepetilnikova), V. A. 1959. (Results of the studies on use of parasites in the insect control in the Soviet Union.) Int. Conf. Insect Pathol. Biol. Contr. (1st, Praha, August 1958) Trans. p. 441–453. p

Shchepetil'nikova, V. A. 1963. (The problem of biological methods in plant protection.) Tr. Vsesoiûznogo [Nauchno-Issled.] Inst. Zashchity Rasteniĭ 17: 162–185. p

Shenefelt, R. D. 1972. Braconidae 4. Microgasterinae. *Apanteles. in* Van der Vecht, J. and R. D. Shenefelt, eds. Hymenopterorum catalogus (nova editio). Pars 7. Gravenhage, W. Junk. p. 429–668. m, p, o

Smith, G. A. 1921. Report of the superintendent of gypsy-moth work. Mass. Commissioner Conserv. State Forest. Annu. Rep. 1920: 53–60. m

Smulyan, M. T. 1936. A revision of the chalcid flies of the genus *Perilampus* Latreille occurring in America north of Mexico. Proc. U.S. Nat. Mus. 83: 369–412. m

Stadler, H. 1933. Ein neuer ichneumonide aus schwammspinnerraupen *(Lymantria dispar* L.). [A new ichneumonid from gypsy moth larvae *(Lymantria dispar* L.).] Entomol. Anz. 13: 27–30, 43–45, 58–60. m, p, o

Stellwaag, F. 1921. Die schmarotzerwespen (schlupfwespen) als parasiten. [The parasitic wasps as parasites.] Monogr. Angew. Entomol. 6: 1–100. m, o

Swan, L. A. 1964. Beneficial insects; nature's alternatives to chemical insecticides... New York, Harper & Row. xvii + 429 p. m

Sweetman, H. L. 1936. The biological control of insects. Ithaca, N.Y., Comstock. xii + 461 p. m

———. 1958. The principles of biological control. Dubuque, Ia., W. Brown. xii + 560 p. m

Szépligeti, G. V. 1904. Hymenoptera fam. Braconidae. Genera Insectorum 22: 1–253. m, o

Szmidt, A. 1955. Możliwości wykorzystania pasożytów rodzaju *Apanteles* Först do biologicznego zwalczania barczatki sosnówki *(Dendrolimus pini* L). (Prospects of utilizing the parasite *Apanteles* Först. in biological combating of *Dendrolimus pini* L.) Sylwan 99: 490–500. m, p

Tadić, M. 1961. Prilog poznavanju dijapauze jajnog parazita gubara *Anastatus disparis* R. na Hvaru. (A contribution to the knowledge of the diapause of the gypsy moth egg parasite *Anastatus disparis* R. on the Island Hvar.) Zaštita Bilja 63–64: 13–19. m

Tadić, M. D., and B. Binčev. 1959. *Ooencyrtus kuwanai* How. u Jugoslaviji. [*Ooencyrtus kuwanai* How. in Yugoslavia.] Zaštita Bilja 52–53: 51–59. m

***Taschenberg, E. L.** 1880. Praktische insektenkunde... [Practical insect study...] Vol. 3. Die schmetterlinge. [The butterflies.] Bremen, M. Hensius. 311 p. m

Tchorbadjieff, P. *see* Chorbadzhiev, P.

***Telenga, N. A.** 1955. [Fauna of the URSS. Hymenoptera. Vol. V, Pt. 4. Fam. Braconidae: Subfam. Microgasterinae, Subfam. Agathinae.] Moscow, Zool. Inst. Akad. Nauk SSSR. 312 p. m, p, o

Thatcher, T. O. 1961. Forest entomology. Minneapolis, Burgess. iii + 225 p. m

Thompson, W. R. 1944. A catalogue of the parasites and predators of insect pests. Section 1. Parasite host catalogue. Part 4. Parasites of the Hymenoptera, Isopoda and Isoptera. Belleville, Can., Imp. Parasite Serv. v + 130 p. m

———. 1946. A catalogue of the parasites and predators of insect pests. Section 1. Parasite host catalogue. Part 7. Parasites of the Lepidoptera, (G-M). Belleville, Can., Imp. Parasite Serv. p. 259–385. m

———. 1946. A catalogue of the parasites and predators of insect pests. Section 1. Parasite host catalogue. Part 8. Parasites of the Lepidoptera, (N-P). Belleville, Can., Imp. Parasite Serv. p. 386–523. m, p, o

———. 1947. A catalogue of the parasites and predators of insect pests. Section 1. Parasite host catalogue. Part 9. Parasites of the Lepidoptera, (Q-Z). Belleville, Can., Imp. Bur. Biol. Contr. p. 524–627. m

———. 1953. A catalogue of the parasites and predators of insect pests. Section 2. Host parasite catalogue. Part 2. Hosts of the Hymenoptera (Agaonidae to Braconidae). Ottawa, Commonwealth Inst. Biol. Contr. ii + 190 p. m, p, o

———. 1954. A catalogue of the parasites and predators of insect pests. Section 2. Host parasite catalogue. Part 3. Hosts of the Hymenoptera (calliceratid to evaniid). Ottawa, Commonwealth Inst. Biol. Contr. p. 191–332. m

———. 1957. A catalogue of the parasites and predators of insect pests. Section 2. Host parasite catalogue. Part 4. Hosts of the Hymenoptera (Ichneumonidae). Ottawa, Commonwealth Inst. Biol. Contr. p. 333–561. m

———. 1958. A catalogue of the parasites and predators of insect pests. Section 2. Host parasite catalogue. Part 5. Hosts of the Hymenoptera (Miscogasteridae to Trigonalidae), Lepidoptera and Strepsiptera. Ottawa, Commonwealth Inst. Biol. Contr. p. 562–698. m

——— and F. J. Simmonds. 1964. A catalogue of the parasites and predators of insect pests. Section 3. Predator host catalogue. Farnham Royal, Engl., Commonwealth Inst. Biol. Contr. 204 p. m

——— and F. J. Simmonds. 1965. A catalogue of the parasites and predators of insect pests. Section 4. Host predator catalogue. Farnham Royal, Engl., Commonwealth Inst. Biol. Contr. 198 p. m

*Tobias, V. I. 1954. [Data relating to the fauna and biology of Braconidae of West Kazakhstan.] Tr. Zool. Inst. Akad. Nauk SSSR 16: 417–426. m

———. 1971 (Review of the Braconidae (Hymenoptera) of the USSR.) Tr. Vsesoiuznogo Entomol. Obshchest. 54: 156–268. m, p, o

——— and A. B. Jakimavičius. 1971. (Key to braconid parasites (Hymenoptera, Braconidae) of orchard pests.) Tr. Vsesoiuznogo Entomol. Obshchest. 54: 269–285. m, p, o

Torre, C. G. Dalla *see* Dalla Torre, C. G.

Tschorbadjiew, P. *see* Chorbadzhiev, P.

Turner, N. 1963. The gypsy moth problem. Conn. Agr. Exp. Sta. (New Haven) Bull. 655: 1–36. m

Vasić, K. 1958. Parazitske Hymenoptera gubara. (Parasitic Hymenoptera of gypsy moth.) Zaštita Bilja 41–42: 17–21. m, p

——— and L. Janković. 1958. Prilog poznavanju indikatora za prognozu stanja gradacije gubara. (A contribution to the knowledge of indicators for the prognostication of the evolution of the gypsy moth gradation.) Zaštita Bilja 41–42: 3–15. m

——— and S. Salatić. 1959. Novi prilog poznavanju parazitskih Hymenoptera gubara. Parazitske Hymenoptera gubara u 1958 godini. (A new contribution to the knowledge of the parasitic Hymenoptera of the gypsy moth. Parasitic Hymenoptera of the gypsy moth in 1958.) Zaštita Bilja 52–53: 47–50. m

Wardle, R. A. 1929. The problems of applied entomology. New York, McGraw-Hill. xii + 587 p. m

Webber, R. T., and J. V. Schaffner, Jr. 1926. Host relations of *Compsilura concinnata* Meigen, an important tachinid parasite of the gipsy moth and the brown-tail moth. U.S. Dep. Agr. Dep. Bull. 1363: 1–32. m

Wilkinson, D. S. 1936. A list of Lepidoptera from which parasites are particularly desired. Entomologist 69: 81–84. m, o

Wolff, M., and A. Krausse. 1922. Die forstlichen lepidopteren. [The forest Lepidoptera.] Jena, G. Fischer. vii + 337 p. m

Full titles of serials

Acta Zoologica Academiae Scientiarum Hungaricae
Analele Universitătea C. I. Parhon—Bucureşti. Seria Ştiintele Naturii
Annales des Épiphyties
Annali della Facoltà di Science Agrarie della Università degli Studii di Napoli
Annals of the Entomological Society of America
Annual Report of the Commissioner of Agriculture of Maine
Anzeiger für Schädlingskunde
Beiträge zur Entomologie
Bollettino del Laboratorio di Entomologia del R. Instituto Superiore Agrario di Bologna
Bollettino del Laboratorio di Entomologia Agraria Filippo Silvestri
Bŭlgarsko Entomologichno Druzhestvo
Bulletin Agricole du Congo Belge
Bulletin of the Connecticut State Geological and Natural History Survey
Bullettino della Società Entomologica Italiana
Canadian Entomologist
Connecticut Agricultural Experiment Station (New Haven) Bulletin
Deutsche Entomologische Zeitschrift
Entomologische Zeitschrift, Frankfurt a. M.
Entomologischer Anzeiger
Entomologist
Entomophaga
Environment
Erdészeti Kisérletek
Folia Forestalia Polonica. Seria A
Genera Insectorum
Insect Life
International Conference of Insect Pathology and Biological Control (. . .) Transactions
International Congress of Entomology (. . .) Proceedings
International Congress of Entomology (. . .) Transactions
Journal of Agricultural Research
Journal of Economic Entomology
Journal of the New York Entomological Society
Leningrad. Izvestiia Otdela Prikladnoĭ Ėntomologii
Lesnoe Khoziaĭstvo
Massachusetts Commissioner of Conservation and State Forester. Annual Report
Massachusetts State Forester. Annual Report
Mémoires de la Societé des Sciences Naturelles du Maroc
Memoirs of the American Entomological Institute
Monographien zur Angewandten Entomologie
New York State Department of Farms & Markets. Agricultural Bulletin
Pennsylvania Department of Agriculture. Miscellaneous Bulletin
Polskie Pismo Entomologiczne
Proceedings of the Entomological Society of Washington
Proceedings of the National Academy of Sciences of the United States of America
Proceedings of the United States National Museum
Proceedings of the Zoological Society of London
Report of the Commissioner of Agriculture of Maine
Report of the Entomological Society of Ontario
Revista de Fitopatologia
Sylwan
Transactions of the Connecticut Academy of Arts and Sciences
Transactions of the Entomological Society of London
Trudy Obshchestva Estestvoispytateleĭ pri Imperatorskom Khar'kovskom Universita
Trudy Vsesoiuznogo Entomologicheskogo Obshchestva

Trudy Vsesoi͡uznogo Nauchno-Issledovatel'skogo Instituta Zashchity Rasteniĭ
Trudy Zoologicheskogo Instituta Akademii Nauk SSSR
U.S. Department of Agriculture. Agriculture Handbook
———. Agriculture Monograph
———. Annual Report
———. Bureau of Entomology. Bulletin
———. Circular
———. Department Bulletin
———. Farmers' Bulletin
———. Miscellaneous Publication
———. Technical Bulletin
———. Yearbook of Agriculture
Vedecké Práce Výskumného Ústavu Lesného Hospodárstva v Banskej Štiavnici
Zaštita Bilja
Zeitschrift für Angewandte Entomologie
Zoologica Poloniae
Zoologicheskiĭ Zhurnal

References

American Library Association. Divison of Cataloging and Classification. 1949. A. L. A. cataloging rules for author and title entries. 2nd ed. Chicago, American Library Association. xxi + 265 p.

American Standards Association. 1964. American standard for periodical title abbreviations. New York, American Standards Association. 19 p.

Shervis, L. J., and R. D. Shenefelt. 1973. Poor access to *Apanteles* species literature through titles, abstracts and automatically extracted species names as keywords. J. Wash. Acad. Sci. 63: 22–25.

New Synonyms and New Combinations in North American Doryctinae (Hymenoptera: Braconidae)

Paul M. Marsh

Systematic Entomology Laboratory, Agricultural Research Service, USDA. Mail address: % U. S. National Museum, Washington, D. C. 20560.

ABSTRACT

New specific and generic synonyms are listed along with the resulting new name combinations for several groups of North American Doryctinae.

During the preparation of the Braconidae section of the forthcoming revised Catalog of Hymenoptera of North America, it has become necessary to propose several new synonyms and new combinations, particularly in the subfamily Doryctinae. There is a possibility that the Doryctinae section of the new *Hymenopterorum Catalogus* being prepared by Roy D. Shenefelt will appear at about the same time as the North American catalog. Since it is uncertain which catalog will appear first and, therefore should include the new synonyms and new combinations, it seems desirable to propose them at this time.

I am grateful to several persons who have helped by allowing me to study types in their collections or by offering information: J. W. Beardsley, University of Hawaii; Karl-Johan Hedqvist, Swedish Museum of Natural History; E. Kieryck, Polish Academy of Sciences; J. Papp, Hungarian Natural History Museum; U. Parenti, University of Turin; J. R. Steffan, National Museum of Natural History, Paris; and G. C. Varley, University of Oxford.

Genus **Acrophasmus** Enderlein

Acrophasmus immigrans (Beardsley), new combination

Doryctes immigrans Beardsley, 1961. Proc. Haw. Entomol. Soc. 16:326.

Acrophasmus lycti Marsh, 1968. Proc. Entomol. Soc. Wash. 70:105. **NEW SYNONYMY.**

This species, previously known from the southwestern United States, is now recorded from Hawaii also. It was undoubtedly introduced accidently into Hawaii. The new synonymy is based on the comparison of the type of *lycti* with specimens of *immigrans* from Hawaii sent by J. W. Beardsley.

Acrophasmus scobiciae (Marsh), new combination

Doryctodes scobiciae Marsh, 1966. Trans. Amer. Entomol. Soc. 92:513.

Acrophasmus atriventris (Cresson), new combination

Exothecus atriventris Cresson, 1872. Trans. Amer. Entomol. Soc. 4:189.
Doryctodes atriventris (Cresson): Marsh, 1966. Trans. Amer. Entomol. Soc. 92:506.

The above two species were tentatively placed in the genus *Doryctodes,* but after further study I feel they should be assigned to *Acrophasmus.*

Genus **Allorhogas** Gahan

Allorhogas pallidiceps (Perkins), new combination

Ischiogonus pallidiceps Perkins, 1910. Fauna Haw. 2(6):684.

Doryctes pallidiceps (Perkins): Beardsley, 1961. Proc. Haw. Entomol. Soc. 17:364.

Doryctes strioliger Kieffer, 1921. Bull. Agr. Inst. Sci. Saigon 3:134. **NEW SYNONYMY.**

Monolexis brugirouxi Cheesman, 1928. Ann. Mag. Nat. Hist. (Ser. 10) 1:185. **NEW SYNONYMY.**

The new combination and synonymies above are based on examination of types and authentically determined specimens. Nixon (1939. Ann. Mag. Nat. Hist. (Ser. 11) 3:493) synonymized *brugirouxi* with *strioliger*. I have seen specimens from Florida reared from *Oeme rigida* (Say) which is the first record of *pallidiceps* for North America.

Genus **Curtisella** Spinola

Curtisella Spinola, 1853. Mem. Roy. Acad. Sci. Torino 13:30. Type-species: *Curtisella pimploides* Spinola.

Neorhyssa Szépligeti, 1902. Term. Füz. 25:57. Type-species: *Neorhyssa nigra* Szépligeti (=*Curtisella pimploides* Spinola).

Lissophrymnus Cameron, 1911. Timehri 1:312. Type-species: *Lissophrymnus annulicaudus* Cameron (=*Curtisella pimploides* Spinola).

Subcurtisella Roman, 1924. Arkiv Zool. 16:33. Type-species: *Subcurtisella waterstoni* Roman. **NEW SYNONYMY.**

Polystenoides Muesebeck, 1950. Proc. Entomol. Soc. Wash. 52:79. Type-species: *Polystenoides lignicola* Muesebeck.

The synonymy of *Polystenoides* with *Curtisella* was made in an earlier paper (Marsh, 1971. Ann. Entomol. Soc. Amer. 64:844), and the complete generic synonymy is presented here. *Neorhyssa* and *Lissophrymnus* were synonymized by Roman (1924. Arkiv Zool. 16: 38); I have seen both type specimens and confirm this action. The synonymy of *Subcurtisella* is based also on recent examination of the type.

Genus **Doryctes** Haliday

Doryctes Haliday, 1836. Entomol. Mag. 4:43. Type-species: *Bracon obliteratus* Nees, not sensu Haliday (=*Ichneumon mutillator* Thunberg).

Ischiogonus Wesmael, 1838. Nouv. Mém. Acad. Sci. Bruxelles 11:125. Type-species: *Ischiogonus erythrogaster* Wesmael (=*Bracon leucogaster* Nees).

Udamolcus Enderlein, 1920(1918). Arch. Naturgesch. 84(A)(11):142. Type-species: *Udamolcus herero* Enderlein.

Pristodoryctes Kieffer, 1921. Bull. Agr. Inst. Sci. Saigon 3:133. Type-species: *Pristodoryctes striativentris* Kieffer (=*Doryctes tristriatus* Kieffer). **NEW SYNONYMY.**

Paradoryctes Granger, 1949. Mém. Inst. Sci. Madagascar (Sér. A) 2:102. Type-species: *Paradoryctes coxalis* Granger. **NEW SYNONYMY.**

Nixon (1939. Ann. Mag. Nat. Hist. (Ser. 11) 3:498) first mentioned the possible synonymy of *Pristodoryctes,* stating that *striativentris* was probably the male of *Doryctes tristriatus* Kieffer. After studying the descriptions of these species and specimens of *tristriatus,* I concur with this conclusion and hereby establish the synonymy of *Pristodoryctes* with *Doryctes*. The synonymy of *Paradoryctes* is based on recent examination of the type.

Genus **Heterospilus** Haliday

Heterospilus Haliday, 1836. Entomol. Mag. 4:40. Type-species: *Rogas (Heterospilus) quaestor* Haliday.

Bracon (Synodus) Ratzeburg, 1848. Ichn. Forstins., v. 2, p. 31. Preoccupied by Gronovius, 1763 and Latreille, 1828. Type-species: *Bracon incompletus* Ratzeburg.

Caenophanes Forester, 1862. Verh. Naturh. Ver. Rheinlande 19:236. New name for *Synodus* Ratzeburg.

Telebolus Marshall, 1888. *In* André, Spec. Hym. Eur. Alg., v. 4, p. 202. Type-species: *Telebolus corsicus* Marshall.

Kareba Cameron, 1904. Invert. Pac. 1:50. Type-species: *Kareba flavipes* Cameron. **NEW SYNONYMY.**

Anacatostigma Enderlein, 1920(1918). Arch. Naturgesch. 84(A)(11):131. Type-species: *Anacatostigma paradoxum* Enderlein. **NEW SYNONYMY.**

The synonymy of *Kareba* and *Anacatostigma* is based on recent examination of the types. A revision of the genus *Heterospilus* is now in progress but notes on the following two species are given now.

Heterospilus cephi Rohwer

Heterospilus cephi Rohwer, 1925. Jour. Wash. Acad. Sci. 15:178.

Heterospilus basifurcatus Fischer, 1960. Polskie Pismo Entomol. 30:38. **NEW SYNONYMY.**

The synonymy of *basifurcatus* is based on recent examination of the holotype. This species, which is a parasite of the European wheat stem sawfly in North America, was probably accidently introduced into this country with its host.

Heterospilus scolyticida (Ashmead)

Lysitermis scolyticida Ashmead, 1893. Can. Entomol. 25:74.
Heterospilus blackmanni Rohwer, 1919. Can. Entomol. 51:161. **NEW SYNONYMY.**

Specimens under both of these names were reared from *Scolytus quadrispinosus* Say and the synonymy is based on examination of the holotypes.

Genus **Ontsira** Cameron

Ontsira Cameron, 1900. Mem. Proc. Manchester Lit. Phil. Soc. 44:89. Type-species: *Ontsira reticulata* Cameron.
Doryctes (Doryctodes) Hellén, 1927. Acta Soc. Fauna Flora Fenn. 56:40. Type-species: *Rogas imperator* Haliday. **NEW SYNONYMY.**
Doryctodes Hellén: Marsh, 1966. Trans. Amer. Entomol. Soc. 92:503.

The above synonymy of *Doryctodes* with *Ontsira* is based on recent examination of the type-species of *Ontsira*. The new combinations for the North American species included in my recent revision (loc. cit. supra) are as follows.

Ontsira antica (Wollaston), new combination

Clinocentrus anticus Wollaston, 1858. Ann. Mag. Nat. Hist. (Ser. 3) 1:24.
Doryctes gallicus Reinhard, 1865. Berlin. Entomol. Ztschr. 9:248. **NEW SYNONYMY.**
Doryctes incertus Ashmead, 1889(1888). Proc. U. S. Natl. Mus. 11:627. **NEW SYNONYMY.**
Doryctodes gallicus (Reinhard): Marsh, 1966. Trans. Amer. Entomol. Soc. 92:508.

Ontsira carinata (Ashmead), new combination

Rhyssalus carinatus Ashmead, 1889(1888). Proc. U. S. Natl. Mus. 11:630.
Doryctodes carinatus (Ashmead): Marsh, 1966. Trans. Amer. Entomol. Soc. 92:507.

Ontsira imperator (Haliday), new combination

Rogas imperator Haliday, 1836. Entomol. Mag. 4:46.
Ischiogonus zonatus Wesmael, 1838. Nouv. Mém. Acad. Sci. Bruxelles 11:127.
Bracon praecisus Ratzeburg, 1852. Ichn. Forstins., v. 3, p. 36.
Syngaster cingulatus Provancher, 1880. Nat. Can. 12:162.
Doryctodes imperator (Haliday): Marsh, 1966. Trans. Amer. Entomol. Soc. 92:509.

Ontsira krombeini (Marsh), new combination

Doryctodes krombeini Marsh, 1966. Trans. Amer. Entomol. Soc. 92:511.

Ontsira mellipes (Ashmead), new combination

Doryctes mellipes Ashmead, 1889(1888). Proc. U. S. Natl. Mus. 11:627.
Doryctodes mellipes (Ashmead):Marsh, 1966. Trans. Amer. Entomol. Soc. 92:511.

Ontsira occipitalis (Marsh), new combination

Doryctodes occipitalis Marsh, 1966. Trans. Amer. Entomol. Soc. 92:512.

Ontsira tuberculata (Marsh), new combination

Doryctodes tuberculatus Marsh, 1966. Trans. Amer. Entomol. Soc. 92:514.

Ontsira wasbaueri (Marsh), new combination

Doryctodes wasbaueri Marsh, 1966. Trans. Amer. Entomol. Soc. 92:515.

Genus **Pioscelus** Muesebeck and Walkley

Pioscelus borealis (Ashmead), new combination

Caenophanes borealis Ashmead, 1891. Can. Entomol. 23:2.
Heterospilus borealis (Ashmead):Muesebeck and Walkley, 1951. U. S. Dept. Agr., Agr. Monog. 2:179.

This generic transfer is based on recent examination of the holotype.

Genus **Rhaconotus** Ruthe

Rhaconotus Ruthe, 1854. Stettin. Entomol. Ztg. 15:349. Type-species: *Rhaconotus aciculatus* Ruthe.
Hedysomus Foerster, 1862. Verh. Naturh. Ver. Rheinlande 19:238. Type-species: *Hedysomus elegans* Foerster.
Hormiopterus Giraud, 1869. Ann. Soc. Entomol. France (4) 9:238. Type-species: *Hormiopterus ollivieri* Giraud.
Rhadinogaster Szépligeti, 1908. Notes Leyden Mus. 29:223. Type-species: *Rhadinogaster testacea* Szépligeti. **NEW SYNONYMY.**
Euryphrymnus Cameron, 1910. Wien. Entomol. Ztg. 29:100. Type-species: *Euryphrymnus testaceiceps* Cameron.

The synonymy of *Rhadinogaster* is based on recent examination of the type. A revision of the North American species of *Rhaconotus* is now in progress.

Notiospathius, a New Neotropical Genus (Hymenoptera: Braconidae)

Robert W. Matthews and Paul M. Marsh

Respectively: Department of Entomology, University of Georgia, Athens 30602; and Systematic Entomology Laboratory, Agricultural Research Service, USDA—Mail Address: ℅ U. S. National Museum, Washington, D. C. 20560.

ABSTRACT

The new genus *Notiospathius* is proposed for those species from Central and South America formerly placed in *Spathius*. The type-species *N. terminalis* (Ashmead) is redescribed and *Stenophasmus apicalis* Ashmead is a new synonym of it. Thirteen previously described species are transferred to the new genus.

A recent revision of the North American *Spathius* (Matthews, 1970) pointed out that the spathiines appeared to have undergone extensive radiation in Central and South America. However, while sharing the general habitus of typical *Spathius*, certain striking venation anomalies suggested that these Neotropical species may not be congeneric with *Spathius* as currently defined. Further study has confirmed this; therefore, as a prelude to a published revision of the Neotropical spathiines, those described species belonging to this group are here segregated into a newly described genus, *Notiospathis* to allow their more accurate placement in the Doryctinae in the Braconidae section of the forthcoming *Hymenopterorum Catalogus* being prepared by Dr. R. D. Shenefelt.

Notiospathius Matthews and Marsh, new genus

Type-species.—Stenophasmus terminalis Ashmead, 1894. Present designation.

Description.—Head subcubical, variously sculptured; occipital carina fused with hypostomal carina ventrally; first flagellar segment longer than second; fore wing with 3 cubital cells; recurrent vein entering first cubital cell, rarely interstitial with first intercubitus; subdiscoideus leaving first brachial cell below middle; hind wing with mediellen cell narrow, its widest part less than ½ greatest hind wing width; first segment of mediella about 6X basella length; radiella absent or at most very weakly developed; abdomen petiolate; first abdominal tergum lengthened, and distinctly dilated towards apex; fore tibia with a row of 5 or more stout spines on anterior edge; ovipositor varying in length.

The species included in this genus are superficially similar to those in the genus *Spathius,* but differ in wing venation by having the recurrent vein received by the first cubital cell and the subdiscoideus arising below the middle of the brachial cell in the fore wing and by the narrow mediellen cell, very long first segment of the mediellen and absence or only weak development of the radiella in the hind wing. This venation is widespread among Neotropical braconids having the *Spathius* general habitus. However, several other less common venation types also exist among undescribed Neotropical spathiines, including one specimen which was found to possess the typical *Spathius* venation (recurrent vein received by second cubital cell, the subdiscoideus arising above the middle of the brachial cell in the fore wing and mediellen cell at least as wide as ½ hind wing width, the first segment of the mediella not more than 3X basella length and radiella distinct).

Another character which is useful in distinguishing the two is shape of the hind coxa. In many *Spathius*, including all North American species, there is a ventral tooth near the base of the hind coxa. This ventral tooth is absent in *Notiospathius* (and some Oriental species of *Spathius*).

Notiospathius terminalis (Ashmead), n. comb.
(Figs. 1–2)

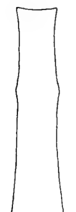
Stenophasmus terminalis Ashmead, 1894, p. 114.
Stenophasmus apicalis Ashmead, 1900, p. 296. (Not *Stenophasmus apicalis* Westwood, 1882). Nomen nudum.

Female.—Body length, 4.0–6.0 mm; ovipositor 4.0–5.5 mm. Color brownish orange, palpi and fore and mid coxae tan, antennal tips white, ovipositor sheaths brown except white subapical annulus. Head subcubical, vertex and frons uniformly transversely striate; temples smooth; malar space smooth, about ⅓ eye height; temple width about $^2/_5$ eye height; ocellar triangle slightly wider than long, lateral ocelli separated by less than their diameters; ocellocular distance less than width of ocellar triangle; antennae about as long as body, each with about 36 flagellomeres, the apical 6 white. Pronotum with distinct wide lateral areas with several irregular cross carinae; proepisternum rugulose; notauli weakly impressed, fused posteriorly into broad area of longitudinal rugosity; mesonotal lobes strongly transversely rugose, median lobe weakly depressed centrally; scutellar furrow deep, with 4–6 cross carinae; scutellar disc smooth; mesopleural disc smooth and shining above sternaulus, becoming longitudinally rugose-striate dorsally; mesosternum smooth; sternaulus shallow with weak cross carinae anteriorly; prepectal carina complete; prepectal area smooth; propodeum sloping gradually to petiole, lacking distinct carinae or defined areas, rather the whole longitudinally strigose-granular becoming rugulose laterally. Fore tibiae with an irregular row of 6–9 spines along anterior margin and a row of 6 or 7 apically; hind coxae elongate cylindrical with a basal tooth ventrally and weakly transversely strigose-granular dorsally. Wings hyaline, veins light brown; venation as in Fig. 1. Petiole (Fig. 2) straight, 3½ times as long as apical width and about as long as hind tibiae, uniformly coarsely granular, except apical medial lobe smooth; tergum (2 + 3) strongly granular over basal ¾, apically smooth, the lateral margins thickened along full length; tergum 4 with weaker granular sculpture anterior to subapical transverse row of setae and lateral margins thickened; remaining terga smooth; ovipositor about equal to body length.

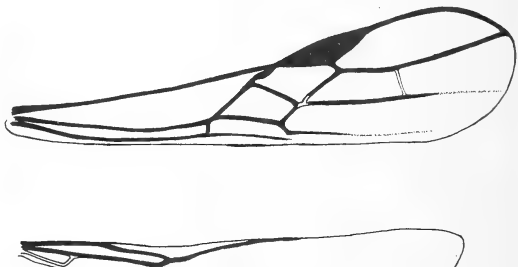
Male.—Essentially as in female; vertex and frons only weakly transversely striate; mesonotum granular, lacking distinct transverse strigosity; antennae entirely brown with 29–31 flagellomeres.

Distribution.—West Indies: Islands of St. Vincent and Grenada.

Ashmead described this species from 23 specimens, of which 10 are now in the U. S. National Museum, the remainder being in the British Museum (Natural History). We are deferring any lectotype



2



1

Figs. 1 and 2, *Notiospathius terminalis* (Ashmead): 1, fore and hind wings of female; 2, first abdominal tergum of female.

designations until all of the specimens concerned are studied.

Based on examination of all but 3 of the types, we here transfer 13 other described Neotropical braconids to *Notiospathius*. All appear to possess the characters of the genus and are listed below together with the location of the type. Redescriptions are deferred until a full revision and keys can be presented. The two Fabricius species were not seen, but appear to belong here based on comments by Schulz (1912) and Townes (1961).

Notiospathius caudatus (Szepligeti), n. comb.

Psenobolus caudatus Szepligeti, 1902. Term. Fuz. 25: 49. Brazil. (Budapest)

Notiospathius columbianus (Enderlein), n. comb.

Psenobolus columbianus Enderlein, 1912. Archiv Naturges. 78(A) (2): 6. Colombia. (Warsaw)

Notiospathius diversus (Szepligeti), n. comb.

Spathius diversus Szepligeti, 1902. Term. Fuz. 25: 50. Brazil. (Budapest)

Notiospathius eleutherae (Ashmead), n. comb.

Spathius eleutherae Ashmead, 1896. Bull. Lab. Nat. Sci. St. Univ. Iowa 1896: 32. Bahamas. (Ames, Iowa)

Notiospathius flavotestaceus (Ashmead), n. comb.

Spathius flavotestaceus Ashmead, 1895. Proc. Zool. Soc. London 1895: 783. Grenada. (London)

Notiospathius fuscipes (Cameron), n. comb.

Spathius fuscipes Cameron, 1887. Bio. Cent.-Amer., Hymen. 1: 381. Panama. (London)

Notiospathius leucacrocera (Enderlein), n. comb.

Psenobolus leucacrocera Enderlein, 1912. Archiv Naturges. 78(A) (2): 8. Brazil. (Warsaw)

Notiospathius meliorator (Fabricius), n. comb.

Pimpla meliorator Fabricius, 1804. Systema Piezatorum, p. 118. British Guiana. (Copenhagen)

Notiospathius necator (Fabricius), n. comb.

Pimpla necator Fabricius, 1804. Systema Piezatorum, p. 117. British Guiana. (Copenhagen)

Notiospathius ornaticornis (Cameron), n. comb.

Spathius ornaticornis Cameron, 1887. Bio. Cent.-Amer., Hymen. 1: 381. Panama. (London)

Notiospathius sculpturatus (Enderlein), n. comb.

Psenobolus sculpturatus Enderlein, 1912, Archiv Naturges. 78(A) (2): 7. Columbia. (Warsaw)

Notiospathius striatifrons (Cameron), n. comb.

Spathius striatifrons Cameron, 1887. Bio. Cent.-Amer., Hymen. 1: 382. Panama. (London)

Notiospathius tinctipennis (Cameron), n. comb.

Spathius tinctipennis Cameron, 1887. Bio. Cent.-Amer., Hymen. 1: 379. Panama. (London)

References Cited

Ashmead, W. H. 1894. Report upon the parasitic Hymenoptera of the island of St. Vincent. (In: Riley, C. V., Ashmead, W. H. and Howard, L. O.) J. Linn. Soc. (Zool.) 25: 56–254.

———. 1900. Report upon the Aculeate Hymenoptera of the islands of St. Vincent and Grenada, with additions to the parasitic Hymenoptera and a list of the described Hymenoptera of the West Indies. Trans. R. Entomol. Soc. Lond., 1900: 207–367.

Matthews, R. W. 1970. A revision of the genus *Spathius* in America north of Mexico (Hymenoptera: Braconidae). Contr. Amer. Entomol. Inst. 4(5): 1–86.

Schulz, W. A. 1912. Aelteste und alte Hymenopteren skandinavischer Autoren. Berlin. Ent. Ztschr. 57: 52–102.

Townes, H. 1961. Some species described as ichneumonids but belonging to other families (Hymenoptera). Proc. Entomol. Soc. Wash. 63: 287–289.

Westwood, J. O. 1882. Descriptions of new or imperfectly known species of Ichneumones adsciti. Tijdschr. Ent. 25: 17–48.

New North American Euvrilletta *and* Xyletinus *with Keys to Species (Coleoptera: Anobiidae)*

Richard E. White

Systematic Entomology Laboratory, Agricultural Research Service, USDA. Mail address: ℅ U. S. National Museum, Washington, D. C. 20560.

ABSTRACT

The new species *Euvrilletta californica* from California and Nevada, *E. serricornis* from Nevada, *Xyletinus obsoletus* from Nevada, and the new subspecies *X. mucoreus variabilis* from Maryland, are described. An identification note is given for *X. distans* Fall. Keys are given for the North American species of *Euvrilletta* and *Xyletinus;* illustrations are presented.

The following descriptions of 3 new species and a new subspecies result from study of collections recently sent to me for identification.

Euvrilletta californica, n. sp.
(Fig. 2, 3)

General.—Elongate-cylindrical, body 2.6 to 2.7 times as long as wide, elytra nearly parallel-sided at about basal 3/5; body color beneath pubescence orange or red-brown to moderately dark brown, color of legs as that of body, antennae more or less orange-brown; pubescence tan, with a silky sheen in proper light, moderately dense, obscuring surface, mostly appressed, dorsal surface and head with short, bristling hairs.

Head.—Surface with very small, moderately dense granules on a nearly smooth, shining, finely punctate background, vertex with a fine, longitudinal carina, a fine groove adjacent to eye; eyes of femal small, bulging, separated by 4.7 to 4.8 times frontal width of an eye, eyes of male moderately large, bulging, separated by 2.4 to 3.3 times frontal width of an eye; antenna of male about 0.6 times as long as body, segment 3 weakly serrate, segments 4 through 8 more distinctly serrate, each of these 5 segments progressively more elongate than 1 preceding it, 9th segment 1.4 times as long as segment 8, segments 9 through 11 as long as 7 preceding segments combined, segments 9 and 10 weakly serrate, each about 3.5 times as long as wide, 11th segment 5 to 6 times as long as wide; antenna of female a little less than ⅓ as long as body, segments 3 through 10 moderately serrate, last 3 segments united as long as 6 to 7 preceding united. Last segment of maxillary palpus subfusiform, that of male nearly 3 times as long as wide, that of female about 2 times as long as wide; last segment of labial palpus subfusiform, that of male about 3 times as long as wide, that of female about 2 times as long as wide.

Dorsal surface.—Pronotal disk nearly evenly rounded throughout in both sexes, very slightly depressed at base each side of center, often slightly depressed along margin above anterior angle, extreme side in male sometimes flattened, usually nearly evenly rounded, sometimes slightly, broadly bulging, side in female broadly, more distinctly bulging than in male; lateral margin in male complete, usually narrowly produced, sometimes moderately produced and explanate, lateral margin of female sometimes (1 of 3 specimens) incomplete anteriorly, margin narrowly produced; sculpture at side of pronotum of small (moderately dense) granules on a very finely granulate surface. Scutellum about as wide as long, apex rounded to somewhat pointed. Elytra more or less distinctly striate, each elytron with 10 complete, 1 short scutellar and 1 short subhumeral stria, striae of small, elongate punctures, intervals usually obscurely to weakly convex; surface extremely finely granulate; pubescence of female usually (2 or 3 specimens) forming weak vittae.

Ventral surface.—Metasternal carina behind middle coxae broadly angulate, metasternum longitudinally, more or less distinctly grooved at center, groove weak to absent basally; surface finely punctate-granulate. Abdomen with first suture more impressed than others, surface finely granulate-punctate; outer face of front tibia concave at apex only, outer face of middle tibia more or less flattened to concave at apex.

Length.—5.0 to 7.8 mm.

The holotype (male, no. 72496 in USNM) bears the data "SAN YSIDRO, CA; VII-25 1970; BLACKLIGHT."

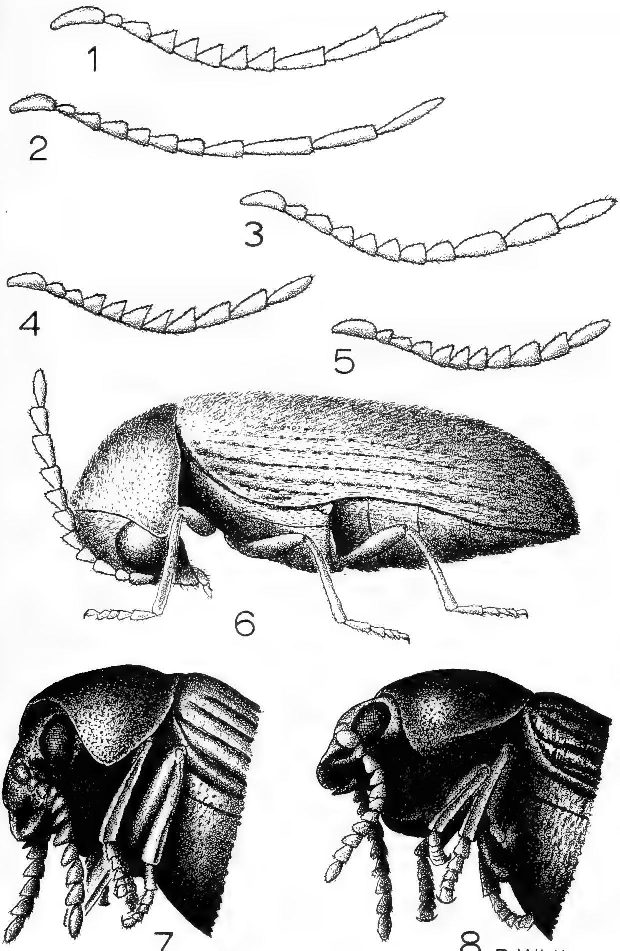


Fig. 1–5, Antennae: 1, *Euvrilletta serricornis,* n. sp., male holotype; 2, *Euvrilletta californica,* n. sp., male paratype; 3, *Euvrilletta californica,* n. sp., female paratype; 4, *Xyletinus distans* Fall, male paratype; 5, *Xyletinus distans* Fall, female holotype; Figs. 6–8, lateral views: 6, *Xyletinus variabilis,* n. sp., male holotype; 7, *Xyletinus fucatus* Leconte; 8, *Xyletinus obsoletus,* n. sp., male paratype.

The allotype (in USNM) bears the same data except that it was taken on VII-21, 1970. Four paratypes with the following data are in USNM: "Box Spr. Mats., Cal., Riverside; VII-9-64, G. E. Wallace; light", ♀ ; "Riverside, Calif., VIII-5-63; at light, E. I. Schlinger", ♂ ; "CAL., Alameda Co., 3 m. S. Sunol, 22-VIII-1971, W. H. Tyson; Collected at u.v. light", ♂ ; and "Riverside, Calif., VII-12-64; at light, E. I. Schlinger", ♂ . Five male paratypes (4 in NDA, 1 in USNM) have the data "Oak Springs Summit, Lincoln Co., Nev., VIII-10-1971, elev. 6231′; G. M. Nishida, D. F. Zoller Collectors". One female (in NDA) bears the data "Reno, Nev., Washoe Co., VII-7-1966; R. C. Bechtel Collector". A single male specimen (in CAS) bears the following "Daggett, San Bern. Co., Cal. 7-22-57; D. Giuliani Collector". A male paratype (in William Tyson collection) bears the data "CAL., Alameda Co., 3 m. s. Sunol, 22-VIII-1971, W. H. Tyson; Collected at u.v. light". In total, 14 specimens have been seen.

For the differences between *californica* and *texana* VanDyke, its nearest relative, see the key, below, to *Euvrilletta* species.

Euvrilletta serricornis, n. sp.
(Fig. 1)

General.—Elongate-cylindrical, body 2.5 to 2.7 times as long as wide, elytra nearly parallel-sided at about basal ¾; dorsal surface, metasternum, and legs red-brown, pronotum and metasternum clouded with dark brown, head and abdomen very dark brown, head at vertex and apex, and abdomen at base more or less red-brown, antennae more or less orange-brown; pubescence tan, with a slight silky sheen in bright light, very short, not bristling, less than moderate in density, not obscuring surface.

Head.—Surface with small, moderately dense granules on a finely granulate background; vertex with a fine, longitudinal carina, weaker apically, attaining level of eyes, with an obscure groove adjacent to each eye; eyes of male large and bulging, separated by about 1.4 to 2.0 times frontal width of an eye; antenna of male just over 0.5 as long as body, 3rd segment serrate, segments 4 through 8 strongly serrate, 4 through 7 subequal, 8th a little longer than others, segments 9 through 11 as long as 7 preceding united, 9th and 10th serrate at apex. Last segment of maxillary palpus subtriangular, over 2 times as long as wide, widest beyond middle, apex obliquely truncate; last segment of labial palpus subtriangular, about 1.6 times as long as wide, widest beyond middle, apex obliquely truncate.

Dorsal surface.—Pronotal disk nearly evenly rounded, pronotum at base each side of middle shallowly depressed, bulging at side, at side behind anterior margin and before bulge somewhat to distinctly depressed, lateral margin complete, moderately produced; surface at side with small, moderately dense granules on a finely granulate background. Scutellum about as wide as long, apex bluntly pointed. Elytra more or less clearly striate, each elytron with 10 complete, more or less clearly indicated striae plus a short scutellar and a short subhumeral stria, striae of small, elongate, impressed punctures, intervals weakly convex; surface at base with small, moderately dense granules on a very finely granulate background, small granules sparse to nearly absent over rest of elytron, fine granules occurring throughout.

Ventral surface.—Metasternal carina behind middle coxae small, angulate, metasternal surface finely, longitudinally grooved at middle, weak to absent at base; surface finely granulate-punctate. Abdomen with first suture slightly more distinct than others; surface finely punctate and minutely, obscurely granulate; outer face of fore and middle tibiae flattened nearly throughout.

Length.—4.8 to 5.8 mm.

The holotype (♂, in NDA) and 3 male paratypes (2 in USNM, 1 in NDA) bear the data "Sawmill Canyon, Nye Co., Nev., VII-21-1964, elev. 7600′, Light trap; R. C. Bechtel, collector."

This species is most similar to *texana* VanDyke, and *xyletinoides* Fall; for the differences see the key to *Euvrilletta* species.

There is a female specimen (in NDA) which I have identified as *serricornis* or near. The metasternal carina is broadly arcuate; this and other differences from male types of *serricornis* cause doubts as to whether it is the female of *serricornis* or not.

The addition of *E. serricornis* and *E. californica* to our known fauna emphasises the arbitrary nature of the distinction between *Euvrilletta* and *Xyletinus*. These genera are separated on the basis of the length of the last 3 antennal segments as compared with the rest of the antenna (club as long as all preceding segments combined in *Euvrilletta,* as long as 5 to 6 preceding in *Xyletinus),* but this distinction is not good, for there is no sharp dividing line between the somewhat lengthened last 3 antennal segments of *X. distans,* through the moderately lengthened last 3 segments of *X. brevis* White, to the distinctly lengthened last 3 segments of *E. californica, E. serricornis,* and *E. texana.* I am convinced that a revision of the genera is desirable. In such an endeavor consideration should be given to restriction of *Xyletinus* to the small-eyed, stout-bodied species (these agree with *X. ater* the type-species), restriction of *Euvrilletta* to the type-species *xyletinoides,* and erection of 1 or 2 new genera for the remaining species now placed in *Xyletinus* or *Euvrilletta.*

Xyletinus mucoreus variabilis, n. ssp.
(Fig. 6)

General.—Elongate-cylindrical, body 2.47 to 2.50 times as long as wide, elytra nearly parallel-sided at basal ⅔; body color beneath pubescence as follows, head red-orange, darker red-orange (nearly brown) along mid-line and at top, pronotal color as on head, darker red-orange basally (nearly brown), lightest apically, elytra light red-orange to dull orange, ventral surface dark red-orange, metasternum clouded with brown, abdomen predominantly dark brown to nearly black, apex of each abdominal segment more or less lighter than remainder, legs (except tarsi) and first antennal segment red-orange, tarsi and antennal segments 2–11 dull light orange; pubescence of all surfaces semierect, moderately dense, with a light yellow sheen, more or less obscuring surface sculpture.

Head.—Front very finely, densely granulate, granules of 2 sizes; surface most strongly rounded at vertex, very shallowly depressed above eyes, vaguely, longitudinally carinate at center, with a narrow, more or less distinct groove over each eye. Antenna of male about 0.5 times as long as body (female not seen), segment 3 weakly serrate, segments 4 through 10 distinctly serrate, outer segments of this portion becoming more elongate, segments 4 and 5 similar, a little longer than wide, segment 6 as long as wide, wider than 4 and 5, segment 7 large, wider than 6, a little longer than wide, segment 8 as long, not as wide as 7, longer than wide, segment 9 as wide as 8 but longer, about 1.6 times as long as wide, segment 10 not as wide as 9, slightly shorter, more than 2 times as long as wide, 11th segment elongate-cylindrical, 4.6 times as long as wide, 9th through 11th segments as long as 5 preceding united. Eyes of male large and bulging, separated by 1.8 to 2.0 times frontal width of an eye. Last segment of maxillary palpus elongate, pointed, widest near middle, 2.4 to 2.7 times as long as wide; last segment of labial palpus similar to that of maxillary palpus, 2.5 times as long as wide.

Dorsal surface.—Pronotal disk nearly evenly rounded, at base slightly depressed each side of middle, at side flat or slightly concave, weakly undulate; lateral margin sharp, distinct, raised, more or less undulate between posterior and anterior angles; surface finely, evenly granulate throughout, granules of 2 sizes. Scutellum slightly wider than long, apex rounded. Elytra distinctly striate, each elytron with 10 complete striae, a scutellar stria and 2 short striae diagonally below humerus, striae irregular, of impressed, broken lines, or elongate punctures, intervals more or less convex; surface very finely, nearly evenly granulate throughout, intervals with minute, shallow punctures.

Ventral surface.—Metasternal process behind middle coxae arcuate to nearly angulate, surface of metasternum rather finely granulate, longitudinally, deeply, rather broadly grooved on midline from posterior margin to past middle. First abdominal suture a little less distinct than others, surface granulate-punctate; outer face of anterior, middle, and hind tibiae more or less flat.

Length.—4.4 to 5.1 mm.

The male holotype (USNM no. 72495) and 2 paratypes (both males, I believe; in USNM) bear the data "Snow Hill, Md. Spring-1950, WHAnderson; reared from dead holly branch." Most of the abdomen of 1 paratype is missing with just the sternites present, and the entire abdomen of the other paratype is missing.

I find no differences between the genitalia of the holotype of *m. variabilis* and *m. mucoreus* Leconte. The external differences between these subspecies and the distribution are given in the key to *Xyletinus* species.

Xyletinus obsoletus, n. sp.
(Fig. 8)

General.—Elongate-robust, 1.7 to 1.9 times as long as wide, elytra widest at middle; body and head dark red-brown, head, pronotum, and, to a lesser extent, ventral surface and elytra clouded with black, appendages red-brown, antennae often lightest, sometimes nearly orange; pubescence of dorsal surface dark, blending into background, extremely short, very sparse, individual hairs separated on an average by a little less than their length, hairs of ventral surface longer, lighter in color, more prominent than those of dorsal surface, pubescence appressed throughout.

Head.—Front finely, very densely punctate, punctures varying in size; surface nearly evenly rounded throughout, but often with shallow depressions each side of midline near center. Eyes small, not or slightly bulging, eyes of ♂ separated by 5.0 to 5.7 times frontal width of an eye, those of female separated by 6.2 to 7.0 times frontal width of an eye. Antennae of male about 0.4 times as long as body, that of female about 0.3 times as long as body, antenna of male with segments 4 through 10 serrate, basal segments of this portion a little wider than long and outer segments more elongate, longer than wide; antenna of female with segments 4 through 10 serrate, basal segments of this portion about as wide as long and outer segments longer than wide, last segment (both sexes) about 2 times as long as wide. Last segment of maxillary palpus (both sexes) about 2 times as long as wide, inner margin arcuate, tip blunt; last segment of labial palpus (both sexes) nearly triangular, longer than wide, inner angle very broadly rounded.

Dorsal surface.—Pronotum rounded nearly throughout, inflated at sides, male often with shallow depressions on disk each side of center, at base (both sexes) rather broadly depressed each side of center; surface of disk very finely, densely punctate, at side punctures larger, very dense, partially running together, surface thus finely scabrous; lateral margin sharp, explanate at posterior half, weaker before middle of side, usually broadly absent anteriorly, sometimes feebly indicated to near anterior margin, side of pronotum rounded at anterior ⅓. Scutellum a little wider than long, apex rounded. Elytra striate, each elytron with 10 complete, distinct, finely impressed grooves (a little weaker apically), plus a short scutellar, and 1 or 2 short striae at side below humerus, striae most deeply impressed below humerus, intervals flat, some more or less convex at apex; surface finely, densely punctate, punctures often running together and forming more or less distinct transverse ridges.

Ventral surface.—Metasternal process behind middle coxae arcuate, surface densely punctate, punctures varying in size; first abdominal suture less distinct than others, 5th segment of male shallowly depressed before apex, that of female shallowly depressed and with a small tubercle each side of depression; outer face of anterior and middle tibiae shallowly concave except at base, outer face of hind tibia flat.

Length.—3.0 to 4.9 mm.

The male holotype, the allotype and 23 paratypes (9 males, 14 females) bear the data "Incline Village, Washoe Co. Nev., V-7-1971; House; C. W. Haas Collector; Nev. Dept. Agr. No. 71 E 10–3." Four paratypes are in the USNM, the holotype and the rest of the specimens are in NDA.

This species is nearest *X. fucatus* Leconte; the differences are given in the key to *Xyletinus* species.

Xyletinus distans Fall
(Fig. 4, 5)

Xyletinus distans Fall, 1905, p. 200.

I have, for some years, confused one or the other of the species I herein described as *Euvrilletta californica* and *E. serricornis* with *Xyletinus distans*. The female type has recently been sent to me (no. 24666 in MCZ, with data "S. Madre, Cal.; June; distans, TYPE; M.C.Z. Type 24666") and a male paratype (in CAS, with data "SAN DIEGO. CAL.; *Xyletinus distans* Fall.; Blaisdell Collection.") so I can now assign the name with certainty. The locality at which the female type was collected is not given in the original description.

The male and female antennae of this species are illustrated.

Key to North American Species of *Euvrilletta*

1. Last 3 antennal segments as long as all 8 preceding together .... *xyletinoides* Fall
   Last 3 antennal segments no longer than 7 preceding together 2

2(1). Hairs of dorsal surface entirely appressed, bristling hairs absent .... *serricornis* White
   Hairs of dorsal surface with both appressed and short, or minute, bristling hairs 3

3(2). Length of each antennal segment of male from 4 through 7 subequal to width; Texas .... *texana* VanDyke
   Length of each antennal segment of male from 4 through 7 nearly 2 times width; California .... *californica* White

Key to North American Species of *Xyletinus*

1. Body more elongate, 2.3 to 2.7 times as long as wide; eyes large, separated by 1.0 to 3.7 times frontal width of an eye 2
   Body less elongate, 1.6 to 2.0 times as long as wide; eyes small, separated by 4 to 7 times frontal width of an eye 9

2(1). Pubescence of dorsal surface with both appressed and short, or minute, bristling hairs 3
Pubescence of dorsal surface entirely appressed, bristling hairs absent 4
3(2). Head and pronotum red-brown, ventral surface predominantly dark brown, elytra orange-brown; Maryland ....*mucoreus variabilis* White
Color nearly uniform red-brown to brown throughout; South Carolina to Florida to Texas ....*m. mucoreus* Leconte
4(2). Antennal segments 9 through 11 together subequal in length to preceding 4 to 5 segments 5
Antennal segments 9 through 11 together subequal in length to preceding 5 to 7 segments 6
5(4). Side of pronotum distinctly rounded, lateral margin very narrow and not reflexed; eastern half of U. S. ....*peltatus* (Harris)
Side of pronotum flat to weakly rounded, lateral margin rather broad and reflexed; northern U. S. and Canada ....*harrisii* Fall
6(4). Metasternal carina adjacent to mesocoxae broadly, nearly evenly arcuate 7
Metasternal carina adjacent to mesocoxae not as above, angulate..... 8
7(6). Body orange-brown; pronotal lateral margins more broadly produced; striae weak; California ....*distans* Fall
Body red-brown to brown; pronotal lateral margins narrower; striae strong; South Carolina to South Dakota ....*brevis* White
8(6). Intermediate antennal segments longer than wide........*grossus* VanDyke
Intermediate antennal segments wider than long ....*sequoiae* VanDyke
9(1). Tarsi elongate and slender, last segment 4 to 5 times as long as wide; Wyoming ....*gracilipes* Fall
Tarsi stout, last segment not over 2 times as long as wide 10
10(9). Pubescence of elytra patterned, yellow with brown patches; southern Texas ....*fasciatus* White
Pubescence of elytra unicolorous; various localities 11
11(10). Lateral margin of prothorax incomplete (fig. 8) ....*obsoletus* White
Lateral margin of prothorax complete (fig. 7)...................... 12
12(11). Outer face of anterior tibia concave only at apical half; Texas ....*pubescens* Leconte
Outer face of anterior tibia concave throughout; various localities 13
13(12). Eyes larger, separated by 4.0 to 4.5 times frontal width of an eye (males) 14
Eyes smaller, separated by 5 to 7 times frontal width of an eye (females) 15
14(13). First two abdominal segments with a median longitudinal line of erect hairs ....*lugubris* Leconte
First two abdominal segments lacking a line of erect hairs ....*fucatus* Leconte
15(13). Intermediate segments of antennae two times as wide as long........ ....*lugubris* Leconte
Intermediate segments of antennae but slightly wider than long....... ....*fucatus* Leconte

Acknowledgements

My thanks are offered to John Lawrence of the Museum of Comparative Zoology (MCZ) at Harvard, and to Hugh Leech of the California Academy of Sciences (CAS) for loan of type specimens; to Robert Bechtel, Nevada Department of Agriculture (NDA), and to William Tyson of Fremont, California, for loan of specimens.

Reference

Fall, H. C. 1905. Revision of the Ptinidae of Boreal America. Trans. Amer. Ent. Soc. 31: 97–296.

SCIENTISTS RECEIVE ACADEMY'S ANNUAL AWARDS

Awards for outstanding scientific achievement were conferred upon two research scientists and two science teachers at the Annual Awards Dinner Meeting of the Academy on March 15 at the Cosmos Club.

The research investigators honored were James L. Reveal of the University of Maryland in the biological sciences, and Martin E. Glicksman of the Naval Research Laboratory in the physical sciences.

The science teachers honored were Jerry B. Marion of the University of Maryland's Department of Physics, and Robert C. Vincent of George Washington University's Department of Chemistry.

Award winners were introduced by Dr. David S. Sparks, Dean of the Graduate School at the University of Maryland, Dr. J. H. Schulman, Associate Director of Research of the Naval Research Laboratory, and Dr. Charles R. Naeser, Head of the Department of Chemistry at George Washington University.

The Academy's awards program was initiated in 1939 to recognize young scientists of the area for "noteworthy discovery, accomplishment or publication" in the biological, physical and engineering sciences. An award for outstanding teaching was added in 1955 and another for mathematics in 1959. Except in teaching, where no age limit is set, candidates for awards must be under 40. Previous award winners are listed at the end of the article.

Biological Sciences

James L. Reveal was cited "for distinguished research in Plant Systematics, especially in *Eriogonium* and for the Intermountain Flora." Dr. Reveal, an Assistant Professor in the Department of Botany at the University of Maryland, has made major contributions to the systematics of a large group of plants and has worked with several senior investigators in the preparation of an important flora.

James L. Reveal

Dr. Reveal was born March 29, 1941 in Reno, Nevada. He obtained his B.S. and M.S. from Utah State University in 1963 and '65 respectively. He received his Ph.D. from Brigham Young University in 1969 where he was selected as the outstanding graduate student in 1968. His professional experience, teaching assistantships at Utah State (1963–65) and Brigham Young (1965–68), Predoctoral Internship, Smithsonian Institution (1966–67), NSF Traineeship, Brigham Young (1968–69) and Assistant Professor at the University of Maryland since 1969, has embraced field work in Utah, Mexico, California, Arizona, Nevada, Colorado, New Mexico, Texas and the Chesapeake Bay Region. In addition to his remarkable research record (over 70 publications), Dr. Reveal serves as Research Associate, Smithsonian

Institution, and Secretary, Steering Committee, First International Congress of Systematic and Evolutionary Biology, and he gives numerous talks to local public schools on botany, fossil plants, ecology, flowering plants and mushrooms. He is a member of Sigma Xi, AAAS, AIBS, ACPT, BSA, CBC, and IAPT.

Physical Sciences

Martin E. Glicksman was cited "for outstanding contributions to physical metallurgy and materials science." Dr. Glicksman, Branch Head, Transformations and Kinetics Branch, Metallurgy Division, Naval Research Laboratory, was honored for the development and quantitative application of gradient hot-stage electron microscopy to the study of crystallization and nucleation processes in metals and the sequelae of theoretical studies leading to the new concept

Martin E. Glicksman

of heterophase dislocations. He conceived the idea that, with proper thermomechanical constraints (the gradient hot stage) a thin metallic specimen could be melted and solidified under precisely controlled conditions within the transmission electron microscope, thus permitting *in situ* observation of sub-micron processes accompanying the solid-liquid phase transition. It represents an important advance in the application of electron microscopy.

Dr. Glicksman's professional education and training include two degrees earned at Rensselaer Polytechnic Institute (B. Met. E., June 1957 and Ph.D., February 1961). For the two-year period Feb. 1961 to Feb. 1963, he held a National Academy of Science—National Research Council Postdoctoral Associateship. Professional positions with which he has been associated recently are Metallurgist, Research Staff, Naval Research Laboratory (Feb. 1963–Oct. 1967); Section Head, Code 6330, NRL (Oct. 1967–Feb. 1969); and Branch Head, Code 6350, NRL (June 1969–present). He holds membership in several technical societies. Asards and honors received by him are the following: RESA Award in Pure Science (1968); A. S. Fleming Award (1968); Outstanding Young Men of America (1969); NRL Research Paper Award (1969); American Society for Metals, Grossman Award (1971); NRL Research Paper Award (1971). Dr. Glicksman has published more than one hundred research papers in leading science periodicals.

Teaching of Science

Jerry B. Marion and Robert C. Vincent share the Teaching of Science Award. Dr. Marion, a professor in the Physics Department at the University of Maryland, was cited "for contributions to the teaching of science personally and through his books." Dr. Vincent, a professor in the Chemistry Department at George Washington University, was cited "for his dedicated and inspiring service as a teacher of analytical chemistry."

Professor Marion is not only an excellent and highly productive research scientist but also an unusually effective classroom teacher. On both a national and international level he has made great contributions to teaching through the writing and editing of influential and popular books. He has written nine textbooks in elementary and intermediate physics which have become used and accepted textbooks at universities all over the world. His books range from *Classical Electromagnetic Radiation and Mathematical Preparation for General Physics*

Jerry B. Marion

Robert C. Vincent

for the serious student of physics to *Physics: The Foundations of Modern Science* and *Physics and the Physical Universe* for the non-scientist and general reader.

Professor Marion was born in Mobile, Alabama, December 10, 1929. He obtained his B.A. from Reed College in 1952 and his M.S. and Ph.D. both from Rice Institute in '53 and '55, respectively. Following an NSF post-doctoral fellowship in 1955–56, and an instructorship at the University of Rochester in 1956–57, he came to the University of Maryland as an Assistant Professor in 1957 with promotions to Associate Professor in 1960 and full Professor in 1962. He was a Guggenheim Fellow in 1965. With over 125 publications, Professor Marion is one of the nation's most outstanding University science educators. "His writing style and illustrations make physics exciting to learn. He is a champion lecturer and author who strives for excellence in science education and never loses sight of the basic needs and interests of the student."

Professor Vincent's greatest interests are chemistry and students. His lectures are models of clarity and exposition and he holds his students to high standards of performance. As an inspiring teacher he has influenced many of his students to select chemistry as their undergraduate major.

His interest in students extends well outside of the classroom. He served seventeen years as the advisor to the pre-medical students, ten years as the faculty advisor to Alpha Chi Sigma, and served as faculty sponsor for the pre-medical group that received a charter to establish Alpha Epsilon Delta, the national honorary pre-medical society. Currently he is serving as faculty advisor to that group. Because of his demonstrated interest in and assistance to students, he was elected to Omicron Delta Kappa, an undergraduate organization for campus leaders.

Professor Vincent was born in Maine, New York, in September, 1912. He obtained his A.B., A.M. and Ph.D. all from Cornell University in 1935, 1937, and 1940 respectively. His life-long devotion to teaching began with an instructorship at the George Washington University in 1940–41. On military leave as a Captain in the United States Army from 1942–45, he returned to George Washington University as an Assistant Professor in 1946, was promoted to Associate Professor in 1949 and full Professor in 1953. The personality and sincerity of Professor Vincent inspires his students with a desire to reciprocate with a far-above-average effort to succeed. His patience, understanding and sympathy make a lasting impression and he sends his students off with a feeling of warmth and durable respect.

BOARD OF MANAGERS MEETING NOTES

October 1972

The 620th meeting of the Board of Managers of the Washington Academy of Sciences was called to order at 8:10 p.m., October 3, 1972 by President-elect Sherlin in the Conference Room of the Lee Building at FASEB.

Treasurer.—Treasurer Rupp presented an interim report for the period Jan. 1 to Sept. 30, 1972. The general conclusion is that the Academy is running a deficit of approximately $6000 for 1972. Mr. Sherlin moved, seconded by Dr. Robbins, acceptance of the report. The motion passed.

Auditing.—Mr. Detwiler reported the satisfactory audit of the Treasurer's books.

Nominating.—The committee report was presented by the Chairman, Dr. Robbins. The following slate of nominees was prepared for 1973–74:

President-elect: Richard P. Farrow, Kurt H. Stern
Secretary: Jean Boek, Patricia Sarvella
Treasurer: George Abraham, Nelson W. Rupp
Managers-at-Large (two to be elected): Rita R. Colwell, Alphonse F. Forziati, Howard J. Laster, H. Ivan Rainwater, Mary Louise Robbins, Alfred Weissler.

Mr. Detwiler, seconded by Dr. Gaum, moved acceptance of the report. The motion passed. On a motion of Dr. Irving, seconded by Dr. Griffiths, the slate was approved for submission to the Academy members.

Executive Committee.—Dr. Cook discussed the agreement with George Washington University for the use of half the Academy's office space for Mr. Cornfield's project. FWU will pay half the rent on a month-to-month basis.

Meetings Committee.—Dr. Ederer announced that the first meeting of the Academy would be held jointly with the Junior Academy on October 28 at Georgetown University with Dr. Westerhout of the University of Maryland as speaker. The problem of declining Junior Academy membership was also discussed.

Dr. Honig announced that the November meeting would include a panel discussion with university students and Academy members concerning student motivation in science. The December meeting tentatively has been arranged with the President's science adviser as speaker.

Symposium Committee.—Drs. Cook and Forziati described tentative plans to have the symposium center on inadvertant man-made climatic changes.

Membership Committee.—On a motion by Dr. Stern, seconded by Dr. Robbins, the following individuals were elected to fellowship: L. D. Ballard, E. H. Fife, Jr., Kun-Yen Huang, P. E. Menzer, H. K. Sleeman, G. L. Wright, Jr. Also approved were R. A. Ward and R. N. Ghose.

Grants-in-Aid.—Dr. Sarvella read several letters of thanks from grant recipients and announced that $630, reimbursable by AAAS, was currently available for distribution.

Encouragement of Science Talent.—Dr. Ederer presented a list of Junior Academy meetings.

Membership Promotion.—Dr. O'Hern described the committee's activities. Letters have been sent to all delegates asking for a list of affiliated society members eligible for fellowship. These individuals will then be contacted.

Public Information.—Dr. Noyes read a letter he is sending to various organizations to promote sales of symposium issues. He requested a lead time of two weeks for announcements.

Editor.—Dr. Foote reported that the September issue is in print. He suggested a committee be formed to promote the sale of symposium issues.

Joint Board.—Dr. Oswald described the planned use of WAS office space by JBSE. A motion, to approve the financial arrangements proposed for this purpose, passed.

Miscellaneous.—Dr. Irving described the D.C. Institute of Chemists which has requested affiliation with WAS. His motion to approve the request passed.

Mr. Abraham suggested a divisional structure for WAS, similar to the N. Y. Academy of Sciences. The suggestion will be passed on the to Policy Planning Committee for study.—Kurt H. Stern, *Secretary.*

February, 1973

The 621st meeting of the Board of Managers was called to order by President Cook at 8:10 p.m. in Conference Room of the Lee Building at FASEB.

Announcements.—The minutes of the October 3, 1972 meeting were approved after the attendance record was corrected as follows: G. W. Irving and L. A. Depue present, J. Honig absent.

Secretary.—Dr. Stern presented the membership figures of recent years, showing a 20% drop since 1968 and suggested that delegates be more active in recruiting Members and Fellows. He also mentioned that the Academy has a large supply of Dr. Farber's last book which has not been sold due to lack of publicity. As a result of subsequent discussion the Editor offered to have a review of the book published in the *Journal.* This will be used to stimulate sales.

Treasurer.—Dr. Rupp presented the budget for 1972–3 and the projected (balanced) budget for the following year. After extensive discussion the budget was approved as presented. Dr. Rupp also read a letter from Dr. Leo Schubert asking for continued support from the Academy for the summer institute for high school students at American University. Such support will become particularly important when and if NSF discontinues its funding. It was the sense of the Board that, although it could not commit future Boards, financial support was desirable and should continue.

Executive Committee.—Dr. Cook reported on the meeting of Feb. 7 at which the following actions were taken:

1. The move to a less expensive office at FASEB was approved.
2. The budget was approved.
3. A cost-of-living increase for Miss Ostaggi was approved.
4. A "brainstorming" session will be held shortly to gather ideas for a (self-supporting) symposium in the Fall.

Membership Committee.—On a motion by Dr. Weissler, seconded by Dr. Honig, the following nominees for fellowship were approved: Hope E. Hopps, Lester D. Shubin, Frederick K. Willenbrock, Bradley F. Bennett.

Awards for Scientific Achievement. Dr. Cook read Dr. Aldridge's report recommending the following nominees: For Biological Sciences: James L. Reveal, Univ. of Md.; For Physical Sciences: Martin E. Glicksman, Naval Research Lab.; Teaching of Sciences, a joint award: Jerry B. Marion, Univ. of Md., Robert C. Vincent, The George Washington Univ.

The Board approved the awards which will be presented at the March 15 meeting. [See elsewhere this issue. Ed.]

Grants-in-Aid.—Dr. Sarvella read the list of five applications accepted for financial support:

Robert H. Cooke, McKinley High School, Washington, D.C.

Jeffrey R. Cousins, Central Senior High School, Seat Pleasant, Md.

Cecil D. Haney, Eastern High School, Washington, D.C.

Richard M. Prevatt, West Springfield High School, Springfield, Va.

Parma Yarkin, Washington-Lee High School, Arlington, Va.

Membership Committee.—Dr. O'Hern urged delegates who have not yet sent her the list of eligible members and/or fellows from their societies, to do so. She will draft a letter to invite these people to submit applications.

Tellers Committee.—Mr. Detwiler announced the results of the recent election as follows:

President-elect: Kurt H. Stern
Secretary: Patricia Sarvella
Treasurer: Nelson W. Rupp
Managers-at-Large (1973–76): Alphonse F. Forziati, Mary Louise Robbins. [See elsewhere this issue. Ed.]

NEW BUSINESS.—Mr. Sherlin announced that the Catholic high schools in the D.C. area will hold a Science Fair, April 6 at St. Bartholomews Church on River Road. Students from public schools are eligible to participate.

The meeting was adjourned at 9:50 p.m.—Kurt H. Stern, *Secretary*.

SCIENTISTS IN THE NEWS

Contributions in this section of your Journal are earnestly solicited. They should be typed double-spaced and sent to the Editor two months preceding the issue for which they are intended.

DEPARTMENT OF AGRICULTURE

Ashley B. Gurney, Systematic Entomology Laboratory, discussed a field trip made in Nevada and adjacent states during June 1972, at the February 1 meeting of the Entomological Society of Washington. The main purpose of the trip was to observe and record current populations of the "Nevada sage grasshopper," *Melanoplus rugglesi*. Solitary populations, not adequately reported previously, were found and observed in typical range-land areas of five different states. These thinly distributed colonies, made up of small relatively short-winged individuals which remain in closely localized areas, are in contrast to migratory populations of large, long-winged, highly mobile and gregarious individuals which threatened native range shrubs in the late 1940's and early 1950's.

Reece I. Sailer, former Chairman of the Insect Identification and Beneficial Insect Introduction Institute, retired effective March 2, 1973, to accept a position as Research Professor of Biological Control at the University of Florida. Dr. Sailer's government service began in 1942 as USDA's specialist on the taxonomy of heteropterous insects (the true bugs), soon becoming a world authority in this field. Since 1960, when he became Officer-in-Charge of the European Parasite Laboratory in Paris, Dr. Sailer's research and interests have been primarily in the field of biological control, and in this field too, he has become a leading world figure. In 1966, he returned to the States to serve as Assistant Chief of the Insect Identification & Parasite Introduction Research Branch of the former Entomology Research Division at Beltsville, and became Chief of the Branch in July 1967. Since the ARS reorganization in July 1972, he has served as Chairman of IIBIII. In these capacities, he has not only provided able leadership and coordination of the Division's biological control program, including the many PL 480 research programs in this area, but his many worldwide contacts enabled him to serve as a guiding influence in enlarging the European Organization Internationale de Lutte Biologique into a truly worldwide organization, the International Organization for Biological Control, and in creating the Western Hemisphere Regional Section of this organization.

A party in Dr. Sailer's honor was held Friday, February 23, in the Conference Room of the new Bioscience Building at Beltsville, on the occasion of his retirement and to wish him well in his new position. Obviously his retirement from ARS after 30 years of outstanding service in insect taxonomy and biological control will mean a real loss to the Department's work in this important area.

Russell L. Steere of the ARS Northeast Region, Beltsville, Md., received the Ruth Allen Award and the Fellow Award of the American Phytopathological Society. The Ruth Allen Award is presented annually to an individual whose research has contributed significantly to the science of plant pathology. The Fellow Award is presented in recognition of contributions to scientific research and to the profession of phytopathology. Both Awards were presented to Dr. Steere at the Society's meeting in Mexico City.

Henry M. Cathey, Northeast Region, Beltsville, was named a Fellow of the American Society for Horticultural Science. The honor was conferred in recognition of his outstanding research contributions to horticultural science, particularly on the interaction of light and growth-controlling chemicals as they affect plant growth.

DEPARTMENT OF INTERIOR

Aaron L. Shalowitz of the Coast and Geodetic Survey (now the National Ocean Survey) was recently honored by the Government, through its Board on Geographic Names, when it named a newly discovered underwater mountain (technically known as a "seamount") for him. The Shalowitz seamount is located in the northeast Pacific Ocean off the Oregon-Washington coast. It rises 6800 feet from the ocean bottom. This is the first time an underwater geographic feature has been named for a living person.

The Board cited Dr. Shalowitz for his "...monumental contributions for more than three decades in the realm of the law of the sea, particularly seaward boundaries, culminating in his two-volume work, *Shore and Sea Boundaries,* which has become a classic in the fields of oceanography, marine cartography, and the law of the sea."

Dr. Shalowitz retired in 1964 as a Special Assistant to the Director of the Coast and Geodetic Survey after serving nearly five decades in both field and office. He is a fellow of the Academy.

NATIONAL BUREAU OF STANDARDS

Marilyn E. Jacox, internationally recognised research chemist, is one of six government career women who received the 13th annual Federal Women's Award. The winners received the awards at a dinner March 6, 1973, in the Shoreham Hotel. As a public service, Woodward and Lothrop defrays all expenses connected with the award.

Judges for the 1973 Federal Woman's Award were Dr. Philip A. Abelson, president, Carnegie Institution of Washington; Rep. Martha W. Griffiths, D-Mich.; Mrs. Mary D. Janney, president, Washington Opportunities for Women, Inc.; John H. Johnson, publisher and editor of Ebony, Black Stars, and Black World magazines, and Mrs. Mary G. Roebling, chairman of the board, the National State Bank, Trenton, N.J.

OBITUARIES

Nathan B. Eddy

Dr. Nathan B. Eddy, 82, well known for research on pain-relieving drugs, died March 29 at his home in Bethesda.

A widely recognized authority on drug addiction and analgesics, Dr. Eddy retired from the National Institute of Arthritis, Metabolism, and Digestive Diseases in August 1960.

He had served as a PHS consultant in addition to having served as executive secretary of the Committee on Drug Addiction and Narcotics of the National

Academy of Sciences, National Research Council.

Dr. Eddy's lifetime devotion to the study of narcotics made his office a world clearinghouse for information concerning all aspects of narcotics, analgesics, and addiction.

In 1951, Dr. Eddy and Dr. Everette L. May, also of NIAMDD's Laboratory of Chemistry, undertook a research program to develop synthetic substitutes for the pain-relieving drugs, morphine and codeine, which are derived from the opium poppy.

From this research emerged a new class of pain-relieving agents, the benzomophans, which in many instances are more potent than morphine, but less liable to produce addiction.

Since 1930 Dr. Eddy had been concerned almost exclusively with research in the field of analgesia and analgesics with particular emphasis on chemical structure, analgesic activity, and dependence liability relationships.

Born in Glen Falls, N.Y., Dr. Eddy received his M.D. from Cornell University Medical School in 1911, University Medical School in 1911, and practiced medicine in New York City until 1916.

After 13 years of teaching at a number of universities, he joined NIH as a principal pharmacologist and became chief of the Section on Analgesics, Laboratory of Chemistry, in 1951.

Since 1960 Dr. Eddy had been a consultant for the Section on Medicinal Chemistry, NIAMDD.

During his career Dr. Eddy received several awards including an honorary D.Sc. from the University of Michigan in 1963, the William Freeman Snow Award (for distinguished service to humanity) in 1967, and a year later the Hillebrand Prize which he shared with Dr. May for their analgesic research.

In 1972 he won the Edward W. Browning Achievement Award for Outstanding Contribution to Prevention and Treatment of Drug Addiction.

Dr. Eddy is survived by his wife, the former Wilhelmina Marie Ahrens.

Leo A. Wall

Dr. Leo A. Wall, a prominent Washington area research chemist who also was well known in track and field circles here, was found dead on a beach on Smith Island in Chesapeake Bay, apparently the victim of a boating accident.

Dr. Wall, 54, had been a lifelong resident of the District until he moved to a home in McLean, Va., about three years ago.

He was chief of the polymer chemistry section at the National Bureau of Standards, where he had worked for 26 years. He had planned to retire in about two years. Dr. Wall had received many honors for his work and had written a number of scientific papers and books.

He also was a track and field star during the 1930's at McKinley Tech High School here and at Catholic University, where he excelled as a high jumper and hurdler. Since then, he frequently judged area track meets.

The Coast Guard said Dr. Wall's body was found near his overturned 20-foot sailboat after a fisherman had reported seeing the capsized craft. A search led to discovery of the body.

Coast Guard vessels and a Navy helicopter also combed the area afterward until it was determined no one else was with Dr. Wall.

His wife, the former Leola Grace Ingalls of Washington, said Dr. Wall set out alone in his newly-acquired sailboat from their summer home in Colonial Beach, Va., on Sunday.

Dr. Wall was born in the McKinley High School area. He was graduated from there in 1936 and received his B.S. degree in physics from Catholic University in 1941, and his Ph.D degree in 1945.

Dr. Wall first joined the Bureau of Standards in 1946 and had been there ever since except for brief periods with the California Research Corp. in 1947 and as a Fulbright Fellow at the University of Paris in 1951–52.

He was the recipient of the two highest

awards from the Commerce Department—the Gold Medal for exceptional service in 1962 and the Silver Medal for meritorious service in 1955. In 1957, he received the Arthur S. Fleming Award from the U.S. Junior Chamber of Commerce as one of the outstanding young men in government service. In 1964, he was awarded the Catholic University of America Alumni Achievement Award.

He was a member of Phi Beta Kappa and Sigma Xi honor societies, the Washington Academy of Sciences, Cosmos Club, American Chemistry Society and was a fellow of the American Association for the Advancement of Science.

Professionally, Dr. Wall had been chairman of two Gordon Research Conferences, had co-authored about 120 research papers and was awarded approximately 20 patents.

He was an instructor at Catholic University from 1943 to 1945 and had been teaching polymer chemistry at American University since 1966.

Dr. Wall lived in the vicinity of North Capitol Street in the District until he moved to Stoneham Court in McLean.

Besides his wife, he leaves four married daughters, Mrs. Julia Ann Barnes of Washington, Mrs. Mary Ellen Beckham of Newport, R.I.; Mrs. Kathleen Prangley of Baltimore and Mrs. Margaret Riesinger of Alameda, Calif.

Dear Sir:

I refer to the brief article in the December 1972 issue of the *Journal* of the Washington Academy of Sciences by Dr. Charles Milton titled *Note on a Drawing by M. C. Escher.*

For almost 20 years I have admired and collected Mr. Escher's unusual prints. During that time I first came to know him through correspondence, and later met with him on several occasions. On one of these in June 1968 I found myself in The Hague on Mr. Escher's 70th birthday when he was being honored by an important retrospective exhibition of his graphics at the Gemeentemuseum.

The afternoon following the opening of the exhibition I visited him at his house in Baarn, and our conversation ranged far and wide. In the course of our discussions he asked if I had ever heard of anyone having published an explanation of the position of the chessmen in his woodcut *Metamorphose.*

I replied that I had not. He repeated to me what he had often said to others: that his "prints were games, serious games", and he went on to explain the significance of the situation displayed on the chessboard. He asked that I not tell anyone else since he was curious to see when someone would notice the game within a game he had played in this print.

I promised him I would say nothing, but would keep my eyes open and report to him as soon as I read of anyone having noticed the position of the chessmen and identified what he had in mind.

Mr. Escher died almost exactly a year ago today so I was unable to write him and tell him that Dr. Milton was, so far as I know, the first person to notice and correctly identify what was happening on the chessboard in *Metamorphose,* the first edition of which Mr. Escher had produced a third of a century ago.

Sincerely yours,

C. V. S. Roosevelt
2500 Que St., N.W.
Washington, D.C. 20007

Dear Sir:

Over the past twenty-two months the Milton S. Eisenhower Library of the Johns Hopkins University has been collecting and collating the papers of the late Hugh L. Dryden (1898–1965), who was the aerodynamicist in the National Bureau of Standards, 1919–1947, director of the old National Advisory Committee for Aeronautics (NACA), 1947–58, and deputy director of NASA, 1958–65.

His papers have been located at Johns Hopkins at the request of Mrs. Dryden because Hugh Dryden was a Hopkins graduate. He received his Ph.D. in mathematics and physics from Hopkins in 1919 when he was 20 years old.

The *Basic Collection* of the Dryden Papers is now complete. An archival system is now ready to receive all other letters, memoranda, notes, reports, photographs and other forms of documentation that directly relate to the life and times of Hugh L. Dryden, by way of expanding the existing Collection.

It is hoped that those friends and associates of Hugh Dryden's who presently hold correspondence (and other relevant documentation), in their private files, will see fit to donate these items to the Dryden Collection. In cases in which the material may have intrinsic value to the donor, the Collection will be equally pleased by xerox copies.

Hugh Dryden's career cut across the

lives of tens of thousands of persons in hundreds of different ways. In addition to documentation, the Collection also wishes to include those things that but rarely get put on paper. Anecdotes live only in the minds of mortal men, and when they die the anecdotes die with them. Those persons who have Dryden anecdotes to contribute are especially invited to send them in.

Those who wish to contribute their Dryden materials to the Hugh L. Dryden Papers should send their materials to me at the address given below.

Sincerely,

Richard K. Smith

Hugh L. Dryden Papers
Milton S. Eisenhower Library
Johns Hopkins University
Baltimore, Maryland 21218

JOURNAL OF THE WASHINGTON ACADEMY OF SCIENCES

Instructions to Contributors

General

Type manuscripts on white bond paper either 8½ by 11 or 8 by 10½ inches. Double space all lines, including those in abstracts, tables, legends, quoted matter, acknowledgments, and references cited. Number pages consecutively. Place your name and complete address in the upper right hand corner of the title page.

Title, Author, and Affiliation

Page 1 of your manuscript should contain only this information and your name and address. Choose a concise but complete and meaningful title. In research papers concerning biological subjects, include an indication of the order and family of the taxa discussed. Academic degrees will not normally be included unless the author so specifies. If possible, combine your affiliation and mailing address (including Zip) so that readers can write to you directly.

Abstract

Type on a separate sheet at the end of the manuscript. Make the abstract intelligible without reference to the text of the paper. Write an informative digest of the significant content and conclusions, not a mere description. Generally, the abstract should not exceed 3% of the text.

Footnotes

Use footnotes as sparingly as possible. Number text footnotes consecutively with Arabic numerals and type them on a separate sheet of paper at the end of the manuscript. Type table footnotes, if any, below each pertinent table on the same page.

Illustrations and Legends

The quality of all original illustrations must be high enough to facilitate good offset reproduction. They should have ample margins and be drawn on heavy stock or fastened to stiff cardboard to prevent bending. They should be proportioned to column (1 x 3) or page (2 x 3) type-dimensions, leaving space for legend material. Photographs should have a glossy finish. They reproduce best when the contrast is fairly high. Identify each illustration with number and author in light pencil marks on the reverse side. Submit all illustrations separately – please do not glue or clip them to the pages of the manuscript.

Do not type or write legends directly on the illustrations. Type legends on a separate sheet or sheets at the end of the manuscript. Indicate where you want illustrations to appear in the printed paper by writing the figure numbers lightly in the text margins, and be sure that each figure is properly referenced in the text itself. Original "art" will be returned only at the author's request and expense.

Tables

Include tables only when the same information cannot be presented economically in the text, or when a table presents the data in a more meaningful way. Consider preparing extremely complicated tabular matter in a form suitable for direct reproduction as an illustration. In such cases, the use of the typewriter is not recommended.

References to Literature

Limit references within the text and in synonymies to author and year (and page if needed). In a "Reference Cited" section, list alphabetically by senior author only those papers you have included in the text. Likewise, be sure all the text references are listed. Type the "References Cited" section on a separate sheet after the last page of text. Abbreviations should follow the *USA Standard for Periodical Title Abbreviations*, Z39.5-1963.

Submission of Manuscripts

Send completed manuscripts and supporting material to the Academy office (see address inside front cover) in care of the Editor. Authors will be requested to read Xerox "proofs" and invited to submit reprint orders prior to publication.

Reprints – Prices for reprints may be obtained on request.

Washington Academy of Sciences
Room 29, 9650 Rockville Pike (Bethesda)
Washington, D.C. 20014
Return Requested with Form 3579

2nd Class Postage Paid
at Washington, D.C.
and additional mailing offices.

VOLUME 63
Number 3
SEPTEMBER, 1973

Journal of the WASHINGTON ACADEMY OF SCIENCES

Issued Quarterly
at Washington, D.C.

Directory Issue

CONTENTS

Editorial 94

Directory, 1973

Foreword 95

Directory of the Academy 95

Alphabetical Listing 100

Bylaws of the Academy 121

Washington Academy of Sciences

Founded in 1898

ACADEMY OFFICE

9650 Rockville Pike (Bethesda)
Washington, D.C. 20014
Telephone (301) 530-1402

The Journal

This journal, the official organ of the Washington Academy of Sciences, publishes historical articles, critical reviews, and scholarly scientific articles; proceedings of meetings of the Academy and its Board of Managers; and other items of interest to Academy members. The *Journal* appears four times a year (March, June, September, and December) – the September issue contains a directory of the Academy membership.

Subscription Rates

Members, fellows, and patrons in good standing receive the *Journal* without charge. Subscriptions are available on a calendar year basis only, payable in advance. Payment must be made in U.S. currency at the following rates:

U.S. and Canada	$10.00
Foreign	11.00
Single Copy Price	3.00

Back Issues

Obtainable from the Academy office (address at bottom of opposite column): **Proceedings:** Vols. 1-13 (1898-1910) **Index:** To Vols. 1-13 of the *Proceedings* and Vols. 1-40 of the *Journal* **Journal:** Back issues, volumes, and sets (Vols. 1-62, 1911-1972) and all current issues.

Claims for Missing Numbers

Claims will not be allowed if received more than 60 days after date of mailing plus time normally required for postal delivery and claim. No claims will be allowed because of failure to notify the Academy of a change in address.

Changes of Address

Address changes should be sent promptly to the Academy office. Such notification should show both old and new addresses and zip number.

Published quarterly in March, June, September, and December of each year by the Washington Academy of Sciences, 9650 Rockville Pike, Washington, D.C. Second class postage paid at Washington, D.C. and additional mailing offices.

DELEGATES TO THE WASHINGTON ACADEMY OF SCIENCES, REPRESENTING THE LOCAL AFFILIATED SOCIETIES

Philosophical Society of Washington	Bradley F. Bennett
Anthropological Society of Washington	Jean K. Boek
Biological Society of Washington	Delegate not appointed
Chemical Society of Washington	Alfred Weissler
Entomological Society of Washington	William E. Bickley
National Geographic Society	Alexander Wetmore
Geological Society of Washington	Charles Milton
Medical Society of the District of Columbia	Delegate not appointed
Columbia Historical Society	Paul H. Oehser
Botanical Society of Washington	Conrad B. Link
Society of American Foresters	Robert Callaham
Washington Society of Engineers	George Abraham
Institute of Electrical and Electronics Engineers	Harry Fine
American Society of Mechanical Engineers	Michael Chi
Helminthological Society of Washington	James H. Turner
American Society for Microbiology	Lewis Affronti
Society of American Military Engineers	H.P. Demuth
American Society of Civil Engineers	Carl H. Gaum
Society for Experimental Biology and Medicine	Carlton Treadwell
American Society for Metals	Glen W. Wensch
International Association for Dental Research	Norman H.C. Griffiths
American Institute of Aeronautics and Astronautics	Franklin Ross
American Meteorological Society	Delegate not appointed
Insecticide Society of Washington	H. Ivan Rainwater
Acoustical Society of America	Gerald J. Franz
American Nuclear Society	Delegate not appointed
Institute of Food Technologists	William Sulzbacher
American Ceramic Society	W.T. Bakker
Electrochemical Society	Stanley D. James
Washington History of Science Club	Delegate not appointed
American Association of Physics Teachers	Bernard B. Watson
Optical Society of America	James B. Heaney
American Society of Plant Physiologists	Walter Shropshire
Washington Operations Research Council	John G. Honig
Instrument Society of America	Delegate not appointed
American Institute of Mining, Metallurgical and Petroleum Engineers	Delegate not appointed
National Capitol Astronomers	John A. Eisele
Mathematical Association of America	Daniel B. Lloyd
D.C. Institute of Chemists	Miloslav Recheigl, Jr.

Delegates continue in office until new selections are made by the respective societies.

Editorial

The universal question these days—"where has the time gone?"—remains unanswered. Your editor answers the question with the contention that lack of time is not a matter of wasting it. Rather, less time is in fact *available* to us now than ever before. Hence, the size of the present issue is due entirely to the editors lack of *available* time during the late summer!

A number of interesting articles have had to be relegated to the December 1973 *Journal,* but I am sure that when you receive Vol. 63, No. 4, you will agree that it was worth waiting for. The present Directory Issue is offered in its present state for the sake of making a current Directory and alphabetical listing available for those who need it.

Lack of available time also prevented your editor from recreating any of the adjunct listings that once accompanied the alphabetical list of members. He welcomes suggestions from the users of the Directory concerning the most effective way to re-sort the alphabetical membership list for use in the next Directory Issue.

THE DIRECTORY OF THE ACADEMY FOR 1973

Foreward

The present, 48th issue of the Academy's directory is again this year issued as part of the September number of the Journal. As in previous years, the alphabetical listing is based on a postcard questionnaire sent to the Academy membership. Members were asked to update the data concerning address and membership in affiliated societies by July 30, 1973. In cases in which cards were not received by that date, the address appears as it was used during 1972, and the remaining data were taken from the directory for 1972. Corrections should be called to the attention of the Academy office.

Code for Affiliated Societies, and Society Officers

1 The Philosophical Society of Washington (1898)

President:	Bradley F. Bennett, 3301 Macomb St., N.W., Washington, D.C. 20008
Vice-President:	George E. Hudson, code 026, Naval Ordnance Lab, Silver Spring, Md. 20910
Secretary:	Robert J. Rubin, 3308 McKinley St., N.W., Washington, D.C. 20015
Delegate:	Bradley F. Bennett

2 Anthropological Society of Washington (1898)

President:	Regina F. Herzfeld, Dept. of Anthropology, Catholic Univ., Washington, D.C. 20017
Vice-President:	Bela C. Maddy, Cultural Anthropology Fellowship Review Office, NIMH, NIH, 5600 Fishers Lane, Rockville, Md. 20852
Secretary:	Gary Hume, Dept. of Anthropology, American Univ., Washington, D.C. 20016
Delegate:	Jean K. Boek, Director, Div. of Special Studies, National Graduate Univ., 3408 Wisconsin Ave., N.W., Washington, D.C. 20016

3 Biological Society of Washington (1898)

President:	Joseph Rosewater, Smithsonian Institution
Secretary:	Richard C. Banks, Smithsonian Institution

4 Chemical Society of Washington (1898)

President:	Harvey Alter, National Center for Resource Recovery, 1211 Conn. Ave., N.W., Washington, D.C. 20036
Vice-President:	Alfred Weissler, Food & Drug Adm., Washington, D.C. 20204
Secretary:	Robert F. Cozzens, Dept. of Chemistry, George Mason Univ., 4400 Univ. Dr., Fairfax, Va. 22040
Delegate:	Alfred Weissler

5 Entomological Society of Washington (1898)

President:	Victor E. Adler, USDA, Biol. Act. Nat. Prod. Lab., Rm. 108, Bldg. A-476 Agricultural Research Ctr., East, Beltsville, Md. 20705
President-elect:	Barnard Burks, Systematic Entomology Lab., USDA, U.S. National Museum, Washington, D.C. 20560
Secretary:	Raymond J. Gagne, Systematic Entomology Lab., USDA, U.S. National Museum, Washington, D.C. 20560
Delegate:	William E. Bickley, Dept. of Entomology, Univ. of Md. College Park, Md. 20742

6 National Geographic Society (1898)

President:	Melvin M. Payne, 17th & M Sts., N.W., Washington, D.C. 20036
Vice-President & Secretary:	Robert E. Doyle, 17th & M Sts., N.W., Washington, D.C. 20036
Delegate:	Alexander Wetmore, Smithsonian Institution, Washington, D.C. 20560

7 Geological Society of Washington (1898)

President:	Douglas M. Kinney, U.S. Geological Survey, Washington, D.C. 20242
Vice-President:	E. A. Zen, U.S. Geological Survey, Washington, D.C. 20242
Secretary:	Douglas Harwood, U.S. Geological Survey, Washington, D.C. 20242
Delegate:	Charles Milton, Dept. of Geology, George Washington Univ. Washington, D.C. 20005

8 **Medical Society of the District of Columbia (1898)**

President:	William S. McCune
President-elect:	Frank S. Bacon
Secretary:	Thomas Sadler

9 **Columbia Historical Society (1899)**

President:	Hemer T. Rosenberger, Rose Hill, Waynesboro, Pa. 17268
Vice-President:	Wilcomb E. Washburn, Smithsonian Institution, Washington, D.C. 20560
Secretary:	William L. Ellis, 1307 New Hampshire Ave., N.W., Washington, D.C.
Delegate:	Paul H. Oehser, National Geographic Society, Washington, D.C. 20036

10 **Botanical Society of Washington (1902)**

President:	Richard H. Eyde, Dept. of Botany, Smithsonian Institution, Washington, D.C. 20560
Vice-President:	John J. Wurdack, Dept. of Botany, Smithsonian Institution, Washington, D.C. 20560
Secretary:	Theodore R. Dudley, U.S. National Arboretum, Washington, D.C. 20225
Delegate:	Conrad B. Link, Dept. of Horticulture, Univ. of Md., College Park, Md. 20742

11 **Society of American Foresters, Washington Section (1904)**

Chairman:	Carrow T. Prout, Jr., Soil Conservation Serv., USDA, Washington, D.C. 20250
Chairman-elect:	Thomas B. Glazebrook, 7809 Bristow Dr., Annandale, Va. 22003
Secretary:	Murl Storms, 5003 Wenruth Pl., Annandale, Va. 22003
Delegate:	R. Z. Callaham, 3720 Acosta Rd., Fairfax, Va. 22030

12 **Washington Society of Engineers (1907)**

President:	Walter H. McCartha, 3804 14th St., N., Arlington, Va. 22201
Vice-President:	Thomas P. Meloy, 6715 Electronic Dr., Springfield, Va. 22151
Secretary:	Joseph L. Scott, 140 11th St., S.E., Washington, D.C. 20020
Delegate:	George Abraham, 3707 Westover Dr., S.E., Washington, D.C. 20020

13 **Institute of Electrical & Electronics Engineers, Washington Section (1912)**

President:	Stuart Bouchey, 1900 Pennsylvania Ave., N.W., Washington, D.C. 20006
Vice-President:	Marjorie Townsend, 3529 Tilden St., N.W., Washington, D.C. 20008
Secretary:	Robert Briskman, 950 L'Enfant Plaza, S.W., Suite 6204, Washington, D.C. 20024
Delegate:	Harry Fine, 808 Hyde Court, Silver Spring, Md. 20902

14 **American Society of Mechanical Engineers, Washington Section (1923)**

Chairman:	Henry M. Curran, Hittman Assoc., Columbia, Md. 21045
Vice-chairman:	Andre H. Gage, PEPCO, 1900 Pennsylvania Ave., N.W., Washington, D.C. 20006
Secretary:	William H. Walston, Jr., Dept. of Mechanical Engineering, Univ. of Md., College Park, Md. 20742
Delegate:	Michael Chi, Dept. of Mechanical Engineering, Catholic Univ., Washington, D.C. 20017

15 **Helminthological Society of Washington (1923)**

President:	Harry Herlich, Animal Parasitology Institute, ARS, Beltsville, Md. 20705
Vice-President:	Kendall G. Powers, National Institute of Allergy & Infectious Diseases, NIH, Bethesda, Md. 20014
Secretary:	Robert S. Isenstein, Animal Parasitology Institute, ARS, Beltsville, Md. 20705
Delegate:	James H. Turner, Division of Research Grants NIH, Bethesda, Md. 20014

16 **American Society for Microbiology, Washington Branch (1923)**

President:	Carl Lamanna, Dept. of Army, 3045 Columbia Pike, Arlington, Va. 22204
Vice-President:	Lewis F. Affronti, Dept. of Microbiology, George Washington Univ. Medical School, Washington, D.C. 20005
Secretary:	Charles R. Manclark, Division of Biological Standards, NIH, Bethesda, Md. 20014
Delegate:	Lewis F. Affronti

17 Society of American Military Engineers, Washington Post (1927)

President: Capt. W. F. Reed, Jr., 3319 Albion Ct., Fairfax, Va. 22030
Vice-President: Capt. Robert Munson, Washington Sci. Ctr., Bldg. 1, Rockville, Md. 20852
Secretary: LCDR. W. G. Matthews, 8811 Queen Elizabeth Blvd., Annandale, Va. 22003
Delegate: Hal P. Demuth, 4025 Pinebrook Rd., Alexandria, Va. 22310

18 American Society of Civil Engineers, National Capital Section (1942)

President: Alfred W. Maner, 1902 Wooded Court, Adelphi, Md. 20783
Vice-President: Floyd D. Peterson, 9627 Hzywick Dr., Kensington, Md. 20795
Secretary: Bernard M. McCarthy, 4733 Bethesda Ave., Washington, D.C. 20014
Delegate: Carl H. Gaum, 9609 Carriage Rd., Kensington, Md. 20795

19 Society for Experimental Biology & Medicine, D.C. Section (1952)

Chairman: Harriet Maling, Bldg. 10, NIH, Bethesda, Md. 20014
Vice-chairman: Benjamin Bruckner, NIH, Parklawn Bldg., Bethesda, Md. 20014
Secretary: Vera Usbin, Gillette Laboratories, Rockville, Md. 20852
Delegate: Carleton R. Treadwell, 1339 H St., N.W., Washington, D.C. 20005

20 American Society for Metals, Washington Chapter (1953)

Chairman: Klaus M. Zwilsky, U.S. Atomic Energy Comm., Washington, D.C. 20545
Vice-chairman: Alan H. Rosenstein, Air Force Office of Scientific Res., 1400 Wilson Blvd., Arlington, Va. 22209
Secretary: Joseph Malz, NASA, Code RWM, Washington, D.C. 20546
Delegate: Glen W. Wensch, U.S. Atomic Energy Comm., Washington, D.C. 20545

21 International Association for Dental Research, Washington Section (1953)

President: James M. Cassel, Dental Res. Section, NBS, Washington, D.C. 20234
Vice-President: Francis A. San Filippo, 8644 Woodward Ave., Alexandria, Va. 22309
Secretary: Louis W. Wachtel, Westwood Bldg., Natl. Inst. of Dental Res., Bethesda, Md. 20014
Delegate: Norman H. C. Griffiths, 3100 20th St., N.E., Washington, D.C. 20018

22 American Institute of Aeronautics and Astronautics, National Capital Section (1953)

President: Philip R. Compton, 6303 Mori St., McLean, Va. 22101
Vice-President: Jack Suddreth, Code RLC/Aero. Prop. Div., NASA Headquarters, Washington, D.C. 20546
Secretary: Paul M. Burris, The Boeing Co., 955 L'Enfant Plaza North, S.W., Washington, D.C. 20024
Delegate: Franklin J. Ross, Deputy for Rqmts., Off. Asst. Sec. of A.F., The Pentagon, Rm. 4E973, Washington, D.C. 20330

23 American Meteorological Society, D.C. Chapter (1954)

Chairman: Clifford J. Murino, National Science Foundation
Vice-chairman: James K. Angell, ESSA
Secretary: Mary Ann Ruzecki, ESSA

24 Insecticide Society of Washington (1959)

President: Alexej B. Borkovec, Entomology Research Div. USDA, Beltsville, Md. 20705
Vice-President: Richard L. Cowden, Plant Protection Div., USDA, Hyattsville, Md. 20740
Secretary: Robert E. Menzer, Dept. of Entomology, Univ. of Md., College Park, Md. 20740
Delegate: H. Ivan Rainwater, Agricultural Quarantine Inspection Div., USDA, Hyattsville, Md. 20782

25 Acoustical Society of America (1959)

Chairman: Pearl G. Weissler, 5510 Uppingham, Chevy Chase, Md. 20015
Vice-chairman: John A. Molino, Sound Section, National Bureau of Standards Washington, D.C. 20234
Secretary: Gerald J. Franz, 9638 Culver St., Kensington, Md. 20795
Delegate: Gerald J. Franz

26 American Nuclear Society, Washington Section (1960)

Chairman: Oscar M. Bizzell, Atomic Energy Comm.
Vice-chairman: Justin L. Bloom, Atomic Energy Comm.
Secretary: Leslie S. Ayres, Arms Control & Disarmament Agency

27 Institute of Food Technologists, Washington Section (1961)

Chairman: Tannous Khalil, Giant Foods, Inc., Landover, Md. 20785
Vice-chairman: Florian C. Majorack, Food & Drug Adm., Washington, D.C. 20204
Secretary: Glenn V. Brauner, National Canners Assoc., Washington, D.C. 20036
Delegate: William Sulzbacher, 8527 Clarkson Dr., Fulton, Md. 20759

28 American Ceramic Society, Baltimore-Washington Section (1962)

Chairman: W. T. Bakker, General Refractories Co., P.O. Box 1673, Baltimore, Md. 21203
Chairman-elect: L. Biller, Glidden-Dirkee Div., SCM Corp., 3901 Hawkins Point Rd., Baltimore, Md. 21226
Secretary: Edwin E. Childs, J. E. Baker Co., 232 E. Market St., York, Pa. 17405
Delegate: W. T. Bakker

29 Electrochemical Society, National Capital Section (1963)

Chairman: Gerald Halpert, 5011 Regina Dr., Annandale, Va. 22003
Vice-chairman: James R. Huff, 8603 Buckboard Dr., Alexandria, Va. 22308
Secretary: Judith Ambrus, 13128 Greenmount Ave., Beltsville, Md. 20705
Delegate: Stanley D. James, U.S. Naval Ordnance Lab., Code 232, White Oak, Md. 20910

30 Washington History of Science Club (1965)

Chairman: Richard G. Hewlett, Atomic Energy Comm.
Vice-chairman: Deborah Warner, Smithsonian Institution
Secretary: Dean C. Allard

31 American Association of Physics Teachers, Chesapeake Section (1965)

President: William Logan, D.C. Teachers College, 2565 Georgia Ave., Washington, D.C. 20001
Vice-President: Eugenie V. Mielczarek, George Mason Univ., 4400 University Dr., Fairfax, Va. 22030
Secretary: John B. Newman, Towson State College, Towson, Md. 21204
Delegate: Bernard B. Watson, Res. Analysis Corp., McLean, Va. 22101

32 Optical Society of America, National Capital Section (1966)

President: C. Verne Muffoletto, Muffoletto Optical Co., 6100 Everall Ave., Baltimore, Md. 21206
Vice-President: Joseph A. Curcio, Code 6532, Naval Res. Lab., Washington, D.C. 20375
Secretary: William B. Fussell, Optical Radiation Section, National Bureau of Standards, Washington, D.C. 20234
Delegate: James B. Heaney, Code 765, Goddard Space Flight Ctr., Greenbelt, Md. 20771

33 American Society of Plant Physiologists, Washington Section (1966)

President: Neal M. Barnett, Dept. of Botany, Univ. of Md., College Park, Md. 20742
Vice-President: William R. Krul, USDA, Plant Hormone and Reg. Lab., Plant Industry, Beltsville, Md. 20705
Secretary: Bert Drake, Smithsonian Radiation Biology Lab., 12441 Parklawn Dr., Rockville, Md. 20852
Delegate: W. Shropshire, Jr., Radiation Biology Lab., Smithsonian Institution, 12441 Parklawn Dr., Rockville, Md. 20852

34 Washington Operations Research Council (1966)

President: Armand B. Weiss, Logistics Management Institute, 4701 Sangamore Rd., Washington, D.C. 20016
Vice-President: Donald Gross, George Washington Univ., Washington, D.C. 20005
Secretary: Gerald McNichols, Office, Director Defense Programs, Analysis & Evaluation, The Pentagon, Washington, D.C. 20310
Delegate: John G. Honig, Office, Chief of Staff, Army, The Pentagon, Rm. 1E, 620, Washington, D.C. 20310

35 Instrument Society of America, Washington Section (1967)

President: Francis C. Quinn
President-elect: John I. Peterson
Secretary: Frank L. Carou

36 American Institute of Mining, Metallurgical & Petroleum Engineers (1968)

President:	Robert N. Morris, Southern Railway Systems
Vice-President:	Ralph C. Kirby, Bureau of Mines
Secretary:	Harold W. Lynde, Jr., Department of Commerce

37 National Capital Astronomers (1969)

President:	John A. Eisele, 3310 Curtis Dr., No. 202, Hillcrest Heights, Md. 20023
Vice-President:	Henning E. Leidecker, 4811 Avondale Rd., Washington, D.C. 20018
Secretary:	Estelle Finkle, 939 26th St., N.W., Washington, D.C. 20037
Delegate:	John A. Eisele, 3310 Curtis Dr., #202, Hillcrest Heights, Md. 20023

38 Maryland-District of Columbia and Virginia Section of Mathematical Assoc. of America (1971)

Chairman:	Geraldine A. Coon, Goucher College, Baltimore, Md.
Secretary:	John Smith, George Mason College, Fairfax, Va.
Delegate:	Daniel B. Lloyd, 5604 Overlea Rd., Bethesda, Md. 20016

39 D.C. Institute of Chemists (1973)

President:	Miloslav Rechcigl, Jr., 1703 Mark Lane, Rockville, Md. 20852
President-elect:	Kelso B. Morris, 1448 Leegate Rd., N.W., Washington, D.C. 20012
Secretary:	Edmund M. Buras, Jr., 824 Burnt Mills Ave., Silver Spring, Md. 20901
Delegate:	Miloslav Rechcigl, Jr.

M=Member; F=Fellow; E=Emeritus member. Numbers in parentheses refer to numerical code in foregoing list of affiliated societies.

A

AARONSON, STUART A., 1600 S. Joyce St., Arlington, Va. 22202 (F)
ABBOT, CHARLES G., Smithsonian Institution, Washington, D.C. 20560 (E-1, 23, 32)
ABELSON, PHILIP H., President, Carnegie Institution of Washington, 1530 P St., N.W., Washington, D.C. 20005 (F-1, 4, 7, 16)
ABRAHAM, GEORGE, M.S., 3107 Westover Dr., S.E., Washington, D.C. 20020 (F-1, 6, 12, 13, 31)
ACHTER, M. R., Code 6306, U.S. Naval Research Lab., Washington, D.C. 20390 (F-20, 36)
ADAMS, CAROLINE L., 242 North Granada St., Arlington, Va. 22203 (E-10)
ADAMS, ELLIOT Q., 1889 Edgewood Dr., Twinsberg, Ohio 44087 (E)
ADLER, SANFORD C., 14238 Briarwood Terr., Rockville, Md. 20853 (M-1)
AFFRONTI, LEWIS, Ph.D., Dept. of Microbiology, George Washington Univ. Sch. of Med., 2300 Eye St., N.W., Washington, D.C. 20037 (F-16)
AHEARN, ARTHUR J., Ph.D., 9621 East Bexhill Dr., Box 294, Kensington, Md. 20795 (F-1)
AKERS, ROBERT P., Ph.D., 9912 Silverbrook Dr., Rockville, Md. 20850 (F-6)
ALBUS, JAMES S., 6100 Westchester, 1406, College Park, Md. 20740 (F)
ALDRICH, JOHN W., Ph.D., 6324 Lakeview Dr., Falls Church, Va. 22041 (F-3)
ALDRIDGE, MARY H., Ph.D., Dept. of Chemistry, American University, Washington, D.C. 20016 (F-4)
ALEXANDER, ALLEN L., Ph.D., Code 6120, Naval Research Lab., Washington, D.C. 20390 (F-4)
ALEXANDER, BENJAMIN H., Ph.D., 2522 S. Dakota Ave., N.E., Washington, D.C. 20018 (F-4)
ALGERMISSEN, S. T., 3355 Heidelburg Dr., Boulder, Colo. 80303 (F)
ALLEN, ANTON M., 11718 Lakeway Dr., Manassas, Va. 22110 (F)
ALLEN, J. FRANCES, 7507 23rd Ave., Hyattsville, Md. 20783 (F-3)
ALLEN, WILLIAM G., 8306 Custer Rd., Bethesda, Md. 20034 (F-14)
ALTER, HARVEY, Ph.D., Nat. Center for Resource Recovery, Inc., 1211 Connecticut Ave., N.W., Washington, D.C. 20036 (F)
ALTMAN, PHILIP L., 9206 Ewing Dr., Bethesda, Md. 20034 (M)
AMIRIKIAN, ARSHAM, Sc.D., 6526 Western Ave., Chevy Chase, Md. 20015 (F-17, 18)
ANDERSON, FRENCH, Nat. Heart & Lung Inst., Nat. Inst. Health, Bethesda, Md. 20014 (F)
ANDERSON, MYRON S., Ph.D., 1433 Manchester Lane, N.W., Washington, D.C. 20011 (F-4)
ANDERSON, WENDELL L., Rural Rt. 2, Box 2069G, La Plata, Md. 20646 (F-4)
ANDREWS, JOHN S., Sc.D., Animal Parasitology Inst., Agr. Res. Cent. (E), USDA, Beltsville, Md. 20705 (F-15)
ANDRUS, EDWARD D., 1600 Rhode Island Ave., N.W., Washington, D.C. 20036 (M-7, 25)
APPEL, WILLIAM D., B.S., 12416 Regent Ave., N.E., Albuquerque, N. Mex. 87112 (E-6)
APSTEIN, MAURICE, Ph.D., Harry Diamond Labs., Connecticut Ave. & Van Ness St., N.W., Washington, D.C. 20438 (F-13)
ARGAUER, ROBERT J., Ph.D., 4208 Everett St., Kensington, Md. 20795 (F)
ARMSTRONG, GEORGE T., Ph.D., 1401 Dale Dr., Silver Spring, Md. 20910 (F-1, 4, 6)
ARNOLD, KIETH, Ph.D., 6303 Cedell St., Camp Springs, Md. 20031 (F)
ARONSON, C. J., 3401 Oberon St., Kensington, Md. 20910 (M-1, 32)
ARSEM, COLLINS, 6405 Maiden Lane, Bethesda, Md. 20034 (M-1, 6, 13)
ASLAKSON, CARL I., 5707 Wilson Lane, Bethesda, Md. 20034 (E-1, 6, 12, 18)
ASTIN, ALLEN V., Ph.D., 5008 Battery Lane, Bethesda, Md. 20014 (F-1, 13, 22, 31, 35)
AXILROD, BENJAMIN M., 9915 Marquette Dr., Bethesda, Md. 20034 (F-1)
AYENSU, EDWARD S., Ph.D., 103 G St., N.W., #B219, Washington, D.C. 20024 (F-3, 10)

B

BAKER, ARTHUR A., Ph.D., 5201 Westwood Dr., N.W., Washington, D.C. 20016 (F-7)
BAKER, LOUIS C.W., Ph.D., Dept of Chemistry, Georgetown University, N.W., Washington, D.C. 20007 (F-4)
BALLARD, LOWELL D., 722 So. Colonial, Sterling, Va. 22170 (M-1, 13, 32)
BARBEAU, MARIUS, Natl. Museum of Canada, Ottawa, Ont., Can. (F)
BARBROW, LOUIS E., Natl. Bureau of Standards, Washington, D.C. 20234 (F-1, 13, 32)
BARGER, GERALD L., Ph.D., The Bay House, Apt. 312, 2103 San Sebastian Ct., Houston, Tex. 77058 (F-23)
BARNHART, CLYDE S., Sr., 715 Joppa Farm Rd., Joppatowne, Md. 21085 (F)
BARRETT, MORRIS K., Mrs., Ph.D., 5528 Johnson Ave., Bethesda, Md. 20034 (F-6)
BASS, ARNOLD M., Ph.D., 11920 Coldstream Dr., Potomac, Md. 20854 (F-1, 32)
BEACH, LOUIS A., Ph.D., 1200 Waynewood Blvd., Alexandria, Va. 22308 (F-1, 6)
BEACHAM, LOWRIE M., Jr., Rm. 4815, 200 C St., N.W., Washington, D.C. 20204 (F-4, 27)

BEACHEM, CEDRIC D., Code 6322 Metallurgy Div., Naval Res. Lab., Washington, D.C. 20390 (F-6, 20, 36)

BEASLEY, EDWARD E., Ph.D., Physics Dept., Gallaudet College, Washington, D.C. 20002 (F-1)

BECKER, EDWIN D., Inst. Arthritis & Metabolic Dis., National Institutes of Health, Bethesda, Md. 20014 (F-4)

BECKETT, CHARLES W., 5624 Madison St., Bethesda, Md. 20014 (F-1, 4)

BECKMANN, ROBERT B., Dean, College of Engineering, Univ. of Md., College Park, Md. 20742 (F-4)

BEDINI, SILVIO A., 4303 47th St., N.W., Washington, D.C. 20016 (F)

BEIJ, K. HILDING, B.S., 69 Morningside Dr., Laconia, N.H. 03246 (F-1)

BEKKEDAHL, NORMAN, Ph.D., 405 N. Ocean Blvd., Apt. 1001, Pompano Beach, Fla. 33062 (E-4, 6)

BELSHEIM, ROBERT, Ph.D., Code 8403, U.S. Naval Research Lab., Washington, D.C. 20390 (F-1, 12, 14)

BENDER, MAURICE, Ph.D., Arctic Health Res. Center, PHS, Fairbanks Alaska 99701 (F)

BENESCH, WILLIAM, Inst. for Molecular Physics, Univ. of Maryland, College Park, Md. 20742 (F-1, 32)

BENJAMIN, C. R., Ph.D., IO/AGR, Dept. of State, Washington, D.C., 20520 (F-10)

BENNETT, BRADLEY F., 3301 Macomb St., N.W., Washington, D.C. 20008 (F)

BENNETT, JOHN A., 7405 Denton Rd., Bethesda, Md. 20014 (F-20)

BENNETT, LAWRENCE H., 6524 E. Halbert Rd., Bethesda, Md. 20034 (F-20)

BENNETT, MARTIN TOSCAN, 3700 Mt. Vernon Ave., Rm. 605, Alexandria, Va. 22305 (F-4)

BENNETT, ROBERT R., 5312 Yorktown Rd., Washington, D.C. 20016 (F-6, 7)

BENNETT, WILLARD H., Dept. of Physics, North Carolina State Univ., Raleigh, N.C. 27607 (F)

BENSON, WILLIAM, 2101 Constitution Ave., N.W., Washington, D.C. 20418 (M)

BERCH, JULIAN, 2100 Washington Ave., #10B, Silver Spring, Md. 20910 (E-4)

BERLINER, ROBERT W., M.D., National Institutes of Health, Bethesda, Md. 20014 (F)

BERNTON, HARRY S., 4000 Cathedral Ave., N.W., Washington, D.C. 20016 (F-8)

BEROZA, MORTON, Ph.D., Agr. Res. Center (E), Rm. 312 So. Lab., USDA, Beltsville, Md. 20705 (F-4, 5, 19, 24)

BESTUL, ALDEN B., 9400 Overlea Ave., Rockville, Md. 20850 (F-1, 6)

BICKLEY, WILLIAM E., Ph.D., Dept. of Entomology, Univ. of Md., College Park, Md. 20742 (F-5, 24)

BIRD, H. R., Animal Science Bg., Univ. of Wisconsin, Madison, Wisc. 53706 (F)

BIRKS, L. S., Code 6680, U.S. Naval Research Lab., Washington, D.C. 20390 (F)

BLAKE, DORIS H., M.A., 3416 Glebe Rd., North, Arlington, Va. 22207 (E-5)

BLANK, CHARLES A., Ph.D., 5110 Sideburn Rd., Fairfax, Va. 22030 (M-6)

BLOCK, STANLEY, Ph.D., National Bureau of Standards, Washington, D.C. 20234 (F-4)

BLUNT, ROBERT F., 5411 Moorland Lane, Bethesda, Md. 20014 (F)

BOEK, JEAN K., Ph.D., Natl. Graduate Univ., 3408 Wisconsin Ave., N.W., Washington, D.C. 2001 (F-2)

BONDELID, ROLLON O., Ph.D., Code 6610, Naval Research Lab., Washington, D.C. 20375 (F)

BORTHWICK, HARRY A., Ph.D., 13700 Creekside Dr., Silver Spring, Md. 20904 (E-10, 33)

BOWLES, ROMALD E., Ph.D., 2105 Sondra Ct., Silver Spring, Md. 20904 (F-6, 22)

BOWMAN, PAUL W., 3114 5th St. N., Arlington, Va. 22201 (F)

BOWMAN, THOMAS E., Ph.D., Div. of Crustacea, U.S. Nat. Mus. Nat. Hist., Smithsonian Inst., Washington, D.C. 20560 (F-3)

BOZEMAN, F. MARILYN, Dept. of Rickettsia Disease, Walter Reed Army Inst. of Res., Walter Reed Army Med. Ctr., Washington, D.C. 20012 (F-16, 19)

BRANCATO, E. L., Code 4004, U.S. Naval Research Lab., Washington, D.C. 20390 (F)

BRANDEWIE, DONALD F., 6811 Field Master Dr., Springfield, Va. 22153 (F)

BRAUER, G. M., Dental Research A-123 Polymer, Natl. Bureau of Standards, Washington, D.C. 20234 (F-4, 21)

BRECKENRIDGE, R. G., Atomics International, P.O. Box 309, Canoga Park, Calif. 91364 (F)

BREGER, IRVING A., Ph.D., 212 Hillsboro Dr., Silver Spring, Md. 20902 (F-4, 6, 7)

BREIT, GREGORY, State Univ. of N.Y. at Buffalo, 4248 Ridge Lea Rd., Amherst, N.Y. 14226 (F)

BRENNER, ABNER, Ph.D., 7204 Pomander Lane, Chevy Chase, Md. 20015 (F-4, 6, 29)

BREWER, CARL R., Ph.D., 8113 Lilly Stone Dr., Bethesda, Md. 20034 (F-16)

BRICKWEDDIE, F. G., Ph.D., 104 Davey Lab., Dept. of Physics, Penn. State Univ., University Park, Pa. 16802 (F-1)

BRIER, GLENN W., M.A., 1729 N. Harrison St., Arlington, Va. 22205 (F-23)

BROADHURST, MARTIN G., 504 Calvin Lane, Rockville, Md. 20851 (F)

BROMBACHER, W. G., 6914 Ridgewood Ave., Chevy Chase, Md. 20015 (E-1)

BROOKS, RICHARD C., M.S.E., 301 Tiger Lane, Apt. 417, Columbia, Mo., 65201 (M-13)

BROWN, EDWARD H., U.S. Office of Education, P.O. Box 8240, Washington, D.C. 20024 (M)

BROWN, RUSSELL G., Dept. of Botany, Univ. of Maryland, College Park, Md. 20742 (F-10)

BROWN, THOMAS McP., S. 25th St. and Army-Navy Dr., Arlington, Va. 22206 (F)

BRUBAKER, GERALD L., Ph.D., 2958 Hewitt Ave., #314, Silver Spring, Md. 20906 (M-4)

BRUCK, STEPHEN D., Ph.D., 1113 Pipestem Pl., Rockville, Md. 20854 (F-4, 6)

BRYAN, MILTON M., 3322 N. Glebe Rd., Arlington, Va. 22207 (M-11)

BRYANT, JAMES I., Ph.D., Office Chief of Res. & Dev., Dept. of Army, Washington, D.C. 20310 (M)

BUGGS, C. W., 5600 S. Verdun Ave., Los Angeles, Calif. 90043 (F-6, 16, 19)

BURAS, EDMUND M., Jr., Gillette Research Inst., 1413 Research Blvd., Rockville, Md. 20850 (F-4)

BURGER, ROBERT J., (USAF Ret.) Natl. Acad. Engineering, 2101 Constitution Ave., N.W., Washington, D.C. 20418 (F-22)

BURGERS, J. M., D.M.P.S., 4622 Knox Road, Apt. 7, College Park, Md. 20740 (F-1)

BURINGTON, RICHARD S., Ph.D., 1834 N. Hartford St., Arlington, Va. 22201 (F-1, 6)

BURK, DEAN, Natl. Cancer Institute, Bethesda, Md. 20014 (F)

BURKE, KENNETH S., 310 Souder Rd., Brunswick, Md. 21716 (M-25)

BURNETT, H. C., Metallurgy Division, Natl. Bureau of Standards, Washington, D.C. 20234 (F)

BYERLY, PERRY, Ph.D., Dept. of Geology & Geophysics, Univ. of California, Berkeley, Calif. 94720 (F)

BYERLY, T. C., Asst. Director, Science & Education, U.S. Dept. of Agriculture, Washington, D.C. 20250 (F)

C

CALDWELL, FRANK R., 4821 47th St., N.W., Washington, D.C. 20016 (E-1, 6)

CALDWELL, JOSEPH M., 2732 N. Kensington St., Arlington, Va. 22207 (E-18)

CALLAHAM, ROBERT Z., Ph.D., 3720 Acosta Rd., Fairfax, Va. 22030 (F-11)

CAMERON, JOSEPH M., A345 Physics Bldg., Natl. Bureau of Standards, Washington, D.C. 20234 (F-1)

CAMPAGNONE, ALFRED F., P.E., 9321 Warfield Rd., Gaithersburg, Md. 20760 (F)

CAMPBELL, F. L., Ph.D., 2475 Virginia Ave., N.W., Washington, D.C. 20037 (F-5, 24)

CAREY, FRANCIS E., 12 N. Edison St., Arlington, Va. 22203 (F)

CARHART, HOMER W., Ph.D., 6919 Lee Place, Annandale, Va. 22003 (F-1, 6)

CARLSTON, RICHARD C., Calif. State Polytechnic Coll., San Luis Obispo, Calif. 93401 (F-6, 20, 29)

CARMICHAEL, LEONARD, Ph.D., Natl. Geographic Society, 17th & M Sts., N.W., Washington, D.C. 20036 (F-1, 6, 19)

CARROLL, WILLIAM R., 4802 Broad Brook Dr., Bethesda, Md. 20014 (F)

CARRON, MAXWELL K., 2404 Esther Ct., Silver Spring, Md. (F-4, 7)

CARTER, HUGH, 2039 New Hampshire Ave., N.W., Washington, D.C. 20009 (F)

CASH, EDITH K., Box 44, Nineveh, N.Y., 13813 (E-10)

CASSEL, JAMES M., Route 1, Sunnyview Dr., Germantown, Md. 20767 (F-4, 20)

CATHEY, HENRY M., 1817 Bart Dr., Silver Spring, Md. 20904 (F-33)

CHALKLEY, HAROLD W., Ph.D., 4609 Highland Ave., Bethesda, Md. 20014 (E-19)

CHANEY, JAMES G., Rt. 2, Box 232L, Sotterley Hghts., Hollywood, Md. 20636 (M)

CHAPLIN, HARVEY P., Jr., 1561 Forest Villa Lane, McLean, Va. 22101 (F-22)

CHAPLINE, W. R., 4225 43rd St., N.W., Washington, D.C. 20016 (E-6, 10, 11)

CHEEK, CONRAD H., Ph.D., Code 8330, U.S. Naval Research Lab., Washington, D.C. 20390 (F-4)

CHEZEM, CURTIS G., Ph.D., Mgr., Nuclear Activities, Middle South Services, Box 61000, New Orleans, La. 70160 (F-26)

CHRISTIAN, ERMINE A., 7802 Lakecrest Dr., Greenbelt, Md. 20770 (M)

CHURCH, LLOYD E., D. D. S., Ph.D., 8218 Wisconsin Ave., Bethesda, Md. 20014 (F-1)

CLAIRE, CHARLES N., 4403 14th St., N.W., Washington, D.C. 20011 (F-1, 12)

CLARK, FRANCIS E., ARS Research Lab., P.O. Box E, Ft. Collins, Colo. 80521 (F)

CLARK, GEORGE E., Jr., 4022 North Stafford St., Arlington, Va. 22207 (F)

CLARK, JOAN ROBINSON, Ph.D., U.S. Geological Survey Nat. Center, 906 So. Lakes Dr., Reston, Va. 22092 (F-7)

CLARK, KENNETH G., Ph.D., 4816 46th St., N.W., Washington, D.C. 20016 (E-4)

CLAUSEN, CURTIS P., University of Calif., Riverside, Calif. 92507 (E-5)

CLEEK, GIVEN W., 5512 N. 24th St., Arlington, Va. 22205 (M-4, 28, 32)

CLEMENT, J. REID, Jr., 3720 Weltham St., Washington, D.C. 20023 (F)

CLEVEN, GALE W., Ph.D., Normandy House, Apt. 107, 1701 N. Kent St., Arlington, Va. 22209 (F-1, 6)

COHN, ERNST M., 103 G St., S.W., Apt. 620-B, Washington, D.C. 20024 (M-4, 29)

COHN, ROBERT, M.D., 7221 Pyle Rd., Bethesda, Md. 20034 (F-1)

COLE, KENNETH S., Ph.D., National Institutes of Health, Bethesda, Md. 20014 (F-1)

COLLINS, HENRY B., Dept. Anthropology, Smithsonian Inst., Washington, D.C. 20560 (E-2)

COLWELL, R. R., Ph.D., Dept. of Microbiology, Univ. of Maryland, College Park, Md. 20742 (F-6, 16)

COMPTON, W. DALE, Executive Dir., Sci. Res. Staff, Ford Motor Co., 20000 Rotunda Drive, Dearborn, Mich. 48121 (F)

CONGER, PAUL S., M.S., U.S. National Museum, Washington, D.C. 20560 (E)

COOK, HAROLD T., Ph.D., Box 303, Rt. 3, Edgewater, Md. 21037 (E-10)

COOK, RICHARD K., Ph.D., Room A311, Bldg. 226, Natl. Bur. Standards, Washington, D.C. (F-1, 25)

COOKE, C. WYTHE, Ph.D., Princess Issena Hotel, Daytona Beach, Fla. 32020 (E-7)

COOLIDGE, HAROLD J., 2101 Constitution Ave., Washington, D.C. 20037 (E-6)

COOLIDGE, WILLIAM D., 1480 Lenox Rd., Schenectady, N.Y. 12308 (F)

COONS, GEORGE H., Ph.D., 7415 Oak Lane, Chevy Chase, Md., 20015 (E-10)

COOPER, G. ARTHUR, U.S. Natl. Museum, Washington, D.C. 20560 (F-7)

CORLISS, JOSEPH J., 6618 Bellview Dr., Columbia, Md. 21046 (M)

CORNFIELD, JEROME, 9650 Rockville Pike, Bethesda, Md. 20014 (F)

CORY, ERNEST N., Ph.D., 4710 College Ave., College Park, Md. 20742 (E-5, 24)

COSTRELL, LOUIS, Chief 241. 02, Natl. Bureau of Standards, Washington, D.C. 20234 (F-1, 13)

COTTAM, C., Welder Wildlife Foundation, Box 1400, Sinton, Texas 78387 (F-3, 6)

COX, EDWIN L., Biometrical Serv., ARS, Bg. 226, Ag. Res. Center (E), Beltsville, Md. 20705 (F-6)

COYLE, THOMAS D., National Bureau of Standards, Washington, D.C. 20234 (F-4, 6)

CRAFT, CHARLES C., U.S. Dept. of Agriculture, Box 700, Pomona, Calif. 91766 (F)

CRAFTON, PAUL A., P.O. Box 454, Rockville, Md. 20850 (F)

CRAGOE, CARL S., 6206 Singleton Place, Bethesda, Md. 20034 (E-1)

CRANE, LANGDON T., Jr., 7103 Oakridge Ave., Chevy Chase, Md. 20015 (F-1)

CREITZ, E. CARROLL, 10145 Cedar Lane, Kensington, Md. 20795 (E-32)

CROSSETTE, GEORGE, 4217 Glenrose St., Kensington, Md. 20795 (M-6, 9, 11, 17)

CULBERT, DOROTHY K., 812 A St., S.E., Washington, D.C. 20003 (M-6)

CULLINAN, FRANK P., 4402 Beechwood Rd., Hyattsville, Md. 20782 (E-6, 10, 33)

CURRAN, HAROLD R., Ph.D., 3431 N. Randolph St., Arlington, Va. 22207 (E-16)

CURRIE, CHARLES L., S.J., Dept. of Chemistry, Georgetown Univ., Washington, D.C. 20007 (F-4)

CURTIS, ROGER W., Ph.D., 6308 Valley Rd., Bethesda, Md. 20034 (F)

CURTISS, LEON F., 1690 Bayshore Drive, Englewood, Fla. 33533 (E-1)

CUTHILL, JOHN R., Ph.D., 12700 River Rd., Potomac, Md. 20854 (F-20, 36)

CUTKOSKY, ROBERT DALE, 19150 Roman Way, Gaithersburg, Md. 20760 (F-6, 13)

CUTTITTA, FRANK, 12911 Bluhill Rd., Silver Spring, Md. 20906 (F-4, 6, 7)

D

DACONS, JOSEPH C., Ph.D., Naval Ordnance Lab., White Oak, Silver Spring, Md. 20910 (F-4)

DARRACOTT, HALVOR T., M.S., 3325 Mansfield Rd., Falls Church, Va. 22041 (F-13)

DAVENPORT, JAMES C., Virginia State College, Petersburg, Va. 23803 (M)

DAVIS, CHARLES M., Jr., 8458 Portland Place, McLean, Virginia 22101 (M-25)

DAVIS, MARION, MACLEAN, M.M.D., 5315 29th St., N.W., Washington, D.C. 20015 (F-4, 6)

DAVIS, R. F., Ph.D., Chairman, Dept. of Dairy Science, Univ. of Maryland, College Park, Md. 20742 (F)

DAVIS, RAYMOND, 5315 29th St., N.W., Washington, D.C. 20015 (E-1, 4)

DAVISSON, JAMES W., Ph.D., 400 Cedar Ridge Dr., Oxon Hill, Md. 20021 (F-1)

DAWSON, ROY C., 4019 Beechwood Rd., Univ. Park, Md. 20782 (E-16)

DAWSON, VICTOR C. D., 9406 Curran Road, Silver Spring, Md. 20901 (F-6, 14, 20, 22)

DE BERRY, MARIAN B., 1116 Lamont St., N.W., Washington, D.C. 20010 (M)

DE FERIET, J. KAMPE, Prof. A. La Faculte Des-Sci., de L'Univ. de Lille, 82 Rue Meurein, Lille, France (F)

DE PUE, LELAND A., Ph.D., Code 2303.3, Naval Res. Lab., Washington D.C. 20375 (F-6, 20)

DE VOE, JAMES R., 17708 Parkridge Dr., Gaithersburg, Md. 20760 (F-4, 6)

DE WIT, ROLAND, Metallurgy Division, Natl. Bureau of Standards, Washington, D.C. 20234 (F-1, 6, 36)

DEHL, RONALD E., 3895 Rodman St., N.W., Washington, D.C. 20016 (F)

DEITZ, VICTOR R., 3310 Winnett Rd., Chevy Chase, Md. 20016 (F-28)

DELANEY, WAYNE R., The Wyoming Apts., 111, 2022 Columbia Rd., N.W., Washington, D.C. 20009 (M-6, 20, 22, 32)

DEMUTH, HAL P., MSEE, 4025 Pinebrook Rd., Alexandria, Va. 22310 (F-13, 17)

DENNINGHAM, ROBERT L., 321 Terrell Ave., Forest Heights, Md. 20021 (M)

DENNIS, BERNARD K., 915 Country Club Dr., Vienna, Va. 22180 (F)

DESLATTES, RICHARD D., Jr., 610 Aster Blvd., Rockville, Md. 20850 (F)

DETWILER, ROBERT H., 5027 N. 30th St., Arlington, Va. 22210 (M)

DETWILER, SAMUEL B., Jr., 631 S. Walter Reed Dr., Arlington, Va. 22204 (F-4)

DI MARZIO, E. A., 14205 Parkvale Rd., Rockville, Md. 20853 (F)

DIAKNOK, OREST L., 6038 Richmond Hwy., Alexandria, Va. 22303 (M)

DIAMOND, J. J., Physics B-150, Natl. Bureau of Standards, Washington, D.C. 20234 (F-1, 4, 6, 28)

DIAMOND, PAULINE, 6436 Bannockburn Dr., Bethesda, Md. 20034 (F-1, 4, 28)

DICKSON, GEORGE, M.A., Dental Research Section, National Bureau of Standards, Washington, D.C. 20234 (F-6, 21)

DIEHL, WALTER S., 4501 Lowell St., N.W., Washington, D.C. 20016 (F-22)

DIEHL, WILLIAM W., Ph.D., 1512 N. McKinley Rd., Arlington, Va. 22205 (E-3, 10)

DIGGES, THOMAS G., 3900 N. Albemarie St., Arlington, Va. 22207 (E-20)

DOCTOR, NORMAN, B.S., 3814 Littleton St., Wheaton, Md. 20906 (F-13)

DOETSCH, RAYMOND N., Ph.D., Microbiology Dept., Univ. of Maryland, College Park, Md. 20742 (F-16)

DOFT, FLOYD S., Ph.D., 6416 Garnett Drive, Kenwood; Chevy Chase, Md. 20015 (E-4, 6, 19)

DONNERT, HERMANN J., Ph.D., Dept. Nuclear Engineering, Kansas State Univ., Manhattan, Kans. 66506 (F)

DOUGLAS, CHARLES A., Sec. 221.12, Natl. Bureau of Standards, Washington, D.C. 20234 (F-1, 6, 32)

DOUGLAS, THOMAS B., Ph.D., 3031 Sedgwick St., N.W., Washington, D.C. 20008 (F-4)

DRAEGER, R. HAROLD, M.D., 1201 N. 4th Ave., Tucson, Ariz. 85705 (E-32)

DRECHSLER, CHARLES, Ph.D., 6915 Oakridge Rd., University Park (Hyattsville), Md. 20782 (E-6, 10)

DU PONT, JOHN ELEUTHERE, Newton Square, Pennsylvania 19073 (M)

DUPRÉ ELSIE, Mrs., Code 6553, Optical Sci. Div., Naval Res. Lab., Washington, D.C. 20390 (F-32)

DUERKSEN, J. A., 3134 Monroe St., N.E., Washington, D.C. 20018 (E-1, 6)

DUNKUM, WILLIAM W., 256 Burgess Ave., Alexandria, Va. 22305 (F)

DUNN, JOSEPH P., 14721 Flintstone La., Silver Spring, Md. 20904 (M)

DUNNING, K. L., Ph.D., Code 6670, Naval Res. Lab., Washington, D.C. 20375 (F-1)

DURIE, EDYTHE G., 5011 Harna Dr., Alexandria, Va. 22310 (M)

DURST, RICHARD A., Ph.D., Radiometer A/S, Emdrupvej 72, DK 2400 Copenhagen NV, Denmark (F-4)

E

EASTER, DONALD, Research Mgr. CRSR, Cornell Univ., Ithaca, N.Y. 14850 (M)

ECKHARDT, E. A., Ph.D., 840 12th St., Oakmont, Allegheny County, Pa. 15139 (E-1)

EDDY, BERNICE E., Ph.D., Div. Biologic Standards, National Institutes of Health, Bethesda, Md. 20014 (F-6, 16, 19)

EDERER, DAVID L., Far U V Physics Section, Rm. A251, Bldg. 221, National Bureau of Standards, Washington, D.C. 20234 (F-32)

EDMUNDS, LAFE R., Ph.D., 6003 Leewood Dr., Alexandria, Va. 22310 (F-5)

EGOLF, DONALD R., 3600 Cambridge Court, Upper Marlboro, Md. 20870 (F-10)

EISELE, JOHN A., 3310 Curtis Dr., #202, Hillcrest Hghts., Md. 20023 (F)

EISENHART, CHURCHILL, Ph.D., Met A-123, National Bureau of Standards, Washington, D.C. 20234 (F-1, 30)

EL-BISI, HAMED M., Ph.D., 1017 Aponi Rd., Vienna, Va. 22180 (M-16)

ELBOURN, ROBERT D., 8221 Hamilton Spring Ct., Bethesda, Md. 20034 (F-1, 13)

ELLINGER, GEORGE A., 739 Kelly Dr., York, Pa. 17404 (E-6)

ELLIOTT, F. E., 7507 Grange Hall Dr., Oxon Hill, Md. 20022 (F)

EMERSON, K. C., Ph.D., 2704 N. Kensington St., Arlington, Va. 22207 (F-3, 5)

EMERSON, W. B., 415 Aspen St., N.W., Washington, D.C. 20012 (E)

ENNIS, W. B., Jr., 4011 College Hgts. Dr., Hyattsville, Md. 20782 (F)

ETZEL, HOWARD W., 7304 River Hill Rd., Washington, D.C. 20021 (F)

EWERS, JOHN C., 4432 26th Rd., N, Arlington, Va. 22207 (F-2)

F

FAHEY, JOSEPH J., U.S. Geological Survey, Washington, D.C. 20242 (E-4, 6, 7)

FALLON, ROBERT, 8251 Toll House Rd., Annandale, Va. 22003 (F)

FARROW, RICHARD P., National Canners Assn., 1133 20th St., N.W., Washington, D.C. 20036 (F-4, 6, 27)

FAULKNER, JOSEPH A., 1007 Sligo Creek Pky., Takoma Park, Md. 20012 (F-6)

FAUST, GEORGE T., Ph.D., 9907 Capitol View Ave., Silver Spring, Md. 20910 (F-7, 31)

FAUST, WALTER L., Ph.D., U.S. Naval Res. Lab., Code 6510, Washington, D.C. 20375 (M)

FAUST, WILLIAM R., Ph.D., 5907 Walnut St., Temple Hills, Md. 20031 (F-1, 6)

FEARN, JAMES E., Ph.D., A367 Chem. Organic Chemistry Sec., Natl. Bureau of Standards, Washington, D.C. 20234 (F-4)

FELSENFELD, OSCAR, M.D., Tulane Research Center, Covington, La. 70433 (F-6)

FELSHER, MURRAY, Sr. Staff Geologist, Off. Techn. Anal. Enforcement, EPA, Washington, D.C. 20460 (M-1, 7)

FERGUSON, ROBERT E., 6307 Tone Dr., Washington, D.C. 20034 (F-4)

FERRELL, RICHARD A., Ph.D., Dept. of Physics, University of Maryland, College Park, Md. 20742 (F-6, 31)

FIELD, WILLIAM D., Dept. Entomology, Smithsonian Institution, Washington, D.C. 20560 (F-5)

FIFE, EARL H., Jr., 6412 Elliott Pl., Hyattsville, Md. 20783 (F)

FINLEY, HAROLD E., Head, Dept. of Zoology, Howard Univ., Washington, D.C. 20001 (F-3)

FIVAZ, ALFRED E., 804 Dale Drive, Silver Spring, Md. 20910 (E-11)

FLETCHER, DONALD G., Natl. Bureau of Standards, Rm. A102, Bldg. 231–IND, Washington, D.C. 20234 (M-4)

FLETCHER, HEWITT G., Jr., Box 217, Sandy Spring, Md. 20860 (F)

FLINT, EINAR P., 6229 Radcliffe Rd., Alexandria, Va. 22307 (F-4, 20, 28, 36)

FLORIN, ROLAND E., Ph.D., Polymer Chemistry Section, B-328 Poly, National Bureau of Standards, Washington, D.C. 20234 (F-4)

FLYNN, DANIEL R., 17500 Ira Court, Derwood, Md. 20855 (F)

FLYNN, JOSEPH H., Ph.D., 5309 Iroquois Rd., Washington, D.C. 20016 (F-4)

FOCKLER, H. H., MSLS, 10710 Lorain Ave., Silver Spring, Md. 20014 (M)

FONER, S. N., Applied Physics Lab., The Johns Hopkins University, Silver Spring, Md. 20910 (F-1)

FOOTE, RICHARD H., Sc.D., 8807 Victoria Road, Springfield, Va. 22151 (F-5, 6)

FORD, W. KENT, Jr., Dept. of Terrestrial Magnetism, Carnegie Institution of Washington, 5241 Broad Branch Rd., N.W., Washington, D.C. 20015 (F)

FORZIATI, ALPHONSE F., Ph.D., 9812 Dameron Dr., Silver Spring, Md. 20902 (F-1, 4, 21, 29)

FORZIATI, FLORENCE H., Ph.D., 9812 Dameron Dr., Silver Spring, Md. 20902 (F-4)

FOSTER, AUREL O., 4613 Drexel Rd., College Park, Md. 20740 (F-15, 24)

FOURNIER, ROBERT O., 108 Paloma Rd., Portola Valley, Calif. 94025 (F-6, 7)

FOWELLS, H. A., Ph.D., 10217 Green Forest, Silver Spring, Md. 20903 (F-11)

FOWLER, EUGENE, U.S. Atomic Energy Comm., Washington, D.C. 20545 (M-26)

FOWLER, WALTER B., Code 673, Goddard Space Flight Center, Greenbelt, Md. 20771 (M)

FOX, DAVID W., The Johns Hopkins Univ., Applied Physics Lab., Silver Spring, Md. 20910 (F)

FOX, ROBERT B., Naval Res. Lab., Code 6120, Washington, D.C. 20390 (F-4, 6)

FRANKLIN, PHILIP J., 5907 Massachusetts Ave. Extended, Washington, D.C. 20016 (F-4, 13)

FRANZ, GERALD J., M.S., 9638 Culver St., Kensington, Md. 20795 (M-6, 25)

FREDERIKSE, H. P. R., Ph.D., 9625 Dewmar Lane, Kensington, Md. 20795 (F)

FREEMAN, ANDREW F., 5012 N. 33rd St., Arlington, Va. 22207 (M)

FRENKIEL, FRANCOIS N., Computation and Math. Lab., Naval Ship Res. & Develop. Ctr., Bethesda, Md. 20034 (F-1, 22, 23)

FRIEDMAN, LEO, Ph.D., Director, Div. of Toxicology (BF-150), Bureau of Foods, Food & Drug Admin., HEW, Washington, D.C. 20204 (F-4, 19)

FRIESS, S. L., Ph.D., Environmental Biosciences Dept., Naval Med. Res. Inst. NNMC, Bethesda, Md. 20014 (F-4)

FRUSH, HARRIET L., 4912 New Hampshire Ave., N.W., Apt. 104, Washington, D.C. 20011 (F-4, 6)

FULLMER, IRVIN H., Lakeview Terrace Retirement Center, P.O. Box 116, Altoona, Fla. 32702 (E-1, 6, 14)

FULTON, ROBERT A., 530 Merrie Dr., Corvallis, Oregon 97330 (E-4, 5)

FURUKAWA, GEORGE T., Ph.D., National Bureau of Standards, Washington, D.C. 20234 (F-1, 4, 6)

FUSILLO, MATTHEW H., VA Hospital, 50 Irving St., N.W., Washington, D.C. 20422 (M-6, 16)

G

GAFAFER, WILLIAM M., 133 Cunningham Dr., New Smyrna Beach, Fla. 32069 (E)

GAGE, WILLIAM, Ph.D., 2146 Florida Ave., N.W., Washington, D.C. 20008 (F-2)

GALLER, SIDNEY, 6242 Woodcrest Ave., Baltimore, Md. 21209 (F-6)

GALLOWAY, RAYMOND A., Dept. of Botany, University of Maryland, College Park, Md. 20742 (F-10, 33)

GALTSOFF, PAUL S., Ph.D., P.O. Box 167, Woods Hole, Mass. 20543 (E-3)

GALVIN, CYRIL J., Jr., 2915 Tennyson St., N.W., Washington, D.C. 20015 (F-7, 18, 30)

GANT, JAMES O., Jr., 1835 Eye St., N.W., Suite 201, Washington, D.C. 20006 (M)

GARNER, C. L., The Garfield, 5410 Connecticut Ave., N.W., Washington, D.C. 20015 (E-1, 4, 12, 17, 18)

GARVIN, DAVID, Ph.D., 4000 Tunlaw Rd., N.W., Apt. 323, Washington, D.C. 20007 (F-4)

GAUM, CARL H., 9609 Carriage Rd., Kensington, Md. 20795 (F-18)

GELLER, ROMAN F., 4977 Battery Lane, #406, Bethesda, Md. 20014 (E)

GHAFFARI, ABOLGHASSEN, Ph.D., D.Sc., 7109 Connecticut Ave., N.W., Washington, D.C. 20015 (Life-1)

GHOSE, RABINDRA N., 8167 Mulholland Terr., Los Angeles Hill, Calif. 90046 (F)

GIBSON, JOHN E., Box 96, Gibson, N.C. 28343 (E)

GIBSON, KASSON S., 4817 Cumberland St., Chevy Chase, Md. 20015 (E)

GINTHER, ROBERT J., Code 6406, U.S. Naval Res. Lab., Washington, D.C. 20390 (F-28, 29)

GISH, OLIVER H., 7107 S. Indian River Dr., Fort Pierce, Fla. 33450 (E-1, 6)

GIWER, MATTHIAS M., 204-206 S. St. Asaph St., Alexandria, Va. 22314 (M)

GLADSTONE, VIC S., 7 Deauville Ct., Baltimore, Md. 21208 (M-6, 25)

GLASGOW, A. R., Jr., Ph.D., 4116 Hamilton St., Hyattsville, Md. 20781 (F-4, 6)

GLASSER, ROBERT G., Ph.D., 2812 Abilene Dr., Chevy Chase, Md. 20015 (F)
GLICKSMAN, MARTIN E., 2223 Hindle Lane, Bowie, Md. 20715 (F-20)
GODFREY, THEODORE B., 7508 Old Chester Rd., Bethesda, Md. 20034 (E)
GOLDBERG, MICHAEL, 5823 Potomac Ave., N.W., Washington, D.C. 20016 (F-1)
GOLDMAN, ALAN J., Applied Math. Div., Inst. for Basic Standards, Natl. Bureau of Standards, Washington, D.C. 20234 (F)
GOLDSMITH, HERBERT, 238 Congressional Lane, Rockville, Md. 20852 (M)
GOLDSTEIN, GORDON D., 9520 Saybrook Ave., Silver Spring, Md. 20901 (M)
GOLUMBIC, CALVIN, ARS, USDA, Rm. 637 Fed. Center Bg., Hyattsville, Md. 20782 (F)
GONET, FRANK, 4007 N. Woodstock St., Arlington, Va. 22207 (F-4)
GOODE, ROBERT J., B.S., Strength of Metals Br., Code 6380, Metallurgy Div., U.S.N.R.L., Washington, D.C. 20390 (F-6, 20, 36)
GOODMAN, RALPH, 6600 Melody Lane, Bethesda, Md. 20034 (F)
GORDON, CHARLES L., 5512 Charles St., Bethesda, Md. 20014 (F-1, 4, 6)
GORDON, NATHAN, 1121 Univ. Blvd., Apt. 205, Silver Spring, Md. 20902 (F-4)
GORDON, RUTH E., Ph.D., Inst. of Microbiology, Rutgers Univer., New Brunswick, N.J. 08903 (F-16)
GRAF, JOHN E., 2035 Parkside Dr., N.W., Washington, D.C. 20012 (F-3, 5, 6)
GRAHN, MRS. ANN, 1508 34th St. N.W., Washington, D.C. 20007 (M)
GRASSL, CARL O., Sugar Plant Field Station, P.O. Box 156, Canal Point, Fla. 33438 (F)
GRAY, ALFRED, Dept. Math., Univ. of Maryland, College Park, Md. 20742 (F)
GRAY, IRVING, Georgetown Univ., Washington, D.C. 20007 (F)
GREENBERG, LEON, Ph.D., 6209 Poindexter Lane, Rockville, Md. 20852 (F)
GREENBERG, O. W., Dept. Phys. & Astron., Univ. of Maryland, College Park, Md. 20742 (F)
GREENOUGH, M.L., M.S., Rm. A109 Poly, National Bureau of Standards, Washington, D.C. 20234 (F)
GREENSPAN, MARTIN, 12 Granville Dr., Silver Spring, Md. 20902 (F-1, 25)
GRIFFITHS, NORMAN H. C., 3100 20th St., N.E., Washington, D.C. 20018 (F-21)
GRISAMORE, NELSON T., 9536 E. Bexhill Dr., Kensington, Md. 20795 (F)
GROSSLING, BERNARDO F., U.S. Geological Survey, Rm. 5216, GSA Bg., Washington, D.C. 20242 (F-7)
GUARINO, P. A., 6714 Montrose Rd., Rockville, Md. 20852 (F-13)
GURNEY, ASHLEY B., Ph.D., Systematic Entomology Lab., USDA, % U.S. National Museum, Washington, D.C. 20560 (F-3, 5, 6)

H

HACSKAYLO, EDWARD, Ph.D., Plant Industry Station, USDA, Beltsville, Md. 20705 (F-6, 10, 11, 33)
HAENNI, EDWARD O., Ph.D., Div. Chem. & Phys., BF-140, FDA, Washington, D.C. 20204 (F-4)
HAGAN, LUCY B., Natl. Bur. Stds., Rm. A155, Bg. 221, Washington, D.C. 20243 (M)
HAINES, KENNETH A., ARS, USDA, Federal Center Bldg., Hyattsville, Md. 20781 (F-5)
HAKALA, REINO W., Ph.D., 2817 N.W. 21st St., Oklahoma City, Okla. 73107 (F)
HALL, E. RAYMOND, Museum of Natural History, Univ. of Kansas, Lawrence, Kans. 66044 (F)
HALL, R. CLIFFORD, M.F., 316 Mansion Drive, Alexandria, Va. 22302 (E-11)
HALL, STANLEY A., Agric. Res. Center (E), USDA, Beltsville, Md. 20705 (F-24)
HALL, WAYNE C., 1755 Ivy Oak Square, Reston, Va. 22070 (F-1, 6, 13, 31)
HALLER, WOLFGANG, Ph.D., National Bureau of Standards, Washington, D.C. 20234 (F)
HAMBLETON, EDSON J., 5140 Worthington Dr., Washington, D.C. 20016 (E-3, 5, 6)
HAMER, WALTER J., 3028 Dogwood St., N.W., Washington, D.C. 20015 (F-6, 13, 29)
HAMILTON, C. E. MIKE, Federal Power Comm., 441 G St., N.W., Washington, D.C. 20426 (M-7, 36)
HAMMERSCHMIDT, W. W., Ph.D., 7818 Holmes Run Dr., Falls Church, Va. 22042 (M)
HAMMOND, H. DAVID, Ph.D., 14 Chappel St., Brockport, N.Y. 14420 (M-10)
HAMPP, EDWARD G., D.D.S., National Institutes of Health, Bethesda, Md. 20014 (F-21)
HANCOCK, JUDITH M., Biol. Dept., St. Joseph's College, North Windham, Me. 04062 (M)
HAND, CADET H., Jr., Bodega Marine Lab., Bodega Bay, Calif. 94923 (F-6)
HANSEN, LOUIS S., D.D.S., School of Dentistry, San Francisco Med. Center, Univ. of Calif., San Francisco, Calif. 94122 (F-21)
HANSEN, MORRIS H., M.A., Westat Research, Inc., 11600 Nebel St., Rockville, Md. 20852 (F-34)
HARDENBURG, ROBERT EARLE, Ph.D., Plant Industry Station, U.S. Dept. of Agriculture, Beltsville, Md. 20705 (F-6)
HARRINGTON, FRANCIS D., Ph.D., 4612 N. 2nd Rd., Arlington, Va. 22203 (M)
HARRINGTON, M. C., Ph.D., Physics Directorate (NPP), Air Force Off. Sci. Res., 1400 Wilson Blvd., Arlington, Va. 22209 (F-1, 13, 22, 31, 32)
HARRIS, MILTON, Ph.D., 3300 Whitehaven St., N.W., Suite 500, Washington, D.C. 20007 (F)
HARRIS, ROBERT H., Ph.D., 12915 Travilah Rd., Rockville, Md. 20850 (M)
HARRISON, W. N., 3734 Windom Pl., N.W., Washington, D.C. 20016 (F-1)

HARTLEY, JANET W., Ph.D., National Inst. of Allergy & Infectious Diseases, National Institutes of Health, Bethesda, Md. 20014 (F)
HARTMANN, GREGORY K., 10701 Keswick St., Garrett Park, Md. 20766 (F-1, 25)
HARTZLER, MARY P., 3326 Hartwell Ct., Falls Church, Va. 22042 (M-6)
HASKINS, C. P., Ph.D., 2100 M St., N.W., Suite 600, Washington, D.C. 20037 (F)
HASS, GEORG H., 7728 Lee Avenue, Alexandria, Va. 22308 (F)
HAUPTMAN, HERBERT, Ph.D., Medical Foundation of Buffalo, 73 High St., Buffalo, N.Y. 14203 (F-1)
HAYDEN, GEORGE A., 1312 Juniper St. N.W., Washington, D.C. 20012 (M)
HEANEY, JAMES B., Code 765, Goddard Space Flight Center, Greenbelt, Md. 20771 (F)
HEINRICH, KURT F., 804 Blossom Dr., Woodley Gardens, Rockville, Md. 20850 (F)
HEINZE, P. H., Ph.D., Horticultural Crops Research, USDA, ARS, MQ., Rm. 803 F.C.B., Hyattsville, Md. 20782 (F-4, 6, 10)
HENDERSON, E. P., Div. of Meteorites, U.S. National Museum, Washington, D.C. 20560 (E)
HENDERSON, MALCOLM C., Ph.D., 2699 Shasta Rd., Berkeley, Calif. 94708 (F-1)
HENNEBERRY, THOMAS J., 2608 Shenandale Dr., Silver Spring, Md. 20904 (F-5, 24)
HENVIS, BERTHA W., Code 6472, Naval Res. Lab., Washington, D.C. 20375 (M)
HERMACH, FRANCIS L., 2415 Eccleston St., Silver Spring, Md. 20902 (F-13, 35)
HERMAN, ROBERT, Theoretical Physics Dept., General Motors Res. Lab., 12 Mi & Mound Rds., Warren, Mich. 48091 (F-1)
HERSCHMAN, HARRY K., 4701 Willard Ave., Chevy Chase, Md. 20015 (F-20)
HERSEY, JOHN B., 8911 Colesbury Pl., Fairfax, Va. 22030 (M)
HERSEY, MAYO D., M.A., Div. of Engineering, Brown Univ., Providence, R.I. 02912 (E-1)
HERZFELD, KARL F., Dept. of Physics, Catholic Univ., Washington, D.C. 20017 (F-1)
HERZFELD, REGINA F., Ph.D., Dept. of Anthropology, Catholic Univ., Washington, D.C. 20017 (F-1, 2)
HESS, WALTER C., 3607 Chesapeake St., N.W., Washington, D.C. 20008 (E-4, 6, 19, 21)
HEWSTON, ELIZABETH M., Felicity Cove, Shady Side, Md. 20867 (F)
HEYDEN, FR. FRANCIS, Manila Observatory, P.O. Box 1231, Manila, Philippines D-404 (F-32)
HIATT, CASPAR W., Ph.D., Univ. of Texas Health Science Center, 7703 Floyd Curl Dr., San Antonio, Texas 78284 (F)
HICKLEY, THOMAS J., 626 Binnacle Dr., Naples, Fla. 33940 (F-13)
HICKOX, GEORGE H., Ph.D., 9310 Allwood Ct., Alexandria, Va. 22309 (F-6, 14, 18)
HILDEBRAND, EARL M., 11092 Timberline Dr., Sun City, Ariz. 85351 (E)
HILL, FREEMAN K., 12408 Hall's Shop Rd., Fulton, Md. 20759 (F-1, 6, 22)
HILSENRATH, JOSEPH, 9603 Brunett Ave., Silver Spring, Md. 20901 (F-1)
HILTON, JAMES L., Ph.D., Plant Industry Station, USDA, ARS, Beltsville, Md. 20705 (F-33)
HOBBS, ROBERT B., 7715 Old Chester Rd., Bethesda, Md. 20034 (F-4)
HOERING, THOMAS C., Carnegie Inst. of Washington, Geophysical Lab., 2801 Upton St., N.W., Washington, D.C. 20008 (F-4, 7)
HOFFMANN, C. H., Ph.D., 6906 40th Ave., University Park, Hyattsville, Md. 20782 (F-5, 11, 24)
HOGE, HAROLD J., Ph.D., Head, Thermodyn. Lab. Prd., U.S. Army Natick Labs., Natick, Mass. 01760 (F-1)
HOLLIES, NORMAN R. S., Gillette Research Institute, 1413 Research Blvd., Rockville, Md. 20850 (F-4)
HOLLINSHEAD, ARIEL C., Ph.D., Lab. for Virus & Cancer Research, Dept. of Medicine, 2300 K St., N.W., Washington, D.C. 20037 (F-16, 19)
HOLMGREN, HARRY D., Ph.D., P.O. Box 391, College Park, Md. 20740 (F-1)
HOLSHOUSER, WILLIAM L., Bureau of Aviation Safety, Natl. Trans. Safety Board, Washington, D.C. 20591 (F-6, 20)
HONIG, JOHN G., Office Chief of Staff, Army, The Pentagon, Washington, D.C. 20310 (F-1, 4, 34)
HOOD, KENNETH J., 2000 Huntington Ave., 1118, Alexandria, Va. 22303 (M-33)
HOOKER, MISS MARJORIE, U.S. Geological Survey, Washington, D.C. 20242 (F-7)
HOOVER, JOHN I., 5313 Briley Place, Washington, D.C. 20016 (F-1, 6)
HOPKINS, STEPHEN, M.Ed., Compackager Corp., 2135 Wisconsin Ave., N.W., Washington, D.C. 20007 (F)
HOPP, HENRY, Ph.D., 7003 Wells Parkway, Hyattsville, Md. 20782 (F-11)
HOPPS, HOPE E., Mrs., 1762 Overlook Dr., Silver Spring, Md. 20903 (F)
HORNSTEIN, IRWIN, 5920 Bryn Mawr Rd., College Park, Md. 20740 (F-4, 27)
HOROWITZ, E., Deputy Director, Institute for Materials Res., National Bureau of Standards, Washington, D.C. 20234 (F)
HORTON, BILLY M., 3238 Rodman St., N.W., Washington, D.C. 20008 (F-1, 13)
HOUGH, FLOYD W., C.E., Woodstock, Va. 22664 (E-17, 18)
HOE, PAUL E., 3601 Connecticut Ave., N.W., Washington, D.C. 20008 (E-3, 4, 6, 8, 19)
HUANG, KUN-YEN, 6100 Johnson Ave., Bethesda, Md. 20034 (F)
HUBBARD, DONALD, 4807 Chevy Chase Dr., Chevy Chase, Md. 20015 (F-4, 6, 32)
HUBBARD, HARVEY H., 23 Elm Ave., Newport News, Va. 23601 (M)
HUBERT, LESTER F., 4704 Mangum Rd., College Park, Md. 20740 (F-23)

HUDSON, COLIN M., Ph.D., Chief Scientist, U.S. Army Armament Command, Rock Island, Ill. 61201 (F-22)

HUGH, RUDOLPH, Ph.D., George Washington Univ. Sch. of Med., Dept. of Microbiology, 2300 Eye St. N.W., Washington, D.C. 20037 (F-16, 19)

HUNDLEY, JAMES M., American Heart Assn., 44 E. 23rd St., New York, N.Y. 10010 (F)

HUNT, W. HAWARD, 11712 Roby Ave., Beltsville, Md. 20705 (M)

HUNTER, RICHARD S., 9529 Lee Highway, Fairfax, Va. 22030 (F-27, 32)

HUNTER, WILLIAM R., Code 7143, U.S. Naval Research Lab., Washington, D.C. 20390 (F-1, 6, 32)

HUNTOON, R. D., Ph.D., 13904 Blair Stone Lane, Wheaton, Md. 20906 (F-1, 13)

HUTCHINS, LEE M., Cacao Ctr., Institute of Agriculture, Turrialba, Costa Rica (E-10, 11)

HUTTON, GEORGE L., 809 Avondale Dr., W. Lafayette, Ind. 47906 (F)

I

INSLEY, HERBERT, Ph.D., 5219 Farrington Rd., Washington, D.C. 20016 (F-1, 7)

IRVING, GEORGE W., Jr., Ph.D., 4836 Langdrum Lane, Chevy Chase, Md. 20015 (F-4, 27)

IRWIN, GEORGE R., Ph.D., 7306 Edmonston Rd., College Park, Md. 20740 (F-1, 6)

ISBELL, H. S., 4704 Blagden Ave., N.W., Washington, D.C. 20011 (F-4)

J

JACKSON, H. H. T., Ph.D., 122 Pinecrest Rd., Durham, N.C. (E-3)

JACOBS, WOODROW C., Ph.D., 6309 Bradley Blvd., Bethesda, Md. 20034 (F-23)

JACOBSON, MARTIN, U.S. Dept. of Agriculture, Agr. Res. Center (E) Beltsville, Md. 20705 (F-4, 24)

JACOX, MARILYN E., Ph.D., National Bureau of Standards, Washington, D.C. 20234 (F-4)

JAMES, L. H., The James Laboratories, 189 W. Madison St., Chicago, Ill. 60602 (F)

JAMES, MAURICE T., Ph.D., Dept. of Entomology, Washington State University, Pullman, Washington 99163 (E-5)

JAMES, STANLEY D., U.S. Naval Ord. Lab., Code 232, White Oak, Md. 20910 (F)

JANI, LORRAINE L., 2733 Ontario Rd., N.W., Washington, D.C. 20009 (M)

JAY, GEORGE E., Jr., Ph.D., National Cancer Inst., Bethesda, Md. 20014 (F-6)

JEN, C. K., Applied Physics Lab., 8621 Georgia Ave., Silver Spring, Md. 20910 (F)

JENKINS, WILLIAM D., 1829 Ingleside Terr., N.W., Washington, D.C. 20010 (M-20)

JENSON, ARTHUR S., Ph.D., Westinghouse Defense & Electronic Systems Ctr., Box 1521, Baltimore, Md. 21203 (M-13, 32)

JESSUP, R. S., 7001 W. Greenvale Pkwy., Chevy Chase, Md. 20015 (F-1, 6)

JOHANNESEN, ROLF B., National Bureau of Standards, Washington, D.C. 20234 (F-4)

JOHNSON, DANIEL P., 9222 Columbia Blvd., Silver Spring, Md. 20910 (F-1)

JOHNSON, KEITH C., 4422 Davenport St., N.W., Washington, D.C. 20016 (F)

JOHNSON, PHYLLIS T., Ph.D., Nat. Marine Fisheries Serv., Oxford Lab., Oxford, Md. 21654 (F-5, 6)

JOHNSTON, FRANCIS E., 307 W. Montgomery Ave., Rockville, Md. 20850 (E-1)

JONES, HENRY A., Desert Seed Co., Inc., Box 181, El Centro, Calif. 92243 (F)

JORDAN, GARY BLAKE, 1012 Olmo Ct., San Jose, Calif. 95129 (M-13)

JUDD, NEIL M., Georgian Towers, Apt. 120-C, 8715 First Ave., Silver Spring, Md. 20910 (E)

K

KAISER, HANS E., 433 South West Dr., Silver Spring, Md. 20901 (M-6)

KARLE, ISABELLA, Code 6030, U.S. Naval Res. Lab., Washington, D.C. 20375 (F)

KARLE, JEROME, Code 6030, U.S. Naval Research Lab., Washington, D.C. 20390 (F-1, 4)

KARR, PHILIP R., 5507 Calle de Arboles, Torrance, Calif. 90505 (F-13)

KARRER, ANNIE M. H., Port Republic, Md. 20676 (E)

KARRER, S., Port Republic, Md. 20676 (F-1, 4, 6, 31, 32)

KAUFMAN, H. P., Box 1135, Fedhaven, Fla. 33854 (F-12)

KEARNEY, PHILIP C., Ph.D., 13021 Blairmore St., Beltsville, Md. 20705 (F-4)

KEGELES, GERSON, RFD 2, Stafford Springs, Conn. 06076 (F)

KENNARD, RALPH B., Ph.D., 3017 Military Rd., N.W., Washington, D.C. 20015 (E-1, 6, 31, 32)

KENNEDY, E. R., Ph.D., Biology Department, Catholic University, Washington, D.C. 20017 (F-16)

KESSLER, KARL G., Ph.D., Optical Physics Div., Natl. Bureau of Standards, Washington, D.C. 20234 (F-1, 6, 32)

KEULEGAN, GARBIS H., Ph.D., 215 Buena Vista Dr., Vicksburg, Miss. 39180 (F-1, 6)

KINNEY, J. P., Hartwick, Otsego County, N.Y. 13348 (E-11)

KLEBANOFF, PHILIP S., Aerodynamics Sect., National Bureau of Standards, Washington, D.C. 20234 (F-1, 22)

KLINGSBERG, CYRUS, Natl. Academy of Sciences, 2101 Constitution Ave., Washington, D.C. 20418 (F-28)

KLUTE, CHARLES H., Ph.D., Apt. 118, 4545 Connecticut Ave., N.W., Washington, D.C. 20008 (F-1, 4)

KNAPP, DAVID C., 4695 Osage Dr. Boulder, Colo. 80303 (F)

KNIPLING, EDWARD F., Ph.D., Sc.D., Science Advisor, ARS-OA, USDA, Rm. 205, Nat. Agr. Library, Beltsville, Md. 20705 (F-5)

KNIPLING, PHOEBE H., Ph.D., 2623 N. Military Rd., Arlington, Va. 22207 (F)

KNOBLOCK, EDWARD C., 12002 Greenleaf Ave., Rockville, Md. 20854 (F-4, 19)

KNOPF, ELEANORA B., Ph.D., Sch. of Earth Sciences, Stanford Univ., Stanford, Calif. 94305 (E)

KNOWLTON, KATHRYN, Apt. 837, 2122 Massachusetts Ave., N.W., Washington, D.C. 20009 (F-4, 19)

KNOX, ARTHUR S., M.A., M.Ed., U.S. Geological Survey, Washington, D.C. 20006 (M-6, 7)

KNUTSON, LLOYD V., Ph.D., Systematic Entomology Lab., ARS, USDA, Bg. 003, ARC (W), Beltsville, Md. 20705 (M-5)

KOHLER, HANS W., 607 Owl Way, Bird Key. Sarasota, Fla. 33577 (F-6, 13, 31)

KOHLER, MAX A., NOAA Office of Hydrology, Natl. Weather Serv., Silver Spring, Md. 20910 (F-18, 23)

KRAUSS, ROBERT W., College of Science, Oregon State Univ., Corvallis, Oregon 97331 (F-3)

KRUGER, JEROME, Ph.D., Rm B254, Materials Bldg., Natl. Bur. of Standards, Washington, D.C. 20234 (F-4, 29)

KRUL, WILLIAM R., 1809 Belvedere Blvd., Silver Spring, Md. 20902

KULLBACK, SOLOMON, Statistics Dept., George Washington Univ., Washington, D.C. 20006 (F-13)

KURTZ, FLOYD E., 8005 Custer Rd., Bethesda, Md. 20014 (F-4)

KURZWEG, HERMAN H., 731 Quaint Acres Dr., Silver Spring, Md. 20904 (F-1, 22)

KUSHNER, LAWRENCE M., Ph.D., Commissioner, Consumer Product Safety Commission, Washington, D.C. 20016 (F-36)

L

LABENZ, PAUL J., 9504 Kingsley Ave., Bethesda, Md. 20014

LADO, ROBERT, Ph.D., Georgetown Univ., Washington, D.C. 20007 (F)

LAKI, KOLOMAN, Ph.D., Bldg. 4, Natl. Inst. of Health, Bethesda, Md. 20014 (F)

LAKIN, HUBERT W., U.S. Geological Survey, Bldg. 25, Denver Fed. Ctr., Denver, Colo. 80201 (F)

LAMANNA, CARL, Ph.D., 3812 37th St., N., Arlington, Va. 22207 (F-16, 19)

LAMBERTON, BERENICE, Georgetown Univ. Observ., Washington, D.C. 20007 (M)

LANDER, JAMES F., Nat. Earthquake Info. Center, NOAA, ERL, R1015, Boulder, Colo. 80302 (F)

LANDIS, PAUL E., 6304 Landon Lane, Bethesda, Md. 20034 (F-6)

LANDSBERG, H. E., 5116 Yorkville Rd., Temple Hills, Md. 20031 (F-1, 23)

LANG, WALTER B., M.S., Kennedy-Warren, Washington, D.C. 20008 (E-4, 6, 7, 36)

LANGFORD, GEORGE S., Ph.D., 4606 Hartwick Rd., College Park, Md. 20740 (F-5, 24)

LAPHAM, EVAN G., 5340 Cortez Ct., Cape Coral, Fla. 33904 (E)

LARMORE, LEWIS, Off. of Naval Res., 800 N. Quincey St., Arlington, Va. 22217 (M)

LASHOF, THEODORE W., 10125 Ashburton Lane, Bethesda, Md. 20034 (F)

LASTER, HOWARD J., Ph.D., Dept. of Physics & Astron., Univ. of Maryland, College Park, Md. 20742 (F-1, 31)

LATTA, RANDALL, 2122 California St., N.W., Washington, D.C. 20008 (E-5)

LAYMAN, JOHN, Ed.D., Science Teaching Center, Univ. Maryland, College Park, Md. 20742 (M)

LE CLERG, ERWIN L., 14620 Deerhurst Terrace, Silver Spring, Md. 20906 (E)

LEE, RICHARD H., RD 2, Box 143E, Lewes, Del. 19958 (E)

LEINER, ALAN L., Hopinson House, 602 Washington Square So., Philadelphia, Pa. 19106 (F)

LEJINS, PETER P., Univ. of Maryland, Dept. of Sociology, College Park, Md. 20742 (F-10)

LENTZ, PAUL LEWIS, 5 Orange Ct., Greenbelt, Md. 20770 (F-6, 10)

LEOPOLD, LUNA B., Room 3203, 95 A Bldg., Washington, D.C. 20242 (F)

LEVERTON, RUTH M., Ph.D., 3900 16th St. N.W., Apt. 240, Washington, D.C. 20011 (F)

LEVIN, ERNEST M., 7716 Sebago Rd., Bethesda, Md. 20034 (F-4, 28)

LEVY, SAMUEL, 2279 Preisman Dr., Schenectady, N.Y. 12309 (F)

LEWIS, ANDREW M., Jr., MD, NLAID, LVD Bg. 7, Rm. 313, NIH, Bethesda, Md. 20014 (F)

LEWIS, KEITH H., Ph.D., 1701 No. Kent, Apt. 1006, Arlington, Va. 22209 (M)

LEY, HERBERT L., Jr., M.D., P.O. Box 34434, Bethesda, Md. 20034 (F-6, 8, 16)

LI, HUI-LIN, The Morris Arboretum, Chestnut Hill, Philadelphia, Pa. 19118 (F)

LIDDEL, URNER, 2939 Van Ness St. N.W., Apt. 1135, Washington, D.C. 20008 (E-1)

LIEBERMAN, MORRIS, 107 Delford Ave., Silver Spring, Md. 20904 (F-4, 6, 33)

LINDQUIST, ARTHUR W., Rte. 1, Bridgeport, Kans. 67424 (E-6)

LINDSEY, IRVING, M.A., 202 E. Alexandria Ave., Alexandria, Va. 22301 (E)

LING, LEE, Food & Agri. Organ. of U.N., Viale Delle, Terme Di Caracalla, Rome, Italy (F)

LINK, CONRAD B., Dept. of Horticulture, Univ. of Maryland, College Park, Md. 20742 (F-6, 10)

LINNENBOM, VICTOR J., Ph.D., Code 8300, Naval Res. Lab., Washington, D.C. 20390 (F-4)

LIPKIN, LEWIS E., Bg. 36, Rm. 40-25, NIH, Bethesda, Md. 20014 (M)

LIST, ROBERT J., 1123 Hammond Pkwy., Alexandria, Va. 22302 (F-23)

LITTLE, ELBERT L., Jr., Ph.D., U.S. Forest Service, Washington, D.C. 20250 (F-10, 11)

LLOYD, DANIEL BOONE, 5604 Overlea Rd., Sumner, Washington, D.C. 20016 (F-6)

LOCKARD, J. DAVID, Ph.D., Botany Dept., Univ. of Maryland, College Park, Md. 20742 (M-33)

LOCKHART, LUTHER B., Jr., Ph.D., 6820 Wheatley Ct., Falls Church, Va. 22042 (F-4)

LONG, AUSTIN, 2715 E. Helen St., Tucson, Ariz. 85716 (F)

LONG, B. J. B., Mrs., 416 Riverbend Rd., Oxon Hill, Md. 20022 (M)

LORING, BLAKE M., Sc.D., Rt. 2, Laconia, N.H. 03246 (F-20, 36)

LUSTIG, ERNEST, Ph.D., GMBF, D3301 Stockheim/Braunschweig, Mascheroder Weg 1, W. Germany (F-4)

LYMAN, JOHN, Ph.D., 404 Clayton Rd., Chapel Hill, N.C. 27514 (F-23)

LYNCH, MRS. THOMAS J., 4960 Butterworth Pl., N.W., Washington, D.C. 20016 (M)

M

MA, TE-HSIU, Dept. of Biological Science, Western Illinois Univ., Macomb, Ill. 61455 (F-3)

MAC DONALD, TORRENCE H., 622 Chain Bridge Rd., McLean, Va. 22101 (M)

MADDEN, ROBERT P., A251 Physics Bldg., Natl. Bureau of Standards, Washington, D.C. 20034 (F-32)

MAENGWYN-DAVIES, G. D., Ph.D., 2909 34th St., N.W., Washington, D.C. 20008 (F-4, 6, 19)

MAGIN, GEORGE B., Jr., 7412 Ridgewood Ave., Chevy Chase, Md. 20015 (F-6, 7, 26)

MAHAN, A. I., 10 Millgrove Gardens, Ednor, Md. 20904 (F-1)

MAIENTHAL, MILLARD, 10116 Bevern Lane, Potomac, Md. 20854 (F-4)

MALONEY, CLIFFORD J., Bureau of Biologies, FDA, Bethesda, Md. 20014 (F)

MANDEL, H. GEORGE, Ph.D., Dept. of Pharmacology, George Washington Univ. Sch. of Med., Washington, D.C. 20037 (F-4, 19)

MANDEL, JOHN, A345 Chem. Bg., Natl. Bur. of Standards, Washington, D.C. 20234 (F-1)

MANNING, JOHN R., Ph.D., Metal Physics Sec., Natl. Bur. of Standards, Washington, D.C. 20234 (F-20)

MARCUS, MARVIN, Ph.D., Dept. Math., Univ. of California, Santa Barbara, Calif. 93106 (F-6)

MARGOSHES, MARVIN, Ph.D., 69 Midland Ave., Tarrytown, N.Y. 10591 (F)

MARION, JERRY B., Dept. of Physics, Univ. of Maryland, College Park, Md. 20742 (F)

MARSHALL, LOUISE H., Div. Med. Sci., Rm. 351 NAS-NRC, 2101 Constitution Ave., Washington, D.C. 20418 (F)

MARTIN, BRUCE D., P.O. Box 234, Leonardtown, Md. 20650 (F-7)

MARTIN, JOHN H., Ph.D., 124 N.W. 7th St., Apt. 303, Corvallis, Oregon 97330 (E-6)

MARTIN, ROBERT H., 2257 N. Nottingham St., Arlington, Va. 22205 (M-23)

MARTON, L., Ph.D., Editorial Office, 4515 Linnean Ave., N.W., Washington, D.C. 20008 (E-1, 13)

MARVIN, ROBERT S., Natl. Bur. of Standards, A537 Admin., Washington, D.C. 20234 (F-1, 4, 6)

MARYOTT, ARTHUR A., Natl. Bur. of Standards, Washington, D.C. 20234 (F-4, 6)

MASON, HENRY LEA, Sc.D., 7008 Meadow Lane, Chevy Chase, Md. 20015 (F-1, 6, 14, 35)

MASSEY, JOE T., Ph.D., 10111 Parkwood Dr., Bethesda, Md. 20014 (F)

MATHERS, ALEX P., 320A Mansion Dr., Alexandria, Va. 22302 (F-4)

MATLACK, MARION, Ph.D., 2700 N. 25th St., Arlington, Va. 22207 (E)

MAUSS, BESSE D., Rural Rt. 1, New Oxford, Pa. 17350 (F)

MAXWELL, LOUIS R., Ph.D., 3506 Leland St., Chevy Chase, Md. 20015 (F)

MAY, DONALD C., Jr., Ph.D., 5931 Oakdale Rd., McLean, Va. 22101 (F)

MAY, IRVING, U.S. Geological Survey, Washington, D.C. 20244 (F-4, 7)

MAYER, CORNELL H., 1209 Villamay Blvd., Alexandria, Va. 22307 (F-1, 6, 13)

MAYOR, JOHN R., A.A.A.S., 1515 Massachusetts Ave., N.W., Washington, D.C. 20005 (F)

MAZUR, JACOB, Ph.D., Natl. Bureau of Standards, Washington, D.C. 20234 (F-6)

MC BRIDE, GORDON W., Ch.E., 100 Park Ave., Suite 2209, New York, N.Y. 10017 (F)

MC CAMY, CALVIN S., All Angels Hill Rd., Wappingers Falls, N.Y. 12590 (F-32)

MC CLELLAN, WILBUR D., Ph.D., Rm. 4114, Federal Bg., 1130 O St., Fresno, Calif. 93721 (F-6, 10)

MC CLURE, FRANK T., 810 Copley Lane, R.F.D. 1, Silver Spring, Md. 20904 (F-1, 4)

MC CULLOUGH, JAMES M., Ph.D., 6209 Apache St., Springfield, Va. 22150 (M)

MC CULLOUGH, N. B., Ph.D., M.D., Dept. of Microbiology & Public Health, Michigan State Univ., East Lansing, Mich. 48823 (F-6, 8)

MC ELHINNEY, JOHN, Ph.D., 11601 Stephen Rd., Silver Spring, Md. 20904 (F-1)

MC GRATH, JAMES R., Ph.D., 5900 Madawaska Rd., Washington, D.C. 20016 (M-25)

MC GUNIGAL, THOMAS E., J.D., 13013 Ingleside Dr., Beltsville, Md. 20705 (F-1, 13)
MC INTOSH, ALLEN, 4606 Clemson Rd., College Park, Md. 20740 (E-6, 15)
MC KEE, S. A., 5431 Lincoln St., Bethesda, Md. 20034 (F)
MC KELVEY, VINCENT E., Ph.D., 6601 Broxburn Dr., Bethesda, Md. 20034 (F-7)
MC KENZIE, LAWSON M., 5311 Westpath Way, Washington, D.C. 20016 (F-1)
MC KINNEY, HAROLD H., 1620 N. Edgewood St., Arlington, Va. 22201 (E-6, 10, 16, 33)
MC KOWN, BARRETT L., M.S., 3580 So. River Terr., Edgewater, Md. 21037 (M-6)
MC MURDIE, HOWARD F., Natl. Bur. of Standards, Washington, D.C. 20234 (F-28)
MC NESBY, JAMES R., Natl. Bur. of Standards 223.53, Washington, D.C. 20234 (F)
MC PHEE, HUGH C., 3450 Toledo Terrace, Apt. 425, Hyattsville, Md. 20782 (E-6)
MC PHERSON, ARCHIBALD T., Ph.D., 4005 Cleveland St., Kensington, Md. 20795 (F-1, 4, 6, 27)
MC WRIGHT, CORNELIUS G., 7409 Estaban Pl., Springfield, Va. 22151 (M)
MEADE, BUFORD K., NOAA, Nat'l Ocean Survey, Washington Science Ctr., Rockville, Md. 20852 (F-17)
MEARS, FLORENCE, Ph.D., 8004 Hampden Lane, Bethesda, Md. 20014 (F)
MEARS, THOMAS W., B.S., 2809 Hathaway Terrace, Wheaton, Md. 20906 (F-1, 4, 6)
MEBS, RUSSELL W., Ph.D., 6620 32nd St., N., Arlington, Va. 22213 (F-12, 20)
MEINKE, W. WAYNE, Ph.D., Analytical Chemistry Div., Natl. Bur. of Standards, Washington, D.C. 20234 (F-4)
MELMED, ALLAN J., 732 Tiffany Court, Gaithersburg, Md. 20760 (F)
MELOY, THOMAS P., 5124 Baltan Rd., Sumner, Md. 20016 (M)
MENDLOWITZ, HAROLD, 708 Lamberton Dr., Silver Spring, Md. 20902 (F)
MENIS, OSCAR, Analytical Chem. Div., Natl. Bureau of Standards, Washington, D.C. 20234 (F)
MENZER, ROBERT E., Ph.D., 7203 Wells Pkwy., Hyattsville, Md. 20782 (F)
MERRIAM, CARROLL F., Prospect Harbor, Maine 04669 (F-6)
MEYERHOFF, HOWARD A., Ph.D., 3625 S. Florence Pl., Tulsa, Okla. 74105 (F-7)
MEYERSON, MELVIN R., Ph.D., Rm. A349, Bldg. 224, National Bureau of Standards, Washington, D.C. 20234 (F-20)
MEYKAR, OREST A., P.E., 200 E. Luray Ave., Alexandria, Va. 22301 (M-13, 14)
MEYROWITZ, ROBERT, Analytical Chem., Environmental Geology Progr., Univ. So. California, Los Angeles, Calif. 90007
MICHAELIS, ROBERT E., National Bureau of Standards, Chemistry Bldg., Rm. B316, Washington, D.C. 20234 (F-20)
MICKEY, WENDELL V., 1965 Kohler Dr., Boulder, Colo. 80303 (F)
MIDDLETON, H. E., 430 E. Packwood, Apt. H-108, Maitland, Fla. 32751 (E)
MIDER, G. BURROUGHS, M.D., Exec. Off., Amer. Soc. Exper. Path. & Univ. Assoc. Res. & Educ. Pathol., 9650 Rockville Pike, Bethesda, Md. 20014 (F)
MILLAR, DAVID B., NMRI, NNMC, Environmental Biosciences Dept., Physical Biochemistry Div., Washington, D.C. 20014 (F)
MILLER, CARL F., 18 W. Windsor Ave., Alexandria, Va. 22301 (E-6)
MILLER, CLEM O., Ph.D., 6343 Nicholson St., Falls Church, Va. 22044 (F-4, 6)
MILLER, J. CHARLES, 10600 Eastbourne Ave., Apt. 7, W. Los Angeles, California 90024 (E-7)
MILLER, PAUL R., Ph.D., ARS, USDA, Beltsville, Md. 20705 (F-10)
MILLER, RALPH L., Ph.D., 5215 Abington Rd., Washington, D.C. 20016 (F-7)
MILLER, ROMAN R., 1232 Pinecrest Circle, Silver Spring, Md. 20910 (F-4, 6, 28)
MILLIGAN, DOLPHUSE E., Ph.D., National Bureau of Standards, Washington, D.C. 20234 (F-4)
MILLIKEN, LEWIS T., SSL Res. Inst., 43-20, NHTSA, 400 7th St., S.W., Washington, D.C. 20590 (M-1, 4, 7)
MILTON, CHARLES, Dept. of Geology, George Washington Univ., Washington, D.C. 20006 (F-7)
MITCHELL, J. MURRAY, Jr., Ph.D., 1106 Dogwood Dr., McLean, Va. 22101 (F-6, 23)
MITCHELL, JOHN W., 9007 Flower Ave., Silver Spring, Md. 20901 (F)
MITTLEMAN, DON, 80 Parkwood Lane, Oberlin, Ohio 44074 (F)
MIZELL, LOUIS R., 108 Sharon Lane, Greenlawn, N.Y. 11740 (F)
MOEZIE, FATEMEH T., 5432 N. 24th St., Arlington, Va. 22205 (M)
MOHLER, FRED L., Ph.D., 2853 Brandywine St., N.W., Washington, D.C. 20008 (E-1)
MOLLARI, MARIO, 4527 45th St., N.W., Washington, D.C. 20016 (E-3, 5, 15)
MOLLER, RAYMOND W., Ph.D., Catholic Univ. of America, Washington, D.C. 20017 (F)
MOORE, GEORGE A., Ph.D., Natl. Bur. of Standards 312.03, Washington, D.C. 20234 (F-6, 20, 29, 36)
MOORE, HARVEY C., Dept. of Anthropology, American Univ., Washington, D.C. 20016 (F-2)
MORAN, FREDERICK A., 7711 Kipling Pkwy., Washington, D.C. 20028 (M-23)
MORRIS, J. A., 23-E Ridge Rd., Greenbelt, Md. 20770 (M-6, 15, 16)
MORRIS, JOSEPH BURTON, Chemistry Dept. Howard Univ., Washington, D.C. 20001 (F)
MORRIS, KELSO B., Howard Univ., Washington, D.C. 20001 (F-4)
MORRISS, DONALD J., 102 Baldwin Ct., Pt. Charlotte, Fla. 33950 (E-11)

MORTON, JOHN D., M.A., 10217 Forest Ave., Fairfax, Va. 22030 (F-16, 23)
MOSHMAN, JACK, LEASCO, Inc., 4033 Rugby Ave., Bethesda, Md. 20014 (M-34)
MOSTOFI, F. K., M.D., Armed Forces Inst. of Pathology, Washington, D.C. 20306 (F)
MUEHLHAUSE, C. O., Ph.D., 9105 Seven Locks Rd., Bethesda, Md. 20034 (F-1, 26)
MUELLER, H. J., 4801 Kenmore Ave., Alexandria, Va. 22304 (F)
MUESEBECK, CARL F. W., U.S. Natl. Museum of Nat. Hist., Washington, D.C. 20560 (E-3, 5)
MURDOCH, WALLACE P., Ph.D., Rt. 2, Gettysburg, Pa. 17325 (F-5)
MURPHY, LEONARD M., Seismology Div., U.S. Nat. Ocean Surv., Rockville, Md. 20852 (F)
MURRAY, WILLIAM S., 1281 Bartonshire Way, Potomac Woods, Rockville, Md. 20854 (F-5)
MYERS, ALFRED T., USGS Geochemistry & Petr., Denver Federal Ctr., Denver, Colo. 80225 (F-4, 6)
MYERS, RALPH D., Physics Dept., Univ. of Maryland, College Park, Md. 20740 (F-1)

N

NAESER, CHARLES R., Ph.D., 6654 Van Winkle Dr., Falls Church, Va. 22044 (F-4, 7)
NAMIAS, JEROME, Sc.D., 2251 Sverdrup Hall, Scripps Institution of Oceanography, La Jolla, Calif. 92037 (F-23)
NELSON, R. H., 7309 Finns Lane, Lanham, Md. 20801 (E-5, 6, 24)
NEPOMUCENE, SR. ST. JOHN, Villa Julie, Valley Rd., Stevenson, Md. 21153 (E-4)
NEUENDORFFER, J. A., 911 Allison St., Alexandria, Va. 22302 (F-6, 34)
NEUSCHEL, SHERMAN K., U.S. Geological Survey, Washington, D.C. 20244 (F-7)
NEUSTADT, HERBERT M., E.E. Dept., U.S. Naval Academy, Annapolis, Md. 21042 (M-25)
NEWMAN, MORRIS, Natl. Bur. of Standards, Washington, D.C. 20234 (F)
NEWMAN, SANFORD B., Ph.D., Room A 1000, Administration, Natl. Bur. of Standards, Washington, D.C. 20234 (F)
NEWTON, CLARENCE J., Ph.D., 1504 S. 2nd Ave., Edinburg, Texas 78539 (E)
NICKERSON, DOROTHY, 2039 New Hampshire Ave., Washington, D.C. 20009 (E-6, 32)
NIKIFOROFF, C. C., 4309 Van Buren St., University Park, Hyattsville, Md. 20782 (E)
NIRENBERG, MARSHALL W., 7001 Orkney Pkwy., Bethesda, Md. 20034 (F-4)
NOFFSINGER, TERRELL L., Spec. Weather Serv. Br., NOAA/NWS, Gramax Bldg., Silver Spring, Md. 20910 (F-23)
NOLLA, J. A. B., Ph.D., Apartado 820, Mayaguez, Puerto Rico 00708 (F-6)
NORRIS, KARL H., 11204 Montgomery Rd., Beltsville, Md. 20705 (F-27)
NOYES, HOWARD E., Ph.D., 4807 Aspen Hill Rd., Rockville, Md. 20853 (F-16, 19)

O

O'BRIEN, JOHN A., Ph.D., Dept. of Biology, Catholic Univ. of America, Washington, D.C. 20017 (F-10)
O'CONNOR, JAMES V., 5309 Riverdale Rd., #325, Riverdale, Md. 20840 (M)
O'HERN, ELIZABETH M., Ph.D., 633 G St., S.W., Washington, D.C. 20024 (M-16)
O'KEEFE, JOHN A., Code 640, Goddard Space Flight Ctr., Greenbelt, Md. 20771 (F-1)
OBOURN, ELLSWORTH S., Ph.D., 2100 S. Ocean Dr., Apt. 2CD, Ft. Lauderdale, Fla. 33316 (E-1, 6)
OEHSER, PAUL H., 9012 Old Dominion Dr., McLean, Va. 22101 (F-1, 3, 9, 30)
OKABE, HIDEO, Ph.D., 316.00, Natl. Bur. of Standards, Washington, D.C. 20234 (F-4)
OLIPHANT, MALCOLM W., Ph.D., Hawaii Loa Coll., P.O. Box 764, Kaneohe, Oahu, Haw. 96744 (F)
OLSEN, HAROLD W., Br. of Engr. Geol., U.S. Geological Survey, 345 Middlefield Rd., Menlo Park, Calif. 94025 (M)
OLSON, JOSEPH C., Jr., Ph.D., BF-210, Food & Drug Admin., 200 C St., S.W., Washington, D.C. 20204 (M-16, 27)
OLTJEN, ROBERT R., 3514 Susquehanna Dr., Beltsville, Md. 20705 (F)
ORDWAY, FRED, Ph.D., 5205 Elsmere Ave., Bethesda, Md. 20014 (F-4, 6, 20, 28)
ORLIN, HYMAN, Ph.D., NOAA-NOS, Rockville, Md. 20852 (F-17)
OSER, HANS J., 8810 Quiet Stream Ct., Potomac, Md. 20852 (F-6)
OSGOOD, WILLIAM R., Ph.D., 2756 Macomb St., N.W., Washington, D.C. 20008 (E-14, 18)
OSWALD, ELIZABETH J., Ph.D., Genetic Toxicology Br., FDA, 200 C St., N.W., Washington, D.C. 20204 (F-16)
OWENS, JAMES P., M.A., 14528 Bauer Dr., Rockville, Md. 20853 (F-7)

P

PACK, DONALD H., 1826 Opalacka Dr., McLean, Va. 22101 (F-23)
PAFFENBARGER, GEORGE C., D.D.S., ADA Res. Div., Natl. Bur. of Standards, Washington, D.C. 20234 (F-21)
PAGE, BENJAMIN L., 1340 Locust Rd., Washington, D.C. 20012 (E-1, 6)
PAGE, CHESTER H., 15400 Layhill Rd., Silver Spring, Md. 20906 (F-1, 6, 13)
PAGE, R. M., 10222 Berkshire Rd., Bloomington, Minn. 55437 (F-13)
PARK, J. HOWARD, 3614 59th Ave., S.W., Seattle, Washington 98116 (F-13)
PARKER, KENNETH W., 6014 Kirby Rd., Bethesda, Md. 20034 (E-3, 10, 11)

PARKER, ROBERT L., Ph.D., Chief, Crystalliz. of Metals Sect., Rm. B-164 MATLS, Natl. Bur. of Standards, Washington, D.C. 20234 (F)

PARMAN, GEORGE K., % UNIDO, P.O. Box 837, A-1011, Vienna, Austria (F-27)

PARR, L. W., 302 Scientists Cliffs, Port Republic, Md. 20676 (E-16, 19)

PASSER, MOSES, Ph.D., 6647 32nd Pl., N.W., Washington, D.C. 20015 (F)

PATTERSON, GLENN W., 8916 2nd St., Lanham, Md. 20801 (F-4, 33)

PATTERSON, WILBUR I., Ph.D., Blakely Island, Washington 98222 (F)

PAYNE, L. E., Dept. Math., Cornell Univ., Ithaca, N.Y. 14850 (F)

PEISER, H. STEFFEN, 638 Blossom Dr., Rockville, Md. 20850 (F-1, 4, 28)

PELCZAR, MICHAEL J., Jr., Vice Pres. for Grad. Studies & Research, Univ. of Maryland, College Park, Md. 20742 (F)

PERROS, THEODORE P., Ph.D., Dept. of Chemistry, George Washington Univ., Washington, D.C. 20006 (F-1, 4)

PFEIFFER, M. M., Whitehall, Apt. 701, 4977 Battery Lane, Bethesda, Md. 20014 (F)

PHAIR, GEORGE, Ph.D., 14700 River Rd., Potomac, Md. 20854 (F-7)

PHILLIPS, MRS. M. LINDEMAN, Union Farm, Mount Vernon, Va. 22121 (F-1, 13, 25)

PIKL, JOSEF, 211 Dickinson Rd., Glassboro, N.J. 08028 (E)

PITTMAN, MARGARET, Ph.D., 3133 Connecticut Ave., N.W., Washington, D.C. 20008 (E)

POLACHEK, HARRY, 12000 Old Georgetown Rd., Rockville, Md. 20852 (E)

POMMER, ALFRED M., Ph.D., 3117 Fayette Rd., Kensington, Md. 20795 (F-4, 7, 19, 35)

POOS, F. W., Ph.D., 3225 N. Albemarle St., Arlington, Va. 22207 (E-5, 6, 26)

POPENOE, WILSON, Antigua, Guatemala, Central America (E-3, 11)

POTTS, B. L., 119 Periwinkel Ct., Greenbelt, Md. 20770 (F)

PRESLEY, JOHN T., 3811 Courtney Circle, Bryan, Texas 77801 (E)

PRINZ, DIANNE K., Ph.D., Code 7121.5, Naval Res. Lab., Washington, D.C. 20375 (M)

PRO, MAYNARD J., 7904 Falstaff Rd., McLean, Va. 22101 (F-26)

PRYOR, C. NICHOLAS, Ph.D., Naval Ord. Lab., White Oak, Silver Spring, Md. 20910 (F)

PURCELL, ROBERT H., Rt. 1, Box 113B, Boyds, Md. 20720 (F)

R

RABINOW, JACOB, I. A. T., Natl. Bur. of Standards, Washington, D.C. 20234 (F)

RADER, CHARLES A., 15807 Sherwood Ave., Laurel, Md. 20810 (F-4)

RADO, GEORGE T., Ph.D., 818 Carrie Court, McLean, Va. 22101 (F-1)

RAINWATER, H. IVAN, Plant Protect. & Quarantine Programs, APHIS, Fed. Center Bg. #1, Hyattsville, Md. 20782 (E-5, 6, 24)

RALL, DAVID P., Director, National Institute of Envir. Health Sciences, P.O. Box 11233, Research Triangle, Raleigh, N.C. 27709 (F-6, 19)

RAMBERG, WALTER G. C., Belfast Rd., Sparks, Md. 21152 (E-1)

RANEY, WILLIAM P., Code 102, Office of Naval Research, Arlington, Va. 22217 (M)

RAPPLEYE, HOWARD S., 6712 4th St., N.W., Washington, D.C. 20012 (E-1, 6, 12, 17, 18)

RAUSCH, ROBERT, Arctic Health Res. Center, U.S. Public Health Service, Fairbanks, Alaska 99701 (F-3, 15)

RAVITSKY, CHARLES, M.S., 1808 Metzerott Rd., Adelphi, Md. 20783 (F-32)

READING, O. S., 6 N. Howells Point Rd., Bellport Suffolk County, New York, N.Y. 11713 (E-1)

REAM, DONALD F., Holavallagata 9, Reykjavik, Iceland (F)

RECHCIGL, MILOSLAV, Jr., Ph.D., 1703 Mark Lane, Rockville, Md. 20852 (F-3, 4, 19)

REED, WILLIAM D., 3609 Military Rd., N.W., Washington, D.C. 20015 (F-5, 6)

REEVE, WILKINS, 4708 Harvard Rd., College Park, Md. 20740 (F-4)

REEVES, ROBERT G., Ph.D., 12524 W. Virginia Ave., Denver, Colo. 80228 (F-7, 14)

REGGIA, FRANK, MSEE, 6207 Kirby Rd., Bethesda, Md. 20034 (F-6, 13)

REHDER, HARALD A., U.S. Natl. Museum of Nat. Hist., Washington, D.C. 20560 (F-3, 6)

REICH, MELVIN, Dept. Microbiology, George Washington Univ. Med. Ctr., 2300 Eye St., N.W., Washington, D.C. 20037 (F)

REINHART, FRANK W., 9918 Sutherland Rd., Silver Spring, Md. 20901 (F-4, 6)

REINHART, FRED M., P.O. Box 591, Oak View, Calif. 93022 (F-20)

REINING, PRISCILLA, Ph.D., 3601 Rittenhouse St., N.W., Washington, D.C. 20015 (F-2)

REMMERS, GENE M., 7322 Craftown Rd., Fairfax Station, Va. 22039 (M)

REVEAL, JAMES L., Ph.D., Dept. Botany, Univ. of Maryland, College Park, Md. 20742 (F)

REYNOLDS, CALVIN O., 3661 E. Virginia Beach Blvd., P.O. Box 12342, Norfolk, Va. 23502 (M)

REYNOLDS, ORR E., 2134 LeRoy Place, N.W., Washington, D.C. 20008 (F)

RHODES, IDA, MRS., 6676 Georgia Ave., N.W., Washington, D.C. 20012 (F)

RICE, DONALD A., 1518 East West Highway, Silver Spring, Md. 20910 (F)

RICE, FREDERICK A. H., 8005 Carita Court, Bethesda, Md. 20034 (F-4, 6, 19)

RINEHART, JOHN S., 756 Sixth St., Boulder, Colo. 80302 (F-6, 20)

RIOCH, DAVID McK., M.D., 2429 Linden Lane, Silver Spring, Md. 20910 (F-3, 8)

RITT, P. E., Ph.D., GTE Labs., Inc., 40 Sylvan Rd., Waltham, Mass. 02154 (F)

RITTS, ROY E., Jr., Dept. of Microbiology, Mayo Clinic, Rochester, Minn. 55901 (F)
RIVLIN, RONALD S., Lehigh University, Bethlehem, Pa. 18015 (F)
ROBBINS, MARY LOUISE, Ph.D., George Washington Univ. Med. Ctr., 2300 Eye St. N.W., Washington, D.C. 20037 (F-6, 16, 19)
ROBERTS, ELLIOT B., 4500 Wetherill Rd., Washington, D.C. 20016 (E-1, 18)
ROBERTS, RICHARD B., Ph.D., Dept. Terrestrial Mag., 5241 Broad Branch Rd., N.W., Washington, D.C. 20015 (F)
ROBERTS, RICHARD C., 5170 Phantom Court, Columbia, Md. 21044 (F-6)
ROBERTS, RICHARD W., Director, Natl. Bureau of Standards, Washington, D.C. 20234 (F)
ROBERTSON, A. F., Ph.D., 4228 Butterworth Pl., N.W., Washington, D.C. 20016 (F)
ROBERTSON, RANDAL M., Ph.D., 1404 Highland Circle, S.E., Blacksburg, Va. 24060 (F-1, 6)
ROCK, GEORGE D., Ph.D., The Kennedy Warren, 3133 Conn. Ave., N.W., Washington, D.C. 20008 (E)
RODNEY, WILLIAM S., 8112 Whites Ford Way, Rockville, Md. 20854 (F-1, 32)
RODRIGUEZ, RAUL, 3533 Martha Custis Drive, Alexandria, Va. 22302 (F-17)
ROGERS, L. A., Patten, Maine 04765 (E-16)
ROLLER, PAUL S., 825 Colorado Bldg., 1341 G St., N.W., Washington, D.C. 20005 (E)
ROMNEY, CARL F., 4105 Sulgrave Dr., Alexandria, Va. 22309 (F-7)
ROSADO, JOHN A., 1709 Great Falls St., McLean, Va. 22101 (F)
ROSENBLATT, DAVID, 2939 Van Ness St., N.W., Apt. 702, Washington, D.C. 20008 (F-1)
ROSENBLATT, JOAN R., 2939 Van Ness St., N.W., Apt. 702, Washington, D.C. 20008 (F-1)
ROSENSTOCK, HENRY M., 10117 Ashburton Lane, Bethesda, Md. 20034 (F)
ROSENTHAL, SANFORD, M., Bldg. 4, Rm. 122, National Insts. of Health, Bethesda, Md. 20014 (E)
ROSS, FRANKLIN, Off. of Asst. Secy. of the Air Force, The Pentagon, Washington, D.C. 20310 (F)
ROSS, SHERMAN, National Research Council, 2101 Constitution Ave., N.W., Washington, D.C. 20418 (F)
ROSSINI, FREDERICK D., Dept. Chemistry, Rice Univ., Houston, Tex. 77001 (F-1)
ROTH, FRANK L., M.Sc., Box 441, Nogales Star Rt., Amado, Ariz. 85640 (E-6)
ROTH, ROBERT S., Solid State Chem. Sect., National Bureau of Standards, Washington, D.C. 20234 (F)
ROTKIN, ISRAEL, 11504 Regnid Dr., Wheaton, Md. 20902 (F-1, 13, 34)
ROWEN, JOHN W., Washington Towers #2407, 9701 Fields Rd., Gaithersburg, Md. 20760 (F)
RUBIN, MORTON J., M.Sc., Bldg. 5, NOAA, 6010 Executive Bldg., Rockville, Md. 20852 (F-23)
RUBIN, VERA C., Ph.D., 3308 McKinley St., N.W., Washington, D.C. 20015 (F)
RUPP, N. W., D.D.S., American Dental Assoc., Research Division, National Bureau of Standards, Washington, D.C. 20234 (F-21)
RUSSELL, LOUISE M., Bg. 004, Agr. Res. Center (West), USDA, Beltsville, Md. 20705 (F-5)
RYALL, A. LLOYD, Route 2, Box 216, Las Cruces, N. Mex. 88001 (E-6, 10, 27)
RYERSON, KNOWLES A., M.S., Dean Emeritus, 15 Arlmonte Dr., Berkeley, Calif. 94707 (E-6)

S

SAALFIELD, FRED E., Naval Res. Lab., Code 6110, Washington, D.C. 20390 (F-4)
SAENZ, ALBERT W., Nuclear Sciences Div., Naval Research Laboratory, Washington, D.C. 20390 (F)
SAILER, R. I., Ph.D., 3847 S.W. 6th Pl., Gainesville, Fla. 32601 (F-5, 24)
SALISBURY, LLOYD L., 10138 Crestwood Rd., Kensington, Md. 20795 (M)
SALLET, DIRSE W., 12440 Old Fletchertown Rd., Bowie, Md. 20715 (M-1)
SAN ANTONIO, JAMES P., Agr. Res. Center (West), USDA, Beltsville, Md. 20705 (M)
SANDERSON, JOHN A., Ph.D., 303 High St., Alexandria, Va. 22203 (F-1, 32)
SANDOZ, GEORGE, Ph.D., Office of Naval Research, Chicago Office, 536 Clark St., Chicago, Ill. 60605 (F-6, 20)
SANFORD, ROBERT B., Jr., 1719 N. Nelson St., Arlington, Va. 22207 (M)
SARVELLA, PATRICIA A., Ph.D., 4513 Romlon St., Apt. 302, Beltsville, Md. 20705 (F-6)
SASMOR, ROBERT M., 12 Old Mamaroneck Rd., White Plains, N.Y. 10605 (F)
SAULMON, E. E., 202 North Edgewood St., Arlington, Va. 22201 (M)
SAVILLE, THORNDIKE, Jr., M.S., 5601 Albia Rd., Washington, D.C. 20016 (F-6, 18)
SAYLOR, CHARLES P., 10001 Riggs Rd., Adelphi, Md. 20783 (F-1, 4, 32)
SCHAFFER, ROBERT, Chemistry A367, Natl. Bur. Standards, Washington, D.C. 20234 (F)
SCHECHTER, MILTON S., 10909 Hannes Court, Silver Spring, Md. 20901 (F-4, 5, 24)
SCHEER, MILTON D., 811 N. Belgrade Rd., Silver Spring, Md. 20902 (F-1, 4)
SCHINDLER, ALBERT I., Sc.D., Code 6330, U.S. Naval Res. Lab., Washington, D.C. 20390 (F-1)
SCHMID, HELLMUT, 20740 Warfield Court, Gaithersburg, Md. 20760 (F-6, 17)
SCHMIDT, CLAUDE H., 1827 No. 3rd St., Fargo, No. Dak. 58102 (F-5)
SCHMITT, WALDO L., Ph.D., U.S. National Museum, Washington, D.C. 20560 (E-3)
SCHNEIDER, SIDNEY, 239 N. Granada St., Arlington, Va. 22203 (M)
SCHOEN, LOUIS J., Ph.D., 8605 Springdell Pl., Chevy Chase, Md. 20015 (F)

SCHOENEMAN, ROBERT LEE, 217 Sachem Drive, Forest Heights, Washington, D.C. 20021 (F)

SCHOOLEY, ALLEN H., 6113 Cloud Dr., Springfield, Va. 22150 (F-6, 13, 31)

SCHOOLEY, JAMES F., 13700 Darnestown Rd., Gaithersburg, Md. 20760 (F-6)

SCHOONOVER, IRL C., National Bureau of Standards, Washington, D.C. 20234 (F-1, 4)

SCHRECKER, ANTHONY W., Ph.D., National Institutes of Health, Bethesda, Md. 20014 (F-4)

SCHUBAUER, G. B., Ph.D., 5609 Gloster Rd., Washington, D.C. 20016 (F-22)

SCHUBERT, LEO, Ph.D., The American Univ., Washington, D.C. 20016 (F-1, 4, 30)

SCHULMAN, JAMES H., 2284 Dunster Lane, Rockville, Md. 20854 (F)

SCHWARTZ, ANTHONY M., Ph.D., 2260 Glenmore Terr., Rockville, Md. 20850 (F-4)

SCHWARTZ, BENJAMIN, Ph.D., 888 Montgomery St., Brooklyn, N.Y. 11213 (E)

SCHWARTZ, MANUEL, 321-322 Med. Arts Bg., Baltimore, Md. 21201 (M)

SCHWERDTFEGER, WILLIAM J., B.S., 9200 Fowler Lane, Lanham, Md. 20801 (F-13)

SCOFIELD, FRANCIS, 2403 Eye St., N.W., Washington, D.C. 20037 (M-4, 32)

SCOTT, DAVID B., D.D.S., Dean, Case Western Reserve Univ., Sch. of Dentistry, 2123 Abington Rd., Cleveland, Ohio 44106 (F-21)

SCRIBNER, BOURDON F., National Bureau of Standards, Washington, D.C. 20234 (F-4, 32)

SEABORG, GLENN T., Ph.D., Lawrence Berkeley Lab., Univ. of California, Berkeley, Calif. 94720 (F)

SEEGER, RAYMOND J., Ph.D., 4507 Wetherill Rd., Washington, D.C. 20016 (E-1, 30, 31)

SEITZ, FREDERICK, Rockefeller University, New York, N.Y. 10021 (F-36)

SERVICE, JERRY H., Ph.D., Cascade Manor, 65 W. 30th Ave., Eugene, Oreg. 97405 (E)

SETZLER, FRANK M., Sc.D., 950 E. Shore Dr., Culver, Ind. 46511 (E-2, 3, 6)

SHAFRIN, ELAINE G., M.S., Apt. N-702, 800 4th St., S.W., Washington, D.C. 20024 (F-4)

SHALOWITZ A. L., 1520 Kalmia Rd., N.W., Washington, D.C. 20012 (E-17)

SHANAHAN, A. J., 7217 Churchill Rd., McLean, Va. 22101 (F-16)

SHAPIRA, NORMAN, 86 Oakwood Dr., Dunkirk, Md. 20754 (M)

SHAPIRO, GUSTAVE, 3704 Munsey St., Silver Spring, Md. 20906 (F)

SHELTON, EMMA, National Cancer Institute, Bethesda, Md. 20014 (F)

SHEPARD, HAROLD H., Ph.D., 2701 S. June St., Arlington, Va. 22202 (F-5, 24)

SHERESHEFSKY, J. LEON, Ph.D., 9023 Jones Mill Rd., Chevy Chase, Md. 20015 (E)

SHERLIN, GROVER C., 4024 Hamilton St., Hyattsville, Md. 20781 (F-1, 6, 13, 31)

SHIELDS, WILLIAM ROY, A.M.S.S., Natl. Bur. of Standards, Physics Bldg., Rm. A25, Washington, D.C. 20234 (F)

SHMUKLER, LEON, 151 Lorraine Dr., Berkeley Heights, N.J. 07922 (F)

SHOTLAND, EDWIN, 418 E. Indian Spring Dr., Silver Spring, Md. 20901 (M-1)

SHROPSHIRE, W., Jr., Ph.D., Radiation Bio. Lab., 12441 Parklawn Dr., Rockville, Md. 20852 (F-6, 10, 33)

SHUBIN, LESTER D., Proj. Mgr. for Standards, NILECJ/LEAA, U.S. Dept. Justice, Washington, D.C. 20530 (F)

SIEGLER, EDOUARD HORACE, Ph.D., 201 Tulip Ave., Takoma Park, Md. 20012 (E-5, 24)

SILVER, DAVID M., Ph.D., Applied Physics Lab., Johns Hopkins Univ., Silver Spring, Md. 20910 (M-4, 6)

SILVERMAN, SHIRLEIGH, Academic Liaison, Natl. Bur. of Standards, Washington, D.C. 20234 (F-1)

SIMHA, ROBERT, Ph.D., Case Western Reserve Univ., Cleveland, Ohio 44106 (F)

SIMMONS, JOHN A., Rm. A157, Bldg. 223, Natl. Bureau of Standards, Washington, D.C. 20234 (F-1)

SIMMONS, LANSING G., 4425 Dittmar Rd., N., Arlington, Va. 22207 (F-18)

SITTERLY, BANCROFT W., Ph.D., 3711 Brandywine St., N.W., Washington, D.C. 20016 (E-1, 31, 32)

SITTERLY, CHARLOTTE M., Ph.D., 3711 Brandywine St., N.W., Washington, D.C. 20016 (E-1, 6, 32)

SLACK, LEWIS, 106 Garden Rd. Scarsdale, N.Y. 10583 (F)

SLADEK, JAROMIL V., 2940 28th St., N.W., Washington, D.C. 20008 (F-4)

SLAWSKY, MILTON M., 8803 Lanier Dr., Silver Spring, Md. 20910 (F-6, 12, 22, 31)

SLAWSKY, ZAKA I., Naval Ordnance Lab., White Oak, Silver Spring, Md. 20910 (F)

SLEEMAN, H. KENNETH, Ph.D., Div. Biochem, WRAIR. Washington, D.C. 20012 (F)

SLOCUM, GLENN G., 4204 Dresden St., Kensington, Md. 20795 (E-16, 27)

SMILEY, ROBERT L., 1444 Primrose Rd., N.W., Washington, D.C. 20012 (M-5)

SMITH, BLANCHARD DRAKE, M.S., 2509 Ryegate Lane, Alexandria, Va. 22308 (F-6, 13)

SMITH, EDGAR R., Box 52, Lottsburg, Va. 22511 (E-4)

SMITH, FLOYD F., Ph.D., 9022 Fairview Rd., Silver Spring, Md. 20910 (F-5, 24)

SMITH, FRANCIS A., Ph.D., 1023 55th Ave., South, St. Petersburg, Fla. 33705 (E-6)

SMITH, HENRY LEE, Jr., Ph.D., 112 Depew Ave., Buffalo, N.Y. 14214 (F-2)

SMITH, JACK C., 3708 Manor Rd., Apt. 3, Chevy Chase, Md. 20015 (F)

SMITH, NATHAN R., 322 S. Washington Dr., St. Armands Key, Sarasota, Fla. 33577 (E-6, 10, 16)

SMITH, PAUL A., 4714 26th St., N., Arlington, Va. 22207 (F-6, 7, 18, 22)
SMITH, ROBERT C., Jr., 4200 Peachtree Pl., Alexandria, Va. 22304 (F-4, 22)
SMITH, SIDNEY T., D.Eng., 5811 Sunderland Court, Alexandria, Va. 22310 (F-1, 13, 32)
SMITH, WILLIE, Natl. Insts. of Health, Bethesda, Md. 20014 (F-19)
SNAVELY, BENJAMIN L., 721 Springloch Rd., Silver Spring, Md. 20904 (F-24, 31, 32)
SNAY, HANS G., 17613 Treelawn Dr., Ashton, Md. 20702 (F-6, 25)
SNOW, C. EDWIN, 14317 Chesterfield Rd., Rockville, Md. 20853 (M)
SOKOLOVE, FRANK L., 2311 S. Dinwiddie St., Arlington, Va. 22206 (M)
SOLLNER, KARL, Lab. of Physical Bio., Natl. Insts. of Health, Bethesda, Md. 20014 (F-4, 29)
SOLOMON, EDWIN M., 11550 Lockwood Dr., Silver Spring, Md. 20904 (M)
SOMERS, IRA I., 1511 Woodacre Dr., McLean, Va. 22101 (M)
SOMMER, HELMUT, 9502 Hollins Ct., Bethesda, Md. 20034 (F-1, 13)
SONN, MARTIN, Ph.D., Ed.D., 5 Watson Dr., Portsmouth, R.I. 02871 (F)
SORROWS, H. E., 8820 Maxwell Dr., Potomac, Md. 20854 (F)
SPALDING, DONALD H., Ph.D., 17500 S.W. 89th Ct., Miami, Fla. 33157 (F-6, 10)
SPECHT, HEINZ, Ph.D., 4229 Franklin St., Kensington, Md. 20795 (F-1, 6)
SPENCER, LEWIS V., Box 206, Gaithersburg, Md. 20760 (F)
SPERLING, FREDERICK, 1131 University Blvd., W., #1122, Silver Spring, Md. 20902 (F-19)
SPICER, H. CECIL, 2174 Louisa Drive, Belleair Beach, Florida 33534 (E-7)
SPIES, JOSEPH R., 507 N. Monroe St., Arlington, Va. 22201 (F-4)
SPOONER, CHARLES S., Jr., M.F., 346 Springvale Rd., Great Falls, Va. 22066 (F)
SPOONER, RONALD L., Ph.D., Planning Systems, Inc., 7900 Westpark Dr., McLean, Va. 22101 (M-25)
SPRAGUE, G. F., Dept. Agronomy, Univ. of Illinois, Urbana, Ill. 61801 (E)
ST. GEORGE, R. A., 3305 Powder Mill Rd., Adelphi Station, Hyattsville, Md. 20783 (F-3, 5, 11, 24)
STADTMAN, E. R., Bldg. 3, Rm. 108, Natl. Institutes of Health, Bethesda, Md. 20014 (F)
STAIR, RALPH, P.O. Box 310, Newburg, Oreg. 97132 (E-6)
STAKMAN, E. C., Univ. of Minnesota, Inst. of Agric., St. Paul, Minn. 55101 (E)
STALLARD, JOHN M., Ph.D., Naval Ord. Lab., Silver Spring, Md. 20910 (M)
STAUSS, HENRY E., Ph.D., 8005 Washington Ave., Alexandria, Va. 22308 (F-20)
STEARN, JOSEPH L., 6950 Oregon Ave., N.W., Washington, D.C. 20015 (F)
STEELE, LENDELL E., 7624 Highland St., Springfield, Va. 22150 (F-20, 26)
STEERE, RUSSELL L., Ph.D., 6207 Carrollton Ter., Hyattsville, Md. 20781 (F-6, 10)
STEGUN, IRENE A., Natl. Bur. of Standards, Washington, D.C. 20234 (F)
STEIDLE, WALTER E., 2439 Flint Hill Rd., Vienna, Va. 22180 (F)
STEINER, BRUCE W., 6624 Barnaby St., N.W., Washington, D.C. 20015 (M)
STEINER, ROBERT F., Ph.D., 2609 Turf Valley Rd., Ellicott City, Md. 21043 (F-4)
STEINHARDT, JACINTO, Ph.D., Georgetown Univ., Washington, D.C. 20007 (F-4)
STEPHAN, ROBERT M., Ph.D., 4513 Delmont Lane, Bethesda, Md. 20014 (F-21)
STEPHENS, ROBERT E., Ph.D., 4301 39th St., N.W., Washington, D.C. 20016 (E-1, 32)
STERN, KURT H., Ph.D., Naval Res. Lab., Code 6160, Washington, D.C. 20390 (F-4, 29, 30)
STERN, WILLIAM L., Dept. Botany, Univ. of Maryland, College Park, Md. 20742 (F-10)
STEVENS, HENRY, 5116 Brookview Dr., Washington, D.C. 20016 (E)
STEVENS, RUSSELL B., Ph.D., Div. of Biological Sciences, N.R.C., 2101 Constitution Ave., Washington, D.C. 20418 (F-10)
STEVENSON, JOHN A., 4113 Emery Pl., N.W., Washington, D.C. 20016 (E-6, 10)
STEWART, I. E., 4000 Tunlaw Rd., N.W., Washington, D.C. 20007 (F)
STEWART, T. DALE, M.D., 1191 Crest Lane, McLean, Va. 22101 (F-2)
STIEBELING, HAZEL K., 4000 Cathedral Ave., Washington, D.C. 20016 (E)
STIEF, LOUIS J., Ph.D., Code 691, NASA Goddard Space Flight Ctr., Greenbelt, Md. 20771 (F-4)
STIEHLER, ROBERT D., Ph.D., Natl. Bur. of Standards, Washington, D.C. 20234 (F-1, 4, 6, 14)
STILL, JOSEPH W., M.D., 1146 E. Garvey, West Covina, Calif. 91790 (E)
STILLER, BERTRAM, 3210 Wisconsin Ave., N.W., Apt. 501, Washington, D.C. 20016 (F-1)
STIMSON, H. F., 2920 Brandywine St., N.W., Washington, D.C. 20008 (E-1, 6)
STIRLING, MATHEW W., 3311 Rowland Pl., N.W., Washington, D.C. 20008 (F-2, 6)
STRAUSS, SIMON W., Ph.D., 4506 Cedell Pl., Camp Springs, Md. 20031 (F-4)
STUART, NEIL W., 1341 Chilton Dr., Silver Spring, Md. 20904 (F-10)
SULZBACHER, WILLIAM L., 8527 Clarkson Dr., Fulton, Md. 20759 (F-16, 27)
SWEENEY, WILLIAM T., 8411 Buckland Mill Rd., Gainesville, Va. 22065 (F-16, 21)
SWICK, CLARENCE H., 5514 Brenner St., Capitol Heights, Md. 20027 (F-1, 6, 12)
SWINGLE, CHARLES F., Ph.D., Pauma Valley, Calif. 92061 (E)
SYKES, ALAN O., 304 Mashie Dr., S.E., Vienna, Va. 22180 (M-25)

SYSKI, RYSZARD, Ph.D., Dept. of Mathematics, Univ. of Maryland, College Park, Md. 20742 (F)

T

TALBERT, PRESTON T., Dept. of Chemistry, Howard Univ., Washington, D.C. 20001 (F-4)

TALBOTT, F. LEO, R.D. #4, Bethlehem, Pa. 18015 (F-1, 6)

TASAKI, ICHIJI, M.D., Ph.D., Lab. of Neurobiology, Natl. Inst. of Mental Health, Bethesda, Md. 20014 (F)

TATE, DOUGLAS R., B.A., 11415 Farmland Dr., Rockville, Md. 20852 (F-1)

TAUSSKY, OLGA, California Inst. of Technology, Pasadena, Calif. 91109 (E)

TAYLOR, ALBERT L., P.O. Box 12017, Gainesville, Fla. 32604 (E-15)

TAYLOR, JOHN K., Ph.D., Chemistry Bldg., Rm. B-326, Natl. Bur. of Standards, Washington, D.C. 20234 (F-4, 29)

TAYLOR, LAURISTON S., 7407 Denton Rd., Bethesda, Md. 20014 (E)

TAYLOR, LEONARD S., 706 Apple Grove Rd., Silver Spring, Md. 20904 (M)

TAYLOR, MODDIE D., Ph.D., 4560 Argyle Terrace, N.W., Washington, D.C. 20011 (F-4)

TCHEN, CHAN-MOU, City College of the City Univ. of New York, New York, N.Y. 10031 (F)

TEAL, GORDON K., Ph.D., 5222 Park Lane, Dallas, Tex. 75220 (F-6, 13, 29)

TEELE, RAY P., 3713 Jenifer St., N.W., Washington, D.C. 20015 (F-1, 6, 32)

TEITLER, S., Code 6470, Naval Res. Lab., Washington, D.C. 20390 (F)

TEPPER, MORRIS, 107 Bluff Terrace, Silver Spring, Md. 20902 (F-22, 23)

THAYER, T. P., Ph.D., U.S. Geological Surv., Washington, D.C. 20244 (F-7)

THEUS, RICHARD B., 8612 Van Buren Dr., Oxon Hill, Md. 20022 (F)

THOM, H. C. S., Cons. Engr., 14310 Bauer Dr., Rockville, Md. 20853 (F-20)

THOMPSON, ARTHUR H., Dept. Horticulture, Univ. Maryland, College Park, Md. 20742 (M)

THOMPSON, JACK C., 281 Casitas Bulevar, Los Gatos, Calif. 95030 (F)

THURMAN-SCHWARTZWELDER, E. B., 30 Versailles Blvd., New Orleans, La. 70125 (F)

TILDEN, EVELYN B., Ph.D., Apt. 1006, 55 West Chestnut St., Chicago, Ill. 60610 (E-6)

TITUS, HARRY W., 7 Lakeview Ave., Andover, N.J. 07821 (E-6)

TODD, MARGARET RUTH, Miss, U.S. Natl. Museum, Washington, D.C. 20560 (F-7)

TOLHURST, GILBERT, Ph.D., 7 Red Fox Lane, Amherst, Mass. 01002 (F)

TOLL, JOHN S., Pres., State Univ. of New York, Stony Brook, L.I., N.Y. 11790 (F)

TORGESEN, JOHN L., Natl. Bur. of Standards, Materials Bldg. B-354, Washington, D.C. 20234 (F-4, 6)

TORIO, J. C., 226 Cedar Lane, Apt. 84, Vienna, Va. 22180 (M-4)

TORRESON, OSCAR W., 4317 Maple Ave., Bethesda, Md. 20014 (E-6)

TOUSEY, RICHARD, Ph.D., Code 7140, Naval Res. Lab., Washington, D.C. 20375 (F-1, 32)

TRAUB, ROBERT, Ph.D., 5702 Bradley Blvd., Bethesda, Md. 20014 (F-5)

TREADWELL, CARLETON R., Ph.D., Dept. of Biochemistry, George Washington Univ., 2300 Eye St., N.W., Washington, D.C. 20037 (F-19)

TRENT, EVA M., Mrs., 413 Tennessee Ave., Alexandria, Va. 22305 (M)

TRUEBLOOD, MRS. CHARLES K., 7100 Armat Dr., Bethesda, Md. 20014 (E-19)

TRUBUL, THEODORE S., Sc.D., 11711 River Dr., Lorton, Va. 22079 (M-14, 34)

TRYON, MAX, 6008 Namakagan Rd., Washington, D.C. 20016 (F-4, 6)

TULANE, VICTOR J., Assistant President, Livingstone Coll., Salisbury, N.C. 28144 (F)

TUNELL, GEORGE, Ph.D., Dept. of Geol. Sci., Univ. of California, Santa Barbara, Calif. 93106 (E-7)

TURNER, JAMES H., Ph.D., Westwood Bg. Rm A-25, Nat. Insts. Health, Bethesda, Md. 20014 (F-15)

U

UHLANER, J. E., Ph.D., U.S. Army Behavior and Systems Res. Lab., Rosslyn Commonwealth Bldg., 1300 Wilson Blvd., Arlington, Va. 22209 (F)

USDIN, EARL, 2924 N. Oxford St., Arlington, Va. 22207 (F-4, 19)

V

VACHER, HERBERT C., 2317 Huidekoper Pl., N.W., Washington, D.C. 20007 (E)

VAN DERSAL, WILLIAM R., Ph.D., 6 S. Kensington St., Arlington, Va. 22204 (F-6)

VAN EVERA, R. W., 901 No. Kensington St., Arlington, Va. 22205 (F)

VAN TUYL, ANDREW H., Ph.D., 1000 W. Nolcrest Dr., Silver Spring, Md. 20903 (F-1, 6, 22)

VEITCH, FLETCHER P., Jr., Ph.D., Dept. of Chemistry, Univ. of Maryland, College Park, Md. 20742 (F-4)

VIGUE, KENNETH J., Dir., Internatl. Projects, ITT Corp., ITT Bldg., 1707 L St., N.W., Washington, D.C. 20036 (M-13, 31)

VINCENT, ROBERT C., Dept. Chem., George Washington Univ., Washington, D.C. 20006 (F)

VINTI, JOHN P., Sc.D., M.I.T. Measurement Systems Lab., Rm. 37-340, 70 Vassar St., Cambridge, Mass. 02139 (F-1, 6)
VISCO, EUGENE P., B.S., Geomet. Inc., 50 Monroe St., Rockville, Md. 20850 (M-1, 34)
VON BRAND, THEODOR C., M.D., Ph.D., 8606 Hempstead Ave., Bethesda, Md. 20034 (E-15)
VON HIPPEL, ARTHUR, 265 Glen Rd., Weston, Mass. 02193 (E)

W

WACHTMAN, J. B., Jr., Ph.D., B306 Matls. Bldg., Natl. Bur. of Standards, Washington, D.C. 20234 (F-1, 6, 28)
WAGMAN, DONALD D., 7104 Wilson Lane, Bethesda, Md. 20034 (F-4)
WALKER, E. H., Ph.D., 7413 Holly Ave., Takoma Park, Md. 20012 (E-10)
WALKER, RAYMOND F., Ph.D., 670 Shawnee Dr., Franklin Lakes, N.J. 07417 (F-6, 28)
WALTER, DEAN I., Code 6310, Naval Res. Lab., Washington, D.C. 20375 (F-4, 6)
WALTHER, CARL H., Ph.D., 1337 27th St., N.W., Washington, D.C. 20007 (F-6, 18)
WALTON, W. W., Sr., 1705 Edgewater Pkwy., Silver Spring, Md. 20903 (F-4)
WARD, RONALD A., 15404 Carrolton Rd., Rockville, Md. 20853 (F)
WARGA, MARY E., 2475 Virginia Ave., N.W., Washington, D.C. 20037 (F-1, 4, 6, 32)
WARING, JOHN A., 8502 Flower Ave., Takoma Park, Md. 20012 (M-30)
WATSON, BERNARD B., Ph.D., General Research Corp., McLean, Va. 22101 (F-6, 31)
WATSON, ROBERT B., 1167 Wimbledon Dr., McLean, Va. 22101 (M)
WEAVER, DE FORREST E., M.S., Geological Survey, Washington Bldg., Rm. 110, 1011 Arlington Blvd., Arlington, Va. 22209 (E-4)
WEAVER, E. R., 6815 Connecticut Ave., Chevy Chase, Md. 20015 (E-4, 6)
WEBB, RAYMON E., Agr. Res. Center, USDA, Beltsville, Md. 20705 (M)
WEBER, EUGENE W., B.C.E., 2700 Virginia Ave., N.W., Washington, D.C. 20037 (F-6, 12, 17, 18)
WEBER, ROBERT S., 1825 Martha Ave., Harlingen, Tex. 78550 (M)
WEIDA, FRANK, 19 Scientists Cliff, Port Republic, Calvert County, Md. 20676 (E-1)
WEIDLEIN, E. R., Weidacres, P.O. Box 445, Rector, Pa. 15677 (E)
WEIHE, WERNER K., 2103 Basset St., Alexandria, Va. 22308 (F-32)
WEINBERG, HAROLD P., B.S., 1507 Sanford Rd., Silver Spring, Md. 20902 (F-20)
WEINTRAUB, ROBERT L., 305 Fleming Ave., Frederick, Md. 21701 (F-4, 10, 16, 33)
WEIR, CHARLES E., Rt. 3, Box 260B, San Luis Obispo, Calif. 93401 (F)
WEISS, FRANCIS JOSEPH, Ph.D., Sc.D., 6121 Montrose Rd., Rockville, Md. 20852 (E-1, 4, 6, 10, 16, 26, 27, 33)
WEISSBERG, SAMUEL, 14 Granville Dr., Silver Spring, Md. 20901 (F-1, 4)
WEISSLER, ALFRED, Ph.D., 5510 Uppingham St., Chevy Chase, Md. 20015 (F-1, 4, 25)
WELLMAN, FREDERICK L., Dept. of Plant Pathology, North Carolina State Univ., Raleigh, N.C. 27607 (E)
WENSCH, GLEN W., Esworthy Rd., Rt. 2, Germantown, Md. 20767 (F-6, 20, 26)
WEST, WILLIAM L., Dept. of Pharmacology, Howard Univ., Washington, D.C. 20001 (M-19, 26)
WESTERHAUT, GART, Ph.D., Astronomy Program, Space Sciences Bg., Univ. Maryland, College Park, Md. 20742 (F)
WETMORE, ALEXANDER, Ph.D., Smithsonian Inst., Washington, D.C. 20560 (F-3, 6)
WEXLER, ARNOLD, Phys. B 356, Natl. Bur. of Standards, Washington, D.C. 20234 (F-1, 35)
WHEELER, WILLIS H., 3171 N. Quincy St., Arlington, Va. 22207 (E-6, 10)
WHERRY, EDGAR T., Ph.D., Dept. Botany, Univ. of Pennsylvania, Philadelphia, Pa. 19104 (E)
WHITE, HOWARD J., Jr., 8028 Park Overlook Dr., Bethesda, Md. 20034 (F-4)
WHITE, ROBERT M., NOAA, U.S. Dept. Commerce, Washington, D.C. 20230 (F)
WHITELOCK, LELAND D., B.S.E.E., 5614 Greentree Rd., Bethesda, Md. 20034 (F-13)
WHITMAN, MERRILL J., 3300 Old Lee Highway, Fairfax, Va. 22030 (F-26)
WHITTEN, CHARLES A., 9606 Sutherland Rd., Silver Spring, Md. 20901 (F-1, 6)
WICHERS, EDWARD, Ph.D., 9601 Kingston Rd., Kensington, Md. 20795 (E-4)
WILDHACK, W. A., 415 N. Oxford St., Arlington, Va. 22203 (F-1, 6, 22, 31, 35)
WILHELM, PETER G., 6710 Elroy Pl., Oxon Hill, Md. 20021 (F)
WILLENBROCK, F. KARL, Director, Inst. for Appl. Tech., Natl. Bur. Standards, Washington, D.C. 20234 (F)
WILLIAMS, DONALD H., 4112 Everett St., Kensington, Md. 20795 (M-27)
WILSON, BRUCE L., 20 N. Leonora Ave., Apt. 204, Tucson, Ariz. 85711 (F-1, 6)
WILSON, WILLIAM K., M.S., 1401 Kurtz Rd., McLean, Va. 22101 (F-4)
WINSTON, JAY S., Ph.D., 3106 Woodhollow Dr., Chevy Chase, Md. 20015 (F-6, 23)
WISE, GILBERT H., 8805 Oxwell Lane, Laurel, Md. 20810 (M-6)
WITHINGTON, C. F., 3411 Ashley Terr., N.W., Washington, D.C. 20008 (F-7)
WITTLER, RUTH G., Ph.D., 83 Bay Dr., Bay Ridge, Annapolis, Md. 21403 (F-16)
WOLFF, EDWARD A., 1021 Cresthaven Dr., Silver Spring, Md. 20903 (F-6, 13, 22, 23)
WOLFLE, DAEL, Graduate School of Public Affairs, University of Washington, Seattle, Washington 98195 (F)

WOLFRAM, LESZEK J., Gillette Res. Inst., 1413 Research Blvd., Rockville, Md. 20850 (F)

WOLICKI, E. A., Ph.D., Nuclear Sciences Div., Code 6601, U.S. Naval Res. Lab., Washington, D.C. 20390 (F)

WOMACK, MADELYN, 11511 Highview Ave., Silver Spring, Md. 20902 (F-4, 19)

WOOD, LAWRENCE A., Ph.D., Natl. Bur. of Standards, Washington, D.C. 20234 (F-1, 4)

WOOD, MARSHALL K., M.P.A., 2909 Brandywine St., N.W., Washington, D.C. 20008 (F)

WOOD, REUBEN E., 3120 N. Pershing Dr., Arlington, Va. 22201 (F-4, 29)

WOODS, MARK W., Natl. Cancer Inst., Bethesda, Md. 20014 (F-10, 19)

WORKMAN, WILLIAM G., M.D., 5221 42nd St., N.W., Washington, D.C. 20015 (E-6, 8)

WRENCH, CONSTANCE P., 10230 Democracy Lane, Potomac, Md. 20854 (M-6)

WRENCH, JOHN W., Jr., 10230 Democracy Lane, Potomac, Md. 20854 (F-6)

WULF, OLIVER R., Noyes Lab. of Chem. Phys., Calif. Inst. of Tech., Pasadena, Calif. 91108 (E)

WYMAN, LEROY W., Sr., Ch. E., 134 Island View Dr., Cape St. John, Annapolis, Md. 21401 (F-6, 20, 36)

Y

YAO, AUGUSTINE Y. M., Ph.D., 4434 Brocton Rd., Oxon Hill, Md. 20022 (M-23)

YAPLEE, BENJAMIN S., 6105 Westland Dr., Hyattsville, Md. 20782 (F-13)

YEATMAN, JOHN N., 11106 Cherry Hill Rd., Adelphi, Md. 20783 (M)

YOCUM, L. EDWIN, 1257 Drew St., Apt. 2, Clearwater, Fla. 33515 (E-10, 33)

YODER, HATTEN S., Jr., Geophysical Lab., 2801 Upton St., N.W., Washington, D.C. 20008 (F-4, 7)

YOLKEN, H. T., Rm. B314, Natl. Bur. of Standards, Washington, D.C. 20234 (F-29)

YOUNG, BOBBY G., Dept. of Microbiology, Univ. of Maryland, College Park, Md. 20742 (M-16)

YOUNG, CLINTON J. T., M.S., 300 Rucker Pl., Alexandria, Va. 22301 (M-32)

YOUNG, DAVID A., Jr., Ph.D., 612 Buck Jones Rd., Raleigh, N.C. 27606 (F-5)

YOUNG, M. WHARTON, 3230 Park Pl., Washington, D.C. 20010 (F)

YUILL, J. S., M.S., 4307-A Hartwick Rd., College Park, Md. 20740 (E-5, 6, 24)

Z

ZELENY, LAWRENCE, Ph.D., 4312 Van Buren St., University Park, Hyattsville, Md. 20782 (E)

ZIES, EMANUEL G., 3803 Blackthorne St., Chevy Chase, Md. 20015 (E-4, 6, 7)

ZOCH, RICHMOND T., 12612 Craft Lane, Bowie, Md. 20715 (F)

ZWEMER, RAYMOND L., 5008 Benton Ave., Bethesda, Md. 20014 (E)

BYLAWS

Washington Academy of Sciences

Last Revised in February 1972

Article I. OBJECTIVES

Section 1. The purposes of the Washington Academy of Sciences shall be: (a) to stimulate interest in the sciences, both pure and applied, and (b) to promote their advancement and the development of their philosophical aspects by the Academy membership and through cooperative action by the affiliated societies.

Section 2. These objectives may be attained by, but are not limited to:

(a) Publication of a periodical and of occasional scientific monographs and such other publications as may be deemed desirable.
(b) Public lectures of broad scope and interest in the fields of science.
(c) Sponsoring a Washington Junior Academy of Sciences.
(d) Promoting science education and a professional interest in science among people of high school and college age.
(e) Accepting or making grants of funds to aid special research projects.
(f) Symposia, both formal and small informal, on any aspects of science.
(g) Scientific conferences.
(h) Organization of, or assistance in, scientific expeditions.
(i) Cooperation with other Academies and scientific organizations.
(j) Awards of prizes and citations for special merit in science.
(k) Maintaining an office and staff to aid in carrying out the purposes of the Academy.

Article II. MEMBERSHIP

Section 1. The membership shall consist of three general classes: members, fellows and patrons.

Section 2. Members shall be persons who are interested in and will support the objectives of the Academy and who are otherwise acceptable to at least two-thirds of the Committee on Membership. A letter or application form requesting membership and signed by the applicant may suffice for action by the Committee; approval by the Committee constitutes election to membership.

Section 3. Fellows shall be persons who by reason of original research or other outstanding service to the sciences, mathematics, or engineering are deemed worthy of the honor of election to Academy fellowship.

Section 4. Nominations of fellows shall be presented to the Committee on Membership as a form approved by the Committee. The form shall be signed by the sponsor, a fellow who has knowledge of the nominee's field, and shall be endorsed by at least one other fellow. An explanatory letter from the sponsor and a bibliography of the nominee's publications shall accompany the completed nomination form.

Section 5. Election to fellowship shall be by vote of the Board of Managers upon recommendation of the Committee on Membership. Final action on nominations shall be deferred at least one week after presentation to the Board, and two-thirds of the vote cast shall be necessary to elect.

Section 6. Each individual (not already a fellow) who has been nominated as a Delegate by a local affiliated society or who has been chosen to be the recipient of an Academy Award for Scientific Achievement shall be considered nominated for immediate election to fellowship by the Board of Managers without the necessity for compliance with the provisions of Sections 4 and 5.

Section 7. An individual of unquestioned eminence may be recommended by vote of the Committee on Membership Promotion for immediate election to fellowship by the Board of Managers, without the necessity for compliance with the provisions of Sections 4 and 5.

Section 8. Persons who have given to the Academy not less than one thousand (1,000) dollars or its equivalent in property shall be eligible for election by the Board of Managers as patrons (for life) of the Academy.

Section 9. Life members or fellows shall be those individuals who have made a single payment in accordance with Article III, Section 2, in lieu of annual dues.

Section 10. Members or fellows in good standing who are retired and are no longer engaged in regular gainful employment may be placed in emeritus status. Upon request to the treasurer for transfer to this status, they shall be relieved of the further payment of dues, beginning with the following January first; shall receive notices of meetings without charge; and at their request, shall be entitled to receive the Academy periodical at cost.

Section 11. Members or fellows living more than 50 miles from the White House, Washington, D.C., shall be classed as nonresident members or fellows.

Section 12. An election to any dues-paying class of membership shall be void if the candidate does not within three months thereafter pay his dues or satisfactorily explain his failure to do so.

Section 13. Former members or fellows who resigned in good standing may be reinstated upon application to the Secretary and approval by the Board of Managers. No reconsideration of the applicant's qualifications need be made by the Membership Committee in these cases.

Article III. DUES

Section 1. The annual dues of each class of members shall be fixed by the Board of Managers. No dues shall be paid by emeritus members and fellows, life members and fellows, and patrons.

Section 2. Members and fellows in good standing may be relieved of further payment of dues by making a single payment to provide an annuity equal to their annual dues. (See Article II, Section 9.) The amount of the single payment shall be computed on the basis of an interest rate to be determined by the Board of Managers.

Section 3. Members or fellows whose dues are in arrears for one year shall not be entitled to receive Academy publications.

Section 4. Members or fellows whose dues are in arrears for more than two years shall be dropped from the rolls of the Academy, upon notice to the Board of Managers, unless the Board shall otherwise direct. Persons who have been dropped from membership for nonpayment of dues may be reinstated upon approval of the Board and upon payment of back dues for two years together with dues for the year of reinstatement.

Article IV. OFFICERS

Section 1. The officers of the Academy shall be a President, a President-elect, a Secretary, and a Treasurer. All shall be chosen from resident fellows of the Academy.

Section 2. The President shall appoint all committees and such non-elective officers as are needed unless otherwise directed by the Board of Managers or provided in the Bylaws. He (or his substitute—the President-elect, the Secretary, or the Treasurer, in that order), shall preside at all meetings of the Academy and of the Board of Managers.

Section 3. The Secretary shall act as secretary to the Board of Managers and to the Academy at large. He shall conduct all correspondence relating thereto, except as otherwise provided, and shall be the custodian of the corporate seal of the Academy. He shall arrange for the publication in the Academy periodical of the names and professional connections of new members, and also of such proceedings of the Academy, including meetings of the Board of Managers, as may appropriately be of interest to the membership. He shall be responsible for keeping a register of the membership, showing such information as qualifications, elections, acceptances, changes of residence, lapses of membership, resignations and deaths, and for informing the Treasurer of changes affecting the status of members. He shall act as secretary to the Nominating Committee (see Art. VI, Sect. 2).

Section 4. The Treasurer shall be responsible for keeping an accurate account of all receipts and disbursements, shall select a suitable depository for current funds which shall be approved by the Executive Committee, and shall invest the permanent funds of the Academy as directed by that Committee. He shall prepare a budget at the beginning of each year which shall be reviewed by the Executive Committee for presentation to and acceptance by the Board of Managers. He shall notify the Secretary of the date when each new member qualifies by payment of dues. He shall act as business advisor to the Editor and shall keep necessary records pertaining to the subscription list. In view of his position as Treasurer, however, he shall not be required to sign contracts. He shall pay no bill until it has been approved in writing by the chairman of the committee or other persons authorized to incur it. The fiscal year of the Academy shall be the same as the calendar year.

Section 5. The President and the Treasurer, as directed by the Board of Managers, shall jointly assign securities belonging to the Academy and indorse financial and legal papers necessary for the uses of the Academy, except those relating to current expenditures authorized by the Board. In case of disability or absence of the President or Treasurer, the Board of Managers may designate the President-elect or a qualified Delegate as Acting President or an officer of the Academy as Acting Treasurer, who shall perform the duties of these officers during such disability or absence.

Section 6. An Editor shall be in charge of all activities connected with the Academy's publications. He shall be nominated by the Executive Committee and appointed by the President for an indefinite term subject to annual review by the Board of Managers. The Editor shall serve as a member of the Board.

Section 7. An Archivist may be appointed by the President. If appointed, he shall maintain the permanent records of the Academy, including important records which are no longer in current use by the Secretary, Treasurer, or other officer, and such other documents and material as the Board of Managers may direct.

Section 8. All officers and chairmen of standing committees shall submit annual reports at the May meeting of the Board of Managers.

Section 9. The Nominating Committee (Article IV, Section 2) shall prepare a slate listing two or more persons for each of the offices of President-elect, of Secretary and of Treasurer, and four or more persons for the two Managers-at-large whose terms expire each year and at least two persons to fill each vacant unexpired term of manager-at-large. The slate shall be presented for approval to the Board of Managers at its first meeting in October. Not later than November 15, the Secretary shall forward to each Academy Member and Fellow an announcement of the election, the committee's nomination for the offices to be filled, and a list of incumbents. Additional candidates for such offices may be proposed by any Member or Fellow in good standing by letter received by the Secretary not later than Dec. 1. The name of any eligible candidate so proposed by ten Members or Fellows shall be entered on the ballot.

Section 10. Not later than December 15, the Secretary shall prepare and mail ballots to members and fellows. Independent nominations shall be included on the ballot, and the names of the nominees shall be arranged in alphabetical order. When more than two candidates are nominated for the same office the voting shall be by preferential ballot in the manner prescribed by the Board of Managers. The ballot shall contain also a notice to the effect that votes not received by the Secretary before the first Thursday of January, and votes of individuals whose dues are in arrears for one year or more, will not be counted. The Committee of Tellers shall count the votes and report the results at the annual meeting of the Academy.

Section 11. The newly elected officers shall take office at the close of the annual meeting, the President-elect of the previous year automatically becoming President.

Article V. BOARD OF MANAGERS

Section 1. The activities of the Academy shall be guided by the Board of Managers, consisting of the President, the President-elect, the immediate past President, one Delegate from each of the affiliated societies, the Secretary, the Treasurer, six elected Managers-at-Large, and the Editor. The elected officers of the Academy shall hold like offices on the Board of Managers.

Section 2. One Delegate shall be selected by each affiliated society. He shall serve until replaced by his society. Each Delegate is expected to participate in the meetings of the Board of Managers and vote on behalf of his society.

Section 3. The Board of Managers shall transact all business of the Academy not otherwise provided for. A quorum of the Board shall be nine of its members.

Section 4. The Board of Managers may provide for such standing and special committees as it deems necessary.

Section 5. The Board shall have power to fill vacancies in its own membership until the next annual election. This does not apply to the offices of President and Treasurer (see Art. IV, Sect. 5), nor to Delegates (see Art. V, Sect. 2).

Article VI. COMMITTEES

Section 1. An Executive Committee shall have general supervision of Academy finances, approve the selection of a depository for the current funds, and direct the investment of the permanent funds. At the beginning of the year it shall present to the Board of Managers an itemized statement of receipts and expenditures of the preceding year and a budget based on the estimated receipts and disbursements of the coming year, with such recommendations as may seem desirable. It shall be charged with the duty of considering all activities of the Academy which may tend to maintain and promote relations with the affiliated societies, and with any other business which may be assigned to it by the Board. The Executive Committee shall consist of the President, the President-elect, the Secretary and the Treasurer (or Acting Treasurer) ex officio, as well as two members appointed annually by the President from the membership of the Board.

Section 2. The President, with the approval of the Board of Managers, shall appoint a Nominating Committee of six Fellows of the Academy, at least one of whom shall be a past President of the Academy, and at least three of whom shall have served as Delegates for at least one year. The Chairman shall be a past President. (See Article IV, Section 9.)

Section 3. The President shall appoint in advance of the annual meeting an Auditing Committee consisting of three persons, none of whom is an officer, to audit the accounts of the Treasurer (Art. VII, Sect. 1).

Section 4. On or before the last Thursday of each year the President shall appoint a committee of three Tellers whose duty it shall be to canvass the ballots (Art. IV, Sect. 10, Art. VII, Sect. 1).

Section 5. The President shall appoint from the Academy membership such committees as are authorized by the Board of Managers and such special committees as necessary to carry out his functions. Committee appointments shall be staggered as to term whenever it is determined by the Board to be in the interest of continuity of committee affairs.

Article VII. MEETINGS

Section 1. The annual meeting shall be held each year in May. It shall be held on the third Thursday of the month unless otherwise directed by the Board of Managers. At this meeting the reports of the Secretary, Treasurer, Auditing Committee (see Article VI, Sect. 3), and Committee of Tellers shall be presented.

Section 2. Other meetings may be held at such time and place as the Board of Managers may determine.

Section 3. The rules contained in "Robert's Rules of Order Revised" shall govern the Academy in all cases to which they are applicable, and in which they are not inconsistent with the bylaws or special rules of order of the Academy.

Article VIII. COOPERATION

Section 1. The term "affiliated societies" in their order of seniority (see Art. VI, Sect. 2) shall be held to cover the:

Philosophical Society of Washington
Anthropological Society of Washington
Biological Society of Washington
Chemical Society of Washington
Entomological Society of Washington
National Geographic Society
Geological Society of Washington
Medical Society of the District of Columbia
Columbia Historical Society
Botanical Society of Washington
Washington Section of Society of American Foresters
Washington Society of Engineers
Washington Section of Institute of Electrical and Electronics Engineers
Washington Section of American Society of Mechanical Engineers
Helminthological Society of Washington
Washington Branch of American Society for Microbiology
Washington Post of Society of American Military Engineers
National Capital Section of American Society of Civil Engineers
District of Columbia Section of Society for Experimental Biology and Medicine
Washington Chapter of American Society for Metals
Washington Section of the International Association for Dental Research
Washington Section of American Institute of Aeronautics and Astronautics

D.C. Branch of American Meteorological Society
Insecticide Society of Washington
Washington Chapter of the Acoustical Society of America
Washington Section of the American Nuclear Society
Washington Section of Institute of Food Technologists
Baltimore-Washington Section of the American Ceramic Society
Washington-Baltimore Section of the Electrochemical Society
Washington History of Science Club
Chesapeake Section of American Association of Physics Teachers
National Capital Section of Optical Society of America
Washington Section of American Society of Plant Physiologists
Washington Operations Research Council
Washington Section of Instrument Society of America
American Institute of Mining, Metallurgical, and Petroleum Engineers
National Capital Astronomers
Maryland-District of Columbia-Virginia Section of the Mathematical Association of America
District of Columbia Institute of Chemists

and such others as may be hereafter recommended by the Board and elected by two-thirds of the members of the Academy voting, the vote being taken by correspondence. A society may be released from affiliation on recommendation of the Board of Managers, and the concurrence of two-thirds of the members of the Academy voting.

Section 2. The Academy may assist the affiliated scientific societies of Washington in any matter of common interest, as in joint meetings, or in the publication of a joint directory: Provided, it shall not have power to incur for or in the name of one or more of these societies any expense or liability not previously authorized by said society or societies, nor shall it without action of the Board of Managers be responsible for any expenses incurred by one or more of the affiliated societies.

Section 3. No affiliated society shall be committed by the Academy to any action in conflict with the charter, constitution, or bylaws of said society, or of its parent society.

Section 4. The Academy may establish and assist a Washington Junior Academy of Sciences for the encouragement of interest in science among students in the Washington area of high school and college age.

Article IX. AWARDS AND GRANTS-IN-AID

Section 1. The Academy may award medals and prizes, or otherwise express its recognition and commendation of scientific work of high merit and distinction in the Washington area. Such recognition shall be given only on approval by the Board of Managers of a recommendation by a committee on awards for scientific achievement.

Section 2. The Academy may receive or make grants to aid scientific research in the Washington area. Grants shall be received or made only on approval by the Board of Managers of a recommendation by a committee on grants-in-aid for scientific research.

Article X. AMENDMENTS

Section 1. Amendments to these bylaws shall be proposed by the Board of Managers and submitted to the members of the Academy in the form of a mail ballot accompanied by a statement of the reasons for the proposed amendment. A two-thirds majority of those members voting is required for adoption. At least two weeks shall be allowed for the ballots to be returned.

Section 2. Any affiliated society or any group of ten or more members may propose an amendment to the Board of Managers in writing. The action of the Board in accepting or rejecting this proposal to amend the bylaws shall be by a vote on roll call, and the complete roll call shall be entered in the minutes of the meeting.

ACT OF INCORPORATION OF THE WASHINGTON ACADEMY OF SCIENCES

We, the undersigned, persons of full age and citizens of the United States, and a majority being citizens of the District of Columbia, pursuant to and in conformity with sections 545 to 552, inclusive, of the Revised Statutes of the United States relating to the District of Columbia, as amended by an Act of Congress entitled "An Act to amend the Revised Statutes of the United States relating to the District of Columbia and for other purposes," approved April 23, 1884, hereby associate ourselves together as a society or body corporate and certify in writing:

1. That the name of the society is the Washington Academy of Sciences.
2. That the term for which the Corporation is organized shall be perpetual.
3. That the Corporation is organized and shall be operated exclusively for charitable, educational and scientific purposes and in furtherance of these purposes and for no other purpose shall have, but not be limited to, the following specific powers and purposes:

   a. To encourage in the broadest and most liberal manner the advancement and promotion of science.
   b. To acquire, hold, and convey real estate and other property and to establish general and special funds.
   c. To hold meetings.
   d. To publish and distribute documents.
   e. To conduct lectures.
   f. To conduct, endow, or assist investigation in any department of science.
   g. To acquire and maintain a library.
   h. And, in general, to transact any business pertinent to an academy of sciences.

   Provided, however, that notwithstanding the foregoing enumerated powers, the Corporation shall not engage in activities, other than as an insubstantial part thereof, which are not in themselves in furtherance of its charitable, educational and scientific purposes.

4. That the affairs, funds, and property of the Corporation shall be in general charge of a Board of Managers, the number of whose members for the first year shall be nineteen, all of whom shall be chosen from among the members of the Academy.
5. That in the event of dissolution or termination of the Corporation, title to and possession of all the property of the Corporation shall pass to such organization, or organizations, as may be designated by the Board of Managers; provided, however, that in no event shall any property of the Corporation be transmitted to or vested in any organization other than an organization which is then in existence and then qualified for exemption as a charitable, educational or scientific organization under the Internal Revenue Code of 1954, as amended.

Editor's Note: This Act of Incorporation is shown as amended in 1964 by Francois N. Frenkiel, President, and George W. Irving, Jr., Secretary, acting for the Washington Academy of Sciences, in a Certificate of Amendment notarized on September 16, 1964. A copy of the original Act of Incorporation dated February 18, 1898, appears in the Journal for November 1963, page 212.

JOURNAL OF THE WASHINGTON ACADEMY OF SCIENCES

Instructions to Contributors

General

Type manuscripts on white bond paper either 8½ by 11 or 8 by 10½ inches. Double space all lines, including those in abstracts, tables, legends, quoted matter, acknowledgments, and references cited. Number pages consecutively. Place your name and complete address in the upper right hand corner of the title page.

Title, Author, and Affiliation

Page 1 of your manuscript should contain only this information and your name and address. Choose a concise but complete and meaningful title. In research papers concerning biological subjects, include an indication of the order and family of the taxa discussed. Academic degrees will not normally be included unless the author so specifies. If possible, combine your affiliation and mailing address (including Zip) so that readers can write to you directly.

Abstract

Type on a separate sheet at the end of the manuscript. Make the abstract intelligible without reference to the text of the paper. Write an informative digest of the significant content and conclusions, not a mere description. Generally, the abstract should not exceed 3% of the text.

Footnotes

Use footnotes as sparingly as possible. Number text footnotes consecutively with Arabic numerals and type them on a separate sheet of paper at the end of the manuscript. Type table footnotes, if any, below each pertinent table on the same page.

Illustrations and Legends

The quality of all original illustrations must be high enough to facilitate good offset reproduction. They should have ample margins and be drawn on heavy stock or fastened to stiff cardboard to prevent bending. They should be proportioned to column (1 x 3) or page (2 x 3) type-dimensions, leaving space for legend material. Photographs should have a glossy finish. They reproduce best when the contrast is fairly high. Identify each illustration with number and author in light pencil marks on the reverse side. Submit all illustrations separately – please do not glue or clip them to the pages of the manuscript.

Do not type or write legends directly on the illustrations. Type legends on a separate sheet or sheets at the end of the manuscript. Indicate where you want illustrations to appear in the printed paper by writing the figure numbers lightly in the text margins, and be sure that each figure is properly referenced in the text itself. Original "art" will be returned only at the author's request and expense.

Tables

Include tables only when the same information cannot be presented economically in the text, or when a table presents the data in a more meaningful way. Consider preparing extremely complicated tabular matter in a form suitable for direct reproduction as an illustration. In such cases, the use of the typewriter is not recommended.

References to Literature

Limit references within the text and in synonymies to author and year (and page if needed). In a "Reference Cited" section, list alphabetically by senior author only those papers you have included in the text. Likewise, be sure all the text references are listed. Type the "References Cited" section on a separate sheet after the last page of text. Abbreviations should follow the *USA Standard for Periodical Title Abbreviations*, Z39.5-1963.

Submission of Manuscripts

Send completed manuscripts and supporting material to the Academy office (see address inside front cover) in care of the Editor. Authors will be requested to read Xerox "proofs" and invited to submit reprint orders prior to publication.

Reprints – Prices for reprints may be obtained on request.

Washington Academy of Sciences
9650 Rockville Pike (Bethesda)
Washington, D.C. 20014
Return Requested with Form 3579

2nd Class Postage P
at Washington, D.
and additional mailing offic

VOLUME 63
Number 4
DECEMBER, 1973

Journal of the WASHINGTON ACADEMY OF SCIENCES

Issued Quarterly
at Washington, D.C.

CONTENTS

Features:

J. R. PORTER: Challenges to Editors of Scientific Journals II 129

RAYMOND J. SEEGER: On Copernicus in Human Perspective 135

Research Reports:

JOHN M. KINGSOLVER: Description of a New Genus and a New Species of Bruchidae from South America (Coleoptera) 142

A. S. MENKE: A Preliminary Review of the *agile* Group of *Podium* Fabricius (Hymenoptera: Sphecidae) 147

LOUISE M. RUSSELL: The Correct Citations for the Reports on Homoptera Collected During the Harriman Alaska Expedition 154

LOUISE M. RUSSELL: A List of the Species of *Craspedolepta* Enderlein Recorded from North America (Homoptera: Psyllidae: Aphalarinae) 156

PAUL J. SPANGLER: A Description of the Larva of *Hydrobiomorpha casta* (Coleoptera: Hydrophilidae) 160

PAUL J. SPANGLER: A Description of the Larva of *Celina angustata* Aubé (Coleoptera: Dytiscidae) 165

Academy Affairs:

Junior Academy of Sciences 169

Board of Managers Meeting Notes 169

Scientists in the News 171

Obituaries 176

Washington Academy of Sciences

Founded in 1898

EXECUTIVE COMMITTEE

BOARD OF MANAGERS

All delegates of affiliated Societies (see facing page)

EDITOR

Richard H. Foote

EDITORIAL ASSISTANT

Elizabeth Ostaggi

ACADEMY OFFICE

9650 Rockville Pike (Bethesda)
Washington, D.C. 20014
Telephone (301) 530-1402

The Journal

This journal, the official organ of the Washington Academy of Sciences, publishes historical articles, critical reviews, and scholarly scientific articles; proceedings of meetings of the Academy and its Board of Managers; and other items of interest to Academy members. The *Journal* appears four times a year (March, June, September, and December) – the September issue contains a directory of the Academy membership.

Subscription Rates

Members, fellows, and patrons in good standing receive the *Journal* without charge. Subscriptions are available on a calendar year basis only, payable in advance. Payment must be made in U.S. currency at the following rates:

U.S. and Canada	$10.00
Foreign	11.00
Single Copy Price	3.00

Back Issues

Obtainable from the Academy office (address at bottom of opposite column): **Proceedings:** Vols. 1-13 (1898-1910) **Index:** To Vols. 1-13 of the *Proceedings* and Vols. 1-40 of the *Journal* **Journal:** Back issues, volumes, and sets (Vols. 1-62, 1911-1972) and all current issues.

Claims for Missing Numbers

Claims will not be allowed if received more than 60 days after date of mailing plus time normally required for postal delivery and claim. No claims will be allowed because of failure to notify the Academy of a change in address.

Changes of Address

Address changes should be sent promptly to the Academy office. Such notification should show both old and new addresses and zip number.

Published quarterly in March, June, September, and December of each year by the Washington Academy of Sciences, 9650 Rockville Pike, Washington, D.C. Second class postage paid at Washington, D.C. and additional mailing offices.

DELEGATES TO THE WASHINGTON ACADEMY OF SCIENCES, REPRESENTING THE LOCAL AFFILIATED SOCIETIES

Philosophical Society of Washington	Bradley F. Bennett
Anthropological Society of Washington	Jean K. Boek
Biological Society of Washington	Delegate not appointed
Chemical Society of Washington	Alfred Weissler
Entomological Society of Washington	William E. Bickley
National Geographic Society	Alexander Wetmore
Geological Society of Washington	Charles Milton
Medical Society of the District of Columbia	Delegate not appointed
Columbia Historical Society	Paul H. Oehser
Botanical Society of Washington	Conrad B. Link
Society of American Foresters	Robert Callaham
Washington Society of Engineers	George Abraham
Institute of Electrical and Electronics Engineers	Harry Fine
American Society of Mechanical Engineers	Michael Chi
Helminthological Society of Washington	James H. Turner
American Society for Microbiology	Lewis Affronti
Society of American Military Engineers	H.P. Demuth
American Society of Civil Engineers	Carl H. Gaum
Society for Experimental Biology and Medicine	Carlton Treadwell
American Society for Metals	Glen W. Wensch
International Association for Dental Research	Norman H.C. Griffiths
American Institute of Aeronautics and Astronautics	Franklin Ross
American Meteorological Society	Delegate not appointed
Insecticide Society of Washington	H. Ivan Rainwater
Acoustical Society of America	Gerald J. Franz
American Nuclear Society	Delegate not appointed
Institute of Food Technologists	William Sulzbacher
American Ceramic Society	W.T. Bakker
Electrochemical Society	Stanley D. James
Washington History of Science Club	Delegate not appointed
American Association of Physics Teachers	Bernard B. Watson
Optical Society of America	James B. Heaney
American Society of Plant Physiologists	Walter Shropshire
Washington Operations Research Council	John G. Honig
Instrument Society of America	Delegate not appointed
American Institute of Mining, Metallurgical and Petroleum Engineers	Delegate not appointed
National Capitol Astronomers	John A. Eisele
Mathematical Association of America	Daniel B. Lloyd
D.C. Institute of Chemists	Miloslav Recheigl, Jr.

Delegates continue in office until new selections are made by the respective societies.

A FIRST FOR WASHINGTON!

Symposium—STATISTICS AND THE ENVIRONMENT

Washington, D.C.—March 6, 7, and 8, 1974

The objective of this symposium is "to provide a forum for the interchange of ideas of mutual interest to experts in various environmental or related areas, and specialists in the statistical techniques of data gathering and analysis."

This is *not* a meeting where statisticians will speak statistically to other statisticians, or environmentalists will converse in their own language to their co-scientists. If the symposium fulfils its objective it is hoped that attempts to solve environmental problems will be enhanced by an interdisciplinary approach resulting from the communication between the two.

The direct sponsors are the National Academy of Sciences, the Washington Academy of Sciences, the Washington Statistical Society, and the Washington Section of the American Society of Quality Control, plus monetary support from the Environmental Protection Agency and the Department of Transportation. There are many co-sponsors, such as the National Bureau of Standards.

For information, write to Miss Beatrice S. Orleans, General Chairman, Naval Ships Systems Command, Code 0311, Washington, D. C. 20362, or telephone (703) Oxford 2-0871.

Registration will be $20.00, which also includes a copy of the proceedings.

—WATCH FOR FUTURE ANNOUNCEMENTS—

Challenges to Editors of Scientific Journals II[1]

J. R. Porter

Department of Microbiology, College of Medicine, University of Iowa, Iowa City, Iowa 52242

ABSTRACT

Challenges to today's editors lie in the need to demand clarity and concise definition in writing, to avoid overcensureship of the literary style and rights of authors, to protect copyrights, and to monitor rigidly the proofing of the printed word. Science and technology play central roles in contemporary society, and today's editor must play a vital part in bringing developments in these fields of human activity to the attention of the concerned public and policy makers in clearly understandable terms.

I am delighted and honored to receive this prestigious award. In accepting it, however, I do so with recognition of my colleagues who worked so diligently and harmoniously on the first two editions of the *Style Manual:* James S. Ayars, Sheridan Baker, George B. Cummins, Harold Cummins, Graham DuShane, Richard H. Manville, Robert V. Ormes, A. J. Riker, William C. Steere, and H. B. Vickery. I had been editor of the *Journal of Bacteriology* for about 8 years before I began to meet regularly with these gentlemen, and I must admit I learned more from them about editing than I thought was possible. Furthermore, a deep and lasting friendship resulted from our association. Thus thank you from all of us.

Ten years ago this spring in Washington I had the honor of speaking before this distinguished group on "Challenges to Editors of Scientific Journals". While trying to decide what I might say to you tonight, I read that speech (Porter, 1963) again to determine what had happened to the challenges.

At that time I made no claim for original thought or distant vision. Rather I summarized some of the topics we were discussing then in this organization. I am pleased to say now, however, that you editors of biological journals have accomplished many of the things that were mentioned. I believe through your efforts that editorial boards in general are doing a better job today than they were then of evaluating the scientific merits of manuscripts before they are published. The *Style Manual* had been available only three years in 1963, but already over 15,000 copies had been distributed around the world. Now, with the excellent and enlarged third edition available, over 60,000 copies have been sold in 13 years. The *Manual* has undoubtedly had a marked influence on improving manuscripts that are submitted to biological

---

[1] Council of Biology Editors Meritorious Award Address, Bethesda, Maryland, May 21, 1973.

journals. Also many other important activities, such as the publication in 1968 of *Scientific Writing for Graduate Students* by Peter Woodford and colleagues, have been sponsored by the Council of Biology Editors. Such devotion and diligence on your part have improved scientific writing and communication in all branches of biology.

As I read the scientific literature and think about the future, however, I find several reasons to be concerned. These concerns are not a "doomsday complex", but an uneasiness and uncertainty about how we might adjust to the new phases of communication in science.

I realize every editor has pride in publishing a journal that contains documented, well-written, and easy to read articles describing original and worthwhile research. But many areas of science are becoming so specialized with their own lingo, arbitrarily coined words, and abbreviations that one wonders sometimes if the papers from these areas are written in our native language. In fact, some well-known columnists, such as Sydney Harris, think that speaking and writing are worse today than at any period in their experience. But John B. Blake (1971) reports that similar complaints were being echoed about medical writing over 100 years ago.

Perhaps we have reached the stage when we need to think again about what Confucius said about 500 B.C. concerning the importance of using correct and concise language. He had just become the administrator for the affairs of one of the Chinese princes when he was asked by a disciple: "What will you undertake first, Sir?" The most important thing needed replied Confucius "is to correct terms and languages . . . . If terms and language are confusing or incorrect, then statements are difficult to understand or they do not agree with the facts; if what is said is unclear or not what is meant, then what ought to be done remains undone. If things remain undone, order and harmony do not flourish, and morals and art will deteriorate. If morals and art deteriorate, justice becomes arbitrary and goes astray. If justice goes astray, the people will stand about in helpless confusion. Thus, whatever a wise man states he must always define clearly, because having nothing remiss in his definitions ranks above everything" (Barnett, 1967).

Perhaps this statement by Confucius is too idealistic for modern times, but nevertheless, it is a worthy motto for all of us to consider who are concerned with editorial problems. As important as clear, concise language is to everyone, however, this is not the only challenge today. Other problems are becoming increasingly serious and must be watched carefully so that appropriate action can be taken to improve conditions or to prevent catastrophes. As editors you are in an ideal position to recognize and to avoid or to solve these problems.

Financial problems have plagued many scientific periodicals for a long time. But as printing, storage, and postage costs increase, and possibly as income taxes become more stringent and research grants for the basic sciences decrease, many scientific periodicals may find themselves in the same situation as such popular magazines as *Look* and *Life*. We can commend CBE for arranging a workshop on economics of scientific publication to be held here day after tomorrow. The program looks most interesting and worthwhile. Hopefully editors of journals with small circulations, or other publications having financial problems, will profit greatly from this workshop. In an effort to bring about greater economy, efficiency, uniformity, and standardization, however, one must be careful not to reduce the literary style and rights of individual journals and authors.

Earlier I stated that I believe editorial boards are giving more careful consideration to the scientific value of manuscripts today than they were ten years ago. But with the increasing tendency to have manuscripts reviewed by specialists not identified on editorial boards, and with administrations in institutions adhering more and more to the "publish or perish" attitude, editors must be careful and constantly aware of their responsibilities in handling and reviewing manuscripts. The stresses, intense pressures, and frustrations facing many people today are making several fields highly competitive. Unfortunately, some of these problems are thought to be interfering with individual rights and they are taxing the ethical fiber of both scientific investigators and editors.

The confidential nature of information today is a problem for all forms of media, including scientific and technical publications. Recently an issue (16 February 1973, p. 523) of *Nature* carried a most significant discussion on the "continuing classification of research". The article dealt with a paper on theoretical calculations relating to the use of a laser beam in triggering thermonuclear explosions, information which is now discussed openly by physicists in ordinary conversation. The referee of the manuscript, however, insisted that no more than two paragraphs should be published until the information was declassified. We may have few instances, or none, of this type in biology, but editors must be constantly and increasingly alert to the suppression of ideas, or the possibilities of plagiarism.

The final outcome of the court case on the violation of the copyright law could have a great influence on the survival of not only journals, but also scientific and technical books. Every scientist and every scientific society will have to make adjustments no matter how this case is settled. I feel the protection of copyrights is a much more important matter in a free society than the decision by the Internal Revenue Service a few years ago to tax scientific organizations.

The new technologies in printing will speed up composition and undoubtedly keep production costs in line for awhile. But even with all the new mechanical and electronic devices, serious human errors will still creep in, especially, if a punch tape goes from the author's typewriter directly into composition, or to storage on computer tapes, without proper editing or proofreading. We may soon face a situation similar to that of the *Athens Daily News*, an English-language paper in Greece. The paper is composed and proofread by persons who may have little or no understanding of English. The foreign news is fairly accurate because the copy is taken directly from the wire service. But typographical errors frequently creep into local stories and are not picked up by proofreaders. For example, in the section on government appointments and meetings one notice read recently: "The Greek Foreign Spinster conceived the English Ambassador yesterday" (Cavender, 1973). Similar spelling errors in scientific journals might produce amusing reading, but they would certainly cause considerable trouble and anguish.

I need not defend before you the unique central roles science and technology play in contemporary society. But unfortunately many people today consider these disciplines as awesome, unessential, magical, unnecessary, or even responsible for most of the current problems facing civilization. In a recent survey by Kadushin and associates (Kadushin *et al.*, 1972; Hover and Kadushin, 1972; Kadushin, 1972) the periodicals most influential among the intelligentsia for the dissemination of new ideas on politics, society, values, literature, and ethics were listed and ranked. One hundred seventy-two distinguished authors, editors, professors, business and professional people, and politicians ranked the 10 most influential publications as follows:

The New York Review of Books, The New Republic,
Commentary, The New York Times Book Review,
The New Yorker, Saturday Review, Partisan Review,
Harper's Magazine, The Nation, and The Atlantic.

The first eight of these periodicals accounted for over 50% of all the selections.

The periodicals selected understandably omitted the principal organs that record basic research in the physical, biological, social, and behavioral sciences, as well as the agricultural, engineering, and medical technical journals. No one would probably consider such publications as having much immediate socio-political influence on national policy. Interestingly, however, *Daedalus* ranked 12th, and the first appearance on the list of a publication relating directly to science was *Science and Society,* ranked 35th. *Science, Nature, The Scientific American, New Scientist, BioScience, The Annals of the American Academy of Political and Social Science,* and *Science and Public Affairs* were not even mentioned. One may ask how intelligent persons can make decisions today on national policy without a broad realization of newer developments in science and its derivative technologies.

According to Kadushin no one should deny that science demands a high degree of intelligence and creativity. But most scientists tend to be diffident about communicating their personal views and feelings to general audiences. When they do make policy or considered pronouncements these tend to be one-shot affairs in the mass media.

In a recent article on citation analysis as a tool in evaluating journals, Garfield (1972) analyzed some 10 million items published in 2,400 journals during the past decade. If 10 million articles represent even a high percentage of the scientific and technical literature of the world during the last decade, one can understand why such vast and widespread information is not easy to take into consideration in establishing national policy.

Since the leading scientific periodicals apparently do not contribute much to decisions on national policy, where does the general public receive its information about science? Reports indicate that 80% of this information is provided by newspapers. A recent survey of newspapers by William Divale (1973), however, reveals that only 3.3% of their contents could be considered science news. Of this percentage, 28% was social science, 21% natural science, 18% medicine, 9% physical science, 8% technology, and 16% other science. We must agree with Divale's conclusion that, even though the published stories may be excellent, the amount of science in newspapers is alarmingly small considering the enormous literature mentioned in the Garfield report and the great significance of science and technology in our society today. But how can the situation be improved?

So far I have talked only about conditions that, I know, concern you even more than me. Now I wish to raise a major challenge for you and the respective organizations you represent. This is: in some way part of the basic biological data appearing in your journals must be analyzed, translated into simple and understandable language, and then brought to the attention of the public. If science is to receive continued support from politicians, and the public in general, more articles must be transmitted through the media that explain the significance of science in our complex society.

The administrators and politicians cannot guide this highly industrialized world on an even course unless they keep up with how it works. Also they must be made to realize that when they make decisions, biology cannot be disregarded. This does not mean that they must speak with profound knowledge, or in detail, about genetic engineering, covergent evolution, behavior control with drugs and electronic devices, the role of prostaglandins in metabolism, immunotherapy in cancer control, the possible importance of immobilized or bound enzymes, research dealing with improving the efficiency of photosynthesis, problems concerned with organ transplantation or prolonging life, or the role of viruses in producing certain types of tumors. But it does mean that these men should be reasonably well-informed about current scientific research and its implications.

By paying too little attention to the impact of science and technology on social problems and human welfare, biologists in various disciplines and organizations may be missing great opportunities to demonstrate responsible leadership, to show a willingness to cooperate with divergent and concerned groups in other disciplines or segments of society, and to gain greater public understanding and trust.

Many persons agree today that the biological sciences are currently producing a great impact on philosophical considerations just as mathematics and the physical sciences altered philosophy in previous decades. But guidelines are needed that state what we hope to do or what we will try to do in establishing human standards for behavior and activity that will ensure the survival of mankind and permit the expansion of personal needs, dignity, happiness, and freedom.

Two years ago the Organization for Economic Cooperation and Development (OECD) published a report by a committee chaired by Harvey Brooks of Harvard University. The committee concluded that "national science policies pursued in the sixties are no longer adequate and require thorough reassessment to make them applicable to the decade of the seventies."

This conclusion of new social priorities for scientific research has resulted in considerable discussion among concerned scientists, historians, administrators, and the public at large. I believe editors of scientific periodicals must play a more important part in helping interpret science in a humanistic way so that the new priorities can be established. To illustrate the types of problems the Brooks committee sees ahead I wish to paraphrase a few statements, as published in the *OECD Observer* (October, 1972).

According to the Brooks committee, one of the most difficult problems in developing and establishing the new order involves the locus of decision making. Who is to decide, for example, how priorities and resources should be assigned among various groups? Are the decisions to be made only by administrators, by politicians, by scientists and technologists, or by the public? Can collaboration among the various groups be brought about so a meaningful and worthwhile plan of action results? Effective public policy demands a proper mixture of scientific and technical knowledge with social, economic, and political information.

Another group of problems is: How can the supply of basic research and the resulting technologies be made to match the demand without destroying natural resources? How can scientists be trained and inspired to deal with social problems that are diffuse, difficult to measure, and still more difficult to translate into terms of the natural sciences? Have we trained too many scientists and technologists?

The master key that must be used to open the doors into these vast and complex areas is communication. Until scientists from various disciplines are able to translate their results into forms that can be understood by social scientists, historians, the press, and politicians, or until these last named groups of persons are better trained to understand science, the above problems will remain unresolved. The need for improving communication must be recognized among all groups as having several dimensions.

There must be an improved flow of information from the scientific community to (i) the persons making important decisions, (ii) the people who have specialized knowledge of social or political conditions, and (iii) the public at large. If scientists are to assume greater responsibilities toward society, they must be able to keep these various groups informed of how their research is progressing, what theoretical and practical significance it may have, and what the time interval may be before a contribution is forthcoming.

To accomplish the above suggestions will require a more active and alert scientific press, the help of editors and the societies they represent, and possibly special institutional responsibilities such as tours or arrangements for open houses in research laboratories. I realize many scientists will respond to such challenges by saying "Heaven help us!". A few years ago I would have agreed most heartily, but as the public becomes more knowledgeable, the more demanding it becomes of educational and research institutions. Thus science must become more sensitive and responsive to demands by those providing the support and having to live with the resulting technologies. In discussing the importance of the scientific press, Lawrence Lessing (1963) states:

> "Science writing has progressed from the fiction of the Sunday supplement to the computer age. Where does it go from here? As science gets more into areas of public controversy, its reporters must shed light on the problems it presents, analyze them, and pave the way to responsible solutions."

Equally important is the reverse flow of information, that is, from society to the scientists. Because of the complex problems that scientists are now being called upon to solve, there is great need for a deeper understanding of society and its requirements for happiness and satisfaction. Whether it is possible for a scientist to gain this breadth of knowledge at the same time he or she has to master a difficult or specialized branch of science is open to question. Whether a theoretician can work in close collaboration with an applied scientist, an historian, or a social scientist so each can contribute to a better understanding of life is difficult to answer. Today many conferences are being held, and various interdisciplinary or correlated courses are being taught in universities and colleges, in an effort to determine how to live in a no growth or balanced economy at peace with nature. But major problems in communication and philosophy plague such sessions.

We have reached a period in science where creative and inventive minds must discover new methods for coping with these problems. If this is not done soon science may face a real crisis and suffocate from its own immense production. The most important instrument in research will always be the mind of man. Much time and effort are devoted to training and equipping a scientist's mind, but some times little attention is paid to the technicalities of making the best use of it. Scientists, and especially biologists, can provide some of the knowledge and leadership that is so essential in making certain wise forecasts today about the importance of science to society. But they cannot make all the decisions. Rational decisions can only be implemented through enlightened citizens, because when knowledge becomes universal, wisdom, freedom, and a better understanding among human beings usually prevails. Much of the important knowledge I refer to is, or will be, published in your journals. I appeal for your help in the interpretive and enlightening processes that will be so necessary if science is to continue to serve as the workhorse of civilization.

References Cited

Barnett, L. 1967. The treasure of our tongue. Alfred A. Knopf, New York.

Blake, J. B. 1971. Literary style in American medical writing—a historical view. J. Amer. Med. Assoc. 216(1): 77–80.

Cavander, K. 1973. The Montmartre of Athens. Saturday Review of the Arts 1(2): 16, 3 February.

Divale, W. 1973. Science in the news. Saturday Rev. Sci. 1(2): 54, 24 February.

Garfield, E. 1972. Citation analysis as a tool in journal evaluation. Science 178: 471–479.

Hover, J., and C. Kadushin. 1972. Influential intellectual journals: a very private club. Change Magazine 4(2): 38–47.

Kadushin, C. 1972. Who are the elite intellectuals? National Affairs 29: 109–125.

Kadushin, C., J. Hover, and M. Tichy. 1971. How and where to find intellectual elite in the United States. Public Opinion Quarterly 35(1): 1–18.

Lessing, L. 1963. The three ages of science writing. Chem. Eng. News, 6 May, p. 88–92.

Porter, J. R. 1963. Challenges to editors of scientific journals. Science 141: 1014–1017.

On Copernicus in Human Perspective[1]

Raymond J. Seeger

4507 Weatherill Rd., Washington, D.C. 20016.

ABSTRACT

The Copernican revolution was truly a typical scientific one, as understood by practising scientists today. In addition it has had broad and far-reaching humanistic consequences, even in this Twentieth Century.

It is commonplace nowadays to speak of a Copernican revolution. What precisely is meant? Does the term connote anything more or less than the hackneyed phrase "scientific revolution"? In order to consider this question, we had better ascertain first just who Copernicus was and just what he did.

Consulting so-called intellectual historians, we are surprised to find a wide range of views. At one extreme, Copernicus is simply ignored. For example, there is no mention of him at all in the index of the abridged (600 pp.) *A Study of History* by the English historian Arnold Joseph Toynbee (1889–). The Viennese historian Friedrich Heers regards Copernicus as essentially a medieval figure, in a class with the speculative Swiss physician Paracelsus (1493?–1541) and the German Protestant free-thinker Sebastian Franck (1499?–1542). The Columbia University philosopher John Herman Randall, Jr. (1899–) sees him as a typical Renaissance man, creator of the Copernican revolution, which is regarded as consummated later by the Italian physicist Galileo Galilei (1564–1642), but which, in no sense, is to be considered as significant as the revolution by the French mathematical philosopher René Descartes (1590–1650), who supposedly created a new physics. At the other extreme, the U.C.L.A. philosopher William James Durant (1885–) groups him with the German theologian Martin Luther (1483–1546), the French writer Voltaire (1694–1778), and the English naturalist Charles Robert Darwin (1861–1882) as the "most powerful personalities in the modern world." In contrast with the opinions of modern socially-minded thinkers, Durant concludes in *Lessons of History* (1968) that "the initiative individual—the great man, the hero, the 'genius'—regains his place as a formative force in history."

Popular authors, too, exhibit a broad spectrum of views. Passing over the negative reactions of some of the English writers in the century after Copernicus, viz., the philosophical lawyer Francis Bacon (1561–1626), the physician Thomas Browne (1605–1682), the clergyman Robert Burton (1577–1640), the poet John Milton (1608–1674). On one hand, we find him assuming at best a minor role in the thinking of the metaphysical poet John Donne (1571–1631), the Protestant convert from Roman Catholicism, the lawyer Dean of St. Paul's (London). In his *Ignatius His Conclave* (1610) we see a group of "contemporary" innovators competing for preferment on the right hand of Lucifer's throne. Chief among them are the soldier Jesuit Ignatius of Loyola (1491–1556), the philosopher statesman Niccolò Machiavelli (1469–1591), and Paracelsus. Copernicus is depicted as one who had moved the

[1]Remarks at the February 16, 1973 meeting of the Philosophical Society of Washington, Washington, D.C., commemoration of the 500th anniversary of Copernicus' birth.

earth (the devil's prison) upward and the sun (the devil's energy) downward in contrast to the winning Ignatius who had left man's life on earth unchanged. Copernicus, accordingly, was relegated to a lower level. The English poet Alfred Noyes (1880–1958), on the other hand, inspired by his experience at the first trial of the Mt. Wilson 100-inch telescope, began his science epic "Torch Bearers" with Copernicus as one of the "Watchers of the Sky." It is, however, the modern Hungarian writer Arthur Koestler who feels impelled to portray Copernicus as a "debunked" hero, "The Timid Canon" in *The Sleepwalkers* (1959) and to characterize the churchman as a dissimulator and a mystifier, colorless and pedestrian, secretive and cautious, frustrated and morose, pedantic and niggardly. Koestler, however, does concede the records of the methodical and thrifty canon to be meticulous.

In the haze of such widely divergent views, let us focus our attention on the bare outline of Copernicus' life—say, a thumbnail sketch (Armitage, 1938). Nicolaus Copernicus (Fig. 1) was born February 19, 1473 (New Style), at Thorn in Poland ("West Prussia") on the Vistula River, about 90 miles south of Danzig on the Baltic Sea. When he was 10 years old, he went to live with his uncle, Lucas Watzelrode (1447–1512). At eighteen he attended the University of Cracow, where he probably studied astronomy with Albert Brudzewski, but did not receive a degree. Four years later he joined his uncle at Heilsberg Castle, where the latter now lived since appointed Bishop of Ermland (Varmia) about 1489. At 23 Copernicus went to study law at the University of Bologna (11th century), where he lived with the student group call the Natio Germanorum. He studied also astronomy with Dominico Maria da Novara (1454–1504). Five years later he pursued canon law and medicine at the University of Padua (13th century). Finally, at the age of 30, he received the degree of Doctor of Canon Law from the University of Ferrara. At 33 Copernicus went to live at Heilsberg as secretary and physician to the Bishop; upon the death of the latter 6 years later he moved to the Frauenburg Cathedral (Fig. 2) (about 40

Fig. 1. Copernicus (from biography (1654) by Pierre Gassendi (1592–1655)).

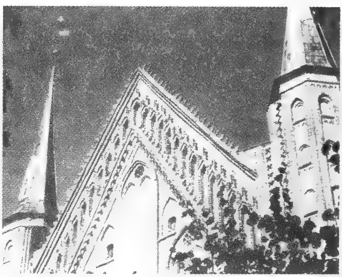


Fig. 2. Frauenburg Cathedral.

miles east of Danzig and 40 miles northwest of Heilsberg), where he had been appointed a canon (16 in all, only one a priest) about 1497 and where he remained until his death at age 70 on May 24, 1543. In line with the Roman playwright Publius Terentius Afer's (185–159 B.C.) dictum, "I count nothing human indifferent to me," Copernicus was truly a humanist; he was a man of affairs, a physician, and an administrator. In the latter capacity he was concerned with the appointment of officials, the collection of taxes, the enforcement of the law. He was responsible for the defense of Allenstein against the Teutonic Knights (1519); he inaugurated a monetary reform (1522–1528) for Sigismund I (1467–1548) of Poland—what turned out to be a precursor of the English financier Thomas Gresham's (1519–1579) so-called law. His everyday humanism, however, is far less significant than the humanistic aspect of his science. Let us, therefore, review briefly what he did in this respect.

His works consist primarily of the "Commentariolus" (1510–1514), essentially an outline based on the Alfonsine (X) Tables (1272), and the *De revolutionibus orbium coelestium* (1543) (Fig. 3),


NICOLAI CO-
PERNICI TORINENSIS
DE REVOLVTIONIBVS ORBI-
um coeleſtium, Libri VI.

Habes in hoc opere iam recens nato, & ædito, ſtudioſe lector, Motus ſtellarum, tam fixarum, quàm erraticarum, cum ex ueteribus, tum etiam ex recentibus obſeruationibus reſtitutos: & nouis inſuper ac admirabilibus hypotheſibus ornatos. Habes etiam Tabulas expeditiſsimas, ex quibus eoſdem ad quoduis tempus quàm facillime calculare poteris. Igitur eme, lege, fruere.

Fig. 3. *Die Revolutionibus* (1543).

which had been started about 1530 and which was basically a modernization of Claudius Ptolemy's (2nd century) *Almagest* for astronomical acceptability. Koestler describes the latter as "the Book that Nobody Read," "the world's worst seller" (it was not even translated into English until 1952). What is its true significance? To what extent does it comprise a Copernican revolution from the viewpoint of astronomy particularly?—of science generally?—of culture broadly?

The Ptolemaic astronomy used in the sixteenth century was based upon the idea of a stationary earth and upon the kinematic description of planetary motions in terms of circles (inner deferents, outer epicycles, and equants with uniform speeds); the approximation was similar to that of a Fourier analysis, but not strictly so inasmuch as the distances involved angular variations (the relative distances themselves were a by-product of the method). There was, indeed, no truly single Ptolemaic system, rather a separate ad hoc calculating scheme for each planet.

The Copernican astronomy (Kuhn, 1959), on the other hand, regarded the sun as stationary, but still retained kinematic description by uniform circular motion. Copernicus actually proved that his calculating method was geometrically equivalent to that of Ptolemy. It had, however, the merit of economy in that it eliminated in each instance the loop requisite for the sun's annual motion; but it was unnecessarily complex mathematically owing to its choice of the "center" of the solar system at the center of the earth's orbit rather than at the sun itself (thereby requiring additional epicycles) and the requirement of uniform angular speed. The latter assumption, it turns out, is more significant than that of circular motion (e.g., Mars with the sun displaced 9% radially from the center produces less than 0.5% change in the mean radius, i.e., approximate circularity). The effect of the elimination of the equant (approximately equivalent to the kenofocus of a planetary ellipse) was not quite solved by Copernicus. All in all, Copernicus did not invent a new calculation impossible with Ptolemy's techniques; he did not produce less difficult calculations; he did not offer a more simple or elegant model. The mathematical techniques, to be sure, are simple and unsophisticated (in keeping with his Dedicatory Preface where Copernicus had warned that "mathematics are made for mathematicians"). The German astronomer Johannes Kepler (1571–1630) wisely commented later that Copernicus had concerned himself with interpreting Ptolemy more than nature. Nevertheless, Copernicus did have *a* solar system with a uniform method of investigation.

It is interesting to compare the calculated results of Ptolemy and those of Copernicus with the observed data of the sixteenth century (Price, 1959). The Ptolemaic agreement was certainly better than it should have been. In the cases of the earth and of Venus the small eccentricities meant that the orbits were almost circular so that the relatively small theoretical discrepancies fell well within the observational errors of that time; in the case of Mercury, which does have considerable eccentricity (20%), observations with the naked eye were possible only for maximum elongation so that non-circularity was not experientially significant. The Copernican calculations, therefore, did not exhibit greater accuracy. One does, however, wonder why a greater discrepancy was not detected in the case of the more elliptical path of Mars, where the expected difference of 30′ of arc was much greater than the 10′ error accepted generally by Copernicus (cf. the 6′ limit reached prior to the work of the Danish astronomer Tycho Brahe (1546–1601)). It so turned out that errors in the parameters themselves amounted to more than 30′ (Brahe's improvement was chiefly in determining the parameters on the basis of the whole orbit).

Venus presented a special paradox. The Ptolemaic epicycle (largest) for Venus is about ¾ the size of the deferent so that much space is covered by the planet, thus presumably causing a variation of its apparent brightness with the distance. The failure to observe any maximum or minimum was one of the criticisms leveled at the Ptolemaic theory by Copernicus. The same difficulty, however, occurs also in his own treatment; it was not resolved until Galileo observed in 1609 the phases of Venus, which counteract the effects of distances, i.e., Venus is full at its greatest distance and crescent-shaped at its least. The critical test, of course, for the Copernican celestial model was the potential existence of stellar parallax, which had to wait 300 years before adequate instrumentation would be available for its detection. Astronomically speaking, one is not at all impressed with any significant result that could be labeled a Copernican revolution. What about science generally?

Let us view first the cosmological outlook. Should one regard Copernicus' geometrical displacement of the earth as merely a matter of mathematical convenience?—a different focus of reference? Such has been the interpretation stemming from a comment in the Foreword to Copernicus' *De revolutionibus*. To understand it, however, we must first examine how it came to be inserted in the actual publication. The manuscript had been initially entrusted for editing to Georg Joachim von Lauchen, Rheticus (1514–1576), Professor of Mathematics at the University of Wittenberg, who at 25 had joined the ailing Copernicus (1539) and published an account of Copernicus' work, *Narratio prima de libris revolutionum* (1540). He had to return to Wittenberg and then transfer to Leipzig shortly afterwards. Accordingly he secured the services of the Lutheran theologian and preacher Andreas Osiander (1498–1552) at Nuremberg for carrying through the project with the printer, Johann Petrajus, there. In the final Foreword there appeared the following apologetic statement: "These hypotheses need not be true or even probable; they provide a calculation that alone is sufficient;" in short, they were to be regarded merely as a mathematical attempt "to save the appearances." It was Kepler who first called attention (cf. *Astronomia nova* (1609)) to the anonymity of the Foreword and ascribed this defensive clerical comment to the editing of Osiander, who was apparently sensitive to the dedication of the book to the scholarly Pope Paul III. In the very dedication, however, as well as throughout the book, it is evident that the model was real to Copernicus, who was truly a Copernican.

Of much greater significance were the implications of such a physical system. In the first place, it assumed a universe without any distinction between superlunary and sublunary phenomena, between the changing 4 earthly elements and the eternal heavenly quintessence; celestial objects had become earthly. The earth itself moved with its sister planets. Nevertheless, Tycho Brahe, even in 1572, still felt it necessary to regard his extralunar comet as a special miracle; not until 1610 did Galileo's tell-tale telescope reveal the earthlike mountains on the moon, the height of which he even estimated. Secondly, this universe had no evident boundary; the sky did not rotate like a container. The ex-Dominican philosopher Giordano Bruno (1548?–1600) insisted upon the unity of an infinite universe; he had great literary influence, but his ideas were largely the result of metaphysical speculations, which eventually led him to the stake owing to their unorthodox theological implications. Finally, this universe had no attractive center per se. Each celestial object had its own center of attraction, thus invalidating Aristotle's doctrine of places. Above all, Copernicus' universe was not a Platonic mathematical entity; it was truly physical.

Copernicus' system lent itself to a rapidly cumulative development through successive modifications. Kepler's critical introduction of novel elliptical orbits enabled him to determine directly planetary distances and thus to establish the so-called "harmony of the spheres." Galileo's telescope exhibited the simple planetary pattern in Jupiter's moons. Unfortunately, at this stage there was apparently little need to apply his terrestrial physics to celestial phenomena. It was the English mathematical physicist Isaac Newton's (1542–1628) comprehensive dynamics which revealed the universe in its theoretical unity, harmony, and simplicity. The Copernican cosmology was truly scientifically revolutionary.

We turn now to the theoretical outlook involving the very meaning of a so-called scientific revolution. We note a strange divergence in the use of this term by some professional historians of science and that by most practitioners of natural science. With others (notably the philosophers of science Ernest Nagel of Columbia University and Dudley Shapere of the University of Illinois) I must confess difficulty in understanding its chameleon uses by the Princeton historian of science Thomas S. Kuhn (1970). His introduction of the term "paradigm" to describe his own artificial doctrine is at best confusing, not to say at times ambiguous or even inconsistent. In the second edition of his book he admits, "Scientists would say they have a theory or set of theories." Why, then, introduce a new nomenclature which certainly purports, at least, to be broad and not an *ad hoc* explanation? Scientists generally (Frank, 1956) regard their theories as dynamically cumulative, in contrast to the static categorization of the paradigm concept—at best merely a semantic device, but at worst, a distortion of popular usage. By virtue of his own narrow definition of science, Kuhn finds himself forced to regard its development as noncumulative. With respect to what he arbitrarily designates "normal science" he asserts, "Practitioners of the developed sciences are, I have argued, fundamentally puzzle solvers." He sees scientists busy chiefly with trial-and-error experimenting or with speculative theorizing. In his view scientists are strictly technicians, hardly comparable with universal humanists shaking the very foundations of science. Accordingly he has to differentiate sharply the occasional occurrence of a typical Copernican development, which he likens to changing the basic rules of a game instead of performing according to established ones. In this case, he insists, one requires a new point of view, a new outlook; hence the noncumulative character. He emphasizes further that "the scientific explanation [with respect to scientific progress] must in the final analysis be psychological and sociological", hence, largely relativistic, dependent upon the community. This feature, too, has long been recognized by scientists (Seeger, 1964) as generally an important factor, but as neither necessary nor sufficient.

Scientists have always been keenly sensitive to natural (experiential) boundary conditions. The English astronomer Arthur Stanley Eddington (1882–1944) was wont to illustrate this characteristic in the case of a child solving a jigsaw puzzle. A passer-by, noting a few pieces already put together, asked what they represented. "White clouds in a blue sky," joyfully responded the child. Later seeing the completed picture, the person inquired what had happened to the clouds. The child disdainfully explained, "Those were white caps on a blue sea!" The view as a whole had seemingly changed, but the individual pieces retained their same relationships. So, too, scientific theories change as viewpoints vary, but the outline of the observed facts remains fixed within a given framework—a relationship frequently neglected by intellectual historians, who are more often concerned with the view or the viewer than with the viewed. It is, however, the very interaction of the viewer and viewed—e.g., the selection of observables themselves—that accounts for theoretical continuity of the view—i.e., old concepts being still valid in a new pattern, though with different meanings. Typical illustrations are the evolution of the concept of mass from its classical approximation to its relativistic generalization and the development of the quantum description "corresponding" to classical electromagnetic radiation. A truly scientific revolution, such as the Copernican revolution, does represent essentially a changed viewpoint for regarding phenomena, a different theoretical outlook. It usually involves a continually developing change in scientifiic foundations, which remain a primary domain of scientists themselves. It is true as the Austrian theoretical physicist Erwin Schrödinger (1954) noted that the history of science is essentially that of changing thought molds, but they may be great or small, sudden or gradual; it is certainly not a matter of linguistic analysis.

In this connection, one should note that science education *per se* is rightly concerned primarily with scientific landmarks, mountain peaks on the road of discovery but not so much with the socially winding road itself and its personal bypaths. Science teachers, therefore, emphasize chiefly the logical evaluation of man-made concepts rather than their psychological and sociological developments, which are more properly the province of historians of science.

More significantly, the new scientific viewpoint of Copernicus became the vantage point of a broader cultural outlook. It is interesting to trace the slow diffusion of Copernicanism, even in astronomy; the spread was only gradual, depending upon the intellectual climate. In the first stage, Copernicus to Galileo (Seeger, 1966), the system was regarded as possible, but without any compelling reason for its adoption; in the second phase, Galileo to Newton, the Copernican theory was considered probable; only subsequently, Newton to Einstein, did the Copernican point of view become generally acceptable (nowadays different viewpoints are seen to be experientially equivalent). In this connection it is profitable to compare the aftermath of the religious impact of Copernicanism (Dillenberger, 1960).

Let us glance first at some of Copernicus' contemporaries. In his *Table Talk* (1539), the Biblical Protestant Luther is reported 20 years later by a student as having said, "The fool would upset the whole art of astronomy." Was this merely the natural remark of a volatile old man? His friend, the German humanist Philipp Melanchton (1497–1560) preferred the Greek tradition, including that of Ptolemy. The French lawyer reformer John Calvin (1509–1564) also preferred Ptolemy, but he was not anti-Copernicus. These scientifically lukewarm individuals were hardly responsible for the later Protestant opposition to science either in the form of 18th-century deism (God inactive) or of its associated atheism (God dead), which, as the English evangelist scholar John Wesley (1703–1791) noted, was often dependent upon "ingenious conjectures."

In the post-Reformation period there developed a competing Protestant scholasticism based upon Aristotelian metaphysics. A prophetic skymark was no longer apparent; no central stage was set for man, "the crowning work of God." Man found himself lost in space; God had apparently vanished from creativity. Scholars sought refuge in a bookmark, in an inerrant Bible, with which science had to agree; conflicts of incomprehensive theology with incomplete science were inevitable. To make matters worse, some scientists, such as the unorthodox Kepler, argued with ruling theologians about theology itself. Copernicanism as a philosophy of science became culturally unacceptable so that even now it is mentioned only once, and then casually, in the ecclesiastical historian Roland H. Bainton's (1894–) *The Penguin History of Christianity* (1967).

Meanwhile, Aristotelianism had become enshrined in the scholasticism of Roman Catholicism by the Dominican philosopher Thomas Aquinas (1225?–1274). Consequently, Copernicus' anti-Arisotelian work was put on the Index Librorum Prohibitorum in 1616, and not removed until 1835. Galileo's suggestion of placing the book of nature on a par with the book of revelation also met aggressive opposition. At best, a loyal churchman might consider Copernicanism as a hypothesis (1620). And yet, from a religious standpoint, Durant judiciously concludes, "Recognizing damages to medieval Christianity, the Copernican revolution was more profound than the Reformation." Beside negative effects there were positive influences; for example, man's God became less anthropomorphic, His province less provincial.

In conclusion, the Copernican revolution, I believe, was truly a typical scientific revolution, as understood by practising scientists today. In addition, however, it has had broad and far-reaching humanistic consequences—even in this twentieth century.

References Cited

Armitage, Angus. 1938. Copernicus. George Allen and Unwin, London.

Dillenberger, John. 1960. Protestant Thought and Natural Science. Garden City (N.Y.), and Doubleday.

Frank, Philipp. 1956. The Validation of Scientific Theories (ed.). Beacon, Boston.

Kuhn, Thomas S. 1959. The Copernicus Revolution. Random House, New York.

Kuhn, Thomas S. 1970. The Structure of Scientific Revolutions (2nd ed.) University of Chicago Press, Chicago.

Price, Derek J. de S. 1959. Contra-Copernicus (pp. 197–218) *in* Critical Problems in the History of Science (ed. M. Clagett). University of Wisconsin, Madison.

Schrödinger, Erwin. 1954. Nature and the Greeks. Cambridge University Press, Cambridge.

Seeger, Raymond J. 1964. On Understanding Physical Phenomena. Physis 6: 245–268.

Seeger, Raymond J. 1966. Galileo Galilei. Pergamon Press, Oxford.

Description of a New Genus and a New Species of Bruchidae from South America (Coleoptera)

John M. Kingsolver

Systematic Entomology Laboratory, Agricultural Research Service, USDA, c/o U. S. National Museum, Washington, D. C., 20560.

ABSTRACT

Penthobruchus, new genus, is described for *Pachymerus germaini* Pic and a new species, *cercidicola,* both from South America. Illustrations of salient characters are included.

The bruchid described as *Pachymerus germaini* by M. Pic and the new species described herein cannot be placed in any described genus, therefore it is necessary to erect a new genus for them.

Penthobruchus, new genus

Body depressed above, elongate; eyes protruding, posterior margin of ocular lobe nearly transverse; antennal segments 5–11 transverse; lateral carina of pronotum lacking; pronotal disk evenly convex laterally, nearly flat in middle, not gibbous; latero-basal umbones present but not prominent. Elytral striae 3 and 4 slightly distorted and bent laterad in basal one-fourth and ending in low umbo, occasionally with tooth at base of each stria on umbo; strial punctures shallow, strial rows indistinct. Pygidium with pair of bare, depressed submarginal spots near apex. Hind femur with apex extending beyond apex of pygidium, latero-ventral margin with 12–14 short teeth and separated by polished channel from pecten on meso-ventral margin with 6–9 long teeth, anterior tooth 1.5 times as long as any one of the posterior teeth; hind tibia strongly arcuate and fitting into ventral channel of femur during flection, lateral carina of tibia complete, intermediate and ventral carinae nearly on same plane on ventral margin, mucro short, coronal teeth lacking, apical margin diagonal, dorsal face of tibia scabrous.

Type-species.—Pachymerus germaini Pic.

Penthobruchus is closely related to *Pygiopachymerus* Pic, but with the following differences: postocular lobe laterally, not posteriorly produced (Fig. 8) causing the head in *Penthobruchus* to appear strongly constricted behind eyes; striae 3 and 4 and occasionally 2 with bases ending in minute subbasal tubercles in *Penthobruchus,* but ending in basal concave ridges in *Pygiopachymerus;* intervals of elytra smooth in *Penthobruchus* but strongly scabrous basally and laterally in *Pygiopachymerus;* striae of elytra obsoletely impressed in *Penthobruchus* but deeply impressed in *Pygiopachymerus.* The characteristic lateral processes of the median lobe in the male genitalia in *Pygiopachymerus* (Kingsolver, 1970, figs. 7 and 10) are lacking in *Penthobruchus.*

From other species and genera in the Bruchinae having a definite, serrate latero-ventral carina on the hind femur, *Penthobruchus* can be separated by its nearly flat pronotal disk (not strongly gibbous), by the nearly obsolete strial impressions, by the obsolete umbo at the bases of striae 3 and 4, and by the short mucro. In certain species of *Caryedes* Hummel and related groups, the latero-ventral margin of the hind femur may bear scattered small denticles, but these are not on the crest of a carina.

The name *Penthobruchus* refers to the generally melancholy appearance of the two species included.

Penthobruchus germaini (Pic), new comb.

Pachimerus (sic) *germaini* Pic, 1894, p. 65; Hoffmann, 1945, p. 94.
Pseudopachymerus germaini: Pic, 1938, p. 19; Pic, 1913, p. 11.
Caryedes germaini: Blackwelder, 1946, p. 758; Teran, 1962, p. 232 (misidentification).

Color—Body usually piceous, sometimes reddish in teneral specimens; antennae ranging from all red to having basal 4 and terminal segments red and segments 5–10 piceous; fore and middle legs reddish with dark blotches on femur, hind leg black with reddish tarsal segments. Vestiture of black, white, yellowish gray, and golden brown hairs arranged in distinctive pattern on elytra and pygidium (Fig. 5, 6). Head with vestiture brown on vertex, yellowish gray on frons, postgena, and ocular lobe. Pronotum with vestiture mixed brown and gray on disk and ventral areas, broad grayish stripe along lateral margin of disk. Elytra with vestiture of mottled black, golden brown, and yellowish gray setae in somewhat mottled, quite variable pattern, a velvety black elongate spot at middle of third interval surrounded by grayish hairs, and a smaller black spot on fifth interval opposite anterior end of spot on third interval, latero-apical and humeral areas dark brown or black. Pygidium of ♂ and ♀ with evenly distributed yellowish gray vestiture, but ♀ with a pair of depressed apical submarginal spots, a pair of median spots which are elongate and usually joined across midline, and a pair of small basal spots (Fig. 6). Venter of body with vestiture gray mottled with darker spots. Hind femur with vague transverse bands formed of gray hairs.

Head with eyes protruding, each eye 1 ½ times as wide as width of frons, frontal carina prominent, shining; antennae with segments 1–4 moniliform, 5–11 eccentrically produced.

Pronotum with disk convex but with slight median channel; apical ½ of pronotum somewhat compressed; latero-basal umbones low, rounded; ratio of length to width of pronotum 4:5.

Elytra together slightly longer than wide, quadrangular, depressed medially, depression flanked by low rounded costa extending diagonally from humerus of each elytron to apex of 6th interval; bases of 3rd and 4th striae ending in low umbo which is occasionally armed with 1 or 2 denticles; striae not strongly marked except in middle of disk.

Pygidium of ♂ vertical, evenly convex except for paired subapical depressions, of ♀ sloping, convex except for subapical depressions as in ♂ and a semicircular depression at extreme apex.

Prosternum short, fore coxae contiguous for ¾ of their length; mesepisternum arcuate on posterior margin, mesepimeron reduced to narrow strip medially.

Hind coxae narrow, transverse, densely and finely punctate, and densely setose on face, hind femur extending beyond apex of pygidium.

Male genitalia (Fig. 3, 4) short, broad; ventral valve acute, broad at base, with a row of setae along posterior border; dorsal valve acute, bifid at base, depressed medially; armature of internal sac consisting of a large rounded, hollow median sclerite bearing a dorsal keel; apical ½ of sac with large, paired, minutely spinose leathery plates; gonopore valve ringlike. Lateral lobes short, broad, obliquely truncated apically, cleft for ½ their length.

Female genitalia with valves short, 8th sternite as illustrated by Teran, 1962, fig. 123; lining of bursal neck with about 40 elongated denticles arranged in circle with apex of each denticle directed anteriorly.

Body length: 4.5–5.0 mm. Maximum body width: 3.5–4.0 mm.

Holotype.—Holotype ♂ deposited in Museum National d'Histoire Naturelle, Paris. Label data: Type des Pampas, chasse Germain; Pachymerus germaini, Jekel, Bras. I am grateful to Mme. A. Bons for the loan of this type.

Geographical Distribution.—CHILE: Santiago. ARGENTINA: States of Santa Fe and Buenos Aires. Introduced and perhaps established for a short time in Paris. Pic (1913) lists it as introduced into Germany. Since this species was confused with the following new species by Teran (1962), the locality records listed by him must be rechecked.

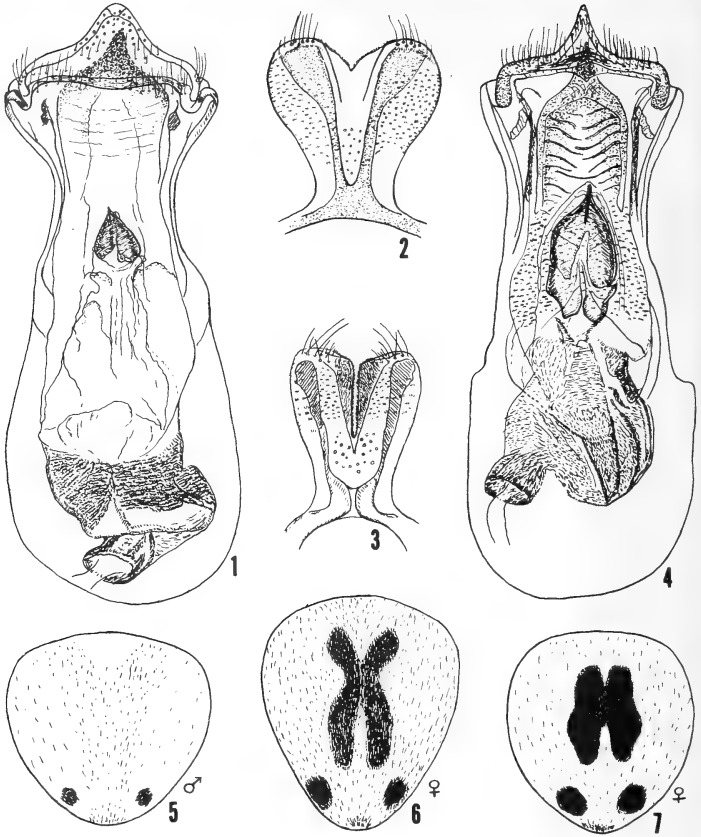
Host.—*Parkinsonia aculeata* L. Although the host is distributed widely in tropical and subtropical America by its cultivation as a medicinal and ornamental tree, *P. germaini* apparently attacks it only in Argentina and Chile.

The differences between this species and the next will be discussed with the latter.

Penthobruchus cercidicola, new species

Caryedes germaini: Teran, 1962, p. 232.

Teran has published an excellent morphological description of adult and larva

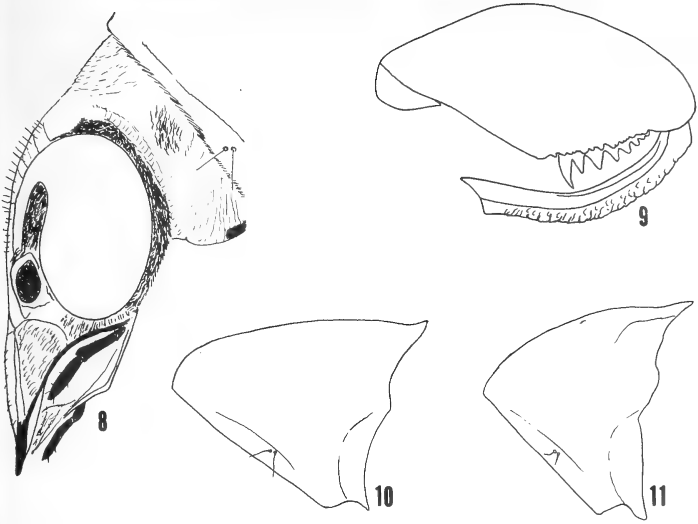


Penthobruchus. Fig. 1–4. Male genitalia. Fig. 1, *P. cercidicola,* median lobe, ventral. Fig. 2, *P. cercidicola,* lateral lobes, ventral. Fig. 3, *P. germaini,* median lobe, ventral. Fig. 4, *P. germaini,* lateral lobes, ventral. Figs. 5–7, pygidia. Fig. 5, *P. cercidicola* and *germaini,* male. Fig. 6, *P. germaini,* female. Fig. 7, *P. cercidicola,* female.

of this species under the name of *C. germaini,* and there is no need to duplicate it here.

The two species are quite similar in general appearance but with the following differences:

1. In *germaini,* the anterior half of the pronotal disk is flanked by obsolete costae marking the dorsal margins of broad depressions on the lateral faces of the pronotum, in dorsal view appearing pinched. In *cercidicola,* the disk is



Penthobruchus. Fig. 8, *P. germaini,* head, lateral. Fig. 9, *P. germaini,* hind leg. Fig. 10, *P. cercidicola,* pronotum, lateral. Fig. 11, *P. germaini,* pronotum, lateral.

evenly convex and without costae, or prominent lateral depressions. 2. In lateral view, the dorsal profile of the pronotum in *germaini* is convex throughout its length, but in *cercidicola* the posterior three-fourths of the profile is nearly flat, the anterior one-fourth strongly convex (Fig. 10, 11). 3. The average gross size is larger in *germaini* 4.5–6.0 mm.; in *cercidicola* 3.0–3.5 mm. 4. In ♂ genitalia, the median sclerite of the internal sac in *germaini* is larger (Fig. 4) as is the dorsal valve, the ventral valve is acute, and the lateral lobes are truncated; in *cercidicola,* the median sclerite is small, the dorsal valve is short and broad, the ventral valve is bluntly rounded, and the lateral lobes are rounded apically.

Coloration and intensity of pattern in the two species is quite variable and offer no definite recognition characteristics. Body length: 3.0–3.5 mm. Maximum body width: 1.6–2.0 mm.

Holotype ♂, allotype ♀, paratypes, 1 ♂, 2 ♀; ARGENTINA, prov. Tucuman, Tapia, 25–VII–1957, A. Teran, in seeds of *Cercidium australe*. Additional paratypes: prov. Buenos Aires, Conesa, 15–IX–1943, Paul Berry, 3 ♂; same data except 20–II–43, 2 ♂, 4 ♀; specimens intercepted US Dept. Agric. Plant Quarantine, Washington, D. C., A7316, 17–X–1929, in seeds of *Caesalpinia praecox* (now *Cercidium australe*), 12 ♂, 10 ♀.

The type and paratypes are deposited in the collection of the Fundacion Miguel Lillo, Tucuman, Argentina. Allotype and paratypes are deposited in the U. S. National Museum. Paratypes are deposited in collections of the Canadian National Collection, Ottawa, and the British Museum, London.

The type and allotype were selected from material included in the description by Teran.

The name *cercidicola* means feeding on *Cercidium*.

References Cited

Blackwelder, R. E. 1946. Checklist of the coleopterous insects of Mexico, Central America, the West Indies, and South America. Bull. U. S. Nat. Mus. 185: 551–763.

Hoffmann, A. 1945. Coléoptères Bruchides et Anthribides. Fed. Fr. des Soc. Sci. Nat., Faune de France, 44:1–184.

Kingsolver, J. M. 1970. Synopsis of the Genus *Pygiopachymerus* Pic, with notes on its relationships to other genera. Proc. Entomol. Soc. Wash. 72: 37–42.

Pic, M. 1894. Descriptions de deux coléoptères. L'Echange 10: 65–66.

———. 1913. Coleopterorum Catalogus, Pars 55, Bruchidae. Junk, Berlin, 74 pp.

———. 1938. Bruchidae en partie nouveaux de l'Amérique méridionale. Rev. Soc. Entomol. Argentina 10: 19–20.

Teran, A. 1962. Observaciones sobre Bruchidae (Coleoptera) del noroeste Argentino. Acta Zool. Lilloana 18: 211–242.

A Preliminary Review of the agile *Group of* Podium *Fabricius (Hymenoptera: Sphecidae)*

A. S. Menke

Systematic Entomology Laboratory, Agr. Res. Serv., USDA.
Mail address: c/o U. S. National Museum, Washington, D. C. 20560.

ABSTRACT

The *agile* species group of *Podium* Fabricius is characterized, and a key to the 4 included species, *agile* Kohl, *friesei* Kohl, *plesiosaurus* (Smith) and *trigonopsoides* Menke, a new species, is provided. The last species is described as new from Brazil. A lectotype is designated for *agile*.

The species groups of *Podium* Fabricius are outlined in "Sphecid Wasps, A Generic Revision" by R. M. Bohart and A. S. Menke, which is now in press. Since completion of the manuscript, an unusual new species belonging to the *agile* group has been discovered. Because the members of this assemblage are poorly known, it seems useful to supplement the description of the new form with a brief review of the group. Two species are known only from single females so that a comprehensive treatment is not feasible at this time.

The *agile* group contains the most atypical members of *Podium*. The long collar and prognathus head of the included species suggest at first glance that they belong in the genus *Trigonopsis* Perty. This resemblance is heightened by the broad separation (equal to or greater than length of oral cavity) of the hypostomal carina and lower ends of the occipital carina, a feature not found in other *Podium,* but a characteristic of the closely related genus *Trigonopsis*. The *agile* group does not have the long episternal sulcus, nor the longitudinally bisected and transversely ridged dorsomedian propodeal groove found in all *Trigonopsis,* characters which separate the genus from *Podium;* thus the *agile* group is properly placed in *Podium* where it has the status of the most highly specialized section of the genus. An arcuate intercoxal carina or ridge is present between coxae II and III in all *agile* group species, a feature that is absent in other *Podium* except two species in the *Fumigatium* group. Interestingly, the intercoxal carina is universal in *Trigonopsis*. Species of the *agile* group lack the patch of short, dense setae which is found at the base of tergum I in all other *Podium* species. Tarsal plantulae are absent in the *agile* group, but the same is true of the related *rufipes* group of *Podium*. The first recurrent vein typically is received by submarginal cell I or sometimes is interstitial between I and II in the *agile* group, but this is true also of the *rufipes* group. In rare examples the first recurrent may end just inside submarginal II.

Three species are currently assigned to the *agile* group, to which I now add a fourth.

Podium trigonopsoides Menke, new species
(Fig. 4, 6, 7, 14, 15)

HOLOTYPE MALE: *Color.*—Black with no obvious metallic sheen, mandible, labrum and backside of clypeus light amber, lower surface of scape obscurely yellowish, clypeus narrowly pale along free margin lateral to teeth, palpi brown, inner face of forefemur brownish except at basal fifth, foretibia and basitarsus brown, the latter obscurely so towards apex, wings yellow, forewing with narrow infuscate spot beyond marginal cell, hindwing apex weakly infuscate.

Vestiture—Body, except gaster and apical half of petiole, mostly covered with sparse, erect, pale hair; clypeus and lower frons along orbits with dense, appressed pale gold hair which becomes sparser dorsad, thorax without conspicuous appressed hair but scutum, basalar lobe, upper metapleural area, and base of propodeal dorsum with gold patches in certain lights; propleuron, forecoxae beneath and adjacent mesopleural venter, and mesopleural venter in front of midcoxae covered with appressed silver hair which is visible in certain lights; gastral sterna II-V covered with microsetae which dull the integument.

Structure.—Body greatly elongate, especially head, pronotum, mesopleura, propodeum and petiole (Fig. 7); head sparsely, shallowly punctate, length measured from clypeal tooth apex to occipital carina a third greater than head width; inner orbits essentially parallel, ratio of lower and upper interocular distances = 17:17.5; frontal line absent except for a shallow, dimple-like depression near midocellus; flagellomere II slightly more than one half length of I, the latter slightly longer than upper interocular distance, flagellomeres without placoids or tyli; clypeus with three teeth (Fig. 15), the central one shortest; hypostomal carina complete, forming a V, its apex separated from ends of occipital carina by distance equal to length of oral cavity; upper part of occipital carina lamelliform, most strongly so laterally; width of collar at middle four-fifths median length; collar sparsely, shallowly punctate, with weak mesal, longitudinal sulcus except stronger posterad where collar is weakly bituberculate; scutum with notauli and single admedian line which are slightly longer than length of metanotum; scutal punctation similar to collar except for two linear groups of larger, deeper, round, close punctures posterad; scutellum and metanotum punctured like collar; propodeal dorsum with close, large, deep, round punctures (contiguous to 1 diameter apart) except impunctate along midline which is not sulcate, punctures becoming sparser posterolaterally where integument is smoother and more polished, punctures extending on to sides where they give way posterad to vertical ridges; posterior face of propodeum only slightly descending from dorsum, slightly concave, impunctate, but strongly transversely ridged; mesopleuron more deeply and closely punctured than collar, especially dorsoposteriorly, scrobal sulcus weakly impressed, mesopleural venter concave in lateral profile (Fig. 7), midventral line a simple, shallow sulcus; metapleuron impunctate, petiole punctate, most closely so on basal third, petiole curving upward in lateral profile (Fig. 7), thickening posterad, venter becoming knife-edged posterad (Fig. 7a); petiole longer than hindbasitarsus, ratio = 5:3.5; lower surfaces of trochanters and femora closely punctate; midcoxae separated by distance equal to basal petiole width; marginal cell apex narrowly rounded, appendiculate, the appendix separated from wing margin, length of stigma as measured on wing margin about half marginal cell length; submarginal cell II not strongly narrowed anteriorly, ratio of basal and anterior veinlet lengths = 9:7.5; outer veinlet of submarginal cell III not parallel with basal veinlet, the two obviously convergent; submarginal cells I and II each receiving a recurrent vein (Fig. 6); penis valve head as in figure 14.

Length.—23 mm.

FEMALE: *Color.*—Similar to male except clypeus yellow across entire free margin and forefemur and tibia lighter brown.

Vestiture.—Erect hair shorter and sparser than in male, especially on head, erect hair extending full length of petiole except absent on apical half of dorsum; appressed facial hair silver; appressed thoracic hair like male except that of mesopleural venter continuous between front and middle coxae; gastral sterna II-IV covered with microsetae which dull the integument.

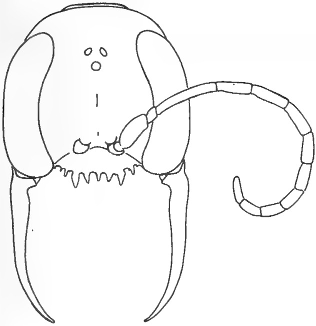
Structure.—Similar to male except as follows: punctation of head very faint, frontal line faint, no dimple below midocellus; clypeus with five large teeth, the middle one the most prominent (Fig. 4), the margin lateral to and some of the intervals between large teeth with a number of small teeth; hypostomal carina incomplete, extending only about half distance to mandible socket; width of collar at middle three-fifths median length; dorsum of collar with only a posteromedian indentation; scutum without two linear groups of large, close punctures posterad; posterior face of propodeum strongly concave; mesopleural venter weakly concave in profile; petiole rather uniformly punctate along entire length, petiole straight, not thickened nor knife-edged posterad, length slightly more than hindbasitarsus, ratio = 5:4; forefemur sparsely punctate; length of stigma two-fifths length of marginal cell.

Length.—24–26 mm.

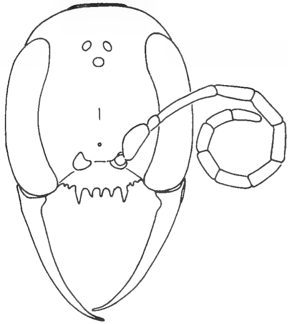
Variation: The paratype males differ from the holotype in being larger, 28–29 mm. long, and in having a better developed central clypeal tooth although it still is not as long as the lateral teeth. The face in these 2 males has a fine frontal line. The scutum lacks the well defined posterior, linear series of large pits found on the type. The posterior thickening of the petiole is more pronounced in the two male paratypes.

The wings vary among the 6 paratypes. In 1 male the veinlet between submarginal cells I and II is missing and the 2 cells are thus confluent. In the other male and one of the females, the first recurrent vein is interstitial between submarginals I-II or nearly so.

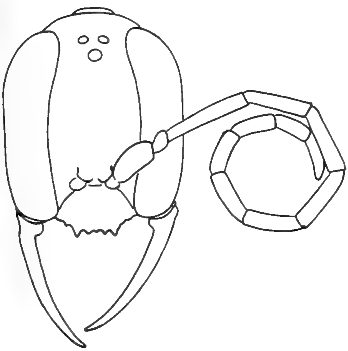
Specimens studied.—Holotype ♂: Nova Teutonia, Santa Catarina, Brasil,



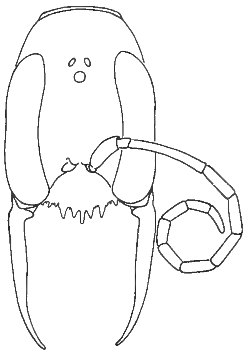
1 agile ♀



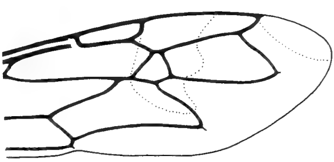
2 friesei ♀



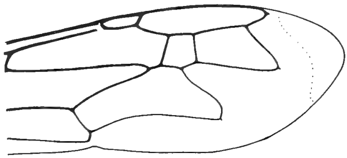
3 plesiosaurus ♀



4 trigonopsoides ♀



5 plesiosaurus



6 trigonopsoides

Fig. 1–4, faces (1 and 3 are holotypes); Fig. 5–6, part of right forewing (5 is holotype).

XII-1968, Fritz Plaumann (deposited in the Entomology Collection of the University of California, Davis, California). Two ♂ and 4 ♀ topotypical paratypes collected by Plaumann III-'67, XII-'68 and II-'69. Paratypes in the Museum of Comparative Zoology, Cambridge, Mass., University of California, Davis, and the U. S. National Museum, Washington, D.C.

Discussion.—The yellow, unbanded wings and nearly quadrate second submarginal cell (Fig. 6) distinguish *trigonopsoides* from other species of the *agile* group. The wings are clear but banded in the other 3 species and submarginal cell II is strongly narrowed towards the marginal cell (Fig. 5). The 3-toothed male clypeus is unusual for *Podium*, but some males of *friesei* have a weak median tooth also, so the 3-toothed clypeus may be peculiar to the *agile* group. Discovery of the male of *plesiosaurus* and *agile* will settle this point.

Podium plesiosaurus (Smith)
(Fig. 3, 5, 8)

1873. Ann. Mag. Nat. Hist. (4)12:54. Holotype ♀, Ega (= Tefé, Amazonas), Brazil (British Museum, London).

The elongate head and collar prompted Smith to describe this species in *Trigonopsis*, but I have examined the type and it is simply an unusually elongate *Podium*, having all of the characters of the genus. *Podium plesiosaurus* is still known only from the type. The species is the same size as *friesei* and is similarly colored except that the gaster is red. The narrow face, clypeal dentition (Fig. 3) and much more elongate collar (Fig. 8) are diagnostic. The stigma is proportionally longer in *plesiosaurus* than in the other species of the *agile* group. It is about three-fourths the length of the marginal cell, both measured along the wing margin (Fig. 5). The stigma varies from slightly less than half to slightly more than half the marginal cell length in the 3 other species of the group.

Podium agile Kohl
(Fig. 1, 9, 11)

1902. Abhandl. K. K. zool.-bot. Ges. Wien 1:43. Lectotype ♀, Cayenne (Naturhistorisches Museum, Vienna), present designation.

Kohl based his description on 2 female syntypes, 1 with a black gaster, the other with a partially red gaster. The latter was deposited in the Institute Royal des Sciences Naturelles de Belgique, Brussels, the other in Vienna. I have examined the red gaster specimen and selected it as the lectotype. The Brussels specimen may be destroyed since it could not be found by the museum authorities in 1972. The unavailability of the all-black syntype makes it impossible to verify that it is conspecific with the lectotype and also to confirm gastral color variation in *agile*. However, in the lectotype tergum I is black except around the margins, and terga V-VI are partially suffused with black which indicates that the entire gaster may indeed be black in parts of the range of the species.

Podium agile is quite similar to *friesei* structurally, the principle differences being the posteromedian hump of the collar in the former (Fig. 11, see also Fig. 77 in Kohl, 1902). Other slight distinctions are noted in the key to species that follows. At present *agile* is known only by the lectotype from Cayenne, French Guiana. Kohl's other specimen came from Bahia, Brazil.

Podium friesei Kohl
(Fig. 2, 10, 12, 13, 16)

1902. Abhandl. K. K. zool.-bot. Ges. Wien 1:96. Holotype ♂, Guayaquil, Ecuador (Naturhistorisches Museum, Vienna).

Podium friesei looks like a small slender specimen of *rufipes* at first glance, but the hypostomal and occipital carinae are contiguous in the latter. *P. friesei* is the commonest *agile* group species in collections and it has a broad geographic range. In addition to Kohl's type from Ecuador, I have seen material, including the previously unknown female, from Oaxaca,

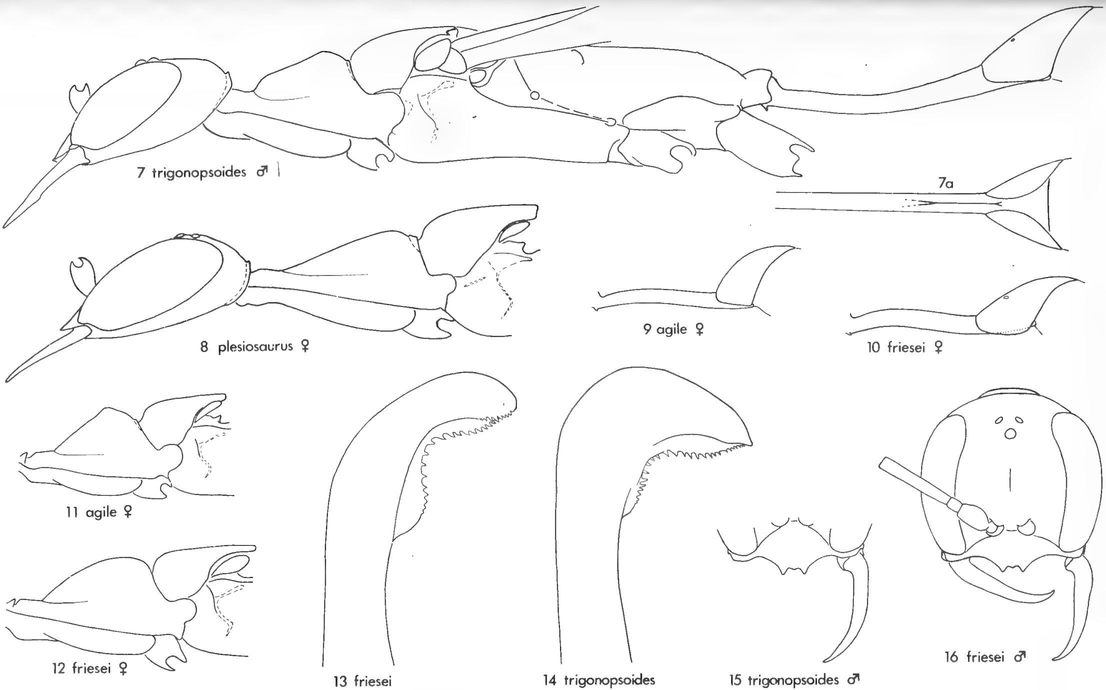


Fig. 7, left profile of head, thorax and segment I of gaster (holotype), 7a is a ventral view of petiole; Fig. 8, left profile of head and part of thorax (holotype); Fig. 9–10, lateral profile of petiole and tergum I (9 is holotype); Fig. 11–12, left profile of prothorax and part of mesothorax (11 is holotype); Fig. 13–14, head of dissected aedeagus in lateral profile; Fig. 15, clypeus and mandible of holotype; Fig. 16, face.

Mexico; Honduras; Trinidad; and Paraguay.

Proceeding from north to south in the species range there is a trend for reduction in the amount of red on the legs. The most extensively red legs are found on Mexican examples. In these the foreleg is red except for the coxa, a dark area on the dorsum of the trochanter and the last 4 tarsomeres, all of which are black or brownish. The midleg is similar but the basitarsus is brownish apically. Only the femur and tibia of the hindleg are red, and the inner basal fourth of the female femur is black also. The mid trochanter and basitarsus are completely black in the Honduras examples, and in these the hindfemur is black on its basal one-fourth and the tibia is black except at the apex. In the Ecuador type only the tibia, trochanter, and dorsum of the femur of the foreleg are red. The midleg trochanter is black beneath and the femur is black on the basal half of the venter, otherwise the leg is colored like the foreleg. The hindleg is black except for the apical two-fifths of the femur and a reddish area on the inner apex of the tibia. The Trinidad specimen is similar except the hindleg is totally black. The Paraguay specimen is also colored like the type except that red of the hindleg is confined to the apical fifth of the femur.

There is considerable variation in forewing venation in *friesei*. In the type, the first recurrent vein is interstitial between submarginal cells I-II in the right wing, but in the left wing the vein ends on

Preliminary key to the *agile* group of *Podium*[1]

1. Face broad, head length as measured from apex of clypeal teeth to occipital carina subequal to head width (Fig. 1–2, 16); flagellomere I length less than upper interocular distance 2
   Face narrow, head much longer than broad (Fig. 3–4); flagellomere I equal to or longer than upper interocular distance 3
2. Upper interocular distance slightly greater than lower interocular distance (15:14) in female; female collar evenly rounded posteriorly in profile (Fig. 12); female petiole slightly longer (as measured dorsally from tergal base to insertion) than hindmetatarsus (23:20), venter and sides thickly covered with erect setae only basally, setae sparser and shorter posterad, petiole sparsely, finely punctate, strongly upcurved posterad (Fig. 10); at least front and middle femora and tibiae mostly red, gaster black; length 14–16 mm. [male flagellomeres I–VIII with tyli, clypeus with 2 or 3 teeth, central one sometimes absent, Fig. 16] .... *friesei* Kohl
   Upper interocular distance slightly shorter than lower interocular distance (19:20) in female; female collar with posteromedian hump (Fig. 11); female petiole much longer than hindmetatarsus (35:28), venter and sides evenly and thickly covered with erect setae and rather densely, coarsely punctate, not strongly upcurved posterad (Fig. 9); legs black except inner apex of forefemur and inner surface of foretibia reddish, gaster red (always?) beyond tergum I; female 21 mm. long .... *agile* Kohl
3. Flagellomere II length much less than upper interocular distance (Fig. 4); frons sparsely, shallowly punctate; submarginal cell II not strongly narrowed on marginal cell, nearly square (Fig. 6); wings yellow, without clouding through marginal cell and submarginal cell II; gaster and mid and hindlegs black; length 23–29 mm.; [male antenna without placoids or tyli, clypeus with 3 teeth] .... *trigonopsoides* Menke
   Flagellomere II about equal to upper interocular distance (Fig. 3); frons with dense, round punctures (separated by about a puncture diameter); submarginal cell II strongly narrowed on marginal cell (Fig. 5); wings clear but forewing with brown band through marginal cell and submarginal cell II; gaster and fore- and midlegs red except black basally; length 16 mm. .... *plesiosaurus* (Smith)

[1]Males of *agile* and *plesiosaurus* are unknown, but key characters should work at least for the latter.

I. In the Mexican and Honduran material the endpoint of the first recurrent vein varies from submarginal I to II. The first recurrent ends well within submarginal I in the Trinidad and Paraguay material.

The collar has a very faint median longitudinal impression in the male, but the female collar has no impression or at most a posterior indentation. The male clypeal margin has two large teeth between which a weak third tooth is sometimes present (Fig. 16). The female face is shown in Fig. 2.

Acknowledgements

I am grateful to Max Fischer, Naturhistorisches Museum, Vienna; Colin Vardy, British Museum (Natural History), London; and J. Verbeke, Institut Royal des Sciences Naturelles de Belgique, Brussels, for their assistance in locating and lending type material; and to R. O. Schuster, University of California, Davis, and H. E. Evans, Museum of Comparative Zoology, Cambridge, for the loan of material used in this study.

The Correct Citations for the Reports on Homoptera Collected During the Harriman Alaska Expedition

Louise M. Russell

*Systematic Entomology Laboratory, Agr. Res. Serv.,
U. S. Department of Agriculture, Beltsville, Md. 20705*

ABSTRACT

Correct citations are given for the articles by Ashmead, Pergande and Schwarz in their reports on the Homoptera (Hemiptera) collected during the Harriman Alaska Expedition of 1899.

The purpose of this article is to provide correct citations for papers on the homopterous insects collected during the Harriman Alaska Expedition of 1899. The reports on the Sternorhyncha included in the papers often have been cited erroneously. Correct citations are as follows:

Ashmead, W. H. 1904. Homoptera of Alaska, 8 (part 1): 127–137, illus. Doubleday, Page and Company, New York. This article deals with the Fulgoroidea, Jassoidea, Psylloidea, Aphidoidea and Coccoidea. The title on page 127 is "Homoptera of Alaska," while on page 129 it is "The Homoptera of Alaska."

Pergande, T. 1900. Papers from the Harriman Alaska Expedition. XVI. Entomological Results (10): Aphididae. Proc. Wash. Acad. Sci. 2: 513–517. This article treats 4 named and 1 unnamed aphid species. It was reprinted as cited below.

———. 1904. Aphididae of the Expedition. 8 (part 1): 119–125 (513–517). Doubleday, Page and Company, New York. The editor (C. Hart Merriam) noted (p. 120) that this article had appeared previously, even though in the Preface to volume 8 he wrote (p. vi), " . . . . . The Introduction by Professor Kincaid, and the papers on Myriapoda and Homoptera, are now published for the first time." His reference to Homoptera presumably was meant to apply only to the article on this suborder by Ashmead and not to all the Homoptera included in the volume.

Schwarz, E. A. 1900. Papers from the Harriman Alaska Expedition. XIX. Entomological Results (13): Psyllidae. Proc. Wash. Acad. Sci. 2: 539–540. This article lists 3 unnamed species of Psyllidae.

The Harriman Expedition was conducted in cooperation with the Washington Academy of Sciences, and the earliest reports on the Expedition were published in the Proceedings of that Society in 1900. Later, however, several privately printed volumes appeared. Volume 1, which was published in 1901 or 1902 (the date varies in volumes I have seen, though the copyright date is 1901 in each one), and subsequent ones through volume 13 were printed by Doubleday, Page and Company, and the title pages that bear this company's name have a similar format. Only volumes 8 and 9 were devoted to the insects and the title page of each bears the date 1904.

In some libraries, volumes 1 through 13 have a Smithsonian Institution as well as a Doubleday, Page title page. In other libraries the Smithsonian title page does not appear until volume 12. Whenever the Smithsonian title page appears, however, its back carries the following statement:

Advertisement

"The publication of the series of volumes on the Harriman Alaska Expedition of 1899, heretofore privately printed, has been transferred to the Smithsonian Institution by Mrs. Edward H. Harriman, and the work will hereafter be known as the Harriman Alaska Series of the Smithsonian Institution.

"The remainder of the edition of Volumes I to V, and VIII to XIII, as also Volumes VI and VII in preparation, together with any additional volumes

that may hereafter appear, will bear special Smithsonian title pages.
"Smithsonian Institution,
"Washington, D. C., July, 1910"

From this statement it is obvious that the volumes did not begin as a Smithsonian series until 1910, and thus the publication date of volumes 8 and 9, which is often cited as 1910, actually was before that time and presumably was 1904 as given on the Doubleday, Page title page.

In the Smithsonian Institution Library, Smithsonian title pages are bound in each volume, and each bears a number, 1990 through 2000 for volumes 1 through 13 which were printed by Doubleday, Page and Company, and number 2140 for volume 14, which has only the Smithsonian title page with the date 1914 and was printed by The Lord Baltimore Press. Apparently volumes 6 and 7 were not published.

It is likely that mistakes in dates, titles and publication medium resulted from dual publication and dual titles of one article, and from the dual dates appearing in some volumes.

A List of the Species of Craspedolepta *Enderlein Recorded from North America (Homoptera: Psyllidae: Aphalarinae)*

Louise M. Russell

Systematic Entomology Laboratory, Agr. Res. Serv., U. S. Department of Agriculture, Beltsville, Md. 20705

ABSTRACT

Craspedolepta is recognized as a valid genus. The list of North American taxa assigned to the genus includes 53 specific or varietal names. Of these, 35 names are treated as representing valid taxa and 17 represent misidentifications, synonyms or nomina nuda. Thirty new name combinations are proposed.

In this article I recognize *Craspedolepta* Enderlein as a valid genus distinct from *Aphalara* Foerster, reassign to *Craspedolepta* 2 North American species placed in the genus by Enderlein but excluded from it by American workers, and propose 31 new name combinations for Nearctic species or varieties originally placed in *Aphalara* and here transferred to *Craspedolepta*. I also dispose of 17 names that represent misidentifications, synonyms or nomina nuda, but I do not comment on the validity of presently recognized species or indicate new synonymy. My purpose is to modernize the nomenclature of one group of North American Psyllidae, and thus provide more meaningful names to persons concerned with this group of psyllids.

Enderlein (1921) established the genus *Craspedolepta* and designated *Aphalara artemisiae* Foerster (1848) as its type-species. He also transferred the Nearctic species *angustipennis* Crawford and *veaziei* Patch from *Aphalara* to his new genus. With the exception of these 2, North American species that are congeneric with *artemisiae* have invariably been described in *Aphalara,* and have not been transferred to *Craspedolepta*.

The reason for the disregard of *Craspedolepta* by Americans is not clear. It is unlikely that all American describers were unaware of the genus even though they did not mention it and continued to place *angustipennis* and *veaziei* in *Aphalara*. It is possible that Americans considered differences between species insufficient for separation into two genera, and choose without stating it, to ignore *Craspedolepta*.

Craspedolepta and *Aphalara* are closely related and though most species are readily assignable to one or the other genus, a few North American species are placed less easily.

Enderlein separated the genera on one unsatisfactory character, stating that the costa was not thickened distad of R_1 in *Craspedolepta,* and that it was thickened distad of R_1 in *Aphalara*. Later workers, including Dobreanu and Manolache (1962), Heslop-Harrison (1949), Loginova (1961, 1963), Vondracek (1957) and Wagner (1947), have provided more reliable characters for the separation of the genera and have furnished new and useful information on the hosts, biology and relationships of members of the group.

North American species of *Craspedolepta* can be separated from those of *Aphalara* as follows:

Clypeus subglobose or pyriform, not tapered from base to apex, not approaching or attaining front margin of head; vertex merging smoothly into the slightly convex genae without interruption; head and thorax yellowish, greenish or black .... *Craspedolepta*

Clypeus elongate, tapered from base to apex, approaching or attaining front margin of head; vertex separated from the small, more strongly convex genae by distinct, shallow furrows; head and thorax usually some shade of orange or red, rarely black .... *Aphalara*

The list of species names includes original citations and former name combinations. Nomina nuda, most of which are manuscript names for species described under other names, and synonyms are placed under the accepted names for the species.

Repositories of type specimens are given when known and are indicated as follows: California Academy of Sciences, San Francisco, CAS; Illinois Natural History Survey, Urbana, INHS; Ohio State University, Columbus, OSU; University of California, Davis, UCD; University of Kansas, Lawrence, UK; U.S. National Museum of Natural History, Washington, D. C., USNM.

The letter C. after the species and author name refers to *Craspedolepta*.

alaskensis (Ashmead) C., **n. comb.**
Aphalara alaskensis Ashmead 1904. Homoptera of Alaska 8 (part 1): 136, illus. Doubleday, Page and Company, New York. (Also Smithsonian Institution Publ. No. 1995.)
Types.—USNM.

angustipennis (Crawford) C.
Aphalara artemisiae Foerster var. *angustipennis* Crawford 1911, Pomona J. Entomol. 3: 480, 494, 499, illus.
Aphalara angustipennis Crawford 1914, U. S. Natl. Mus. Bull. 85: 26, 30, illus.
Craspedolepta angustipennis (Crawford): Enderlein 1921, Zool. Anz. 52: 118.
Aphalara angustipennis Riley *in* Crawford 1911, Pomona J. Entomol. 3: 480, 499; 1914 U. S. Natl. Mus. Bull. 85: 30. Nomen nudum.
Aphalara utahensis Riley *in* Crawford, 1911, Pomona J. Entomol. 3: 480, 498; 1914, U. S. Natl. Mus. Bull. 85: 30. Synonym of *angustipennis* in part. Nomen nudum.
Types.—USNM.

angustipennis Riley—see *angustipennis* (Crawford).

anomala (Crawford) C. *(Anomocera),* **n. comb.**
Aphalara (Anomocera) anomala Crawford 1914, U. S. Natl. Mus. Bull. 85: 27, 37–38.
Aphalara occidentalis anomala Riley *in* Crawford 1914, U. S. Natl. Mus. Bull. 85: 38. Nomen nudum.
Types.—USNM.

artemisiae (Foerster) C.
Aphalara artemisiae Foerster 1848, Verh. Naturh. Vereins Preussischen Rheinlande 5: 96.
Craspedolepta artemisiae (Foerster): Enderlein 1921, Zool. Anz. 52: 118.
Aphalara utahensis Riley *in* Crawford 1911, Pomona J. Entomol. 3: 480, 498; 1914, U. S. Natl. Mus. Bull. 85: 30. Synonym of *artemisiae* in part. Nomen nudum.

bifida (Caldwell) C., **n. comb.**
Aphalara bifida Caldwell 1936, Ohio J. Sci. 36: 222, illus.
Types.—USNM.

caudata (Crawford) C., **n. comb.**
Aphalara caudata Crawford 1914, U. S. Natl. Mus. Bull. 85: 26, 33.
Aphalara koebeli Riley *in* Crawford 1914, U. S. Natl. Mus. Bull. 85: 33. Nomen nudum.
Types.—USNM.

communis Crawford C.—see ***veaziei*** (Patch).

communis metzaria Crawford—see ***veaziei metzaria*** (Crawford).

constricta (Caldwell) C., **n. comb.**
Aphalara constricta Caldwell 1936, Ohio J. Sci. 36: 220, illus.
Types.—OSU.

coquilletti Riley—see ***pulchella*** (Crawford).

cuyama (Tuthill) C., **n. comb.**
Aphalara cuyama Tuthill 1939, Iowa State College J. Sci. 13: 181.
Types.—UK, Tuthill colln.

delongi (Caldwell) C., **n. comb.**
Aphalara delongi Caldwell 1936, Ohio J. Sci. 36: 221, illus.
Types.—OSU, USNM.

eas (McAtee) C., **n. comb.**
Aphalara eas McAtee 1918, Entomol. News 29: 221–222, illus.
Types.—USNM.

easta (Caldwell) C., **n. comb.**
Aphalara easta Caldwell 1938, Ohio Biol. Surv. Bull. 34 (vol. 6 no. 5): 237, 239–240, illus.
Types.—OSU, USNM.

epilobii Riley—see ***nebulosa kincaidi*** (Ashmead).

fascipennis (Patch) C., **n. comb.**
Aphalara fascipennis Patch 1912, Maine Agric. Exp. Stn. Bull. 202: 217–218, illus.
Psylla pallida Harris *in* Crawford 1914, U. S. Natl. Mus. Bull. 85: 35. Nomen nudum.
Type.—USNM (1 dissected ♂ on slide).

flavida (Caldwell) C., **n. comb.**
Aphalara flavida Caldwell 1938, Ohio Biol. Surv. Bull. 34 (vol. 6 no. 5): 237, 243–244, illus.
Types.—OSU, USNM.

flavipennis (Foerster), C.
Aphalara flavipennis Foerster 1848, Verh. Naturh. Vereins Preussischen Rheinlande 5: 89.
Craspedolepta flavipennis (Foerster): Wagner 1947, Verh. Vereins für Naturwissenschaftliche Heimatforschung zu Hamburg 29: 62, 65.
Aphalara picta Crawford (not Zetterstedt 1828)

1911, Pomona J. Entomol. 3: 481, 495, 501–502, illus.; 1914, U. S. Natl. Mus. Bull. 85: 26, 33–34, illus. Misidentification.

Aphalara harrissii Riley *in* Crawford, 1911, Pomona J. Entomol. 3: 481; 1914, U. S. Natl. Mus. Bull. 85: 34. Nomen nudum.

Aphalara leucanthemi Fitch *in* Crawford 1914, U. S. Natl. Mus. Bull. 85: 34. Nomen nudum.

fumida (Caldwell) C., **n. comb.**

Aphalara fumida Caldwell 1938, Ohio Biol. Surv. Bull. 34 (vol 6, no. 5): 237, 243, illus.

Types.—OSU.

furcata (Caldwell) C., **n. comb.**

Aphalara furcata Caldwell, 1936, Ohio J. Sci. 36: 221–222, illus.

Types.—OSU, USNM.

gutierreziae (Klyver) C., **n. comb.**

Aphalara gutierreziae Klyver 1931, Pan.-Pac. Entomol. 7: 134–135, illus.

Types.—UCD.

harrissii Riley—see ***flavipennis*** (Foerster).

hebecephala (Caldwell) C., **n. comb.**

Aphalara hebecephala Caldwell 1936, Ohio J. Sci. 36: 222.

Types.—OSU.

kincaidi Ashmead—see ***nebulosa kincaidi*** (Ashmead).

koebeli Riley—see ***caudata*** (Crawford).

leucanthemi Fitch—see ***flavipennis*** (Foerster).

martini (Van Duzee) C., **n. comb.**

Aphalara martini Van Duzee 1924, Pan-Pac. Entomol. 1: 22–23.

Types.—CAS.

metzaria Crawford—see ***veaziei metzaria*** (Crawford).

minuta (Caldwell) C., **n. comb.**

Aphalara minuta Caldwell 1938, Ohio Biol. Surv. Bull. 34 (vol. 6 no. 5): 237, 240–241, illus.

Types.—INHS, OSU, USNM.

minutissima (Crawford) C. (Anomocera), **n. comb.**

Aphalara minutissima Crawford 1911, Pomona J. Entomol. 3: 494, 500–501, illus.

Aphalara (Anomocera) minutissima Crawford 1914, U. S. Natl. Mus. Bull. 85: 27, 37, illus.

Aphalara occidentalis Riley *in* Crawford 1911, Pomona J. Entomol. 3: 501, 1914, U. S. Natl. Mus. Bull. 85: 37. Nomen nudum.

Types.—USNM.

minutistylus (Klyver) C., **n. comb.**

Aphalara minutistylus Klyver 1931, Pan-Pac. Entomol. 7: 135–137, illus.

nebulosa americana Crawford—see ***nebulosa kincaidi*** (Ashmead).

nebulosa (Zetterstedt) var. ***kincaidi*** (Ashmead) C., **n. comb.**

Aphalara n. sp. Schwarz 1900, Proc. Wash. Acad. Sci. 2: 540.

Aphalara kincaidi Ashmead 1904, Homoptera of Alaska 8 (part 1): 136, illus. Doubleday, Page and Company, New York. (Also Smithsonian Institution Publ. 1995.)

Aphalara nebulosa var. *kincaidi* Ashmead: Crawford 1914, U. S. Natl. Mus. Bull. 85: 26, 36, illus.

Aphalara nebulosa var. *americana* Crawford 1911, Pomona J. Entomol. 3: 494, 503, illus.; 1914, U. S. Natl. Mus. Bull. 85: 36. Synonym.

Aphalara epilobii Riley *in* Crawford 1911, Pomona J. Entomol. 3: 481, 503: 1914, U. S. Natl. Mus. Bull. 85: 36. Nomen nudum.

Types.—USNM.

numerica (Caldwell) C., **n. comb.**

Aphalara numerica Caldwell 1941. Ohio J. Sci. 41: 420–426.

Types—USNM.

nupera (Van Duzee) C., **n. comb.**

Aphalara nupera Van Duzee 1923, Proc. Calif. Acad. Sci. 12 (4th ser.): 200.

Types.—CAS.

occidentalis Riley—see ***minutissima*** (Crawford).

occidentalis anomala—see ***anomala*** (Crawford).

osborni (Caldwell) C., **n. comb.**

Aphalara osborni Caldwell 1936, Ohio J. Sci. 36: 220–221, illus.

Types.—OSU.

pallida Harris—see ***fascipennis*** (Patch).

picta Crawford—see ***flavipennis*** (Foerster).

pinicola (Crawford) C., **n. comb.**

Aphalara pinicola Crawford 1914, U. S. Natl. Mus. Bull. 85: 26, 31.

Types.—USNM.

pulchella (Crawford) C., **n. comb.**

Aphalara pulchella Crawford 1911, Pomona J. Entomol. 3: 494, 500, illus.; 1914, U. S. Natl. Mus. Bull. 85: 26, 33, illus.

Aphalara coquilletti Riley *in* Crawford 1914, U. S. Natl. Mus. Bull. 85: 33. Nomen nudum.

Types.—USNM.

schwarzi (Ashmead) C., **n. comb.**

Aphalara n. sp. Schwarz 1900, Proc. Wash. Acad. Sci. 2: 539.

Aphalara schwarzi Ashmead 1904, Homoptera of Alaska 8 (part 1): 135, illus. Doubleday, Page and Company, New York. (Also Smithsonian Institution Publ. 1995.)

Types.—USNM.

sinuata (Caldwell) C., **n. comb.**

Aphalara sinuata Caldwell 1936, Ohio J. Sci. 36: 222–223, illus.

Types.—OSU.

suedae Riley—see ***suaedae*** (Crawford).

suaedae (Crawford) C., **n. comb.**

Aphalara suaedae Crawford 1914, U. S. Natl. Mus. Bull. 85: 26, 31, illus.

Aphalara suedae Riley *in* Crawford 1914, U. S. Natl. Mus. Bull. 85: 31. Nomen nudum.

Types.—USNM.

utahensis Riley—see ***angustipennis*** (Crawford) and ***artemisiae*** (Foerster).

vancouverensis (Klyver) C., **n. comb.**

Aphalara vancouverensis Klyver 1931, Pan-Pac. Entomol. 8: 11–12, illus.

veaziei (Patch) C.

Aphalara veaziei Patch 1911, Maine Agric. Exp. Stn. Bull. 187: 16–18, illus.

Aphalara communis Crawford 1911, Pomona J. Entomol. 3: 494, 499, illus.; 1914, U. S. Natl. Mus. Bull. 85: 31–32. Synonym.

Craspedolepta veaziei (Patch): Enderlein 1921, Zool. Anz. 52: 118.

Types.—USNM (on slides).

veaziei (Patch) var. ***metzaria*** (Crawford) C., **n. comb.**

Aphalara communis var. *metzaria* Crawford 1911, Pomona J. Entomol. 3: 494, 499–500; 1914, U. S. Natl. Mus. Bull. 85: 32. Synonym.

Aphalara veaziei var. *metzaria* Crawford 1914, U. S. Natl. Mus. Bull. 85: 26, 32.

Types (topotypes).—USNM.

viridis (Crawford) C., **n. comb.**

Aphalara viridis Crawford 1914, U. S. Natl. Mus. Bull. 85: 26, 30–31.

Types.—USNM.

Aphalara mera Van Duzee does not belong in *Aphalara* or *Craspedolepta*. The name was synonymized with *Heteropsylla texana* Crawford (1914) by Jensen (1945). *A. mera* has been recorded as follows:

Aphalara mera Van Duzee 1923, Proc. Calif. Acad. Sci. 12 (4th ser.): 199.

Paurocephala mera (Van Duzee): Caldwell 1941, Ohio J. Sci. 41: 420.

Types.—CAS.

Aphalara punctellus Van Duzee does not belong in *Aphalara* or *Craspedolepta*. The name was synonymized with *Aphalaroida inermis* Crawford (1914) by Jensen (1949). *A. punctellus* has been recorded as follows:

Aphalara punctellus Van Duzee 1923, Proc. Calif. Acad. Sci. 12 (4th ser.): 199.

Aphalara (Anomocera) punctellus Van Duzee; Caldwell 1941, Ohio J. Sci. 41: 420.

Types.—CAS.

References Cited

Crawford, D. L. 1914. A monograph of the jumping plant-lice or Psyllidae of the New World. U. S. Natl. Mus. Bull. 85: I–IX + 186, illus.

Dobreanu, E., and C. Manolache. 1962. Homoptera, Psylloidea *in* Fauna Republicii Populare Romîne. Insecta 8 (fasc. 3): 376 p., illus.

Enderlein, G. 1921. Psyllidologica VI. Zool. Anz. 52: 115–122.

Foerster, A. 1848. 3. Uebersicht der gattungen und arten in der familie der Psylloden. Verh. Naturh. Vereins Preussischen Rheinlande 5: 65–98.

Heslop-Harrison, G. 1949. The Aphalaran genera, Aphalara Förster, Craspedolepta Enderlein and Metaphalara Crawford, with special reference to the European species of Aphalara: Hemiptera-Homoptera, family Psyllidae. Ann. Mag. Nat. Hist 2 (ser. 12): 782–801, illus.

Jensen, D. C. 1945. Notes on the synonymy, nymphs and distribution of Heteropsylla texana Crawford (Homoptera, Psyllidae). Pan-Pac. Entomol. 21: 74–76.

————. 1949. The identity of *Hemitrioza washingtonia* Klyver and *Aphalara punctellus* Van Duzee (Homoptera: Psyllidae). Pan-Pac. Entomol. 25: 145–146, illus.

Loginova, M. M. 1961. A revision of the species of the genera Aphalara Frst. and Craspedolepta Enderl. (Homoptera, Psylloidea) in the fauna of the USSR. 1. Entomol. Obzr. 40: 602–623, illus. (Translation Entomol. Rev. 3: 328–341, illus.).

————. 1963. Revision of the species of the genera Aphalara Frst. and Craspedolepta Enderl. (Homoptera, Psylloidea) in the fauna of the USSR. 2. Entomol. Obozr. 42: 621–648, illus. (Translation Entomol. Rev. 42: 334–346, illus).

Vondrácek, K. 1957. Mery-Psylloidea *in* Fauna CSR (Praha) 9: 431 p., illus.

Wagner, W. 1947. Beitrag zur systematik der Deutschen Aphalarinae. (Homopt. Psyll.) Verh. Vereins für Naturwissenschaftliche Heimatforschung zu Hamburg 29: 55–71, illus.

A Description of the Larva of Hydrobiomorpha casta *(Coleoptera: Hydrophilidae)*

Paul J. Spangler

Smithsonian Institution, Washington, D.C. 20560

ABSTRACT

The larva of *Hydrobiomorpha casta* (Say) is described and illustrated, the synonymies of the species is updated, and a key to the larvae of the genera assigned to the subfamily Hydrophilinae is provided.

The subfamily Hydrophilinae consists of the following six genera: *Dibolocelus, Hydrobiomorpha, Hydrochara, Hydrophilus, Sternolophus,* and *Tropisternus.* The larvae of *Hydrochara, Hydrophilus, Sternolophus,* and *Tropisternus* have been fully described and that of *Dibolocelus* remains undescribed. Bertrand (1962) briefly characterized the larva of *Neohydrophilus* sp. (now *Hydrobiomorpha fide* Mouchamps, 1959) and also included *Neohydrophilus* in his key to the larvae of the genera of Hydrophilidae of the world (Bertrand, 1972).

A full description of the larva of *Hydrobiomorpha casta* (Say) and a key to the larvae of the genera of the Hydrophilinae are presented in this paper. In addition, updated synonymies are given for *H. casta* because as the citations in the synonymy indicate some of the past transfers as well as the current assignment of *casta* to *Hydrobiomorpha* have been overlooked.

Hydrobiomorpha casta (Say)

Hydrophilus castus Say, 1835: 170; type-locality: "Inhabits Louisiana"; type destroyed.—Leng, 1920: 84.—Löding, 1945: 30.—Blackwelder and Blackwelder, 1948: 5.

Hydrocharis castus.—Horn, 1876: 251.—Schwarz, 1878: 439.—Horn, 1895: 233.—Leng and Mutchler, 1918: 103.—Blatchley, 1919: 320.

Hydrophilus (Neohydrophilus) castus.—d'Orchymont, 1911: 62.

Neohydrophilus castus.—Knisch, 1924: 234.—d'Orchymont, 1928: 167; 1929: 1026.—Young, 1954: 193.—Arnett, 1961: 221.

Hydrobiomorpha casta.—Mouchamps, 1959: 328.—Richmond, 1962: 88.

Hydrocharis obtusatus (Say).—LeConte, 1855: 369 (in part).

Hydrous tenebrioides Jacquelin DuVal, 1856: 50.

Hydrocharis perfectus Sharp, 1882: 61.

The genus *Hydrobiomorpha* is essentially pantropical in distribution, and it presently includes 32 species plus 10 subspecies. The only species of *Hydrobiomorpha* found in the United States is *H. casta,* which occurs from Florida to Louisiana and in Cuba, Mexico, Guatemala, and Panama. Because *H. casta* is the only representative of the genus in the United States, larvae collected with adults may be confidently identified to genus and species by association, by size, and by elimination of known hydrophilid larvae. The larva (Fig. 1) described below was identified in this manner.

Third-instar Larva.—Length, 21.0 mm; greatest width of pronotum, 2.8 mm. Color of sclerotized portions of head, thorax, legs, and sclerite on stigmatic atrium reddish brown to dark reddish brown. Integument lightly infuscate and densely covered with fine pubescence.

Head rectangular; 2.3 mm wide; 2.0 mm from labroclypeus to occipital foramen. Frontoclypeal suture distinctly impressed. Ecdysial cleavage line present and forked near base; frontal arms diverging and extending to bases of antennae. Frons sagittate. Cervical sclerites present, subrectangular. Ventral surface of head with few setae laterally, glabrous

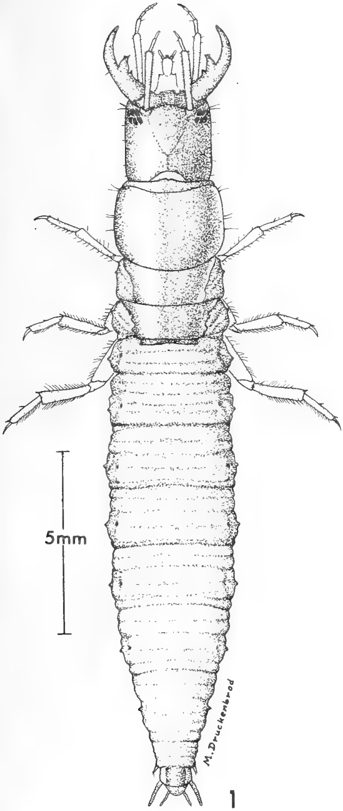


Fig. 1, *Hydrobiomorpha casta* (Say), larva, habitus.

medially; gula roughly pentagonal, rounded posteriorly; 2 tentorial pits behind gula, 1 on each side of midline. Labroclypeus asymmetrical (Fig. 2), left side shortest; with 5 poorly defined teeth, each separated by a short stout seta. Anterolateral angles of epistoma rounded, projecting beyond longest labroclypeal teeth, each with 2 stout setae on anterolateral margins, finely serrulate on medial margins, separated from labroclypeal teeth by a single stout seta. Ocular areas each with 6 ocelli arranged in an ellipse. Ocelli in 2 rows, anterior row with 4 ocelli and posterior row with 2 ocelli; middle pair of ocelli of anterior row largest, lowest ocelli smallest, other ocelli subequal.

Antenna as long as mandibles, subcylindrical, 3 segmented; basal segment slightly more than 3 times as long as ultimate and penultimate segments combined and densely pubescent as illustrated (Fig. 3); penultimate segment about a third longer than ultimate segment, with 1 long hair on anterolateral angle; ultimate segment slender, with 2 stout short setae and 2 long slender setae on apex.

Mandibles (Fig. 4) symmetrical, prominent, stout, sharply tapered apically. Each mandible with 1 large distal tooth and 1 small proximal denticle. Molar area relatively smooth and rounded except for a minute stubby process immediately below basal denticle.

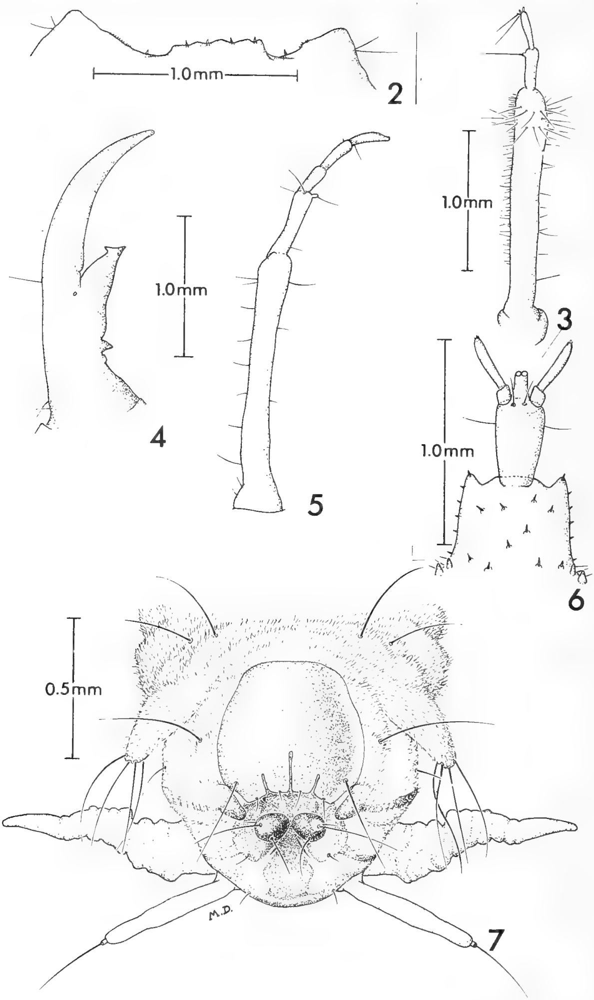
Maxilla (Fig. 5) with stipes slender, elongate, constricted medially, with setae as illustrated. Palpifer as long as 1st and 2nd segments of palpus combined, with slender sclerotized appendage on inner side and bearing a long terminal seta. Palpal segments 1 and 2 slightly swollen distally; 1st segment shortest, penultimate and ultimate segments subequal; ultimate segment tapering sharply, with small slender basal seta.

Labium (Fig. 6) with palpi extending slightly beyond large mandibular tooth. Penultimate segment of labial palpus short; ultimate segment about 5 times as long as penultimate segment, bearing 3 short stout setae on apex. Ligula distinct, twice as long as penultimate segment of labial palpus, shallowly bilobate on apex. Palpiger rectangular; dorsally with 2 setae arising medially near base of ligula and ventrally with 2 elongate slender setae arising anterolaterally behind bases of palpi. Mentum slightly more than twice as wide as palpiger, diverging posteriorly; anterolateral angles prominent and each with a single seta on apex; dorsal surface with numerous setae as illustrated (Fig. 6); posterolateral angles with 2 small denticles.

Pronotum broader than long, with sides gently rounded, slightly wider posteriorly, bearing 4 or 5 long slender setae at anterolateral angle and 5 or 6 posteriorly. Sagittal line present. Prosternal sclerite broader than long; with a few long slender setae at anterolateral angles and along midline. Mesonotum slightly wider than pronotum but only half as long; with 1 large trapezoidal sclerite; sagittal line present. Metanotum slightly wider than mesonotum and about as long; with 1 large trapezoidal sclerite; sagittal line present.

Legs 4-segmented, slightly longer than width of prosternal sclerite. Coxae robust, slightly shorter than trochanter and femur combined. Trochanter about half as long as coxa. Femur slightly longer than tibiotarsus. Tarsal claw single, with 2 short stout setae ventrally near base.

Abdomen of 8 distinct segments and 9th and 10th segments reduced. Segment 1 with a single, straplike sclerite anteriorly. Abdominal segments 2 through 7 without sclerites and separated by an intersegmental membrane; 8th segment with dorsal sclerite. True segmentation obscured by additional transverse folds on segments; segmental folds con-



FIGS. 2–6, *Hydrobiomorpha casta* (Say), larva: 2, labroclypeus, dv; 3, antenna, dv; 4, mandible, vv; 5, maxilla, vv; 6, labium, dv; 7, stigmatic atrium, dv. (dv = dorsal view; vv = ventral view.)

tinued onto sternum. 1st segment with 2 folds; remaining segments with 4 folds. Segments 1 through 7 with 8 setose tubercles, 4 dorsal and 2 on each lateral margin on first fold behind the fold bearing spiracle. Several small blunt setae present on all tubercles. In addition to tubercles discussed above, a large spiracular tubercle present near anterolateral angle of segments 1 through 7. Epipleurites and hypopleurites prominently lobed. 8th tergum represented by superior valve of stigmatic atrium (Fig. 7), a small trapezoidal sclerite; narrow basally, widening apically and apex divided into 4 truncate processes; each process bearing a short apical seta; each lateral process also bearing a long slender basolateral seta. 9th tergum rounded apically, with 3 sclerites; middle sclerite narrow basally, expanded medially and narrowing again apically, with short seta at posterolateral corners; lateral sclerites smaller and narrower, each bearing a seta on apex. Spiracular openings of lateral tracheal trunks present in atrium. Mesocerci prominent, conical, each bearing 3 setae. Procerci present beside posterolateral angles of sclerite of 8th tergum. Paracerci present, very elongate, gill-like, bearing a long slender seta on apex.

The larva described and illustrated in this paper was collected from Alabama, Bibb County, Payne Lake near Brent, on 2 July 1963 by P. J. Spangler.

Acknowledgment

I am pleased to acknowledge the assistance of Smithsonian Institution staff artist Mr. Michael Druckenbrod who prepared the illustrations of the larva of *H. casta* for this paper.

References Cited

Arnett, R. A., Jr. 1961. The Beetles of the United States (A Manual for Identification), Part II, pp. 211–368, 16 figs. The Catholic University of America Press, Washington, D.C.

Bertrand, Henri P. I. 1962. Contribution a l'etude des premiers etats des Coléoptères aquatiques de la region ethiopienne (4th note). Family: Hydrophilidae s. lat. (Palpicornia Auct.). Bull. Inst. Francais Africa Noire, Series A, 24(4): 1065–1114.

———. 1972. Larves et Nymphes des Coléoptères Aquatiques du Globe. 804 pp., 561 figs. F. Paillart, Abbeville, France.

Blackwelder, R. E., and Ruth M. Blackwelder. 1948. 5th Supplement to the Leng Catalogue of Coleoptera of America, North of Mexico. 87 pp. John D. Sherman, Jr., N.Y.

Blatchley, W. S. 1919. Insects of Florida. Va. Supplementary notes on the water beetles. Bull. Am. Mus. Nat. Hist. 41(4): 305–322.

Horn, G. H. 1876. Synoptic tables of some genera of Coleoptera with notes and synonymy. Trans. Am. Ent. Soc. 5: 246–252.

———. 1895. Coleoptera of Baja California. Proc. Cal. Acad. Sci., 2nd Ser., 5(1): 225–234.

Jacquelin DuVal, P. N. C. 1856. Coleoptera. *In* Sagra, Historie physique, politique et naturelle de l' Ile de Cuba. Animaux Articules, insecta. 136 pp. Paris.

Knisch, A. 1924. Coleopterorum Catalogus, pars 79, Hydrophilidae. 306 pp. W. Junk, Berlin.

LeConte, J. L. 1855. Synopsis of the Hydrophilidae

Key to the Larvae of the Genera of the Subfamily Hydrophilinae

1. Head subspherical; mandibles not symmetrical; left mandible very robust; right mandible much more slender than left mandible; ligula not longer than 1st segment of palpus; lateral abdominal gills absent; pronotum not entirely sclerotized .... **Hydrophilus (Dibolocelus?)**
   Head subquadrangular or subrectangular; mandibles symmetrical or not; ligula distinctly longer than 1st palpal segment; lateral gills present or absent; pronotum entirely sclerotized 2
2. Mentum convex towards basal half, anterolateral angles less prominent; lateral abdominal gills well developed and pubescent .... **Hydrochara**
   Mentum with sides almost straight, anterolateral angles very prominent; lateral abdominal gills rudimentary but indicated by tubercular projections, each with several terminal setae 3
3. Mandibles each with 2 large distal teeth and 1 small proximal denticle; apex of ligula shallowly bifid .... **Sternolophus**
   Mandibles each with 1 large distal tooth and 1 or 2 small proximal denticles; apex of ligula bifid or not 4
4. Mesonotal and metanotal sclerites much reduced, triangular, hind margins very narrow, almost pedunculate; apex of ligula not bifid; lateral abdominal gills of 9th segment short, inconspicuous; acrocerci small, inconspicuous .... **Tropisternus**
   Mesonotal and metanotal sclerites not much reduced, trapezoidal, hind margins almost as wide as anterior margin; apex of ligula shallowly bifid; lateral abdominal gills of 9th segment very long, conspicuous; acrocerci distinctly elongate, gill-like .... **Hydrobiomorpha**

of the United States. Proc. Acad. Nat. Sci. Phil. 7: 356–375.

Leng, C. W. 1920. Catalogue of the Coleoptera of America, North of Mexico. 470 pp. John D. Sherman, Jr., Mount Vernon, N.Y.

Leng, C. W., and A. J. Mutchler. 1918. Insects of Florida. V. The water beetles. Bull. Am. Mus. Nat. Hist. 38(3): 73–116.

Löding, H. P. 1945. Catalogue of the Beetles of Alabama. Geological Survey of Alabama. Monogr. 11. 172 pp. University of Alabama.

Mouchamps, R. 1959. Remarques concernant les genres *Hydrobiomorpha* Blackburn et *Neohydrophilus* Orchymont (Coleopt. Hydrophilides). Bull. Ann. Soc. Roy. Ent. Belgique 95(11–12): 295–335.

d'Orchymont, A. 1911. Contribution a l'etude des genres *Sternolophus* Solier, *Hydrophilus* Leach, *Hydrous* Leach (Fam. Hydrophilidae). Mem. Soc. Ent. Belgique 19: 53–72.

———. 1928. Revision des *Neohydrophilus* americains. Bull. Ann. Soc. Ent. Belgique 18(7–8): 158–168.

———. 1929. Remarks on the morphology and geographical distribution of *Neohydrophilus* (Coleoptera, Hydrophilidae), especially the American species. Trans. IV Intern. Congress Entomol., Ithaca 2: 1024–1028.

Richmond, E. A. 1962. The fauna and flora of Horn Island, Mississippi. Gulf Res. Rept. 1(2): 59–106.

Say, Thomas. 1835. Art. X. Descriptions of new North American Coleopterous insects and observations on some already described. Boston J. Nat. Hist. 1(2): 151–203.

Schwarz, E. A. 1878. The Coleoptera of Florida. Proc. Am. Philos. Soc. 17: 353–469.

Sharp, D. 1882. Haliplidae, Dytiscidae, Gyrinidae, Hydrophilidae, Heteroceridae, Parnidae, Georissidae, Cyathoceridae. Biologia Centrali-Americana, Insecta, Coleoptera. 1(2): 1–144.

Young, F. N. 1954. The Water Beetles of Florida. Univ. Florida Studies, Biol. Sci. Ser. 5(1): x + 238 pp.

A Description of the Larva of Celina angustata *Aubé (Coleoptera: Dytiscidae)*

Paul J. Spangler

Smithsonian Institution, Washington, D.C. 20560

ABSTRACT

The larva of *Celina angustata* Aubé is described and illustrated. Couplets are provided to separate the larva of *Celina* from larvae of other North American dytiscid genera.

The genus *Celina* is one of about a dozen genera of North American dytiscid beetles whose larvae have not been described. Therefore, I have prepared the following description of the larva of *Celina* so it may be interpolated into existing keys and may be identified by other workers.

Genus **Celina** Aubé

Celina Aubé, 1836:219.

Celina is primarily a neotropical genus with 28 species described from that area. Four additional species are reported from the United States. Three of these species are known to occur in subtropical Florida and along the Gulf Coast. The fourth North American species, *Celina angustata* Aubé, is known to occur throughout the eastern half of the United States from Florida to New York and westward at least to Kansas.

Adults and larvae of *Celina* occur in lentic habitats. Specimens are most often found in the leafy substrate in shallow weedy margins of ponds and small lakes. Occasionally, I have collected adults and larvae of *Celina* from stands of *Typha* in shallow mucky sloughs and ditches.

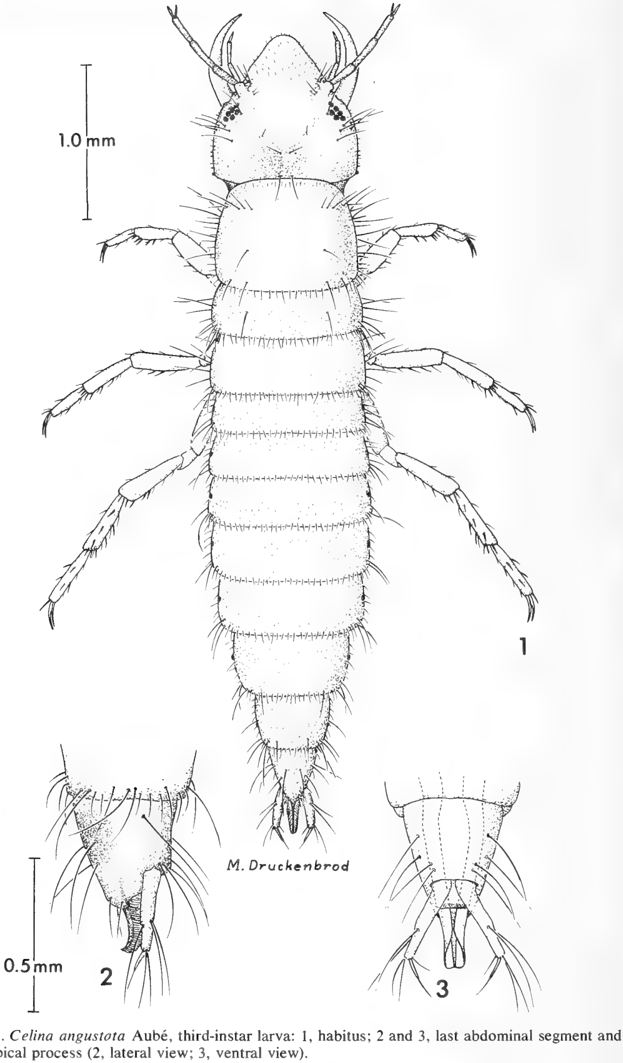
Celina angustata Aubé

Celina angustata Aubé, 1838:447.

During the past 8 years I collected larvae which by association with adults and elimination of known genera of dytiscid larvae presumably were larvae of *Celina*. Unfortunately, these larvae were collected from the Neotropics where more than one species of *Celina* may have been present in each collection site and the species could not be ascertained by association. Because *Celina angustata* is the only species of *Celina* known to occur in Maryland and adjacent states, I attempted to find their presumed larvae for rearing. On 26 July 1970, in a small pond at Rosehaven, Anne Arundel County, Maryland, I collected three of the presumed *Celina* larvae along with adults of *Celina angustata*. I tried to rear the larvae but they died and were preserved. Therefore, although the larvae were not reared, I am describing them by association. I am confident that the specimen described below is the larva of *Celina angustata*.

Third-instar Larva.—Length, 5.0 mm; width of pronotum at base, 0.9 mm. Body depressed, elongate, almost parallel sided but 3d and 4th abdominal segments slightly wider than other abdominal segments. Color of integument creamy white; dorsum testaceous, head with slightly darker discal areas at base behind frontal arms of ecdysial cleavage line.

Head bluntly, broadly sagittate; broadest at level opposite bifurcation of ecdysial cleavage line. Nasale of head blunt and broad. Ecdysial cleavage line distinct at base of head, forked about midway between ocular area and base of head; frontal arms of ecdysial cleavage line diverge and extend to basolateral margin of nasale immediately in front of insertion of antennae. Ocular areas each with 6 ocelli arranged in an ellipse (Fig. 1).



Figs. 1–3. *Celina angustota* Aubé, third-instar larva: 1, habitus; 2 and 3, last abdominal segment and recurved apical process (2, lateral view; 3, ventral view).

Antenna (Fig. 4) tetramerous, cylindrical; basal segment short, about 1/3 as long as second segment; 2d, 3d, and 4th segments subequal; last segment with 2 small, acicular articles on apex. Ventral surface of nasale (Fig. 5) with a primary row of stout setae extending from apex posteriorly along lateral margins to articulation of antennal bases and a secondary row of setae in apical region a short distance behind primary row; numerous small setae behind secondary row; a pair of long setae laterally at midlength and a longer pair laterally near base; a cluster of long, anteriorly slanted setae behind both ends of secondary row of setae; a pair of short, anteriorly slanted setae between the 2 clusters of setae.

Mandible (Fig. 6) long, slender, falciform. Maxillary palpus (Fig. 7) 4-segmented; basal and ultimate segments short, subequal. Labium (Fig. 8) without ligula; labial palpus 2-segmented, basal segment slightly longer than ultimate segment.

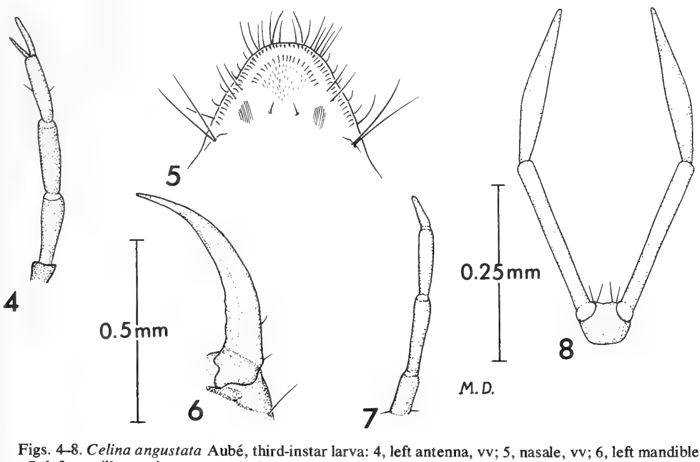
Pronotum with sides arcuate; slightly wider basally; lateral and posterior margins with numerous long setae (Fig. 1). Mesonotum wider than pronotum but slightly less than half as long as pronotum; with long setae along lateral and posterior margins. Metanotum subequal in width and slightly longer than mesonotum, setation similar to mesonotum.

Legs 5-segmented; coxa long, robust; trochanter about ¼ as long as coxa; femur longer than tibia; tarsus with 2 elongate, slender claws. No natatory hairs present on legs.

Abdomen of 8 segments; segments 1 through 5 with setation similar to metanotum; segments 5 through 8 also similar to preceding segments but each bearing an additional pair of very long setae at basolateral angles; segments 1 through 7 each with 2 spiracles, 1 on each side of segment; segment 8 with the lateral tracheal trunks opening above cerci; tracheal trunks terminate in a spiniform, recurved apical process (Figs. 2, 3) with a medial, sclerotized acicular strut; segments 7 and 8 completely sclerotized, cylindrical; segment 8 with a pair of 2-segmented cerci ventrally. Basal segment of cercus with 3 setae at midlength (1 dorsal, 1 ventral, and 1 lateral) and 3 setae on apex (2 lateral, 1 medial); apical segment of cercus slender, elongate, with a single short seta on apex.

The unusually recurved extension of the lateral tracheal trunks suggests that the *Celina* larva may be able to puncture aerenchymatous plant tissues and thus replenish its air supply underwater.

In a key to the dytiscid larvae of the United States by Chandler (1956: 312–314), *Celina* does not fit all of the characters given in either alternative in the first couplet. The following couplets substituted for couplets 1 to 5 in Chandler's key will separate *Celina* larvae from larvae of the other described genera in the Hydroporinae:



Figs. 4–8. *Celina angustata* Aubé, third-instar larva: 4, left antenna, vv; 5, nasale, vv; 6, left mandible, vv; 7, left maxillary palpus, vv; 8, labium, vv. (vv = ventral view.)

1. Head with a frontal projection (Fig. 1); body lacking lateral fringes of swimming hairs 2
   Head without a frontal projection; body with or without lateral fringes of swimming hairs .... (to couplet 6 in Chandler's key)
2. Head broadly sagittate; frontal projection without a notch at each side; maxillary palpus 4 segmented; last abdominal segment with an unusual recurved extension of the lateral tracheal trunks beyond the apex of the segment (Figs. 2, 3) .... **Celina** Aubé
   Head pyriform, not broadly sagittate; frontal projection with or without a notch at each side; maxillary palpus 3 segmented; lateral tracheal trunks not extending beyond apex of last abdominal segment, terminating on apex 3
3. Frontal projection with a notch at each side 4
   Frontal projection without a notch at each side 5
4. Cerci with only primary hairs, 6 or 7 in number .... **Hydroporus** Clairville and **Hygrotus** Stephens
   Cerci with additional secondary hairs .... **Oreodytes** Seidlitz and **Deronectes** Sharp
5. Larva not greatly widened in middle; last abdominal segment long and tapering; cerci with only primary hairs .... Tribe Bidessini
   Larva greatly widened in middle; last abdominal segment long or short; cerci long with secondary hairs, or short with primary hairs only 6
6. Last abdominal segment long and tapering; cerci short, arising beneath segment and projecting beyond it, having primary hairs only .... **Hydrovatus** Motschulsky
   Last abdominal segment short; cerci long, with secondary hairs . **Oreodytes** Seidlitz

The New World genus *Celina,* along with the Old World genus *Methles,* is placed in the subfamily Methlinae based on similarities in adult morphology. Several years ago, Mr. Jack Balfour-Browne showed me a larva he had associated with the African genus *Methles,* and that larva is strikingly similar in habitus to the larva of *Celina*. The larva of *Methles* sp. was described briefly by Bertrand (1963) as "Hydroporinae genus 2?" and was recognized later by Bertrand (1972) as the larva of *Methles* sp. Bertrand's brief description and few illustrations do not allow a thorough comparison of morphological characters of the larvae of the 2 genera. Therefore, I cannot provide a means of separating the larvae of *Methles* and *Celina* at this time.

I thank Mr. Michael Druckenbrod, Smithsonian Institution staff artist, for making the illustrations used in this paper.

References Cited

Bertrand, Henri P. I. 1963. Contribution a l'etude des premiers etats des Coléoptères aquatiques de la region ethiopienne (5th note). Bull. Inst. Francais Afr. Noire, S.A. 25(2):389–466.

———. 1972. Larves et Nymphes des Coléoptères Aquatiques du Globe. 804 pp., 561 figs. Abbeville, France: F. Paillart.

Chandler, H. P. 1956. Key to the known Nearctic genera of Dytiscidae, larvae, pp. 312–314 *In* Usinger, R. E., Aquatic Insects of California. University of California Press. Berkeley, CA.

JUNIOR ACADEMY OF SCIENCES

Officers for 1973–1974:

President	John Cini	424–5736
Vice-President	Mike Bragale	299–6206
Secretary	Cindee Corthell	451–5992
Treasurer	David Leighton	524–5570

Membership Councilors

D. C.	Ken Yao	299–4379
Montgomery	Neil Randall	299–6708
P. G.	Bernard Penney	474–6315
Fairfax	Ken Blais	821–2573
Arl./Alex.	Cris Evanson	527–4281
Ind.	Charles Rabkin	
Prince Wm.	Russel Barnes	491–3791

Committee Chairmen

Membership	Don Barber	772–3537
Convention	Donna Wilkes	723–8955
Funding	William Kanter	299–9446

Calendar:

Junior Science and Humanities Symposium	January
Film Festival	February
Westinghouse Science Talent Search	March
Elections Meeting	May

BOARD OF MANAGERS MEETING NOTES

February, 1973

The 621st meeting of the Board of Managers of the Washington Academy of Sciences was called to order by President Cook at 8:10 p.m. in Conference Room of the Lee Building at FASEB.

Announcements.—The minutes of the October 3, 1972 meeting were approved after the attendance record was corrected as follows: G.W. Irving, L.A. Depue present, and J. Honig absent.

Secretary.—Dr. Stern presented the membership figures of recent years, showing a 20% drop since 1968 and suggested that delegates be more active in recruiting Members and Fellows. He also mentioned that the Academy has a large supply of Dr. Farber's last book which has not been sold due to lack of publicity.

Treasurer.—Dr. Rupp presented the budget for 1972–3 and the projected (balanced) budget for the following year. After extensive discussion the budget was approved as presented. Dr. Rupp also read a letter from Dr. Leo Schubert asking for continued support from the Academy for the summer institute for high school students at American University. Such support will become particularly important when and if NSF discontinues its funding. It was the sense of the Board that, although it could not commit future Boards, financial support was desirable and should continue.

Executive Committee.—Dr. Cook reported on the meeting of Feb. 7 at which the following actions were taken:

1. The move to a less expensive office at FASEB was approved.
2. The budget was approved.
3. A cost-of-living increase for Miss Ostaggi was approved.
4. A "brainstorming" session will be held shortly to gather ideas for a (self-supporting) symposium in the fall.

Membership Committee.—On a motion by Dr. Weissler, seconded by Dr. Honig, the following nominees for fellowship were approved: Hope E. Hopps, Lester D. Shubin, Frederick K. Willenbrock, Bradley F. Bennett.

Awards for Scientific Achievement.—Dr. Cook read Dr. Aldridge's report recommending the following nominees: For Biological Sciences: James L. Reveal, Univ. of Md.; For Physical Sciences: Martin E. Glicksman, Naval Research Lab.; Teaching of Sciences, a joint award: Jerry B. Marion, Univ. of Md., Robert C. Vincent, The George Washington Univ. The Board approved the awards, which will be presented at the March 15 meeting.

Grants-in-Aid.—Dr. Sarvella read the list of five applications accepted for financial support:

Robert H. Cooke, McKinley High School, Washington, D. C.
Jeffrey R. Cousins, Central Senior High School, Seat Pleasant, Md.
Cecil D. Haney, Eastern High School, Washington, D. C.
Richard M. Prevatt, West Springfield High School, Springfield, Va.
Parma Yarkin, Washington-Lee High School, Arlington, Va.

Membership Committee.—Dr. O'Hern urged delegates who have not yet sent her the list of eligible members and/or fellows from their societies, to do so. She will draft a letter to invite these people to submit applications.

Tellers Committee.—Mr. Detwiler announced the results of the recent election as follows:

President-elect: .... Kurt H. Stern
Secretary: .... Patricia Sarvella
Treasurer: .... Nelson W. Rupp
Managers-at-Large (1973–76):
Alphonse F. Forziati
Mary Louise Robbins

New Business.—Mr. Sherlin announced that the Catholic high schools in the D. C. area will hold a Science Fair, April 6 at St. Bartholemews Chruch on River Road. Students from public schools are eligible to participate.

The meeting was adjourned at 9:50 p.m.—Kurt H. Stern, *Secretary.*

May, 1973

The 622nd meeting of the Board of Managers of the Washington Academy of Sciences was called to order at 5:20 p.m. by President Cook in the Board Room of the Cosmos Club.

Secretary.—The report was held over to the Annual Meeting.

Treasurer.—Dr. Rupp presented a resolution to give the Executive Committee the authority to liquidate shares of mutual funds or float a loan to cover expenses during the summer months in the event the checking account balance is inadequate to meet current expenses; the involved funds not to exceed $5000. The resolution, moved by Dr. Robbins, seconded by Dr. Honig, was adopted. Dr. Forziati has requested that the WAS postpone repayment of the $2000 due him. After some discussion, the Board decided to agree to this arrangement and to repay Dr. Forziati when he wished it.

Membership.—On a motion by Dr. Noyes, seconded by Dr. Robbins, the following nominees were elected to Fellowship: Richard S. Fiske, David R. Flinn, Melvin H. Heiffer, William R. Krul, Richard W. Roberts, John W. Rowen.

Grants-in-Aid.—Dr. Sarvella reported for the Grants-in-Aid Committee that two student reports were received.

Announcements.—Dr. Cook announced that Mr. Detwiler was recovering from a heart attack.

The WAS has been asked to cosponsor and contribute $100 toward a concert demonstration by the Catgut Society. The request was held over for consideration by the new Program Committee.

The Joint Board on Science Education requested WAS to approve a change of their name to the Joint Board on Science and Engineering Education. Acceptance of the request was moved by Dr. Heaney, seconded by Dr. Honig. The motion passed.

The meeting was adjourned at 6:10 p.m.—Kurt H. Stern, *Secretary.*

SCIENTISTS IN THE NEWS

Contributions in this section of your Journal are earnestly solicited. They should be typed double-spaced and sent to the Editor three months preceding the issue for which they are intended.

CARNEGIE INSTITUTE

Philip H. Abelson, editor of *Science* and president of the Carnegie Institution of Washington, was a winner of UNESCO's Kalinga Prize for the Popularization of Science for 1972. He shared the award with Nigel Calder, British science writer and editor.

Abelson, 60, obtained his doctorate in physics from the University of California at Berkeley in 1939. He has been associated almost continuously with the Carnegie Institution since then, doing research on chemistry, geophysics, and biophysics. During World War II he worked at the Naval Research Laboratory on the separation of uranium isotopes.

The Kalinga Prize, established in 1951, is awarded annually to someone considered to have made international contributions to the interpretation of science. It is accompanied by £ 1000 and a month-long trip to India.

DEPARTMENT OF AGRICULTURE

Morton Beroza, Northeastern Region, Beltsville, Md., has been chosen to receive the 1973 Gold Medal Award for Outstanding Achievement in Environmental Chemistry of the Synthetic Organic Chemical Manufacturers Association.

Kenneth A. Haines, International Programs Div., Hyattsville, Md., received a diploma from the Board of Directors of the Inter-American Institute of Agricultural Sciences in recognition of his support of the Institute and his contributions to the agricultural development of Latin America.

Paul R. Miller retired on June 30, 1973, having been employed nearly 42 years by the U.S. Department of Agriculture.

Paul has had a unique and productive career as a plant pathologist. In his early years with the Department his work was concerned largely with developing techniques to determine the importance of diseases of cotton, tobacco and peanuts and with disease losses on fresh fruits and vegetables during transit, storage and marketing. Under his direction the Plant Disease Reporter evolved from the old mimeographed few pages to a publication of distinction and a vital medium of communication among people working on plant diseases throughout the world. He is considered a world authority in the field of epidemiology. His work in forecasting and the establishment of a cooperative plant disease warning service has been credited with saving farmers hundreds of thousands of dollars either by reduced use of fungicides or actual disease loss due to proper timing of fungicide applications.

Paul R. Miller

Through the years Paul has vigorously promoted the science of plant pathology by his work with Fort Detrick, Md., with high school science fairs, and with the teaching of short courses at various colleges designed to help college teachers of biology incorporate plant pathology into their classes. He helped organize, and participated in several international meetings having to do with epidemiology and biometeorology. He also taught graduate courses in epidemiology and forecasting at a technical institute in Buenos Aires, Argentina.

During 1971–72 Paul took an assignment as liaison officer between the Department of Agriculture and the Fort Valley State College in Georgia, one of the 16 black land grant colleges. While there he helped their staff initiate a broad agricultural research and extension program, providing advice and counsel to the president and other administrative officials of the institution regarding the structure of their research program. He feels that these were two of the most challenging and rewarding years of his career.

Paul Miller's contributions to the American Phytopathological Society are well known. He has held numerous offices, culminating with the presidency in 1958, the Golden Jubilee Year. He was elected a Fellow of the American Association for the Advancement of Science and the Washington Academy of Sciences.

He has published more than 60 scientific papers dealing with the aforementioned areas of losses, epidemiology, biometeorology, and forecasting. He will continue his professional interests as a collaborator with the Applied Plant Pathology Laboratory, Plant Protection Institute, U.S.D.A., Beltsville, Md., working on a multilingual thesaurus of plant disease names.

NATIONAL INSTITUTES OF HEALTH

Robert W. Berliner, NIH Deputy Director for Science, recently received honorary doctor of science degrees during commencement exercises at Yale University and the Medical College of Wisconsin.

At Yale University, his alma mater, on June 4, Dr. Berliner was praised for developing his own technology "for observing the transport of chemical substances across the membranes of living cells."

The citation also notes his creation of "elegant models, of great precision, which permit us to understand the mechanisms in kidney disease."

For this outstanding contribution and in appreciation of his role as "the Nation's leading statesman in biomedical science," Yale conferred the honorary degree upon Dr. Berliner.

Earlier, on May 27, the Medical College of Wisconsin presented the honorary doctor of science degree to Dr. Berliner "for his contributions to renal physiology, his role as teacher and research scientist, and his expert guidance as a research administrator."

Dr. Berliner announced June 13 he will accept the position of Dean of the Yale University Medical School effective in September.

Dr. Berliner said, "Despite strong ties of institutional loyalty and bonds of personal friendships developed over the 23 years that I have been at NIH, I have come to the difficult conclusion that I should accept the position of Dean of the Yale Medical School."

He added, "I can hardly express my affection for this institution, my pride in its stature and accomplishments, and my hopes for its continuing vigor and health."

He noted that Yale University, from which he received his undergraduate degree in 1936, "shares with NIH an important claim upon my loyalties and affections."

In announcing his decision, Dr. Berliner expressed his "wholehearted support" for Dr. Robert S. Stone, who was sworn in as Director of NIH May 29. "I have confidence in his ability to provide NIH with the leadership and strengths that it requires to emerge from a period of stress with renewed emphasis on quality and undiminished excellence."

Dr. Berliner came to NIH in 1950 as chief of the Laboratory of Kidney and Electrolyte Metabolism, NHLI. He later served as Director of Intramural Research for that Institute and was named Director of Laboratories and Clinics for NIH in 1968.

Commenting on Dr. Berliner's announcement, Dr. Stone said:

"I have long known and admired Dr. Berliner as one of America's most distinguished scientists and science-administrators. For all-too-brief a time, I have been associated with him as a colleague at NIH. In his 23 years of service here he has contributed greatly to the excellence and stability of this institution, traditions which we must maintain.

"In his new position, which is one of the foremost in American medicine, I know that Dr. Berliner will continue as a leader."

Kenneth S. Cole, internationally known NINDS scientist who is widely considered to be the "father of membrane biophysics," has had a silver and gold medal named in his honor.

The medal will be given annually by the Membrane Section of the Biophysical Society. It will go to scientists making an outstanding contribution to the study of cell membranes.

Dr. Cole was presented with an honorary medal at the Biophysics Society meeting held in Columbus, Ohio, by Dr. Walter Woodbury, a University of Washington (Seattle) biophysicist who organized the Society's Section on Membranes 4 years ago.

The first recipient of the Cole award, Dr. David E. Goldman, professor of biophysics at the Medical College of Pennsylvania, received the medal at the same ceremony.

Dr. Goldman is credited with devising an equation which is vital to membrane research.

The Cole award is one of three major honors bestowed on Dr. Cole within a year. In November 1972, he was formally admitted as a Foreign Member of the Royal Society of London at its 312th anniversary meeting. Only a few Americans have received this honor.

In January of this year, a book was dedicated to him entitled *Perspectives in Membrane Biophysics—A Tribute to Kenneth S. Cole.*

The book contains articles on membrane research by 22 authors—students and friends of Dr. Cole. Articles for the book, edited by Daniel Agin, were collected in 1970 for Dr. Cole's 70th birthday.

The snowy-haired, soft-spoken scientist, who pioneered studies of the electrical properties of nerves and other living cells, organized the NINDS Laboratory of Biophysics and served as its chief until 1966.

His work here and at Woods Hole, Mass., where he studies the squid's giant nerve axon, has given a tremendous impetus to biophysical studies of the nervous system.

Gregory K. Hartmann

NAVAL ORDNANCE LABORATORY

Gregory K. Hartmann has retired from his position as Technical Director of the Naval Ordnance Laboratory in White Oak, Silver Spring, Maryland.

A Civil Service employee of the Navy, Dr. Hartmann looks back on his career of 32 years, which began in 1941 as a physicist with the then Bureau of Ordnance. His principal work there was in explosives development and the phenomena of weapons effects. For his contributions to the Bureau's part in the successful outcome of World War II, Dr. Hartmann received the Navy's highest civilian honor—the Distinguished Civilian Service Award.

In 1947, he moved to the Naval Ordnance Laboratory to organize its explosives research program, and within eight years became Technical Director of the entire Laboratory. For his contributions to science and the administration of the Laboratory, he received a second Distinguished Civilian Service Award in 1958.

As Technical Director of the Laboratory, Dr. Hartmann has guided the work of some 3,000 scientists, engineers, administrators and technicians who carry out the Laboratory's mission as the Navy's principal RDT&E Center for Ordnance—its technology, concepts and systems. He has watched the Laboratory grow from the Main Laboratory and Shops buildings to its present complex of facilities valued at almost $75 million.

Under Dr. Hartmann's leadership the Laboratory developed much of the design data in its wind tunnels and aeroballistics ranges for the country's major missiles —TITAN, TERRIER, TALOS, TARTAR, and of course, POLARIS and POSEIDON. The Laboratory also developed the arming-fuzing devices in the POLARIS warhead, which keep it safe before and during launch and arm it only when nearing a target.

Notable ASW weapons developed at NOL during Dr. Hartmann's directorship have been SUBROC, a nuclear underwater-launched rocket for destroying enemy submarines; and BETTY and LULU, two nuclear antisubmarine depth bombs. Recent additions to the Navy's arsenal of ordnance is the now successful

Torpedo MK 48 Mod 1, and the DESTRUCTOR development, which converts a series of air-dropped bombs to mines.

Long one of the Navy's prime developers of mines, NOL has played an important role in the war in Southeast Asia. It was NOL-developed mines that closed Haiphong harbor last May and kept it closed for nine months.

Dr. Hartmann has charted a course for retirement that he expects to be just as fruitful, if not as challenging, as the career he leaves behind. He says possible ventures are: serving as a consultant, not excluding management; writing on a number of subjects; teaching; some travel; perhaps farming, to bring forth the fruits of the earth rather than the fruits of a science laboratory; and a little relaxing, if indeed he finds any time for it. He doesn't plan on becoming idle.

Dr. Hartmann and his wife, Harriet, will continue to live in Garrett Park, Maryland at 10701 Keswick St. Their four children, now grown and pretty well scattered, are carving out their own careers. In the process they have presented the Hartmanns with four grandchildren (and another one expected in May.)

Dr. Hartmann graduated in 1933 from the California Institute of Technology with a B.S. degree in physics, and then spent three years as a Rhodes Scholar at Oxford University, England, which awarded him a B.A. degree in mathematics. He acquired his Ph.D. degree in physics from Brown University, Providence, Rhode Island in 1939.

TARIFF COMMISSION

Frank Gonet, Chief of the Chemical Division of the U.S. Tariff Commission, has retired after more than 33 years on the staff of the Commission, first as the Commission's expert on coal-tar dyes and intermediates and, during the past 14 years, as Assistant Chief and Chief of the Chemical Division. The Chemical Division prepares the statistical data used in the Commission's reports on *Synthetic Organic Chemicals* and *Imports of Benzenoid Chemicals and Products*.

Mr. Gonet was born in New Bedford, Mass., where he received his early education. He attended Alliance Academy and Junior College in Pennsylvania and received a B.S. in chemistry from Boston University in 1932. He did graduate work abroad as an International Student Exchange Scholar and as a Kosciuszko Foundation Scholar at the University of Warsaw. He was private research assistant to Professor Centnerszwer at the University, instructor in English and, later, Assistant Director of the English Language College. When World War II broke out he was Manager of Supply and Director of the Testing Laboratory of Lilpop, Rau, and Leowenstein, the General Motors licensee in Poland. After the siege of Warsaw and subsequent SS harassment, he left Poland in December 1939.

Mr. Gonet began his career in the Federal Government as a Materials Engineer with the Navy Department and transferred to the Tariff Commission in May 1941. He has contributed to numerous Tariff Commission publications and reports and has been a member of various governmental committees dealing with chemicals. During World War II he was on special assignment to the Bureau of the Budget, the War Production Board, and the Board of Economic Warfare. He has also served as Chairman of the Interdepartment Committee on Chemical Statistics; Chemical Advisor to the American Delegation to the 4th GATT Round of Tariff Negotiations at Torquay, England; member of the Interagency Technical Committee and member of the Steering Committee on Standard Commodity Classification; member of the Interagency Technical Committee on Standard Industrial Classification; member of the Board of Civil Service Examiners; member of the National Atlas Project of the U.S. Geological Survey, and Special Agent to the Census Bureau.

He has also been active in industry organizations. He was Technical Advisor to the SOCMA-CAS *Handbook Project,* member of the AATCC *Colour Index* Committee; for almost 40 years he has been an abstractor for the American Chemical Society's *CHEMICAL ABSTRACTS*. He has also worked closely with many chemical associations, helping them to organize and improve their statistical programs.

OBITUARIES

Howard P. Barss

Howard P. Barss, 88, botanist who retired from the U.S. Department of Agriculture's Office of Experiment Stations in 1950 after 17 years of service out of Washington, D.C., died in a Portland, Oregon, nursing home May 8, 1973, after a brief illness.

Mr. Barss and his wife Laura had made their home in Portland after his retirement from the Office of Experiment Stations where he served as administrator of Federal-grant fund research at State experiment stations and specialist in botany and plant pathology. Previously he had been head of the Department of Botany and Plant Pathology at Oregon State University, Corvallis, Oregon, from 1915 to 1934.

A life member of the American Phytopathological Society, Mr. Barss had served as its president, vice-president and secretary. He was a member of the American Association for the Advancement of Science; an honorary member of the Oregon State Horticultural Society; a member of several other scientific societies, and a member of Phi Beta Kappa, Sigma Xi, Gamma Sigma Delta and Phi Sigma, honor societies.

He was the author of more than 100 publications and articles dealing with a wide range of plant diseases and their control.

In 1966 and 1967, Mr. Barss was president of the Portland chapter of the American Association of Retired Persons whose membership grew from 1,000 to about 2,000 during his presidency.

Mr. Barss is survived by his widow Laura of Portland; a brother, Alden F. Barss of Vancouver, British Columbia; a sister, Miss Margaret Barss of Rochester, N.Y.; two sons, Richard and Roger, both of Portland; another son, Theodore, of Medford, Oregon; 11 grandchildren and 6 great-grandchildren.

Leonard Carmichael, 74, a former secretary of the Smithsonian Institution who since 1964 had been a vice president of the National Geographic Society, died of cancer Sept. 16, 1973 in Washington Hospital Center. He lived on Hoban Road NW.

Dr. Carmichael was the Smithsonian's seventh secretary. His death was the first of a secretary of the institution since the death of Charles Doolittle Walcott in 1927. He was secretary from 1953 until 1964.

At the National Geographic Society, Dr. Carmichael was vice president for research and exploration. The society's president, Melvin M. Payne, said yesterday that Dr. Carmichael was "a brilliant man of Renaissance proportions.

"His remarkable intellect, combined with his broad academic and scientific talents, contributed greatly to the society's success in achieving its objectives.

"No one in our organization who came to him for advice or guidance failed to receive his wise and deliberate counsel."

His projects for the society had involved him in many activities, including the work of Dr. Louis S. B. Leakey at Olduvai Gorge in Tanzania, the underwater explorations of Jacques-Yves Costeau and the successful expedition to the summit of Mt. Everest.

Dr. Carmichael was president of Tufts

College for 14 years before coming to the Smithsonian. He taught biology, physiology and psychology, but specialized in psychology. While he was chairman of the psychology department at Brown University in the early 1930s he and a colleague, Dr. Herbert Jasper, pioneered the development of electroencephalography—the measurement of brain waves—at a time when most medical men in the United States doubted that the brain emitted electrical impulses.

While Dr. Carmichael was president of Tufts, the school received some $14 million in special gifts. He said he was happy at Tufts and, after refusing the Smithsonian appointment for several weeks, finally decided to accept the position.

At the Smithsonian he did not leave the academic world, he said, because that institute, "in its areas of specialization, is as distinguished as the faculty of any university in the world."

The Smithsonian also received many gifts during Dr. Carmichael's 11 years as secretary—more than $32 million from foundations and other sources in addition to federal funds.

Dr. Carmichael led in modernizing exhibits at the Smithsonian, which saw a 500 percent increase in the number of visitors during his tenure. This increase in popularity aided greatly in smoothing the path for congressional appropriations for the present Museum of History and Technology, two new wings for the Museum of Natural History, renovation of the National Zoo and other expansion programs.

He leaves his wife, Pearl, a daughter, Mrs. S. Parker Oliphant, of Washington, and two grandsons.

Walter Barnes Lang

Walter Barnes Lang, 82, a resident of The Kennedy-Warren, 3133 Connecticut Avenue, died at his home March 16 after a long illness. He was born in St. Paul, Minn., the son of the late Henry David Lang and the former Loucie Isabel Barnes and a direct descendant, through his Mother's line, of John Putnam, the earliest ancestor of the Putnam family in America and the great grandfather of General Israel Putnam of the Revolution.

Mr. Lang received his B.A. and M.S. degrees from the University of Minnesota in 1915 and 1916; at Yale University, where he was a member of the Gamma Alpha Graduate Scientific Fraternity, Mr. Lang was a research assistant to the Director of the Sloane Physics Laboratory in 1916, 1917 and 1920; from 1920–1922 he was a Currier Fellow working toward the degree of Doctor of Philosophy; later he attended Columbia University. He was an Instructor in Physics and Geology at Minnesota; and in World War I, until the flu epidemic in 1918, he was a Technical Expert and ballistic photographer, with the Aberdeen Proving Grounds in Maryland.

From 1922 until his retirement in 1960, Mr. Lang was a geologist with the U.S. Geological Survey. He was in charge of the Government potash explorations in Texas and New Mexico. He also carried on investigations in the search for clays and bauxite in the South, with many publications on these areas, as well as on other scientific subjects. In recognition of his activity in the Permian Basin oil industry in Texas and New Mexico prior to October 1, 1929, he was designated a Permian Basin Petroleum Pioneer.

Of a different nature is his compilation of all the accounts written by travelers over the Butterfield Trail, the first overland mail route from St. Louis and Memphis to San Francisco, 1858–1861. In this connection he published the first map accurately showing the location of the Trail. He was recognized for his distinguished help and service to the cause of preserving our western trails and the traditions of our American pioneers by the Oregon Trail Memorial Association.

Among the many patents granted to Mr. Lang were inner tubes for pneumatic tires and a seeing-eye deep-sea salvage device. He also patented an apparatus for subaqueous geologic prospecting, a method of drilling and coring to great depths from a floating rig in the ocean. This method has been applied to the attempt to drill a "Mohole" through the crust of the earth. During his work at Yale, one of his accomplishments was the construction of a camera capable of taking 2,000 pictures per second for use in scientific exploration.

From the time Mr. Lang was a child, until his recent illness, he traveled extensively in North America and Europe and was said to be one of the youngest to ride a mule down into the Grand Canyon.

Mr. Lang was a fellow, member emeritus, or member of numerous scientific societies, a senior member of the Cosmos Club, and a member of the Yale Club of Washington.

He is survived by his wife, the former Martha Strait Carr. Burial was in Oakland Cemetery, St. Paul, Minn.

Kenneth W. Parker

Kenneth W. Parker, 68, who retired in 1969 as director of range management and wildlife habitat research of the U.S. Forest Service, died of pneumonia in Washington Hospital Center in May, 1973. He lived on Kirby Road in Bethesda.

Mr. Parker was professor of range management at New Mexico State College for five years before joining the Forest Service in Arizona in 1937. His career in both the management of rangeland and research related to it, Mr. Parker worked in range and plant ecology, artificial revegetation and wildlife habitat improvement.

He was director of range management and wildlife habitat research for 13 years.

He was a member of the Cosmos Club and the Washington Biologists Field Club in addition to several professional organizations that include the Wildlife Society and Washington Academy of Sciences. In 1968 he received a certificate of merit from the Society for Range Management.

Mr. Parker was born in Boston. He received B.S. and M.S. degrees in forestry from the University of California in Berkeley.

He leaves his wife, Kittie F., a botany professor at George Washington University; a sister, Mrs. Havid Sager of Novato, Calif., and two grand-daughters. His daughter was the late Linda Parker Stack.

Frank Trelford McClure

Dr. Frank Trelford McClure, 57, Deputy Director of The Johns Hopkins Applied Physics Laboratory and inventor of the Navy's Satellite Navigation System, died October 18 in The Johns Hopkins Hospital following a heart attack. An internationally-known authority in the field of combustion, rockets, and guided missile technology, Dr. McClure was a member of numerous scientific advisory panels to successive Presidents, the Department of Defense, as well as the U.S. Arms Control and Disarmament Agency. His many honors for contributions to research, national defense, and to the U.S. space program include the Presidential Certificate of Merit.

Dr. McClure joined The Johns Hopkins Applied Physics Laboratory in 1946 and served nearly 25 years as chairman of the Laboratory's Research Center. He was appointed Deputy Director in 1969.

Soon after the launching of the first

Frank T. McClure

SPUTNIK in 1957 Dr. McClure discovered a means of employing the signals of satellites for very precise navigation on the Earth's surface. His invention led to the development of the Navy Satellite Navigation System, which has been guiding Navy ships since 1964, and more recently was extended to commercial shipping.

For his invention, Dr. McClure received the first National Aeronautics and Space Administration inventions award. At the presentation in 1961 T. Keith Glennan, then NASA administrator, praised Dr. McClure's "keen analytical insight."

"You were responsible," he said, "for the undertaking of a development program that will have far-reaching benefits, the extent of which cannot yet be assessed."

For the invention Dr. McClure also received (1965) the John Scott Award of the Philadelphia Directors of City Trusts.

A pioneer in rocket propulsion and a chief of the Ballistics Design Division, Allegany Ballistics Laboratory of the George Washington University (1943–45), Dr. McClure in 1961–64 coordinated a national study that materially contributed to solving the problem of dangerous and unpredictable combustion instability in large solid propellant launch vehicles.

A Department of Defense citation praised his leadership in coordinating the Tri-Service program and credited his imaginative approach and his own research "to making outstanding progress toward a better understanding of one of the major problem areas in the important field of rocket propulsion." His honors also include the Hillebrand Prize of the Chemical Society of Washington in 1959 and a Fellowship in biophysics at the Carnegie Institution in 1960.

In the mid 1960's Dr. McClure, with Dr. Richard J. Johns of The Johns Hopkins Medical Institutions, initiated a collaborative biomedical engineering research program which brought the talents of engineers and physicists at APL and the medical scientists in Baltimore together for solving specific medical problems and developing medical devices. Among the products of this effort is an electronic rechargeable heart pacer which Johns Hopkins announced in August as a major advance in medical technology.

Born in Edmonton, Alberta, Canada (August 21, 1916), Dr. McClure was a graduate of the University of Alberta, B.Sc. in organic chemistry, in 1938. He received his Ph.D. in physical chemistry in 1942 from the University of Wisconsin.

A year later while a young professor of chemistry at the University of Rochester, Dr. McClure was called to the George Washington University to participate in major research in high-speed rocketry.

Dr. McClure also contributed materially in later development of the Navy's antiaircraft missile defense program and the Polaris program at the Applied Physics Laboratory. He was a member of the Air Force Space Study Committee (1960–61); American Rocket Society Solid Propellant Rocket Committee (1962); consultant, U.S. Arms Control and Disarmament Agency (1962–65); Space Technology Panel of the President's Science Advisory Committee (1964–67); ad hoc President's Science Advisory Committee on Chemical and Biological Warfare, since 1969. He had held an Overseas Fellowship at Churchill College, Cambridge, England (1964–65).

Dr. McClure was a member of the American Chemical Society, American Physical Society, Philosophical Society of Washington, Washington Academy of Sciences (Fellow), American Association for the Advancement of Science, Cosmos Club, and the American Institute of Chemists (Fellow).

He is survived by his wife, the former Mary Soffa, sons Charles Frederick, 33, and Michael David, 28. He lived at 810 Copley Lane in Silver Spring.

JOURNAL OF THE WASHINGTON ACADEMY OF SCIENCES

Instructions to Contributors

General

Type manuscripts on white bond paper either 8½ by 11 or 8 by 10½ inches. Double space all lines, including those in abstracts, tables, legends, quoted matter, acknowledgments, and references cited. Number pages consecutively. Place your name and complete address in the upper right hand corner of the title page.

Title, Author, and Affiliation

Page 1 of your manuscript should contain only this information and your name and address. Choose a concise but complete and meaningful title. In research papers concerning biological subjects, include an indication of the order and family of the taxa discussed. Academic degrees will not normally be included unless the author so specifies. If possible, combine your affiliation and mailing address (including Zip) so that readers can write to you directly.

Abstract

Type on a separate sheet at the end of the manuscript. Make the abstract intelligible without reference to the text of the paper. Write an informative digest of the significant content and conclusions, not a mere description. Generally, the abstract should not exceed 3% of the text.

Footnotes

Use footnotes as sparingly as possible. Number text footnotes consecutively with Arabic numerals and type them on a separate sheet of paper at the end of the manuscript. Type table footnotes, if any, below each pertinent table on the same page.

Illustrations and Legends

The quality of all original illustrations must be high enough to facilitate good offset reproduction. They should have ample margins and be drawn on heavy stock or fastened to stiff cardboard to prevent bending. They should be proportioned to column (1 x 3) or page (2 x 3) type-dimensions, leaving space for legend material. Photographs should have a glossy finish. They reproduce best when the contrast is fairly high. Identify each illustration with number and author in light pencil marks on the reverse side. Submit all illustrations separately – please do not glue or clip them to the pages of the manuscript.

Do not type or write legends directly on the illustrations. Type legends on a separate sheet or sheets at the end of the manuscript. Indicate where you want illustrations to appear in the printed paper by writing the figure numbers lightly in the text margins, and be sure that each figure is properly referenced in the text itself. Original "art" will be returned only at the author's request and expense.

Tables

Include tables only when the same information cannot be presented economically in the text, or when a table presents the data in a more meaningful way. Consider preparing extremely complicated tabular matter in a form suitable for direct reproduction as an illustration. In such cases, the use of the typewriter is not recommended.

References to Literature

Limit references within the text and in synonymies to author and year (and page if needed). In a "Reference Cited" section, list alphabetically by senior author only those papers you have included in the text. Likewise, be sure all the text references are listed. Type the "References Cited" section on a separate sheet after the last page of text. Abbreviations should follow the *USA Standard for Periodical Title Abbreviations*, Z39.5-1963.

Submission of Manuscripts

Send completed manuscripts and supporting material to the Academy office (see address inside front cover) in care of the Editor. Authors will be requested to read Xerox "proofs" and invited to submit reprint orders prior to publication.

Reprints – Prices for reprints may be obtained on request.

Washington Academy of Sciences
9650 Rockville Pike (Bethesda)
Washington, D.C. 20014
Return Requested with Form 3579

2nd Class Postage Paid
at Washington, D.C.
and additional mailing offices.

Smithsonian Inst. J-WAS
Library Acquisitions
Washington, D.C. 20560