THE BIOLOGICAL BULLETIN
PUBLISHED BY THE MARINE BIOLOGICAL LABORATORY

THE MARINE BIOLOGICAL LABORATORY

SEVENTY-SECOND REPORT, FOR THE YEAR 1969—EIGHTY-SECOND YEAR

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I. TRUSTEES

Including Action of 1969 Annual Meeting

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Laszlo Lorand
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Daniel S. Grosch
George T. Reynolds

Research Space Committee
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John M. Arnold
S. J. Cooperstein
Rita Guttman

II. ACT OF INCORPORATION

No. 3170

Commonwealth of Massachusetts

Be It Known, That whereas Alpheus Hyatt, William Sanford Stevens, William T. Sedgwick, Edward G. Gardiner, Susan Minns, Charles Sedgwick Minot, Samuel Wells, William G. Farlow, Anna D. Phillips, and B. H. Van Vleck have associated themselves with the intention of forming a Corporation under the name of the Marine Biological Laboratory, for the purpose of establishing and maintaining a laboratory or station for scientific study and investigation, and a school for instruction in biology and natural history, and have complied with the provisions of the statutes of this Commonwealth in such case made and provided, as appears from the certificate of the President, Treasurer, and Trustees of said Corporation, duly approved by the Commissioner of Corporations, and recorded in this office;

Now, therefore, I, Henry B. Pierce, Secretary of the Commonwealth of Massachusetts, do hereby certify that said A. Hyatt, W. S. Stevens, W. T. Sedgwick, E. G. Gardiner, S. Minns, C. S. Minot, S. Wells, W. G. Farlow, A. D. Phillips, and B. H. Van Vleck, their associates and successors, are legally organized and established as, and are hereby made, an existing Corporation, under the name of the MARINE BIOLOGICAL LABORATORY, with the powers, rights, and privileges, and subject to the limitations, duties, and restrictions, which by law appertain thereto.

Witness my official signature hereunto subscribed, and the seal of the Commonwealth of Massachusetts hereunto affixed, this twentieth day of March, in the year of our Lord One Thousand Eight Hundred and Eighty-Eight.

[Seal]

Henry B. Pierce,
Secretary of the Commonwealth
III. BYLAWS OF THE CORPORATION OF THE MARINE BIOLOGICAL LABORATORY

(Revised August 12, 1966)

I. The members of the Corporation shall consist of persons elected by the Board of Trustees.

II. The officers of the Corporation shall consist of a Chairman of the Board of Trustees, President, Director, Treasurer and Clerk.

III. The Annual Meeting of the members shall be held on the Friday following the second Tuesday in August in each year at the Laboratory in Woods Hole, Massachusetts, at 9:30 A.M., and at such meeting the members shall choose by ballot a Treasurer and a Clerk to serve one year, and nine Trustees to serve four years, and shall transact such other business as may properly come before the meeting. Special meetings of the members may be called by the Trustees to be held at such time and place as may be designated.

IV. Twenty-five members shall constitute a quorum at any meeting.

V. Any member in good standing may vote at any meeting, either in person or by proxy duly executed.

VI. Inasmuch as the time and place of the Annual Meeting of members are fixed by these bylaws, no notice of the Annual Meeting need be given. Notice of any special meeting of members, however, shall be given by the Clerk by mailing notice of the time and place and purpose of such meeting, at least (15) days before such meeting, to each member at his or her address as shown on the records of the Corporation.

VII. The Annual Meeting of the Trustees shall be held promptly after Annual Meeting of the Corporation at the Laboratory in Woods Hole, Massachusetts. Special meetings of the Trustees shall be called by the Chairman, the President, or by any seven Trustees, to be held at such time and place as may be designated, and the Secretary shall give notice thereof by written or printed notice, mailed to each Trustee at his address as shown on the records of the Corporation, at least one (1) week before the meeting. At such special meeting only matters stated in the notice shall be considered. Seven Trustees of those eligible to vote shall constitute a quorum for the transaction of business at any meeting.

VIII. There shall be three groups of Trustees:

A. Thirty-six Trustees chosen by the Corporation, divided into four classes, each to serve four years. After having served two consecutive terms of four years each, Trustees are ineligible for re-election until a year has elapsed.

B. Trustees ex officio, who shall be the Chairman, the Director, the Treasurer, and the Clerk.

C. Trustees Emeriti, who shall be elected from present or former Trustees by the Corporation. Any regular Trustee who has attained the age of seventy years shall continue to serve as Trustee until the next Annual Meeting of the Corporation, whereupon his office as regular Trustee shall become vacant and be filled by election by the Corporation and he shall become eligible for election as Trustee Emeritus for life. The Trustees ex officio and Emeriti shall have all the rights of the Trustees, except that Trustees Emeriti shall not have the right to vote.

The Trustees and officers shall hold their respective offices until their successors are chosen and have qualified in their stead.

IX. The Trustees shall have the control and management of the affairs of the Corporation. They shall elect a Chairman of the Board of Trustees who shall be elected annually and shall serve until his successor is selected and qualified and who shall also preside at meetings of the Corporation. They shall elect a President of the Corporation
who shall also be the Vice Chairman of the Board of Trustees and Vice Chairman of meetings of the Corporation, and who shall be elected annually and shall serve until his successor is selected and qualified. They shall appoint a Director of the Laboratory for a term not to exceed five years, provided the term shall not exceed one year if the candidate has attained the age of 65 years prior to the date of the appointment. They may choose such other officers and agents as they may think best. They may fix the compensation and define the duties of all the officers and agents; and may remove them, or any of them except those chosen by the members, at any time. They may fill vacancies occurring in any manner in their own number or in any of the officers. The Board of Trustees shall have the power to choose an Executive Committee from their own number, and to delegate to such Committee such of their own powers as they may deem expedient. They shall from time to time elect members to the Corporation upon such terms and conditions as they may think best.

X. The Associates of the Marine Biological Laboratory shall be an unincorporated group of persons (including associations and corporations) interested in the Laboratory and shall be organized and operated under the general supervision and authority of the Trustees.

XI. The consent of every Trustee shall be necessary to dissolution of the Marine Biological Laboratory. In case of dissolution, the property shall be disposed of in such manner and upon such terms as shall be determined by the affirmative vote of two-thirds of the Board of Trustees.

XII. The account of the Treasurer shall be audited annually by a certified public accountant.

XIII. These bylaws may be altered at any meeting of the Trustees, provided that the notice of such meeting shall state that an alteration of the bylaws will be acted upon.

RESOLUTIONS ADOPTED AT TRUSTEES' MEETINGS
EXECUTIVE COMMITTEE

I. RESOLVED:

(A) The Executive Committee is hereby designated to consist of not more than ten members including the ex officio members who shall be the Chairman of the Board of Trustees, President, Director and Treasurer; six additional Trustees, two of whom shall be elected by the Board of Trustees each year, to serve for a three-year term. (August 11, 1967).

(B) The Chairman of the Board of Trustees shall act as Chairman of the Executive Committee, and the President as Vice President. A majority of the members of the Executive Committee shall constitute a quorum and a majority of those present at any properly held meeting shall determine its action. It shall meet at such times and places and upon such notice and appoint such sub-committees as the Committee shall determine. (August 12, 1966).

(C) The Executive Committee shall have and may exercise all the powers of the Board during the intervals between meetings of the Board of Trustees except those powers specifically withheld from time to time by the Board or law. (August 16, 1963)

(D) The Executive Committee shall keep appropriate minutes of its meetings, and its action shall be reported to the Board of Trustees. (August 16, 1963).

II. RESOLVED

The elected members of the Executive Committee shall be constituted as a standing "Committee for the Nomination of Officers," responsible for making nominations at the Annual Meeting of the Corporation and of the Board of Trustees, for candidates to fill each office as the respective terms of office expire (Chairman of the Board, President, Director, Treasurer, and Clerk).
REPORT OF THE DIRECTOR

IV. REPORT OF THE DIRECTOR

To: The Trustees of the Marine Biological Laboratory

Gentlemen:

In the important aspects of the life of the Marine Biological Laboratory this has been a good year. The scientific work has been maintained at a high level. Indeed, the activities of the scientists working at the Laboratory are a magnificent testimonial to the ability of good people to carry on good work regardless of financial stringency and budget cuts.

In terms of our physical plant, this has been the year in which the long-envisioned plans to house our instructional program in modern, fireproof quarters have been realized. As Conklin wrote in 1900, the wooden buildings all were of a temporary character and could be used only in summer. The then stated need for "at least one substantial, fire-proof building... which can be used the year around" increased with the years. Now three such year around laboratory buildings have replaced the wooden laboratory buildings to make possible the sustained service to scientists envisioned by Conklin. Although the passing of Old Main may be regretted by some, there can be no doubt that the Whitman and Loeb Buildings fulfill a long-standing need for contemporary structures. True, the quality of instruction depends in the first instance on the quality of the instructors and the students—of the senior and junior scientists, if you will. However, adequate modern fireproof quarters will certainly enhance the ability of our people to achieve the standards consistent with the changing requirements of modern science.

It is fitting here to recall the devotion with which Dr. Arthur Parpart as President of the Corporation of the Marine Biological Laboratory worked for the fulfillment of our building program. His untimely death in 1965 was a blow to us all; and the new buildings, completed and under construction, are a fine testament to the dedicated efforts of Arthur Parpart. We are fortunate indeed that the development of this program was carried out by Dr. Philip B. Armstrong initially during his tenure as Director and subsequently as Chairman of the Building Committee.

The MBL and the expanding world of marine sciences

The Marine Biological Laboratory was founded by a group of imaginative and dedicated scientists who visualized a facility serving the interests of all biology. Dr. Conklin, in a report written in 1900, speaks as follows:

"In his address at the opening of the Laboratory and in subsequent publications, Professor Whitman took the position that there was great need for a laboratory which should represent, (1) the whole of biology; (2) both teaching and research; (3) the widest possible cooperation of educational and scientific institutions. Such a laboratory should not be merely a collecting station, nor a summer school, nor a scientific work shop, nor a congress of biologists, but all of these; an institution combining in itself the functions and features of the best biological institutes of the world, having the cooperation of the biologists of this country, and thus forming 'a national center of instruction and research in every department of Biology.' The history of the Laboratory has shown that this ambitious project is not only highly desirable, but that it is entirely feasible and has justified the claim of the Director that such an institution is the greatest need of American biology."

The aims and aspirations set forth by C. O. Whitman and expounded by Conklin seventy years ago still have a scope and validity that is undeniable. The Marine Biological Laboratory has become indeed a national resource and all associated with the
Laboratory must share the responsibility of maintaining the viability of this intellectual asset of the world.

The Marine Biological Laboratory was founded by scientists with the major objective of getting on with science. The Laboratory is designed to provide services to biologists with facilities open to all within the limits of physical space. The early evolution of the Laboratory depended not only on the efforts of scientists, but the growth for the first half century or more was also accomplished with the assistance of funds from individuals and private foundations. Now the pattern has changed. Federal funds are needed in larger proportion, and the research facilities of our sister institutions, the universities and colleges of the world, have expanded enormously over what they were many years ago. Clearly there is a continued and enhanced need to look to the future—to insure that the MBL continues to serve its fundamental purposes.

The new facilities, the Loeb Building and the new dining-dormitory complex, allow us to stretch our active calendar in a way that was not possible before. Particularly, the MBL can now truly cooperate with neighboring institutions of higher learning by making available superb seaside facilities for year around courses of instruction and advanced training. The fine effort by Boston University (Boston University Marine Program) has provided a valuable model for such type of service we can render.

During the forthcoming season, plans will be developed to enhance the scope of activity of the MBL and to seek stable financing. We are indeed fortunate that Dr. James D. Ebert, Director-Designate, has assumed major responsibility for developing these forward-looking plans.

During the 1969 season, Dr. Case undertook the direction of the zoology course (Experimental Invertebrate Zoology), and Dr. Siegelman, the botany course (Experimental Botany). Both courses, under the new directors, achieved exemplary levels of innovation. Also, Dr. Adelman managed a most successful training program in Excitable Membrane Physiology and Biophysics. During the 1969 season, plans were made by Drs. Bennett and Dowling for the new course in neurobiology, and that program is demonstrating the imaginative approaches which we cherish at the MBL.

It is, of course, impossible to make any proper institutional assessment of the scientific advances made by independent investigators during their stay at MBL. The benefits of work here include not only research done in residence, but also ideas exchanged and new viewpoints generated. What can be said with great assurance is that the level of intellectual activity was clearly visible and was good.

A fine illustration of the potentialities of the MBL for extended season work occurred during this past year. Dr. Summers, in charge of our squid survey program, was able to provide squid to Dr. Adelman well on into the late fall. The squid were taken as a part of the ecological survey, and proved to be fine, healthy animals. It is now definitely established that squid users could be provided with animals throughout the year except during a few of the worse winter months. Thus squid join the ranks of other familiar organisms which are available to investigators on a year around basis.

The Systematics-Ecology Program

This program has celebrated its eighth anniversary. Well over a hundred major publications have appeared from work within or sponsored by the Program. Of special interest to the MBL in general has been the "Keys to Marine Invertebrates," of which nearly five thousand copies have been distributed through the Supply Department.

During the eight years of growth, 33 visiting investigators have been on deck, with 24 postdoctoral fellows and 16 graduate trainees. Field sampling for the biotic census of Cape Cod Bay has been completed, and the analysis of the results is proceeding. Staff members have contributed assistance to the Boston University Marine Program.
REPORT OF THE DIRECTOR

and to other visiting groups. The record of accomplishment of this innovative venture is very refreshing indeed and the program may well serve as one model for future year around development of our activities.

The future of the MBL is bright. The problems looming ahead are challenges, not obstacles. We welcome Dr. James Ebert as incoming Director and wish him well.

1. MEMORIAL

ALBERT TYLER

BY CHARLES B. METZ

Albert Tyler’s sudden and untimely death on November 9, 1968 ended a distinguished career in developmental biology and a long association with the Marine Biological Laboratory. Albert Tyler was born in Brooklyn, New York on June 26, 1906. He began his higher education as a chemistry major at Columbia University, where he soon came under the influence of T. H. Morgan. Upon completion of the bachelor’s degree in 1927, he became Morgan's graduate student. He obtained the master’s degree at Columbia in 1928 and then moved to the California Institute of Technology with Morgan where he received a combined biology and chemistry Ph.D. in 1929. He was then appointed to the Institute’s faculty and rose through the ranks to the professorship of embryology which he held the rest of his life. Tyler and Morgan were close friends and scientific colleagues for the remainder of Morgan’s life. Both men were highly imaginative, novel and wide-ranging in their thinking and interests. Their special concerns were problems of developmental and marine biology. This last interest almost certainly originated from Morgan’s experiences as a student at the Annisquam Marine Laboratory the summer of 1886 and led to his long association with its immediate successor, the Marine Biological Laboratory. In due course Morgan transmitted his interest in marine organisms and the Marine Biological Laboratory to Albert Tyler.

Albert Tyler’s direct association with the Marine Biological Laboratory began the summer of 1926, following his junior year at Columbia. He was then listed as a Beginning Investigator at the Laboratory, a status he held each summer until 1929 when he was promoted to Independent Investigator. He was elected to Corporation Membership in 1931, served as an Instructor in the Embryology Course from 1946 through 1950, a Trustee of the Laboratory from 1948 to 1962 and a member of the Editorial Board of the Biological Bulletin from 1951 through 1954. His concern for the Laboratory and his influence on many of its activities were very great.

Albert Tyler was one of the leaders in the transition from classical experimental embryology to the molecular biology of development of the present decade. He was almost uniquely equipped for this role with his strong training in the physico-chemical sciences coupled with the very best possible instruction in classical genetics, cytology and developmental biology obtained from T. H. Morgan, E. B. Wilson and others at the time when these subjects were at their peak. Albert Tyler’s first research was performed here at the Marine Biological Laboratory and followed the classical tradition. It concerned the production of double embryos in annelids and molluscs. Two papers and his Ph.D. thesis resulted from this work. His first officially recorded seminar at the Marine Biological Laboratory was delivered in 1931 on the subject of artificial parthenogenesis in the eggs of the Pacific Coast echinoid, *Urechis caupo*. Shortly, however, his interests turned to more dynamic aspects of development. This was reinforced during the year 1932–33 while a National Research Council Postdoctoral Fellow in Warburg’s Laboratory and at the Zoological Station at Naples. This new line of investigation concerned the energetics of development and particularly the energy
requirements for form changes in the embryo. The first paper in this series appeared in 1933 and the work is now regarded as a classical application of physico-chemical principles to the study of developmental processes. This research led to studies on metabolic changes and particularly the increase in respiration that follows fertilization in sea urchin eggs. In the late 1930's Albert Tyler and several of his colleagues including S. H. Emerson, L. C. Pauling and A. H. Sturtevant recognized that the modern immuno-chemistry, then emerging, had significance for several biological disciplines and could also provide tools for study of other fundamental problems. Albert Tyler took this as an opportunity to explore the macro-molecular events of fertilization and development in a more modern and rigorous fashion. These studies and their offshoots held his interest for the next 20 years.

His investigations on fertilizin and antifertilizin modernized F. R. Lillie's antigen-antibody analogy, and extended our knowledge of fertilizin and antifertilizin chemistry, specificity, mechanism of interaction and role in fertilization. He investigated specific egg membrane lysins from spermatozoa of molluscs. These substances clearly can contribute to fertilization specificity and certainly are essential to provide a passage for the spermatozan to the egg surface. In collaboration with Harry Grundfest and Alberto Monroy here at the Marine Biological Laboratory he demonstrated a resting potential and a change in potential at fertilization in the echinoderm egg. Later, electron microscope studies on sperm-egg interaction resulted in provocative theories to relate the ultrastructural observations to the role of fertilizin and antifertilizin in fertilization.

Characteristically, he introduced many conceptual and experimental novelties into his work. For example, to study the role of antigens in fertilization he developed a method for preparing non-agglutinating and non-precipitating antibodies by photo-oxidation some fourteen years before the discovery of enzymatic digestion methods for preparing univalent antibodies. His studies on sea urchins led him to formulate an autoantibody theory of cell structure which he proceeded to test by examining for specific complementary substances in pneumococci and for antivenom production in Gila monsters. Later he published a theory of cancer and, as usual, undertook extensive laboratory tests, in this case with mice. But problems of fertilization and reproductive physiology commanded his major interest during this period. His precise thinking and laboratory skill set the standard for all who worked in this field.

During the last ten years Albert Tyler concentrated on the molecular biology of fertilization and development. He was among those who first provided evidence that messenger RNA must be present in an inactive or "masked" form in the unfertilized sea urchin egg and he early appreciated that such stored informational RNA might constitute the classical "formative substances" responsible for determination in the egg. This began an intensive study of the nucleic acids of the egg including cytoplasmic DNA and the mechanism of activation of protein synthesis at fertilization. These investigations were cut off when, at age 62, Albert Tyler was at the height of his extraordinarily productive career.

The impact of Albert Tyler's published contributions will long endure. Likewise his influence will continue to be significant through the many students, postdoctorals and friends who received training and inspiration from him in his own laboratory, here at the Marine Biological Laboratory, and at other institutions during visits. Even brief visits had a lasting effect on students. This resulted from an extraordinary combination of energy, personality, imagination and immediate transfer of ideas to laboratory tests.

Albert is survived by his wife, Betty, and two sons: James, a successful engineer, and Steven, a graduate student at Santa Barbara. The family ties were very strong, and all shared Albert's enthusiasm for science and participated in it. Betty and James are co-authors on papers with Albert.
Albert Tyler was sought after to organize and chair many symposia and to function in advisory and consultant capacities to government agencies and private foundations. He served as President of the American Society of Naturalists and the Society of General Physiologists. Nevertheless, Albert was always an informal man who abhorred pretense and display. He especially enjoyed small informal gatherings. Here he shared his zest for science through discussion with friends. His many friends here at Woods Hole, as elsewhere, will long remember such discussions and miss the excitement and challenge of Albert’s subtle wit and penetrating mind.

2. The Staff

EMBRYOLOGY

I. Consultant

Everett Anderson, Professor of Biology, University of Massachusetts

II. Instructors

Malcolm S. Steinberg, Professor of Biology, Princeton University, in charge of course
John M. Arnold, Assistant Professor of Cytology, Pacific Biomedical Research Center, University of Hawaii
Max Burger, Associate Professor of Biology, Princeton University
Gary Freeman, Assistant Professor of Biology, University of California at San Diego
Ralph T. Hinegardner, Associate Professor of Biology, University of California at Santa Cruz
Antone Jacobson, Professor of Biology, University of Texas
Hans Lauper, Associate Professor of Zoology, University of Connecticut

III. Lecturers

Lionel Jaffe, Professor of Biology, Purdue University
Raymond Rappaport, Professor of Biology, Union College
Paul B. Weisz, Professor of Biology, Brown University

IV. Laboratory Assistants

Norman A. Granholm, University of Oregon
Robert S. Turner, University of Oregon

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JEAN C. DAN  Fertilization
RALPH T. HINEGARDNER  Echinoderm development: egg to pluteus
RAYMOND RAPPAPORT  Cytokinesis: establishment of the mechanism
RAYMOND RAPPAPORT  Cytokinesis: nature and operation of the mechanism
RALPH T. HINEGARDNER  Echinoderms: life cycle and experimental embryology
LEWIS TILNEY  Microtubules in mesenchyme formation and differentiation in Arbacia
PAUL GROSS  Regulation of macromolecule synthesis I
PAUL GROSS  Regulation of macromolecule synthesis II
A. B. PARDEE  Division of bacterial cells
LIONEL JAFFE  Localization in the developing fucus egg, and the general role of localizing currents
ERIC DAVIDSON  Localization of "morphogenetic factors" in the cytoplasm of animal eggs, and its possible significance
JOHN M. ARNOLD  Normal development of the spiralian embryo
JOHN M. ARNOLD  An analysis of spiralian development
JOHN M. ARNOLD  Development of the cephalopod embryo
JACK COLLIER  Gene transcription during Ilyanassa embryogenesis
HANS LAUFER  Embryonic development in crustacea
HANS LAUFER  Post embryonic development in crustacea
HERBERT OBERLANDER  Effects of insect hormones on imaginal discs in vitro
GARY FREEMAN  The organization of the ascidian egg
IRWIN KONINGSBERG  Clonal development of embryonic myoblasts in vitro
GARY FREEMAN  Metamorphosis and asexual reproduction in ascidians
J. RICHARD WHITTAKER  Pigment cell differentiation in ascidian embryo
ROGER D. MILKMAN  Development and genetics of Botryllus schlosseri
BEATRICE MINTZ  Four-parent mice offer clues about gene control of mammalian differentiation
PAUL B. WEISZ  The significance of larvae

PHYSIOLOGY

I. Consultants

MERKEL K. JACobs, Professor of Physiology, University of Pennsylvania
ALBERT SZENT-GyöRGyi, Director, The Institute for Muscle Research, Marine Biological Laboratory
W. D. McELROY, Director, McColllum-Pratt Institute, The Johns Hopkins University
J. WOODLAND HASTINGS, Professor of Biology, Harvard University

II. Instructors

ANDREW G. SZENT-GyöRGyi, Professor of Biology, Brandeis University, in charge of course
SYDNEY BRENNER, Medical Research Council, Laboratory of Molecular Biology, Cambridge, England
RODERICK K. CLAYTON, Professor of Biophysics, Cornell University
SEYMOUR S. COHEN, Professor of Biochemistry, University of Pennsylvania
HUGH E. HUXLEY, Medical Research Council, Laboratory of Molecular Biology, Cambridge, England
MAURICE SUSSMAN, Professor of Biology, Brandeis University
DAVID A. YPHANTIS, Professor of Biology, University of Connecticut
REPORT OF THE DIRECTOR

III. Special Lecturers

Harlyn Halvorson, Professor of Bacteriology, University of Wisconsin
Shinya Inoué, Professor of Biology, University of Pennsylvania
K. E. Van Holde, Professor of Physical Chemistry, University of Oregon

IV. Staff Associates

Raymond E. Stephens, Department of Biology, Brandeis University
Annemarie Weber, Department of Biochemistry, St. Louis University
Raquel Sussman, Department of Biology, Brandeis University
Peter Newell, Department of Biology, Brandeis University
Eugene Katz, Department of Biology, Brandeis University
Michael Johnson, Department of Biophysics, University of Connecticut
Dennis Roark, Department of Biophysics, University of Connecticut
Walter F. Stafford, III, Department of Biophysics, University of Connecticut
Peter B. Moore, Department of Molecular Biology, Yale University
Darrell Fleischman, Charles F. Kettering Research Laboratory
Celia E. Freda, Department of Therapeutic Research, University of Pennsylvania

V. Research Assistants

Richard Wayne Linck, Department of Biology, Brandeis University
Rita Burki, Department of Biochemistry, St. Louis University
Ellen Rayner, Department of Biology, Brandeis University
B. J. Clayton, Department of Genetics, Development and Physiology, Cornell University
Ellen Streibel, Department of Therapeutic Research, University of Pennsylvania

VI. Laboratory Assistants

Margaret Ketchum, College of Liberal Arts, Boston University
David Sloane Wilson, University of Rochester

VII. Lectures

Andrew G. Szent-Györgyi
  Aspects of chemistry of muscle contraction
  Assembly and organization of the filaments of molluscan muscles

Annemarie Weber
  Control of contraction and relaxation

Raymond E. Stephens
  "All microtubules are equal but some are more equal than others"

David A. Yphantis
  Physical approaches in biochemistry I
  Physical approaches in biochemistry II
  Physical approaches in biochemistry III

Roderick K. Clayton
  Photosynthesis: ancient history: biochemical and evolutionary speculations
  Photosynthesis: breathes there a man with soul so tough, he thinks two systems aren't enough?
  Photosynthesis: the value of absorption and emission spectroscopy

Maurice Sussman
  DNA and RNA in eucaryotic cells: an embarrassment of riches
  The cellular slime molds XLVI
  The cellular slime molds XLVII
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HARLYN HALVORSON  Developmental control in XLVIII
SEYMOUR S. COHEN  Synthesis of phage proteins I
                    Synthesis of phage proteins II
                    Functions of polyamines
HAROLD S. GINSBERG  Synthesis of adenoviruses
HENRY MAHLER  Biogenetic autonomy of yeast mitochondria
RACHMIEL LEVINE  Action of insulin
HUGH E. HUXLEY  X-ray diffraction results on striated muscle
                    Functional implications of muscle structure
IAN R. GIBBONS  Aspects of ciliary movement
SHINYA INOUÉ  Inscrutable fibers of the spindle
RUTH SAGER  What does chloroplast DNA do?
BERNARD D. DAVIS  Ribosome polysome cycle
M. V. L. BENNETT  Central dogma of neurophysiology I
                    Central dogma of neurophysiology II
LAWRENCE B. COHEN  Changes in optical properties of nerves during activity
EDWARD A. KRAVITZ  Biochemical studies on single neurons and preliminary
                    observations on lobster ganglia in long-term culture
RUTH HUBBARD  Chemistry of visual photoreception
RICHARD CONE  Photoreceptor excitation mechanisms
JOHN E. DOWLING  The vertebrate retina: an approachable piece of the brain
ALBERT SZENT-GYÖRGYI  Biology of Donor-Acceptor interactions
ARTHUR PARDEE  Biochemical studies in active transport
J. WOODLAND HASTINGS  The chemistry and biology of excited singlet oxygen
DARRELL FLEISCHMAN  Luminescence and membrane potential in photo-synthetic bacteria
HENRY LINSCHITZ  Kinetic studies of photoreaction in phytochrome, chlorophyll and rhodopsin
ALVIN NASON  Assimilatory nitrate reductase from Neurospora
KEITH R. PORTER  Microtubules in fish chromatophores
L. C. JUNQUIRA  Control mechanism for oxygen release by hemoglobin I
RUTH E. BENESCH  Control mechanism for oxygen release by hemoglobin II
REINHOLDT BENESCH  Control mechanisms I
SYDNEY BRENNER  Control mechanisms II
                Control mechanisms III
ALEX KEYNAN  The outgrowing bacterial endospore as a system for the
                study of unicellular differentiation
JOHN C. ECCLES  Integration of information by cerebellar Purkinje cells
K. E. VAN HOLDE  Pulsed-field electric dichroism of macromolecules
GUIDO GUIDATTI  Structure and function of hemoglobin
KLAUS WEBER  Structure of aspartic transcarbamylase
EUGENE KENNEDY  Membrane structure and function
RICHARD L. SIDMAN  Cell interaction in developing mouse brain
EDWARD A. ADELBERG  DNA transfer and bacterial conjugation
DAVID F. WAUGH  Clotting mechanisms, implants and thrombosis

VIII. SPECIAL SEMINARS

ALAN WEEDS  The light chains of the myosin molecule
JOSEPH ILAN  Translational control of specific mRNA during insect metamorphosis
REPORT OF THE DIRECTOR

EXPERIMENTAL MARINE BOTANY

I. Consultants

STERLING B. HENDRICKS, U. S. Department of Agriculture
WILLIAM S. HILLMAN, Brookhaven National Laboratory
BESSELL KOK, Research Institute for Advanced Studies
JOHAN A. HELLEBUST, Harvard University

II. Instructors

HAROLD W. SIEGELMAN, Plant Biochemist, Brookhaven National Laboratory, in charge of course
TREVOR W. GOODWIN, Professor of Biochemistry, University of Liverpool, England
ROBERT R. L. GUILLARD, Associate Scientist, Woods Hole Oceanographic Institution
FRANK A. LOEWUS, Professor of Biology, State University of New York at Buffalo
JOHN M. OLSON, Biophysicist, Brookhaven National Laboratory
ROBERT T. WILCE, Associate Professor of Botany, University of Massachusetts

III. Special Lecturers

LAWRENCE BOGORAD, Professor of Biology, Harvard University
MARTIN GIBBS, Professor of Biology, Brandeis University
SARAH GIBBS, Associate Professor of Botany, McGill University
LOUIS A. HANIC, Assistant Professor of Botany, Dalhousie University
JOHAN A. HELLEBUST, Associate Professor of Biology, Harvard University
HARVARD LYMAN, Associate Professor of Biology, State University of New York at Stony Brook
GORDON MACLACHLAN, Associate Professor of Botany, McGill University
CARL A. PRICE, Professor of Botany, Rutgers University
JOSEPH RAMUS, Assistant Professor of Biology, Yale University
JEROME SCHIFF, Professor of Biology, Brandeis University

IV. Assistant and Collector

WILLIAM A. MCDANIEL, Botany Department, University of Massachusetts

V. Lectures

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<td>Photochemically-active chromoproteins of plants</td>
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<td>Zonal centrifugation</td>
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<td>J. A. HELLEBUST</td>
<td>Excretion of organics by phytoplankton</td>
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<td>FRANK A. LOEWUS</td>
<td>Structure and biosynthesis of plant cell walls and polysaccharides</td>
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<td>SARAH GIBBS</td>
<td>Autoradiographic studies on RNA synthesis in chloroplasts</td>
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<td>G. MACLACHLAN</td>
<td>Cellulose metabolism in relation to growth</td>
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<td>T. W. GOODWIN</td>
<td>Introduction to the carotenoids, steroids, and related substances</td>
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<td>R. R. L. GUILLARD</td>
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<td>MARTIN GIBBS</td>
<td>Path of carbon in photosynthesis</td>
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<td>L. A. HANIC</td>
<td>Plant cell wall with special reference to the algae</td>
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The role of hydrocarbons in the sea
Chloroplast development
Introduction to the major groups of benthic marine algae
Aspects of the fine structure and developmental morphology of *Pseudogloiothecia* in culture
Euglena II

EXPERIMENTAL INVERTEBRATE ZOOLOGY

I. Consultants

Frank A. Brown, Jr., Morrison Professor of Zoology, Northwestern University
C. Ladd Prosser, Professor of Physiology, University of Illinois
Clark P. Read, Professor of Biology, Rice University
Alfred C. Redfield, Woods Hole Oceanographic Institution
W. D. Russell-Hunter, Professor of Zoology, Syracuse University

II. Instructors

James F. Case, Professor of Biology, University of California, Santa Barbara, in charge of course
Frank M. Fisher, Jr., Associate Professor of Biology, Rice University
David C. Grant, Assistant Professor of Biology, Davidson College
Jonathan P. Green, Assistant Professor of Biology, Brown University
Michael J. Greenberg, Associate Professor of Biology, Florida State University
Robert K. Josephson, Associate Professor of Biology, Case Western Reserve University
Charlotte P. Mangum, Associate Professor of Biology, College of William and Mary
Alan Gelperin, Assistant Professor of Biology, Princeton University

III. Special Lecturers

Edward R. Baylor, Professor of Biology, State University of New York at Stony Brook
W. D. Russell-Hunter, Professor of Zoology, Syracuse University
Mahlon E. Kriebel, State University of New York, Upstate Medical Center
James G. Morin, Harvard University
C. Ladd Prosser, Professor of Physiology, University of Illinois

IV. Laboratory Assistants

Eldon E. Ball, University of California, Santa Barbara
Alan C. Eggleston, University of California, Santa Barbara
Roger C. Halverson, University of California, Santa Barbara

V. Lectures

H. Burr Steinbach
Robert K. Josephson
James F. Case
Frank M. Fisher, Jr.,
David C. Grant
James F. Case

Introduction to the Marine Biological Laboratory
Coelenterata and Ctenophora
The study of invertebrates
Platyhelminthes, Aschelminthes, Nemertea, I and II
The Cape Cod environment
Porifera
REPORT OF THE DIRECTOR

CHARLOTTE P. MANGUM
Annelids

JONATHAN P. GREEN
Arthropoda, I and II

MICHAEL J. GREENBERG
Mollusca

W. D. RUSSELL-HUNTER
Ancestors and archetypes with reference to Neapilina

ALAN Gelperin
Echinodermata

JAMES F. CASE
Protochordata

DAVID C. GRANT
Plankton

FRANK M. FISHER, Jr.,
Cellular mechanisms of ingestion

CHARLOTTE P. MANGUM
Ingestion mechanisms of multicellular animals

C. LADD PROSSER
Digestive physiology

CHARLOTTE P. MANGUM
Respiration: principles

CHARLOTTE P. MANGUM
Thermal adaptation

CHARLOTTE P. MANGUM
Respiration: exchange mechanisms

DAVID C. GRANT
Respiration: transport mechanisms

MICHAEL J. GREENBERG
Community structure and diversity

MICHAEL J. GREENBERG
Circulation: some aspects of hemodynamics including

flow in ciliated tubes

MAHLON E. KRIEBEL
Physiology of the tunicate heart

MICHAEL J. GREENBERG
Circulation: comparative physiology of the heart, ABRM

and other muscles

JONATHAN P. GREEN
Neuroendocrinology of annelids, arthropods and molluscs

Physiology of the arthropod exoskeleton

JAMES F. CASE
Osmoregulation

EDWARD R. BAYLOR
Stimuli associated with feeding behavior and aggregation

of zooplankton in the sea

JAMES F. CASE
Sensory physiology: I

JAMES G. MORIN
Obelia luminescence

JAMES F. CASE
Sensory physiology: II

ROBERT K. JOSEPHSON
Behavior without brains: I. plants, protozoa, and sponges

Behavior without brains: II, cnidarians

Increasing neural complexity in lower metazoa

ALAN Gelperin
Strategies of behavioral physiology

Executive neurons

Complex behavior in simple systems

MARINE ECOLOGY

I. Consultants

MELBOURNE R. CARRIKER, Director, Systematics-Ecology Program

BOSTWICK H. KETCHUM, Woods Hole Oceanographic Institution

EDWIN T. MOUL, Rutgers University

JOHN H. RYTHER, Woods Hole Oceanographic Institution

HOWARD L. SANDERS, Woods Hole Oceanographic Institution

II. Instructors

LAWRENCE B. SLOBODKIN, Department of Biology, State University of New York at

Stony Brook, in charge of course

EDWARD R. BAYLOR, Department of Biology, State University of New York at Stony

Brook
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SUMNER RICHMAN, Department of Biology, Lawrence University
JOHN STEELE, Department of Agriculture and Fisheries, Aberdeen, Scotland
W. ROWLAND TAYLOR, Department of Earth and Planetary Sciences, The Johns Hopkins University and the Chesapeake Bay Institute
EDWARD O. WILSON, Department of Biology, Harvard University

III. SPECIAL LECTURER

LEV FISHERLSON, University of Tel Aviv, Israel

IV. LABORATORY ASSISTANTS

HERMAN F. BOSCH, Department of Earth and Planetary Sciences, The Johns Hopkins University
WAYNE H. BELL, Department of Biology, Middlebury College

V. LECTURES

LAWRENCE SLOBODKIN
Introduction to the course
The politics of ecology
Approaches to ecology
The strategy of evolution

W. ROWLAND TAYLOR
The marine environment I. Chemistry of seawater
The marine environment II. Solar radiation through seawater
Phytoplankton I
Phytoplankton II
Primary productivity

S. KATONA
Zooplankton

SUMNER RICHMAN
Introduction to ecological energetics
Measurement of zooplankton feeding
Factors affecting zooplankton feeding
Feeding of *Calanus* on synchronously growing cultures of diatoms
Bomb calorimetry and respiration

LAWRENCE SLOBODKIN
Predation theory

EDWARD O. WILSON
Animal communication I
Animal communication II
Colonization and species equilibrium I
Colonization and species equilibrium II
Speciation I
Speciation II

JOHN STEELE
North Sea food chains
Chlorophyll and C¹⁴ uptake in sand

R. MITCHELL
Antagonistic interactions between micro-organisms

JOHN STEELE
Pelagic food chains
Oxygen uptake by sand
Benthic food chains
Energy flow in sand
Theoretical models of food chains
An experimental study of a marine food chain
REPORT OF THE DIRECTOR

Edward R. Baylor
Light-stimulated animal behavior
Analysis of behavior by experiment and computer
Cladoceran behavior—stimuli
Cladoceran behavior—hunting and feeding
Plankton patches and sea surface circulation I
Plankton patches and sea surface circulation II

Howard L. Sanders
Edward R. Baylor
Plankton patches and sea surface circulation III

LEV Fishelson
The ecology of coral reefs in the Gulf of Aquaba

SYSTEMATICS-ECOLOGY PROGRAM

The Staff

Director: Melbourne R. Carriker
Resident Systematist (Zoology): Robert P. Higgins
Acting Resident Systematist (Botany): Robert T. Wilce
Resident Ecologist: David K. Young
Assistant Ecologist: Katharine D. Hobson
Curator: Johanna M. Reinhart
Assistant Curator (Gray Museum Herbarium): Joan R. Conway
Technical Field Assistant: Peter J. Oldham
Field Assistant: Francis Doohan
Scientific Illustrators: Ruth von Arx, Susan P. Heller
Captain, R/V A. E. Verrill: James P. Ostergard
Mate, R/V A. E. Verrill: Peter Graham
Administrative Assistants: Hazel W. Fermino, Constance A. Brackett
Program Secretary: Eva S. Montiero
Visitors: Mohamed Hyder, Pierre Lasserre, Barry A. Wade

SEMINARS (winter included)

Karl Banse
Oxygen consumption by the subtidal sea bed and the importance of the macrofauna

John S. Rankin, Jr.
Antarctic benthic communities

Celia R. Haigh
Polygamy in the redwinged blackbird

Norman R. Sinclair
Studies on the heterophyid trematodes Apophallus brevis and A. imperator

Robert R. Hessler
Deep sea isopods
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<td>Sanford A. Moss</td>
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<td>William Gosline</td>
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<td>Tom Fenchel</td>
<td>Aspects of research in interstitial ecology</td>
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<td>James A. Slater</td>
<td>Aspects of biogeography in South Africa</td>
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<td>James R. Sears</td>
<td>Aspects of life history and habitat ecology of sub-littoral benthic marine algae</td>
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<td>Robert A. Murchelano</td>
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<td>David K. Young</td>
<td>Biogenic reworking of marine sediments</td>
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<td>Joanna Z. Page</td>
<td>Control of reproduction in <em>Derbesia</em></td>
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<td>Wesley N. Tiffney, Jr.</td>
<td>Relationship between tree-line and snow cover in the White Mountains, N. H.</td>
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<td>Robert Marak</td>
<td>Determination of peak spawning times of haddock</td>
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<td>Barry A. Wade</td>
<td>Kingston Harbor—a case study in conservation and development</td>
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<td>Lawrence R. McCloskey</td>
<td>Ecology of an echinospira larvae</td>
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<td>Philip B. Robertson</td>
<td>Larval development of scyllarid lobsters</td>
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<td>R. Jack Schultz</td>
<td>Evolution of unisexuality and polyploidy in fish</td>
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<td>Melbourne R. Carriker</td>
<td>Excavation of boreholes by the gastropod <em>Urosalpinx</em>: an analysis by means of light and scanning electron microscopy</td>
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<td>Pierre Lassere</td>
<td>Distribution of meiobenthic oligochaetes as explained by physiological ecology</td>
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<td>Joel O'Connor</td>
<td>Distribution of fishes over natural and sand-filled bottoms in a Long Island estuary</td>
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<td>Norman Holme</td>
<td>Benthos study techniques</td>
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<td>Robert L. Vadas</td>
<td><em>Agarum</em> and the kelp bed community</td>
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<td>Edward L. Bousfield</td>
<td>Adaptive radiation in sand-burrowing amphipod crustaceans</td>
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<td>Victor A. Zullo</td>
<td>Temperate marine faunas: a paleontologist’s view of the present</td>
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<td>Donald C. Rhoads</td>
<td>The use of bivalves as environmental data recorders</td>
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<td>David W. Folger</td>
<td>Land-derived biogenic particulates recovered from surface water and air during two Atlantic crossings</td>
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<td>Lewis A. Hanic</td>
<td>Seaweed farming—problems and solutions</td>
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<td>Ivan Valiela</td>
<td>Invasion and structuring of dung arthropod communities</td>
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<td>Leland W. Pollock</td>
<td>Aspects of the ecology of interstitial tardigrades</td>
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<td>Martin A. Buzas</td>
<td>Foraminiferal densities and environmental variables: the Linear model in marine ecology</td>
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<td>John C. Russ</td>
<td>Characteristics and applications of the scanning electron microscope</td>
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<td>Clay Sassaman</td>
<td>Aspects of temperature and low oxygen adaptations in coelenterates</td>
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<td>M. Patricia Morse</td>
<td>Direct development in the nudibranch mollusc, <em>Coryphella salmonacea</em> Couthouy</td>
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<td>Louise F. Bush</td>
<td>Small marine turbellaria of Cape Cod: some history, comments and questions</td>
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REPORT OF THE DIRECTOR

THE LABORATORY STAFF

Homer P. Smith, General Manager

Miss Jane Fessenden, Librarian
Carl O. Schweidenback, Manager, Supply Department
John J. Valois, Assistant Manager, Supply Department
Frank A. Wildes, Controller

Robert Kahler, Superintendent Buildings and Grounds
Robert Gunning, Assistant Superintendent, Buildings and Grounds
Robert B. Mills, Manager, Department of Research Service

GENERAL OFFICE

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Edward J. Bender
Mrs. Florence S. Butz
Mrs. Colleen P. Hall
Mrs. Ann W. Loomis

Mrs. Vivian I. Manson
Miss Elaine C. Perry
Mrs. Cynthia S. Regan
Miss Mary Tavares

LIBRARY

Mrs. Virginia Brandenburg
Miss Elizabeth A. Brown
David J. Fitzgerald

Mrs. Lenora Joseph
Mrs. Doris Ricker

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John T. Brady
Bernard F. Cavanaugh
Cecil Costa
John V. Day
Manuel P. Dutra
Charles Fuglister
Richard E. Geggatt, Jr.
Donald B. Lehy

Ralph H. Lewis
Russell F. Lewis
Kenneth J. Marks
Stephen A. Mills
Willy M. Neilson
Robert A. Serrano
Frederick E. Thrasher
Frederick E. Ward
Edward J. White

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Gail M. Cavanaugh
Lowell V. Martin

Mrs. Juliette T. Lauzon
Frank E. Sylvia

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Courtney Barber, III
David H. Graham
Robert Hampton
Lewis M. Lawday
Robert O. Lehy

Miss Joyce B. Lima
Eugene Tassinari
Bruno F. Trapasso
John Varao
DINNING HALL AND HOUSING

ROBERT T. MARTIN, Manager, Food Service
NORMAN MICHAUD, Head Chef
MRS. ELIZABETH KUIF, Supervisor, Dining Room
MRS. ELLEN T. NICKELSON, Supervisor, Dormitories
ALAN G. LUNN, Supervisor, Cottage Colony

3. INVESTIGATORS: LILLIE, GRASS AND RAND FELLOWS; STUDENTS

Independent Investigators, 1969

ABRAHAMSON, EDWIN W., Professor of Chemistry, Case Western Reserve University
ADELMAN, WILLIAM J., JR., Professor of Physiology, University of Maryland, School of Medicine
AGARWAL, RAMAN, Research Associate, Florida State University
AKIYAMA, TOYOHIRO, Research Associate, Columbia University
ALLEN, ROBERT DAY, Chairman and Professor, Department of Biological Sciences, State University of New York at Albany
ANDERSON, EVERETT, Professor of Zoology, University of Massachusetts, Amherst
APRIL, ERNEST W., Postdoctoral Fellow, Columbia University
ARMSTRONG, PHILLIP B., Professor of Anatomy, State University of New York, Upstate Medical Center
ARNOLD, JOHN M., Assistant Professor, University of Hawaii
ATKINSON, BURK G., Postdoctoral Research Associate, Florida State University
ATWOOD, K. C., Professor of Microbiology, University of Illinois, Urbana
AUCLAIR, WALTER, Associate Professor, Reuselaer Polytechnic Institute
BAH, ARYA K., Assistant Professor, University of Montreal
BARTLETT, CLEMER K., Research Associate, Tulane University
BAUER, G. ERIC, Assistant Professor, University of Minnesota
BAYLOR, E. R., Professor of Biology and Marine Sciences, State University of New York at Stony Brook
BAYLOR, MARTHA B., State University of New York at Stony Brook
BELAMARICH, FRANK A., Associate Professor, Boston University
BELL, ALLEN L., Assistant Professor, University of Colorado Medical Center
BENAMY, DANIEL A., Research Associate, Columbia University
BENNETT, M. V. L., Professor of Anatomy, Albert Einstein College of Medicine
BIGGERS, JOHN D., Professor of Biology, The Johns Hopkins School of Hygiene and Public Health
BRANDT, PHILIP WILLIAMS, Associate Professor, College of Physicians and Surgeons, Columbia University
BRENNER, SYDNEY, Head of the Division of Molecular Genetics, Medical Research Council, Laboratory of Molecular Biology, Cambridge England
BROWN, FRANK A., JR., Morrison Professor of Biology, Northwestern University
BROWN, JOEL E., Associate Professor of Physiology, Massachusetts Institute of Technology
BORTOFF, ALEXANDER, Associate Professor, State University of New York, Upstate Medical Center
BUCK, JOHN B., Chief, Laboratory of Physical Biology, National Institutes of Health
BURGER, MAX M., Associate Professor of Biology, Princeton University
BUSH, LOUISE, Visiting Investigator in Residence, Systematics-Ecology Program
BUZAS, MARTIN A., Visiting Investigator in Residence, Systematics-Ecology Program
CARNAY, LAURENCE D., Research Associate, National Institutes of Health
CARRIKER, MELBOURNE R., Director, Systematics-Ecology Program
CASE, JAMES F., Professor of Zoology, University of California, Santa Barbara
CASS, ALBERT, Fellow of the Interdepartmental Institute for Neurological Sciences, Albert Einstein College of Medicine
CASSIDY, FR. JOSEPH D., O. P., Assistant Professor of Biology and Honors Professor of Modern Genetics, Providence College and Northwestern University
REPORT OF THE DIRECTOR

CHAMBERS, EDWARD L., Professor of Physiology and Biochemistry, University of Miami
CHAINEV, HOWARD, Chief, Research in Oral Diseases, Veterans Administration Central Office, Washington, D.C.
CHIARANDINI, DANTE T., Research Associate, Columbia University
CHILD, FRANK M., Associate Professor of Biology, Trinity College
CLAYTON, RODERICK K., Professor of Biology and Biophysics, Cornell University
CLEMENT, A. C., Professor of Biology, Emory University
COGNETTI, GOFFREDO, University of Palermo, Italy
COHEN, LAWRENCE B., Assistant Professor of Physiology, Yale University School of Medicine
COHEN, SEYMOUR S., Chairman and Professor, Department of Therapeutic Research, University of Pennsylvania Medical School
COLE, KENNETH S., Staff Member, Laboratory of Biophysics, National Institutes of Health
COLWIN, ARTHUR L., Professor of Biology, Queens College, The City University of New York
COLWIN, LAURA HUNTER, Professor of Biology, Queens College, The City University of New York
COOHER, THOMAS P., Assistant Professor, Veterans Administration Hospital, Leech Farm and University of Pittsburgh Medical School
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CRANE, ROBERT K., Chairman and Professor of Physiology, Rutgers Medical School
DAVIS, JOHN D., Assistant Professor of Biological Sciences, Smith College
DE ROBERTIS, EDUARDO, Professor and Director of Institute, University of Buenos Aires
DUBOFF, GREGORY S., Professor of Experimental Medicine, University of Michigan School of Medicine
EBERT, JAMES, Director and Professor of Embryology, Carnegie Institution of Washington
EDDS, M. V., JR., Professor of Biology, Brown University
FLAVIN, REV. JOHN W., Chairman, Department of Biology, College of the Holy Cross
GABRIEL, MORDECAI L., Chairman and Professor of Biology, Brooklyn College
GERMAN, JAMES, Investigator and Director of Laboratory of Human Genetics, The New York Blood Center
GIBBS, MARTIN, Professor of Biology, Brandeis University
GITLIN, DAVID, Professor of Pediatrics, University of Pittsburgh School of Medicine
GOUDSMIT, ESTHER M., Research Associate, The Johns Hopkins University
GRANT, ROBERT J., Assistant Professor of Biological Sciences, Hunter College
GREEN, JAMES W., Professor of Physiology, Rutgers University
HANDLER, PHILIP, Professor of Biochemistry, Duke University
REPORT OF THE DIRECTOR

HUBBARD, SUSAN BAUR, Marine Biological Laboratory
ISSELBACHER, KURT J., Professor of Medicine, Massachusetts General Hospital
KALLENBACH, JANE C., Associate Professor of Biological Sciences, Mount Holyoke College
KANE, ROBERT E., Assistant Director and Associate Professor Pacific Biomedical Research
Center, University of Hawaii
KEMP, RUDOLPH T., Professor Emeritus of Biology, Vassar College
KESWAN, JOHN, Professor of Biochemistry, Rutgers University
KRANZ, EDWARD A., Professor of Neurobiology, Harvard Medical School
LEVINTHAL, CYRUS, Chairman, Department of Biological Sciences, Columbia University
LOCHHEAD, JOHN H., Professor of Zoology, University of Vermont
MAHER, HENRY R., Professor of Chemistry, Indiana University
MARSHAK, ALFRED, Professor of Experimental Pathology, Tulane University
NACHMANSON, DAVID, Professor of Biochemistry, Columbia University, College of Physicians
and Surgeons
NASATIR, MAIMON, Chairman and Professor of Biology, University of Toledo
OSTERHOUT, MARION L., Marine Biological Laboratory
RAVIN, HERBERT A., Director and Professor of Medicine, Sinai Hospital of Detroit and Wayne
State University
ROSENBLUTH, JACK, Associate Professor of Physiology and Biophysics, New York University
College of Medicine
ROWLAND, LEWIS P., Chairman and Professor of Neurology, University of Pennsylvania
RUBINOW, SOL I., Professor of Biomathematics, Cornell University Medical College
SAGER, RUTH, Professor of Biological Sciences, Hunter College
SCHLESINGER, R. WALTER, Chairman, Department of Microbiology, Rutgers University
SCOTT, ALAN, Professor of Biology, Colby College
SIRLIN, J. L., Associate Professor of Anatomy, Cornell University Medical College
SMELSER, GEORGE K., Director of Eye Research, College of Physicians and Surgeons, Columbia
University
SONNENBLICK, B. P., Professor of Zoology and Radiation Science, Rutgers University
SPECTOR, ABRAHAM, Professor of Ophthalmology, College of Physicians and Surgeons, Columbia
University
SPREMLAKIS, NICK, Professor of Physiology, University of Virginia School of Medicine
STETTEN, DEWITT, JR., Dean and Professor of Experimental Medicine, Rutgers Medical School
STETTEN, MAZIE R., Research Professor of Experimental Medicine, Rutgers Medical School
STRACHEN, ALFRED, Professor of Biochemistry, State University of New York, Downstate Medical
Center
TROTTER, PHILIP J., Interdisciplinary Postdoctoral Fellow, New England Institute, Inc.
VAGELOS, P. ROY, Chairman and Professor of Biochemistry, Washington University School of
Medicine
WAINIO, WALTER, Chairman and Professor of Biochemistry, Rutgers University
WARKS, BYRON H., Chairman and Professor of Microbiology, Yale University
WEISS, LEON, Professor of Anatomy, The Johns Hopkins University Medical School
WHEELER, GEORGE E., Associate Professor of Biology, Brooklyn College
WHITING, ANNA R., Consultant, Biology Division, Oak Ridge National Laboratory
WICKERTMAN, RALPH, Professor of Biology, Temple University
WILSON, T. HASTINGS, Chairman and Professor of Physiology, Harvard Medical School
WITTMAN, JONATHAN B., Professor of Physiology, Albert Einstein College of Medicine
YOW, FRANK W., Professor of Biology, Kenyon College
YONEDA, CHESTER L., Professor of Anatomy, State University of New York, Upstate Medical
Center
ZACKS, SOMEN I., Associate Professor of Pathology, University of Pennsylvania
ZEIDENBERG, PHILLIP, Senior Research Psychiatrist, New York State Psychiatric Institute
ZIPER, DAVID, Assistant Professor of Molecular Biology, Columbia University

Students, 1969

All students listed completed the formal course program, June 16–July 26. Asterisk indicates
students completing post-course research program, July 27–August 30.
ECOLOGY

ARNETT, PATRICIA M., Indiana State University
*BLOOM, STEPHEN A., University of South Florida
BROTHERS, EDWARD B., Scripps Institution of Oceanography
FLESSA, KARL W., Brown University
*OLEYE, LINDA G., Sarah Lawrence College
*PERMEELY, LESTER S., Tufts University School of Medicine
QUICK, FRANK W., JR., University of Louisville
*REX, MICHAEL A., Harvard University
SCHULTZ, JOHN C., University of Chicago
*SHEMEK, RONALD L., Montana State University
*SLOZAK, FRANCES, University of Massachusetts
*WILLIAMS, ERNEST H., JR., Princeton University
WING, DANIEL C., Oberlin College

EMBRYOLOGY

*BACHELER, LEE T., The Johns Hopkins University
*BROYLES, ROBERT H., The Bowman Gray School of Medicine
BUCKLEY, PATRICIA A., University of Virginia
CALLAWAY, EDWARD E., University of California, Davis
*CAMERON, ROBERT A., University of California, Santa Cruz
*CONWAY, ARTHUR F., University of Miami
*DESMOND, MARY E., University of Colorado
GORDON, RICHARD, Columbia University
HENDRICKSON, SCOTT A., Washington University
*HOFMAN, FLORENCE C., University of Wisconsin
KLAYMAN, MICHAEL B., Union College
LIPTON, BRUCE H., University of Virginia
*PACKARD, DAVID S., JR., Louisiana State University
*SENTKOWSKI, ALAN M., The Johns Hopkins University
*SHERMOEN, ANTONY W., Wesleyan University
*THISTLETHWAITE, J. RICHARD, Amherst College
TISCHFELD, JAY A., Yale University
*TOOLE, BRYAN P., Massachusetts General Hospital
*WIESCHAUS, ERIC F., University of Notre Dame
*WOLIN, EDWARD M., Reed College

EXPERIMENTAL BOTANY

*BURR, JUDITH E., Drew University
CAMPBELL, ROBERT M., University of St. Andrews, Scotland
*DINER, BRIAN A., The Rockefeller University
*GROVES, SAMUEL T., Yale University
*HUGHES, GLORIA J., University of Rhode Island
KAMYKOWSKI, DANIEL L., Scripps Institution of Oceanography
*KENT, GRAHAM RONALD, University of Guelph, Canada
*LEVY, CAROLYN A., University of Massachusetts
McCORMICK, JON M., Millersville State College
*MC DANIEL, WILLIAM A., University of Massachusetts
*MOSHIER, SUZANNE E., University of Chicago
*MOSZALA, WALTER J., University of Massachusetts
NELSON, ANDREA L., University of Massachusetts
*OWENS, OLGA V., University of Maryland
REPORT OF THE DIRECTOR

*SPERLING, PATRICIA G., Kent State College
WILLIAMS, NINA S., University of Maryland

PHYSIOLOGY

*ANDREWS, THOMAS G., Jr., College of Physicians and Surgeons, Columbia University
*Bleich, Hermann E., Columbia University
*Brackenbury, Robert W., California Institute of Technology
*Bronk, Burt V., Queens College
*Chambliss, Glenn H., University of Chicago
*Collins, Terry R., Simon Fraser University, Canada
*Daniel, James L., Carnegie-Mellon University
*Epstein, Paul M., University of Massachusetts
*Fleming, Honoree, University of Chicago
*Goldsmith, Melvin, University of Connecticut
*Hsi, Edward S., University of Minnesota
*Kovacs, Mark A., Massachusetts Institute of Technology
*Lehman, William J., Princeton University
*Li, Jade, Bryn Mawr College
*Lucas, Roger C., Illinois Institute of Technology
*Ma0, Chi-Chiang, The Johns Hopkins University
*Messenger, Anne, University of Oregon
*Nist, Cynthia R., The Rockefeller University
*PapY, Terry L., University of Illinois, Urbana
*Rudd, Jennifer N., Wesleyan University
*Spolsky, Christina M., Yale University
*Straley, Susan C., Cornell University
*Szuts, Ete Z., The Johns Hopkins University
*Teichberg, Saul, Columbia University
*Waters, Coreen A., Brandeis University
*Waterston, Robert H., University of Chicago
*Weiss, Howard D., Northwestern University Medical School
*Wood, Donald S., Washington State University
*Wood, Kathleen A., Washington State University
*Yonath, Jacob, Weizmann Institute, Rehovoth

INVERTEBRATE ZOOLOGY

Billingsley, Brynder C., Tougaloo College
Calderola, Patricia, Cornell University
Casaday, George B., Cornell University
Chaiken, Michael B., State University of New York at Stony Brook
Chin, Kenneth W., Columbia University
*Cowan, Philip E., Glasgow University, Scotland
*Donaldson, Sven, New College, Sarasota
*Eggleston, Linda L., Rice University
Ellsworth, Janet P., State University of New York Upstate Medical Center
Fano, Virginia, University of Wisconsin, Madison
*Foelix, Ranier F., National Science Foundation Department of Mental Health, Raleigh
*Goodman, Mark L., University of Massachusetts, Amherst
*Haberfield, Eve C., University of Rhode Island
*Hackett, John T., University of Illinois
*Inhaber, Francine, City College of New York
*Irwin, George H., III, Emory University
*Jungreis, Arthur M., University of Minnesota
*Kahler, George A., III, Rice University
*McArdle, Florence E., Columbia University
4. FELLOWSHIPS AND SCHOLARSHIPS, 1969

The Lucretia Crocker Scholarship:
NINA S. WILLIAMS, Experimental Botany Course

The James Watt Mavor Scholarship:
ROBERT M. CAMPBELL, Experimental Botany Course
PHILIP E. COWAN, Invertebrate Zoology Course

The Edwin Grant Conklin Scholarship:
BRYON P. TOOLE, Embryology Course

5. TRAINING PROGRAMS

FERTILIZATION AND GAMETE PHYSIOLOGY RESEARCH TRAINING PROGRAM

I. INSTRUCTORS
CHARLES B. METZ, University of Miami, Program Chairman
JOHN D. BIGGERS, The Johns Hopkins University
MARCO CRIPPA, University of Palermo, Italy
GERTRUDE W. HINSCH, University of Miami
KURT KÖHLER, University of Montpellier, France
LEONARD NELSON, Medical College of Ohio at Toledo

II. CONSULTANTS
JEAN CLARK DAN, Ochanomizu University, Tokyo
PAUL GROSS, Massachusetts Institute of Technology
CLAUDE VILLEE, Harvard Medical School

III. LABORATORY ASSISTANTS
MARILYN L. CAYER, Electron Microscope Assistant
LAURA HOSKIN, Secretary
FRANCES WOODCOCK, Photographic Assistant

IV. TRAINEES
BUTZEK, JAMES C., Illinois Institute of Technology
CLARK, WALLIS H., University of California, Riverside
CONWAY, CAROLYN M., University of Miami
COOMES, ROGER K., Monkato State College
ELINSON, RICHARD P., Yale University
FENWICK, RAYMOND G., Jr., Miami University
FORTUNE, JOANNE E., Cornell University
HOPPER, JAMES E., University of Wisconsin

* Miyamoto, David M., University of California, San Diego
  * Norelli, Linda K., Bryn Mawr College
  * Odessby, Richard, Harvard University
  * Pezalla, Paul D., University of Minnesota
  * Prior, David J., University of Virginia
  * Ram, Jeffrey L., California Institute of Technology
  * Rehm, Janet N., Scripps Institution of Oceanography
  * Rohrlich, Susannah T., Harvard University
  * Seguin, Lana R., Indiana University
  * Skarf, Barry, The Johns Hopkins University
  * Stam, William C., Jr., Drew University
  * Terebev, Nicholas, State University of New York, Upstate Medical Center
  * Testerman, John K., University of California, Irvine
  * Vacca, Linda Lee, University of Southern California
  * Weston, Joanne, Cornell University
  * Wilson, Samuel, Scripps Institution of Oceanography
  * Weston, Joanne, Cornell University
  * West, Elizabeth M., University of Miami
  * Weston, Joanne, Cornell University
  * Weston, Joanne, Cornell University
  * Weston, Joanne, Cornell University
  * Weston, Joanne, Cornell University
REPORT OF THE DIRECTOR

KOSEK, RICHARD B., Brooklyn College
LAVIN, LORA H., Rosemont College
LEE, HAROLD H., University of Toledo
O’MELIA, ANNE F., Fordham University
SACCO, ANTHONY G., University of Tennessee
SCHROEDER, PAUL C., Washington State University
SHELLEY, THOMAS F., State University of New York, Upstate Medical Center
WEINBERG, ERIC S., The Rockefeller University

V. Lectures

KURT KÖHLER The passage of mRNA from the nucleus to cytoplasm
R. M.IVERSON RNA synthesis during oogenesis and development
W. J. HUMPHREYS Structure and function of cortical granules in invertebrate eggs
C. J. BROKOW Recent studies on sperm mobility
L. E. FRANKLIN The acrosome reaction and sperm penetration in the golden hamster egg
M. CRIPPA Mechanisms of control of ribosomal RNA synthesis during Xenopus oogenesis
MILDRED GORDON Cytochemical analyses of mammalian sperm flagella
J. GALL Differential gene synthesis during oogenesis
H. A. BERN Vertebrate prolactin: a reproductive hormone with non-reproductive beginnings

Excitable Membrane Physiology and Biophysics Training Program

I. Instructors

WILLIAM J. ADELMAN, JR., University of Maryland School of Medicine, Program Chairman
JOHN W. MOORE, Duke University School of Medicine
TOSHIK NARAHASHI, Duke University School of Medicine
YORAM PALTI, Hebrew University, Hadassah Medical School
TOBIAS SCHWARTZ, University of Connecticut

II. Consultants

KENNETH S. COLE, National Institutes of Health
HARRY GRUNDFEST, College of Physicians and Surgeons, Columbia University
LOREN J. MULLINS, University of Maryland School of Medicine
ICHIJI TASAKI, National Institutes of Health

III. Trainees

CALLAHAN, LEO X., University of Maryland
CLEAVES, CAROL ANN, Duke University
DAVIS, DONALD G., University of Pittsburgh
DAWSON, DAVID C., University of Pittsburgh
DE HEMPTINNE, ALEX, Duke University
DI POLO, REINALDO, Harvard University Medical School
ERNAU, MILDRED C., State University of New York at Albany
JENDRASIAK, GORDON L., University of Notre Dame
JONES, CEDRON, Massachusetts Institute of Technology
KORENBROT, JUAN I., The Johns Hopkins University
MCCREEK, DOUGLAS B., University of Connecticut
WAGGNER, ALAN S., University of Oregon

IV. Lectures

H. BURR STEINBACH Introduction
TOBIAS SCHWARTZ The flux equation
The Ussing-Teorell “unidirectional flux ratio”—osmotic equilibrium—the
Staverman reflection coefficient
The Gibbs-Donnan equilibrium
The Goldman equation
Simple diffusion regimes—electrical equivalent circuits
ANNUAL REPORT OF THE MARINE BIOLOGICAL LABORATORY

RAYMOND A. SJODIN
Struction of cell membranes
Diffusion and permeation in cell membranes
Radioactive tracers and analysis of kinetics
Results: nerve, muscle and erythrocytes
Active ion transport

LORIN J. MULLINS
Active transport techniques in squid axons
Active transport: stoichiometry, substrate requirements and electrical consequences
Models for active and passive ion transport
Models for nerve excitation

KENNETH S. COLE
Passive membrane properties I
Passive membrane properties II

C. R. WORTHINGTON
X-ray analysis of nerve myelin

I. STILLMAN
Preparation of synthetic lipid bilayers
K-selective macrocyclic polypeptides

KENNETH S. COLE
Voltage clamp strategy

JOHN W. MOORE
Voltage clamp technique: normal currents
Ionic conductance kinetics: Hodgkin-Huxley equations
Specifications for nerve membrane models

DANIEL L. GILBERT
Fixed surface charges
Varying potential control voltage clamp
Reconstruction of the membrane action potential
Reconstruction of the propagated action potential and excitation phenomena

R. FITZHUGH
Phase-space analysis of nerve models
Dimensional analysis of nerve models

DANIEL L. GILBERT
Internal perfusion of squid axons: techniques

WILLIAM J. ADELMAN
Internal perfusion of squid axons
Internal perfusion: voltage clamp results
Membrane asymmetries

HARVEY FISHMAN
Voltage clamp studies of frog skin

RITA GUTTMAN
Temperature and nerve membrane function

TOSHIRO NARAHASHI
Polyvalent cations in nerve excitation
Membrane conductance and drug action I—tetrodotoxin
Membrane conductance and drug action II—insecticides and tetrathylenammonium

ROBERT L. DE HAAN
Electrical recording from single heart cells isolated in tissue culture

B. HILLE
Voltage clamp studies of frog myelinated axons
Specifications for an ionic channel

LAWRENCE COHEN
Light scattering and birefringence changes during nerve activity

ICHII TASAII
Internal perfusion studies of the squid axon
Electrophysiological properties of excitable membranes
Optical properties of excitable membranes

HARRY GRUNDFEST
Varities of excitable membranes
General ionic requirements for electogenesis
Electric organs

D. E. GOLDMAN
Model making: general principles
Basic physical mechanisms in excitability
Survey of current model systems
A detailed model of membrane excitability

V. WORKSHOPS

PAUL DE WEVER

YORAM FALTI
Isotopic techniques
Digital computer analysis and reconstruction of nerve behavior
## REPORT OF THE DIRECTOR


<table>
<thead>
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<td><strong>Investigators—Total</strong></td>
<td>572</td>
<td>555</td>
<td>590</td>
<td>528</td>
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<td>Independent</td>
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<td>287</td>
<td>313</td>
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<td>Library Reader</td>
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<td>Research Assistants</td>
<td>227</td>
<td>191</td>
<td>199</td>
<td>171</td>
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<td><strong>Students—Total</strong></td>
<td>128</td>
<td>126</td>
<td>132</td>
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<tr>
<td>Invertebrate Zoology</td>
<td>41</td>
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<td>Embryology</td>
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<td>Physiology</td>
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<td>Experimental Botany</td>
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<td>20</td>
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<tr>
<td>Ecology</td>
<td>17</td>
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<td>20</td>
<td>18</td>
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<tr>
<td><strong>Trainees—Total</strong></td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>17</td>
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<tr>
<td><strong>Total Attendance</strong></td>
<td>734</td>
<td>710</td>
<td>738</td>
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<tr>
<td>Less persons represented in two categories</td>
<td>4</td>
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<td>4</td>
<td>7</td>
<td>5</td>
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<td><strong>Institutions Represented—Total</strong></td>
<td>730</td>
<td>710</td>
<td>734</td>
<td>660</td>
<td>703</td>
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<tr>
<td><strong>Foreign Institutions Represented</strong></td>
<td>218</td>
<td>198</td>
<td>177</td>
<td>169</td>
<td>187</td>
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</table>

### 7. Institutions Represented, 1969

- Albany Medical School
- Albert Einstein College of Medicine
- American Museum of Natural History
- Aquarium Systems, Inc.
- Barnard College
- Baylor University College of Medicine
- Boston University
- Brandeis University
- Brookhaven National Laboratory
- Brooklyn College, The City University of New York
- Brown University
- Bryn Mawr College
- California Institute of Technology
- California, University of, Berkeley
- California, University of, Davis
- California, University of, Irvine
- California, University of, Los Angeles
- California, University of, Riverside
- California, University of, San Diego
- California, University of, San Francisco
- California, University of, Santa Barbara
- California, University of, Santa Cruz
- Carnegie Institution of Washington
- Case Western Reserve University
- Case Western Reserve University Medical School
- Chicago, University of
- Children's Cancer Research Foundation
- Cincinnati, University of
- City College of New York, The
- Colby College
- College of the Holy Cross
- College of Physicians and Surgeons, Columbia University
- College of William and Mary
- Colorado, University of, Colorado
- University of, Medical Center
- Columbia University
- Columbia University, College of Physicians and Surgeons
- Connecticut, University of
- Connecticut, University of, Health Center
- Connecticut, University of, Medical School
- Connecticut, University of, School of Pharmacy
- Cornell University
- Cornell University Medical College
- Dartmouth College
- Davidson College
- Delaware, University of
- Drew University
- Duke University
- Duke University Medical Center
- Emory University
- Florida, University of
- Florida State University
- Fordham University
- George Washington University School of Medicine
- Goucher College
<table>
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<tr>
<th>Harvard Medical School</th>
<th>New York Blood Center, The</th>
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<tr>
<td>Harvard University</td>
<td>New York State Psychiatric Institute</td>
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<tr>
<td>Hawaii, University of</td>
<td>New York University</td>
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<tr>
<td>Hudson Valley Community College</td>
<td>New York University College of Dentistry</td>
</tr>
<tr>
<td>Hunter College</td>
<td>New York University Medical College</td>
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<tr>
<td>Illinois, University of</td>
<td>New York University School of Medicine</td>
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<tr>
<td>Illinois Institute of Technology</td>
<td>North Carolina, University of</td>
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<td>Indiana State University</td>
<td>North Carolina State University, Raleigh</td>
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<td>Indiana University</td>
<td>North Dakota, University of</td>
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<tr>
<td>Institute for Cancer Research, The</td>
<td>Northeastern Illinois State College</td>
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<td>Institute for Muscle Research, The</td>
<td>Northwestern University</td>
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<tr>
<td>Institute of Molecular Evolution, University of Miami</td>
<td>Northwestern University Medical School</td>
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<td>Institute of Psychiatric Research, Indiana University Medical Center</td>
<td>Notre Dame, University of</td>
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<tr>
<td>Iowa, University of</td>
<td>Oak Ridge National Laboratory</td>
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<td>John Carroll University</td>
<td>Oberlin College</td>
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<td>Johns Hopkins University, The</td>
<td>Ohio Dominican College</td>
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<td>Johns Hopkins University, The, School of Hygiene</td>
<td>Oklahoma, University of</td>
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<td>Johns Hopkins University, The, School of Medicine</td>
<td>Oregon, University of</td>
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<td>Juniata College</td>
<td>Oregon State University</td>
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<tr>
<td>Kansas, University of</td>
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<td>Kent State College</td>
<td>Pennsylvania, University of, School of Medicine</td>
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<td>Kentucky, University of</td>
<td>Pennsylvania Hospital</td>
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<td>Kenyon College</td>
<td>Pittsburgh, University of</td>
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<td>Kettering, Charles F., Research Laboratory</td>
<td>Pittsburgh, University of, School of Medicine</td>
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<td>Princeton University</td>
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<td>Lawrence University</td>
<td>Providence College</td>
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<td>Queens College, The City University of New York</td>
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<td>Maryland, University of</td>
<td>Renssela Polytechnic Institute</td>
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<td>Massachusetts General Hospital</td>
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<td>Medical College of Ohio at Toledo</td>
<td>Rochester, University of, Medical School</td>
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<td>Rutgers University</td>
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<td>St. Louis University</td>
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<td>Michigan, University of</td>
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<td>Michigan State University</td>
<td>Scripps Institution of Oceanography</td>
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<td>Millersville State College</td>
<td>Simon Fraser University</td>
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<td>Minnesota, University of</td>
<td>Sinai Hospital of Detroit</td>
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<tr>
<td>Monmouth State College</td>
<td>Sloan-Kettering Institute for Cancer Research</td>
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<td>Montana State University</td>
<td>Smith College</td>
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Toronto, University of, Canada
Weizmann Institution, Israel

8. Friday Evening Lectures, 1969

July 4
TREVOR W. GOODWIN.............. Stereospecific studies on biosynthesis of carotenoids and sterols in plants
University of Liverpool

July 11
JEAN CLARK DAN.............. The acrosomal process membrane
Ochanomizu University, Tokyo
Lillie Fellow at the MBL

July 17
EDUARDO DE ROBERTIS.............. Synthesis, storage and release of transmitter substances
University of Buenos Aires
Alexander Forbes Lecturer at MBL
Senior Grass Fellow at the MBL

July 18
EDUARDO DE ROBERTIS.............. Isolation and nature of chemical receptors

July 25
JOHN H. STEELE.............. Experimental studies of marine food chains
Marine Laboratory
Aberdeen, Scotland
August 1
Hugh E. Huxley .......... The design requirements of striated muscle
Medical Research Council
Cambridge, England

August 8
Martin Lindauer .......... Learning and forgetting in honeybees
University of Frankfurt, Germany
Rand Fellow at the MBL

August 15
J. Woodland Hastings .... Living light: biochemical mechanisms and bio-
Harvard University logical function of bioluminescence

August 22
Sydney Brenner .......... Prospects for the complete analysis of the ner-
Medical Research Council vous system of nematodes
Cambridge, England

9. Tuesday Evening Seminars, 1969

July 15
S. Yuyama ................ Temperature—pressure effects on RNA syn-
Arthur M. Zimmerman thesis in synchronized Tetrahymena
Haruo Kanatani ............... Effects of adenine derivatives on oocyte matura-
tion and spawning in starfish
Arlene C. Schmeer, O.P. ... Mercenaria (clam) extracts: effect on hela
cytokinetics
Catherine Henley .......... The 9 + 1 pattern of microtubules in sperma-
tozoa of certain Turbellaria
D. P. Costello
M. B. Thomas
W. D. Newton

July 22
Roger Milkman .......... An exact study of polygenic variation in natural
populations
A. M. Jungreis .......... Changes in metabolite regulation as functions of
acclimation temperature, starvation and sea-
son in the frog Rana pipiens
L. T. Graham, Jr. ......... Dark adaptation: its influence on GABA in
frog retina, in vivo

July 29
Seymour Zigman .......... Variations in lens insoluble protein
R. Rodewald .......... Selective antibody transport in the proximal
small intestine of the neonatal rat
P. G. Sokolove .......... Role of sodium pump in stretch receptor adapta-
tions
John D. Palmer .......... Preliminary findings on the effect of D2O on the
H. B. Dowse period of circadian activity rhythms
August 5

W. J. Deal ....................... Photoregulation of bioelectricity by photochromic acetylcholine receptor inhibitors

Henry G. Mautner ............... Studies of the conformation of small molecules acting on acetylcholine receptors

E. Shefter ......................... Some properties of junctional cilia in molluscan gills

August 12

F. C. G. Hoskin .................... Possible significance of "DFP-ASE" in squid nerve

Tobias L. Schwartz ............... The Goldman equation: its constraints and its applicability in the face of electrogenic and non-electrogenic pumps

A. L. Pearlman ..................... Color opponent cells in cat lateral geniculate nucleus

N. W. Daw .......................... Application of continuous particle electrophoresis for the separation of lipoproteins having melanin-dispersing activity from eyestalks of fiddler crabs (Uca pugilator)

10. Members of the Corporation, 1969

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REPORT OF THE DIRECTOR

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VILLEE, Dr. CLAUDE A., Department of Biochemistry, Harvard Medical School, Boston, Massachusetts 02115

VINCENT, Dr. WALTER S., Department of Anatomy, University of Pittsburgh, Pittsburgh, Pennsylvania 15213

WAINIO, Dr. W. W., Bureau of Biological Research, Rutgers University, New Brunswick, New Jersey 08903

WALD, Dr. GEORGE, Biological Laboratories, Harvard University, Cambridge, Massachusetts 02138

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WINTERS, Dr. ROBERT WAYNE, Department of Pediatrics, Columbia University, College of Physicians and Surgeons, New York, New York 10032
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ZINN, Dr. DONALD J., Department of Zoology, University of Rhode Island, Kingston, Rhode Island 02881
ZIRKLE, Dr. RAYMOND E., Department of Biophysics, University of Chicago, Chicago, Illinois 60637
ZORZOLI, Dr. ANITA, Department of Physiology, Vassar College, Poughkeepsie, New York 12601
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Gifford, Dr. and Mrs. Prosser
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LOVELL, MR. AND MRS. HOLLIS R.
LOWENGARD, MRS. JOSEPH
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MACK, DR. AND MRS. EDWARD F., JR.
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MARVIN, DR. DOROTHY
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NICHOLS, MRS. GEORGE
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NORMANDIE FOUNDATION INC.
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PARK, MR. MALCOLM S.
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The space problem in the stack area of the library has been solved temporarily. The reprints have been compressed and will be placed in the basement stack leaving no room for expansion. One entire floor of stacks is now available to the serials section, relieving the growth situation for the next few years. Unfortunately this move means that we will be unable to accept any reprints until more floor area is added to the library.

During 1969 we received 4563 requests for articles contained in the library. We made 370 requests to other libraries for use by investigators here. 2,076 volumes were sent to the bindery and holdings now total 140,111. This figure does not include the reprint collection.

Total Number of Serial Titles ................................................. 4,054
Number received currently ............................................... 2,384

(On subscription .................................................. 958
On exchange ......................................................... 981
On gift basis .......................................................... 365)

Number of text books added ............................................. 302
(Received from book exhibit ........................................ 160)

Reprints added in 1969 ..................................................... 1,106
VI. REPORT OF THE TREASURER

The market value of the General Endowment Fund and the Library Fund at December 31, 1969, amounted to $2,197,603 and the corresponding securities are entered in the books at a value of $1,574,735. This compares with values of $2,403,484 and $1,575,096, respectively, at the end of the preceding year. The average yield on the securities was 4.37% of the market value and 6.09% of the book value. Uninvested principal cash was $1,104. Classification of the securities held in the Endowment Fund appears in the Auditor's Summary of Investments.

The market value of the Pooled Securities at December 31, 1969, amounted to $763,700 as compared to book values of $634,152. These figures compare with values of $824,502 and $666,202, respectively, at the close of the preceding year. The average yield on the securities was 3.57% of the market value and 4.30% of the book value. Uninvested principal cash was in the amount of $447.

The proportionate interest in the Pool Fund Account of the various funds, as of December 31, 1969, is as follows:

<table>
<thead>
<tr>
<th>Fund</th>
<th>Proportionate Interest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pension Funds</td>
<td>23.048%</td>
</tr>
<tr>
<td>General Laboratory Investment</td>
<td>20.659%</td>
</tr>
<tr>
<td>F. R. Lillie Memorial Fund</td>
<td>2.252%</td>
</tr>
<tr>
<td>Anonymous Gift</td>
<td>.772%</td>
</tr>
<tr>
<td>Other:</td>
<td></td>
</tr>
<tr>
<td>Bio Club Scholarship Fund</td>
<td>.587%</td>
</tr>
<tr>
<td>Rev. Arsenius Boyer Scholarship Fund</td>
<td>.709%</td>
</tr>
<tr>
<td>Gary N. Calkins Fund</td>
<td>.671%</td>
</tr>
<tr>
<td>Allen R. Memhard Fund</td>
<td>.129%</td>
</tr>
<tr>
<td>Lucretia Crocker Fund</td>
<td>2.438%</td>
</tr>
<tr>
<td>E. G. Conklin Fund</td>
<td>.411%</td>
</tr>
<tr>
<td>Jewett Memorial Fund</td>
<td>.217%</td>
</tr>
<tr>
<td>M. H. Jacobs Scholarship Fund</td>
<td>.294%</td>
</tr>
<tr>
<td>Herbert W. Rand Fellowship</td>
<td>20.834%</td>
</tr>
<tr>
<td>Mellon Foundation</td>
<td>9.835%</td>
</tr>
<tr>
<td>Mary Rogick Fund</td>
<td>2.157%</td>
</tr>
<tr>
<td>Swope Foundation</td>
<td>5.412%</td>
</tr>
<tr>
<td>Clowes Fund</td>
<td>9.575%</td>
</tr>
</tbody>
</table>

Donations from MBL. Associates for 1969 amounted to $9,246 as compared with $8,360 for 1968. Unrestricted gifts from foundations, societies and companies amounted to $18,065.

During the year we administered the following grants and contracts:

<table>
<thead>
<tr>
<th>Investigators</th>
<th>Training</th>
<th>MBL Institutional</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 NIH</td>
<td>3 NIH</td>
<td>2 NIH</td>
</tr>
<tr>
<td>3 NSF</td>
<td>1 NSF</td>
<td>2 NSF</td>
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<tr>
<td>1 ONR</td>
<td></td>
<td>1 AEC</td>
</tr>
<tr>
<td>1 Whitehall</td>
<td></td>
<td>1 Ford</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6</td>
</tr>
</tbody>
</table>
An overhead rate of 20% of allowable direct costs was still in effect for most federally funded research grants at the beginning of the year, but this rate was generally superseded by the new rate of 25% which had been negotiated. However, Federal grants now require a cost sharing contribution by the Laboratory to research projects, usually at a rate of about 5%. An indirect cost rate based on the laboratory space allocated for a research project has now been negotiated with the federal agencies, for grants initiated after August 1, 1969.

The following is a statement of the auditors:

To the Trustees of the Marine Biological Laboratory, Woods Hole, Massachusetts

We have examined the balance sheet of Marine Biological Laboratory as at December 31, 1969, the related statement of operating expenditures and income and statement of funds for the year then ended. Our examination was made in accordance with generally accepted auditing standards, and accordingly included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances. We examined and have reported on financial statements of the Laboratory for the year ended December 31, 1968.

In our opinion, the accompanying financial statements present fairly the assets, liabilities and funds of Marine Biological Laboratory at December 31, 1969 and 1968 and the results of its operations for the years then ended on a consistent basis.

The supplementary schedules included in this report were obtained from the Laboratory's records in the course of our examination and, in our opinion, are fairly stated in all material respects in relation to the financial statements, taken as a whole.

Boston, Massachusetts
March 20, 1970  Lybrand, Ross Bros. and Montgomery

It will be noted from the operating statement that the Laboratory activities for the year under review, amounted to a figure of a little over 1.5 million dollars, which amount is comparable to last year's results.

Alexander T. Daignault,
Treasurer
## Investments

<table>
<thead>
<tr>
<th></th>
<th>1969</th>
<th>1968</th>
</tr>
</thead>
<tbody>
<tr>
<td>Securities, at cost (approximate market quotation 1969—&lt;br&gt;$2,197,603)</td>
<td>$1,574,735</td>
<td>$1,575,096</td>
</tr>
<tr>
<td>Cash</td>
<td>1,104</td>
<td>624</td>
</tr>
<tr>
<td></td>
<td><strong>1,575,839</strong></td>
<td><strong>1,575,720</strong></td>
</tr>
</tbody>
</table>

### Investments of other endowment and unrestricted funds:

<table>
<thead>
<tr>
<th></th>
<th>1969</th>
<th>1968</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pooled investments, at cost (approximate market quotation 1969—&lt;br&gt;$763,700) less $5,728 temporary investment of current fund cash</td>
<td>628,424</td>
<td>660,474</td>
</tr>
<tr>
<td>Other investments</td>
<td>1,474,150</td>
<td>2,282,150</td>
</tr>
<tr>
<td>Cash</td>
<td>447</td>
<td>7,653</td>
</tr>
<tr>
<td>Accounts receivable</td>
<td>33</td>
<td>33</td>
</tr>
<tr>
<td>Due from current fund</td>
<td>61,622</td>
<td>53,276</td>
</tr>
<tr>
<td></td>
<td><strong>$3,740,515</strong></td>
<td><strong>$4,579,306</strong></td>
</tr>
</tbody>
</table>

### Plant Assets

<table>
<thead>
<tr>
<th></th>
<th>1969</th>
<th>1968</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land, buildings, library and equipment</td>
<td>6,072,007</td>
<td>5,732,782</td>
</tr>
<tr>
<td>Less allowance for depreciation (note 1)</td>
<td>1,802,581</td>
<td>1,711,311</td>
</tr>
<tr>
<td></td>
<td><strong>4,269,426</strong></td>
<td><strong>4,021,471</strong></td>
</tr>
<tr>
<td>Construction in progress</td>
<td>3,758,341</td>
<td>1,316,468</td>
</tr>
<tr>
<td>Investments at cost (approximate market quotation 1969—$527,106)</td>
<td>707,327</td>
<td>842,629</td>
</tr>
<tr>
<td>Due from current funds</td>
<td>13,401</td>
<td>38,531</td>
</tr>
<tr>
<td></td>
<td><strong>$8,784,495</strong></td>
<td><strong>$6,219,099</strong></td>
</tr>
</tbody>
</table>

### Current Assets

<table>
<thead>
<tr>
<th></th>
<th>1969</th>
<th>1968</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cash</td>
<td>163,471</td>
<td>251,061</td>
</tr>
<tr>
<td>Temporary investment in pooled securities</td>
<td>5,728</td>
<td>5,728</td>
</tr>
<tr>
<td>Accounts receivable (U. S. Government, 1969—$52,391; 1968—$33,824)</td>
<td>137,757</td>
<td>130,503</td>
</tr>
<tr>
<td>Inventories of supplies and bulletins</td>
<td>45,593</td>
<td>47,036</td>
</tr>
<tr>
<td>Other assets</td>
<td>6,619</td>
<td>7,146</td>
</tr>
<tr>
<td>Due to plant funds</td>
<td>(13,401)</td>
<td>(38,531)</td>
</tr>
<tr>
<td>Due to endowment funds</td>
<td>(61,622)</td>
<td>(53,276)</td>
</tr>
<tr>
<td></td>
<td><strong>$ 284,145</strong></td>
<td><strong>$ 349,667</strong></td>
</tr>
</tbody>
</table>
### Invested Funds

<table>
<thead>
<tr>
<th>Description</th>
<th>1969</th>
<th>1968</th>
</tr>
</thead>
<tbody>
<tr>
<td>Endowment funds given in trust for benefit of the Marine Biological Laboratory</td>
<td>$1,575,839</td>
<td>$1,575,720</td>
</tr>
<tr>
<td>Endowment funds for awards and scholarships:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Principal</td>
<td>427,663</td>
<td>427,663</td>
</tr>
<tr>
<td>Unexpended income</td>
<td>44,630</td>
<td>39,394</td>
</tr>
<tr>
<td>Unrestricted funds functioning as endowment</td>
<td>1,528,190</td>
<td>2,336,190</td>
</tr>
<tr>
<td>Retirement fund</td>
<td>217,433</td>
<td>192,543</td>
</tr>
<tr>
<td>Pooled investments—accumulated (loss) gain</td>
<td>(53,240)</td>
<td>7,796</td>
</tr>
<tr>
<td></td>
<td><strong>$3,740,515</strong></td>
<td><strong>$4,579,306</strong></td>
</tr>
</tbody>
</table>

### Plant Funds

<table>
<thead>
<tr>
<th>Description</th>
<th>1969</th>
<th>1968</th>
</tr>
</thead>
<tbody>
<tr>
<td>Funds expended for plant, less retirements</td>
<td>9,598,348</td>
<td>6,886,046</td>
</tr>
<tr>
<td>Less allowance for depreciation charged thereto</td>
<td>1,802,581</td>
<td>1,711,311</td>
</tr>
<tr>
<td>Accounts payable</td>
<td>240,001</td>
<td>163,204</td>
</tr>
<tr>
<td>Unexpended plant funds</td>
<td>712,727</td>
<td>881,160</td>
</tr>
<tr>
<td></td>
<td><strong>$8,748,495</strong></td>
<td><strong>$6,219,099</strong></td>
</tr>
</tbody>
</table>

### Current Liabilities and Funds

<table>
<thead>
<tr>
<th>Description</th>
<th>1969</th>
<th>1968</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accounts payable and accrued expenses</td>
<td>56,419</td>
<td>44,737</td>
</tr>
<tr>
<td>Advance subscriptions</td>
<td>30,141</td>
<td>23,712</td>
</tr>
<tr>
<td>Unexpended grants—research</td>
<td>33,918</td>
<td>25,727</td>
</tr>
<tr>
<td>Unexpended balances of gifts for designated purposes</td>
<td>23,278</td>
<td>23,764</td>
</tr>
<tr>
<td>Current fund</td>
<td>140,389</td>
<td>231,727</td>
</tr>
<tr>
<td></td>
<td><strong>$284,145</strong></td>
<td><strong>$349,667</strong></td>
</tr>
</tbody>
</table>

Note 1—During the current year the Laboratory reduced the estimated useful lives of certain plant assets. This change had the effect of increasing depreciation expense for 1969 by approximately $43,000. Depreciation charges remain, however, from 1% to 5% of the original cost of the assets.

Note 2—The Laboratory has commitments of approximately $2,600,000 for the construction of a teaching laboratory and a dormitory dining-hall.
### MARINE BIOLOGICAL LABORATORY

#### Statement of Operating Expenditures and Income

Years Ended December 31, 1969 and 1968

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Instruction</td>
<td>$14,867</td>
<td>$4,885</td>
<td>$19,752</td>
<td>$189,107</td>
<td>$208,859</td>
<td>$217,865</td>
<td></td>
</tr>
<tr>
<td>Research</td>
<td>26,824</td>
<td>59,794</td>
<td>86,618</td>
<td>373,786</td>
<td>460,404</td>
<td>505,637</td>
<td></td>
</tr>
<tr>
<td>Dormitories</td>
<td>$22,893</td>
<td>39,104</td>
<td>29,907</td>
<td>91,904</td>
<td>91,904</td>
<td>69,742</td>
<td></td>
</tr>
<tr>
<td>Dining</td>
<td>20,125</td>
<td>41,491</td>
<td>317</td>
<td>61,933</td>
<td>61,933</td>
<td>61,862</td>
<td></td>
</tr>
<tr>
<td>Library</td>
<td>32,838</td>
<td>13,729</td>
<td>18,336</td>
<td>64,903</td>
<td>64,903</td>
<td>41,900</td>
<td></td>
</tr>
<tr>
<td>Back sets, serials and binding</td>
<td>42,186</td>
<td>42,186</td>
<td></td>
<td>42,186</td>
<td>42,186</td>
<td>37,051</td>
<td></td>
</tr>
<tr>
<td>Biological Bulletin</td>
<td>4,748</td>
<td>41,252</td>
<td></td>
<td>46,000</td>
<td>46,000</td>
<td>40,219</td>
<td></td>
</tr>
<tr>
<td>Support services:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apparatus</td>
<td>49,006</td>
<td>44,776</td>
<td>93,782</td>
<td>10,949</td>
<td>104,731</td>
<td>97,698</td>
<td></td>
</tr>
<tr>
<td>Supply</td>
<td>85,096</td>
<td>54,611</td>
<td>11,945</td>
<td>151,652</td>
<td>151,652</td>
<td>141,744</td>
<td></td>
</tr>
<tr>
<td>Administration</td>
<td>87,150</td>
<td>72,446</td>
<td>159,596</td>
<td>159,596</td>
<td>159,596</td>
<td>147,274</td>
<td></td>
</tr>
<tr>
<td>Plant operation</td>
<td>136,791</td>
<td>91,808</td>
<td>1,991</td>
<td>230,590</td>
<td>230,590</td>
<td>217,867</td>
<td></td>
</tr>
<tr>
<td>Grant expenditures for support services</td>
<td>31,800</td>
<td>31,800</td>
<td></td>
<td>48,875</td>
<td>48,875</td>
<td>43,584</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
<td>31,800</td>
<td>31,800</td>
<td>38,082</td>
<td></td>
</tr>
</tbody>
</table>

| Total                             | $438,647                | $514,894                      | $127,175          | $1,080,716 | $622,717               | $1,703,433 | 1,660,525 |
### Marine Biological Laboratory

#### Statement of Operating Expenditures and Income

Years Ended December 31, 1969 and 1968

#### Income (continued)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Instruction</td>
<td>38,110</td>
<td>38,110</td>
<td>189,107</td>
<td>227,217</td>
<td>233,480</td>
</tr>
<tr>
<td>Research</td>
<td>123,776</td>
<td>123,776</td>
<td>373,786</td>
<td>497,562</td>
<td>544,646</td>
</tr>
<tr>
<td>Dormitories</td>
<td>83,640</td>
<td>83,640</td>
<td>83,640</td>
<td>82,833</td>
<td></td>
</tr>
<tr>
<td>Dining</td>
<td>71,938</td>
<td>71,938</td>
<td>73,135</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Library</td>
<td>16,854</td>
<td>27,654</td>
<td>44,508</td>
<td>46,619</td>
<td></td>
</tr>
<tr>
<td>Biological Bulletin</td>
<td>39,789</td>
<td>39,789</td>
<td>38,451</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Support services:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apparatus</td>
<td>29,429</td>
<td>29,429</td>
<td>10,949</td>
<td>40,378</td>
<td>31,409</td>
</tr>
<tr>
<td>Supply</td>
<td>54,762</td>
<td>54,762</td>
<td>54,762</td>
<td>45,602</td>
<td></td>
</tr>
<tr>
<td>Administration</td>
<td>15,336</td>
<td>15,336</td>
<td>15,336</td>
<td>12,769</td>
<td></td>
</tr>
<tr>
<td>Investments income</td>
<td>230,225</td>
<td>230,225</td>
<td>230,225</td>
<td>244,364</td>
<td></td>
</tr>
<tr>
<td>Gifts used for current expense</td>
<td>34,379</td>
<td>34,379</td>
<td>34,379</td>
<td>13,224</td>
<td></td>
</tr>
<tr>
<td>Allowance for indirect costs</td>
<td>74,958</td>
<td>74,958</td>
<td>74,958</td>
<td>96,482</td>
<td></td>
</tr>
<tr>
<td>Grants for general support</td>
<td>83,911</td>
<td>83,911</td>
<td>83,911</td>
<td>87,644</td>
<td></td>
</tr>
<tr>
<td>Grants for support services</td>
<td></td>
<td></td>
<td>48,875</td>
<td>48,875</td>
<td>43,584</td>
</tr>
<tr>
<td>Other</td>
<td>3,658</td>
<td>3,658</td>
<td>3,658</td>
<td>3,212</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>$178,740</td>
<td>$749,679</td>
<td>$622,717</td>
<td>$1,551,136</td>
<td>$1,597,454</td>
</tr>
</tbody>
</table>

| Excess of current expenditures and depreciation over current income | 152,297 | 152,297 | 63,071 |
| Reduction in plant funds for depreciation                        | 127,175 | 127,175 | 86,613 |

| Excess current expenditures | ($25,122) | ($25,122) | $23,542 |
REPORT OF THE TREASURER

MARINE BIOLOGICAL LABORATORY

STATEMENT OF FUNDS

Year Ended December 31, 1969

<table>
<thead>
<tr>
<th>Balance December 31, 1968</th>
<th>Gifts and Other Receipts</th>
<th>Investment Income</th>
<th>Used or Current Expenses</th>
<th>Other Expenditures</th>
<th>Balance December 31, 1969</th>
</tr>
</thead>
<tbody>
<tr>
<td>Invested funds:</td>
<td>$4,579,306</td>
<td>$31,635</td>
<td>$250,688</td>
<td>$229,997</td>
<td>$3,740,515</td>
</tr>
<tr>
<td>(Unexpended plant funds)</td>
<td>$881,106</td>
<td>223,475</td>
<td>24,688</td>
<td>416,596</td>
<td>$712,727</td>
</tr>
<tr>
<td>(Unexpended research grants)</td>
<td>$25,727</td>
<td>2,254,014</td>
<td>781,586</td>
<td>1,464,237</td>
<td>$33,918</td>
</tr>
<tr>
<td>(Unexpended gifts for designated purposes)</td>
<td>$23,764</td>
<td>7,469</td>
<td>7,068</td>
<td>887</td>
<td>$23,278</td>
</tr>
<tr>
<td>Current fund:</td>
<td>$231,727</td>
<td>808,000</td>
<td>(7,500)</td>
<td>(25,122)</td>
<td>$140,389</td>
</tr>
</tbody>
</table>

| Gifts                      | $230,944                 |
| Grant for facilities construction | 1,464,237           |
| Grants for research, training and support | 789,777        |
| Appropriated from current income and other | 24,135         |
| Net gain on sale of securities |                        |
| (1) Excess of current expenditures over income | 25,122           |
| (2) Gift of boat transferred to plant funds expended |                     |
| (3) Transfer from invested funds |                         |

$2,483,971

Expended for new laboratory and dormitory—dining hall... 2,747,548
Scholarship awards... 8,930
Payments to pensioners... 13,152
Loss on sale of securities... 61,036
Other... 887

$2,831,553
### Summary of Investments

December 31, 1969

<table>
<thead>
<tr>
<th>Securities held by Trustee:</th>
<th>Per Cent of Total</th>
<th>Market Quotations</th>
<th>Per Cent of Total</th>
<th>Investment Income 1969</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cost</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>General endowment fund:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>U. S. Government securities</td>
<td>$ 25,065</td>
<td>2.0</td>
<td>$ 24,325</td>
<td>1.3</td>
</tr>
<tr>
<td>Corporate bonds</td>
<td>711,938</td>
<td>57.4</td>
<td>500,123</td>
<td>28.3</td>
</tr>
<tr>
<td>Preferred stocks</td>
<td>84,771</td>
<td>6.8</td>
<td>69,986</td>
<td>4.0</td>
</tr>
<tr>
<td>Common stocks</td>
<td>419,247</td>
<td>33.8</td>
<td>1,175,447</td>
<td>66.4</td>
</tr>
<tr>
<td></td>
<td>1,241,021</td>
<td>100.0</td>
<td>1,769,881</td>
<td>100.0</td>
</tr>
<tr>
<td>General educational broad endowment fund:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>U. S. Government securities</td>
<td>53,113</td>
<td>15.9</td>
<td>51,569</td>
<td>12.1</td>
</tr>
<tr>
<td>Other bonds</td>
<td>184,745</td>
<td>55.4</td>
<td>134,487</td>
<td>31.4</td>
</tr>
<tr>
<td>Preferred stocks</td>
<td>15,476</td>
<td>4.6</td>
<td>11,753</td>
<td>2.7</td>
</tr>
<tr>
<td>Common stocks</td>
<td>80,380</td>
<td>24.1</td>
<td>229,913</td>
<td>53.8</td>
</tr>
<tr>
<td></td>
<td>333,714</td>
<td>100.0</td>
<td>427,722</td>
<td>100.0</td>
</tr>
<tr>
<td>Total securities held by Trustee</td>
<td>$1,574,735</td>
<td></td>
<td>$2,197,603</td>
<td></td>
</tr>
</tbody>
</table>

**Investments of other endowment and unrestricted funds:**

<table>
<thead>
<tr>
<th>Pooled investments:</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>U. S. Government securities</td>
<td>33,338</td>
<td>5.2</td>
<td>34,000</td>
<td>4.5</td>
</tr>
<tr>
<td>Corporate bonds</td>
<td>134,850</td>
<td>21.3</td>
<td>114,244</td>
<td>15.0</td>
</tr>
<tr>
<td>Preferred stocks</td>
<td>67,040</td>
<td>10.6</td>
<td>56,625</td>
<td>7.4</td>
</tr>
<tr>
<td>Common stocks</td>
<td>398,924</td>
<td>62.9</td>
<td>558,831</td>
<td>73.1</td>
</tr>
<tr>
<td></td>
<td>634,152</td>
<td>100.0</td>
<td>$ 763,700</td>
<td>100.0</td>
</tr>
</tbody>
</table>

**Less temporary investment of current fund cash:**

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>5,728</td>
<td></td>
<td></td>
<td></td>
<td>228</td>
</tr>
<tr>
<td></td>
<td>628,424</td>
<td></td>
<td></td>
<td>27,036</td>
</tr>
</tbody>
</table>

**Other investments:**

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>U. S. Government securities</td>
<td>27,938</td>
<td></td>
<td></td>
<td>1,133</td>
</tr>
<tr>
<td>Other bonds</td>
<td>15,029</td>
<td></td>
<td></td>
<td>750</td>
</tr>
<tr>
<td>Common stocks</td>
<td>49,634</td>
<td></td>
<td></td>
<td>2,697</td>
</tr>
<tr>
<td>Real estate</td>
<td>17,549</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Short-term commercial notes</td>
<td>1,364,000</td>
<td></td>
<td></td>
<td>134,134</td>
</tr>
<tr>
<td></td>
<td>1,474,150</td>
<td></td>
<td></td>
<td>138,714</td>
</tr>
</tbody>
</table>

**Total investments of other endowment and unrestricted funds:**

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$2,102,574</td>
<td></td>
<td></td>
<td></td>
<td>165,750</td>
</tr>
</tbody>
</table>

Total: **261,686**
### Summary of Investments (continued)

**December 31, 1969**

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
<th>Income 1969</th>
</tr>
</thead>
<tbody>
<tr>
<td>Custodian's fees charged thereto</td>
<td>10,998</td>
<td></td>
</tr>
<tr>
<td>Investment income distributed to invested funds</td>
<td></td>
<td>250,688</td>
</tr>
<tr>
<td>Plant investments:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Federal agency and corporate bonds</td>
<td>140,000</td>
<td>7,242</td>
</tr>
<tr>
<td>Common stock</td>
<td>564,456</td>
<td>17,394</td>
</tr>
<tr>
<td>Preferred stock</td>
<td>2,871</td>
<td>52</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>707,327</strong></td>
<td><strong>24,688</strong></td>
</tr>
<tr>
<td>Current investments:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temporary investment in pooled securities</td>
<td>5,728</td>
<td>228</td>
</tr>
<tr>
<td><strong>Total investment income</strong></td>
<td></td>
<td><strong>$275,604</strong></td>
</tr>
</tbody>
</table>