Editors Page

The Central Office still has a few copies of the prints of Past-Presidents pictures as published in the November 1959 issue. Copies of these composites in prints 11 x 14 inches are available at $10.00 per set. These are suitable for framing.

A brochure entitled "A Career in Physiology - Your Challenge and Opportunity" prepared by the Education Committee is now available for distribution. Copies may be secured from the Central Office. Distribution has been made to colleges and universities as well as high school biology teachers.

LETTER TO EDITOR

ELECTRODERMAL PHENOMENA

July 20, 1960

Dear Sir:

In 1888 Féré discovered the sudden decrease in the electric resistance of the skin to sensory or emotional stimulation. Two years later Tarchanoff discovered the sudden change in the electric potential of the skin to the same stimulations. Neither Féré nor Tarchanoff gave a special name to the electric change of the skin they had each discovered. In 1904 Müller rediscovered the change in the electric resistance of the skin and brought it to the attention of Veraguth, who further investigated it and who called it "der psychogalvanische Reflex". In the first 25 years of this century, Gildemeister and his associates made a thorough study of the reflex, especially of its physical basis, and rechristened it "der galvanische Hantreflex". This new name has been literally translated into English as "the galvanic skin reflex". The English form of the name is not entirely satisfactory. The noun "skin" is used as an adjective here, which is permissible in German, but which is not strictly permissible in English. The word "galvanic" has almost dropped out of use in physics. Furthermore, the reflex is only one of the electric changes in the skin. There is a very slow drift of the base line of the galvanometer tracing due to very slow change in the potential or resistance of the skin. There are waves due to 'spontaneous' changes in the potential or resistance of the skin. There is the sudden change in the potential or resistance of the skin caused by stimulation of either sympathetic nerve-fibers in the periphery or a sympathetic center in the central neuraxis. And, lastly, the reflex. A word to include all these four electric changes in the skin is needed. We propose to use the term, "electrodermal phenomena", for the needed all-inclusive word; "the electrodermal reflex" for the galvanic skin reflex or the psychogalvanic reflex; "the electrodermal response" for the galvanic skin response to stimulation of sympathetic nerve fibers or center;

"spontaneous electrodermal waves" for spontaneous changes in potential or resistance of the skin; and "electrodermal drift" for the very slow changes in potential or resistance of the skin. Finally, the record of these four changes may be called "electrodermogram", as Turner of Argentina proposed several years ago.

The six new terms proposed in the preceding paragraph meet a need in this field of physiological investigation. They all are purely descriptive and do not have any connotation regarding the supposed origin or cause of the phenomenon, each of them concerns. "Electrodermal" is put together from two Greek words according to the rules of word-formation in the English language.

However, they cannot be adopted without discussions among workers in this field. Only with the general consent of the workers after thorough discussion can they expect general usage. The electrodermal reflex is almost the only one among autonomic reflexes, that readily admits accurate measurements in terms of standard units. It has just begun to receive the attention of physiologists as it deserves. Now is the time to open a discussion on the nomenclature of the electric changes in the skin.

G. H. Wang

AMERICAN PHYSIOLOGICAL SOCIETY

OFFICERS, 1960-1961

President - Julius H. Comroe, Jr., University of California Medical Center, San Francisco, California
President-Elect - Horace W. Davenport, University of Michigan, Ann Arbor, Michigan
Past-President - Robert F. Pitts, Cornell University Medical College, New York City
Council - Robert F. Pitts, Julius H. Comroe, Jr., Horace W. Davenport, Hymen S. Mayerson, John M. Brookhart, Theodore C. Ruch, Hermann Rahn
Executive Secretary-Treasurer - Ray G. Daggs, 9650 Wisconsin Ave., Washington 14, D.C.
Administrative Advisor - Milton O. Lee, 9650 Wisconsin Avenue, Washington 14, D.C.

STANDING COMMITTEES

Membership Advisory - H. Davis (1963), Chairman; L. M. Beidler, C. F. Code, J. D. Hardy, W. S. Root, R. D. Tschirgi.
Education - J. R. Brobeck (1964), A. W. Martin, Jr. (1961), H. Rahn (1962), C. A. M. Hogben (1963), R. B. Tschirgi (1963); Representatives of Society of General Physiologists - S. R. Tipton (1963), R. R. Ronkin (1963).
Use and Care of Animals - A. B. Otis (1961), Chairman; A. Hemingway (1962), R. Galambos (1963).
Placement of Senior Physiologists - D. B. Dill (1962), Chairman; E. M. Landis (1962), W. O. Fenn (1962), E. F. Adolph (1963).
Porter Fellowship - J. M. Brookhart (1961) Chairman; T. C. Ruch (1962), R. S. Alexander (1963).
Program Advisory - T. C. Ruch (1963) Chairman, with power to co-opt.
International Physiology - W. O. Fenn (1965) Chairman; R. W. Gerard (1961), M. B. Visscher (1963).
Historian - John Field II

REPRESENTATIVES TO OTHER ORGANIZATIONS

American Association for the Advancement of Science - C. McC. Brooks (1961), R. G. Daggs.
American Documentation Institute - M. O. Lee (1961).
American Institute of Biological Sciences - W. O. Fenn (1962).
National Research Council - Division of Biology and Agriculture: J. O. Hutchens (1961); Division of Medical Sciences: R. W. Gerard (1961).
Council on Medical Education and Hospitals, A.M.A. - J. S. Gray (1961).
United States National Committee for the International Union of Physiological Sciences - R. W. Gerard (1963), W. O. Fenn (1965), M. B. Visscher (1963), E. M. Landis (alternate).
Federation Public Information Committee - A. C. Guyton.

Joint (with Pharmacology) Symposium Committee on Neuropharmacology - H. E. Himwich (1961), T. C. Ruch (1961).

EDITORIAL BOARDS

Board of Publication Trustees - Philip Bard (1961) Chairman; Hermann Rahn (1962), H. S. Mayerson (1963).
Managing Editor - M. O. Lee.
Associate Editor, Physiological Reviews - R. G. Daggs.
Secretary of Publications - Sara F. Leslie.
American Journal of Physiology and Journal of Applied Physiology - R. S. Alexander (1961), E. J. Baldes (1962), S. B. Barker (1961), R. W. Berliner (1962), J. R. Brobeck (1962), F. P. Chinard (1962), A. F. Cournand (1962), R. C. DeBodo (1963), W. S. Fowler (1962), A. S. Gilson, Jr. (1963), H. D. Green (1963), Arthur Grollman (1963), A. C. Guyton (1961), H. K. Hartline (1962), A. B. Hastings (1962), E. Henneman (1962), H. E. Himwich (1962), A. Hollaender (1963), L. B. Jaquès (1961), F. H. Johnson (1961), R. E. Johnson (1961), W. J. Kolff (1961), H. C. Lawson (1963), N. Lifson (1963), W. Lotspeich (1963), Jere Mead (1963), G. H. Mudge (1962), E. S. Nasset (1962), H. M. Patt (1963), John Remington (1963), Sidney Roberts (1962), Sid Robinson (1962), J. A. Russell (1963), P. F. Salisbury (1961), S. J. Sarnoff (1961), W. H. Seegers (1962), C. W. Sheppard (1963), Clark West (1963), W. B. Youmans (1963). Consultant Editors - A. Albert (1963), A. C. Burton (1963), J. H. Comroe, Jr. (1961), W. O. Fenn (1962), Alfred Gilman (1962), T. C. Ruch (1961), M. B. Visscher (1962).
Physiological Reviews - H. S. Mayerson (1961) Chairman; C. McC. Brooks (1962), D. J. Ingle (1963), M. G. Larrabee (1963), W. L. Nastuk (1962), A. B. Otis (1961), J. R. Pappenheimer 1962), R. M. Reinecke (1961), J. V. Taggart (1963). Appointees of the Society of General Physiologists - I. M. Klotz (1962), T. H. Bullock (1963). Appointee of the Society of Biological Chemists - DeWitt Stetten (1964). European Editorial Committee - G. Kahlson (1960) Chairman; H. Barcroft (1960), E. M. Crook (1962), A. Fessard (1961), G. Moruzzi (1962).
Annual Review of Physiology - Victor E. Hall, Editor and Chairman; J. M. Brookhart (1961), Clara M. Szego (1962), Hudson Hoagland (1963), Robert Alexander (1964), Richard Riley (1965).
The Physiologist - R. G. Daggs, Editor.

PAST OFFICERS

Presidents - 1888 H. P. Bowditch, 1889-90 S. W. Mitchell, 1891-95 H. P. Bowditch, 1896-1904 R. H. Chittenden, 1905-10 W. H. Howell, 1911-13 S. J. Meltzer, 1914-16 W. B. Cannon, 1917-18 F. S. Lee, 1919-20 W. P. Lombard, 1921-22 J. J. R. MacLeod, 1923-25 A. J. Carlson, 1926-29 J. Erlanger, 1930-32 W. J. Meek, 1933-34 A. B. Luckhardt, 1935 C. W. Greene, 1936-37 F. C. Mann, 1938-39 W. E. Garrey, 1938 W. T. Porter Honorary President, 1940-41 A. C. Ivy, 1942-45 P. Bard, 1946-47 W. O. Fenn, 1948 M. B. Visscher, 1949 C. J. Wiggers, 1950 H. C. Bazett (April to

July) D. B. Dill, 1951 R. W. Gerard, 1952 E. M. Landis, 1953 E. F. Adolph, 1954 H. E. Essex, 1955 W. F. Hamilton, 1956 A. C. Burton, 1957 L. N. Katz, 1958 Hallowell Davis, 1959 R. F. Pitts.
Secretaries - 1888-92 H. N. Martin, 1893-94 W. P. Lombard, 1895-1903 F. S. Lee, 1904 W. T. Porter, 1905-07 L. B. Mendel, 1908-09 R. Hunt, 1910-14 A. J. Carlson, 1915-23 C. W. Greene, 1924-29 W. J. Meek, 1930 A. C. Redfield, 1931-32 A. B. Luckhardt, 1933-35 F. C. Mann, 1936-39 A. C. Ivy, 1940-41 P. Bard, 1942 C. J. Wiggers, 1943-46 W. O. Fenn, 1947 M. B. Visscher.
Treasurers - 1888-92 H. N. Martin, 1893-94 W. P. Lombard, 1895-1903 F. S. Lee, 1904 W. T. Porter, 1905-12 W. B. Cannon, 1913-23 J. Erlanger, 1924-26 C. K. Drinker, 1927-36 A. Forbes, 1937-40 W. O. Fenn, 1941 C. J. Wiggers, 1942-46 Hallowell Davis, 1947 D. B. Dill.
Executive Secretary-Treasurer - 1948-56 M. O. Lee, 1956 R. G. Daggs.

BYLAWS

(Amended April 1960)

ARTICLE I. Membership

Section 1. The Society shall consist of members, honorary members, associate members and sustaining associates.

Section 2. Members. Any person who has conducted and published meritorious original research in physiology and/or biophysics and who is a resident of North America shall be eligible for membership in the Society.

Section 3. Honorary Members. Distinguished scientists of any country who have contributed to the advance of physiology shall be eligible for proposal as honorary members of the Society.

Section 4. Associate Members. Advanced graduate students in physiology at a predoctoral level, teachers of physiology, and investigators who have not yet had the opportunity or time to satisfy the requirements for full membership shall be eligible for associate membership in the Society provided they are residents of North America.

Section 5. Sustaining Associates. Individuals and organizations who have an interest in the advancement of biological or biophysical investigation, may be invited by the President, with the approval of Council, to become sustaining associates.

ARTICLE II. Officers

Section 1. The management of the Society shall be vested in a Council consisting of the President, the President-Elect, the Past President for the previous year, and four other members. The terms of the four additional Councilors shall be four years each and they shall not be eligible for immediate reelection except those who have served for two years or less in filling interim vacancies. A person may serve only one term as President, except that if the President-Elect becomes President after September 30 he shall continue as President for the year beginning the next July 1st.

Section 2. Nomination and election of a President-Elect and Councilor(s) shall be by ballot at the Spring meeting of the Society. They shall assume office on July 1 following their election.

Section 3. The President-Elect shall serve as Vice-President and Secretary. Should he have to function as President prematurely, the Council shall select from among its own members a Secretary.

Section 4. The Council shall be empowered to appoint and compensate an Executive Secretary-Treasurer who shall assist it in carrying on the functions of the Society, including the receipt and disbursement of funds under the direction of the Council.

Section 5. The Council may fill any interim vacancies in its membership or vacancies on any Board or Committee of the Society, unless otherwise provided.

ARTICLE III. Dues

Section 1. The annual assessment on members and on associate members shall be determined by the Council and shall be due in advance on July 1.

Section 2. A member whose dues are two years in arrears shall cease to be a member of the Society, unless after payment of his dues in arrears and application to the Council, he shall be reinstated at the next Spring meeting by special vote of the Council. It shall be the duty of the Secretary to notify the delinquent of his right to request reinstatement.

Section 3. A member who has retired from employment because of illness or age may, upon application to the Council, be relieved from the payment of the annual member assessment.

ARTICLE IV. Meetings

Section 1. A meeting of the Society for transacting business, electing officers and members, presenting communications, and related activities, shall be held in the Spring of each year, with other member Societies of the Federation of American Societies for Experimental Biology, except that under exceptional circumstances the Council may cancel such a meeting.

Section 2. A Fall meeting of the Society shall be held at a time and place determined by the Council, for presenting communications and for transacting business except the election of officers.

Section 3. Special meetings of the Society or of the Council may be held at such times and places as the Council may determine.

Section 4. Regional meetings of the Society, for the purpose of presenting scientific communications, may be authorized by the Council.

ARTICLE V. Publications

Section 1. The official organs of the Society shall be the American Journal of Physiology, the Journal of Applied Physiology, Physiological Reviews and such other publications as the Society may own.

Section 2. A Board of Publication Trustees, composed of three members of the Society and appointed by the Council, shall be vested with the full power of the Society to control and manage, both editorially and financially, all of the publications of the Society; to appoint editorial boards; to appoint and compensate a Managing Editor; and to control all publication funds, none of which, however, may be diverted from support of the publications of the Society except by consent of the Council. The term of each member of the Board shall be three years; a member may not serve more than two consecutive terms. The Council shall designate the Chairman of the Board, and shall receive an annual report on the finances, publications and policies. A summary of this report shall be presented to the Society at the Spring meeting.

The Chairman of the Board of Publication Trustees shall be a member ex-officio of the Council but shall have no vote.

ARTICLE VI. Committees and Representatives

The Council may appoint such special and standing committees as it deems necessary or that are voted by the Society.

The Council may name members of the Society as representatives to other organizations whenever it deems such action desirable.

ARTICLE VII. Standing Rules

1. Election to Membership. Two members of the Society must join in proposing a person for membership, in writing and with a statement of his qualifications. The Council may, from the persons so proposed, nominate candidates for election to membership. Nominations shall be presented at Spring and Fall meetings; a two-thirds majority vote of the members present and voting at the next following Fall or Spring meeting shall be necessary for election.

If a Spring or Fall meeting of the Society is not held, the procedures of nomination and/or election of new members may be effected by mail.

The names of the candidates nominated by the Council for membership and statements of their qualifications signed by their proposers shall be available for inspection by members during the Society meetings at which their election is considered.

2. Election to Honorary Membership. The proposal of an honorary member shall be made by two members of the Society to the

Council in writing. The Council may, from the candidates so proposed, make nominations to the Society at a Spring meeting. A two-thirds majority vote of the members present shall be necessary for election.

Honorary members shall have the privilege of attending business sessions of the Society but shall have no vote. They shall pay no membership fees.

3. Election to Associate Membership. Associate members shall be proposed, nominated and elected in the same manner as full members.

Associate members shall have the privilege of attending business sessions of the Society but shall have no vote. Associate members may be nominated for full membership.

4. Presentation of Papers. At a Spring meeting of the Society, held in conjunction with the Federation meetings, a member or honorary member may present orally or by title, be co-author of, or introduce not more than one scientific paper, except upon invitation of the Council. An associate member or a non-member may present orally one scientific paper, only if sponsored by a full member of the Society. At a Fall meeting, a member, honorary member, or associate member may present orally not more than one paper, except upon the invitation of the Council.

Upon invitation by the Council, a member may contribute papers to specially designated sessions of the Society without forfeit of his privilege of presenting a regular scientific communication.

5. There shall be a Committee on Membership appointed by and advisory to the Council.

6. There shall be a Program Advisory Committee appointed by the Council.

ARTICLE VIII. General

Section 1. Amendments. These Bylaws, except Article VII, may be amended at any Spring meeting of the Society by a three-fourths majority vote of the members present.

The Standing Rules of Article VII may be amended by a majority vote of the members present at either a Spring or Fall meeting of the Society.

Section 2. Quorum. At all business meetings of the Society fifty members shall constitute a quorum.

Section 3. Parliamentary Authority. The rules contained in Roberts Rules of Order shall govern the conduct of the business meetings of the Society in all cases to which they are applicable and in which they are not inconsistent with the Bylaws or special rules of order of the Society.

PRESIDENT'S LETTER

J. H. COMROE, JR.

We have just finished the 12th annual Fall Meeting of the Society. The number of ten-minute papers presented (360) and the registration (775) far exceeded figures for the largest previous meeting -- that in Medford and Boston in 1955. One hundred and four new members and 44 associate members were elected at the business meeting. The APS is growing more rapidly than ever before; growth is a sign of vigor but growth also creates problems. I would like to discuss some of these with you.

A. Communications between APS Members and APS Officers

The Council of the Society meets at least four full days each year to discuss problems of importance to physiology and physiologists. The Council wants and needs to know the views of the members of the Society on many issues. The annual tour of the President-Elect and that of a senior Council member permit two of your officers to hear directly the views of some of you. But valuable though these conferences are, they involve at most 80-100 of our 2,000 members each year and recur for any one of you, only at 6-10 year intervals. Clearly an additional forum is needed for you to express your views to your elected officers. The ideal time and place for this, of course, is the business meeting. But in the past, the election of new members, election of officers and the report of each of the Society's committees have occupied so much of the time allowed for the three business meetings each year that little time remained for serious discussion of old and new business. The result has been either that discussion of important issues was shelved and Council made its own decisions, or issues raised by Council or some of you were voted upon with inadequate discussion and factual background.

It is time to revitalize the business meeting and make it what it was originally intended to be -- a forum for discussion. Our new publication THE PHYSIOLOGIST makes this possible, for in it can be published the complete reports of all APS committees for all members to read and study; only those parts that require the advice and opinion of the Society need be presented at the business meeting.

We tried an experiment at the business meeting on August 24th at the Stanford meetings which appeared to be highly successful. We announced in advance of the business meeting that Committee reports would be published in THE PHYSIOLOGIST and that the business meeting would be used as a discussion period to obtain the views of members of the Society on important issues. Approximately 200 of the 275 APS members registered at the meeting attended the business session. We disposed of routine business in ten minutes and used the remaining time to discuss three important issues. Discussion was free, vigorous, stimulating and as valuable to Council as any President-Elect tour. Straw ballots indicated the sentiments of the members present. The results of these, along with suggestions and questions, were referred to the appropriate committees for their careful consideration.

We intend to include the agenda for the April business meetings in a February or March mailing to you, along with pros and cons of issues as they appear to Council or its committees. We hope that you will come to the April business meetings as a well-informed membership prepared to discuss, advise and vote.

B. Possible changes in the Society's Bylaws

1. Nomination and election of officers. As you know, the APS has no Nominating Committee. You nominate and elect the President-Elect and Councilors by ballot at the April business meeting. This is a truly democratic method and I believe that APS officers take great pride in their election to office because their nomination did not originate in a smoke-filled room! Nevertheless, as physiology grows, it is apparent that the elected officers usually represent Medical School physiology very well but only occasionally do they represent directly general physiology, college or university physiology, biophysics, cellular biology, physiological psychology, or mathematical biology. Do we want the APS to become the American Society of Medical School Physiologists, even though this group represents a very wide variety of biological interests? Or do we want to represent all kinds of research, teaching and communication in physiology and be either a "first" or "second" society to a wide variety of physiologists? If we want to be the latter, we cannot afford to guess at the problems and interests of varied groups; we should have direct representation of them on Council.

The present system of nomination does not provide a Council that is balanced so as to represent all interests. Discussion and straw ballot at the August business meeting indicated clearly that the membership present do want some change in the method of nominating Council members, though not in the method of nominating the President-Elect. Suggestions made at that session are being referred to a committee of Council which may then prepare a new Bylaw for presentation in advance of the April meeting (the Bylaws can be changed only by a vote at the Spring session). Burton's suggestion seemed to meet with considerable approval-- the President-Elect would be nominated and elected by ballot at the April meeting as at present but nominees for Council would be selected by a Nominating Committee. The Nominating Committee would not be one hastily elected at the end of the business meeting but would consist of the past three presidents of the Society (all of whom had previously been nominated and elected for office by the Society). The Nominating Committee would be responsive to suggestions by members (made in advance of the meetings) and would be bound to include the name of any one proposed jointly by ten APS members.

2. A Finance and Budget Committee. Council unanimously believes that the APS needs a Finance Committee and a single annual budget. Until a dozen years ago, our Society had only several responsibilities--a Spring meeting (with the Federation) and the publication of three journals (Physiological Reviews, American Journal of Physiology and Journal of Applied Physiology). We now have a second annual meeting and several new continuing publications (The Physiol-

ogist and Handbook of Physiology), in addition to the publication of selected monographs. We also have many new responsibilities such as the Teaching Sessions, the Refresher Courses, the Summer Workshop, Summer Research Fellowships for College Teachers of Biology and the Laboratory Manuals in Physiology. We are also concerned with the relationships between biologists in medical schools, colleges and high schools; the status and salaries of physiologists; employment of senior physiologists; better public understanding of physiology and the work of physiologists; recruitment of top talent at the high school and college level; government support of basic medical science; international meetings and animal care legislation. To accomplish these things, we have a national office and a permanent secretariat.

Council feels the need to establish a Finance Committee which would receive budget estimates each year from the Board of Publications, the Committee on Education, the Executive Secretary and the Council, and then formulate a final budget for Council's approval. This committee would also have the responsibility for maintaining adequate reserve funds for all of the operations of the Society; at the moment the reserve fund for publications is adequate (about $600,000) but that for all of the other functions of the Society is not (about $20,000).

Council has the authority under the present Bylaws to appoint a new standing committee, such as a Finance Committee. However, the present Bylaws give complete financial control of the Society's publications to a Board of Publication Trustees. Council believes that it is time to reunite the two parts of the Society into one and have one Publications Committee, one Education Committee, one Finance Committee -- all responsible to your elected officers. This requires a change in the Bylaws; such a change will be proposed by Council, with the approval of the Board of Publication Trustees, prior to the April meeting.

3. The Relationship between the Society and the Federation.

At the April 1960 meeting, the Society asked Council to look into all of the relations between the APS and the Federation so that the Society, as a well-informed group, could determine whether we should continue our membership in the Federation (as now organized or in modified form). We will make available to you before April details of (1) the varied services of the Federation to Physiology other than the April meetings, (2) the cost of the Federation to the Society and the cost to us of operating without the Federation and (3) a plan to determine how many members of the Federation "cross-over" to attend meetings of another Society in April. We will also prepare data on the past attendance and the number of simultaneous sessions at the Federation meetings -- with projections to 1965 and 1970 -- and to determine whether the physical convention facilities of any American city can hold an unmodified Federation meeting in 1965 or 1970. We hope to spend a large part of one business meeting in April or September hearing your views on the future of the Federation.

There must be other matters that you consider of importance to the Society. Please write to your officers, or write a "Letter to the Editor" for publication in THE PHYSIOLOGIST; in any case, come to future business meetings to participate in our discussions.

GENETICS TV PROGRAM

Another of the Bell System Science Series TV Programs, "The Thread of Life," dealing with the science of genetics, will seek to explain the processes by which the characteristics of man, animals and plants are transmitted from generation to generation. The most important discoveries about the mechanisms of heredity that have been made in the last 100 years will be shown.

The scientific advisors for the program are Dr. J. F. Crow, University of Wisconsin and Dr. N. H. Horowitz, California Institute of Technology.

The hour-long program will be shown over NBC-TV, Friday, December 9, 1960 at 9:p.m., EST; 8:p.m., CST; 7:p.m., MST; 9:p.m., PST.

APS MEMBERSHIP STATUS

Status as of 1 October, 1960

Regular members	1881
Associate members	120
Retired members	122
Honorary members	16
Total membership	2139

DECEASED MEMBERS

The Society received notices during 1960 of the deaths of the following members. The Society expressed its sorrow and extended sympathy to the families.

J. A. E. Eyster (R) - Fort Myers, Florida
John F. Fulton - Sterling Prof. History of Medicine, Yale Univ.
Ross G. Harrison (R) - Prof. Emeritus, Yale Univ.
E. Newton Harvey (R) - Prof. Emeritus, Princeton Univ.
Lewis V. Heilbrunn - Prof. Zool., Univ. Pa.
C. Judson Herrick (R) - Prof. Emeritus, Univ. Chicago
Charles G. Johnston - Chmn. Div. Surg., Wayne State Univ.
Richard W. Lippman - Med. Res. Consultant, Calif. Inst. Tech.
Leo Loeb (R) - Prof. Emeritus, Washington Univ.
Robert O. Loebel (R) - New York City
Brenton R. Lutz (R) - Prof. Emeritus, Boston Univ.
Daniel A. McGinty - Lab. Dir., Parke, Davis & Co., Detroit
Maud L. Menten (R) - Retired Prof. Pathol., Univ. Pittsburgh
John R. Murlin (R) - Prof. Emeritus, Univ. Rochester
Norman S. Olsen - Asst. Dir., Masonic Med. Res. Lab., Utica
Robert H. Oster - Prof. Physiol., Univ. Md. Sch. Dent., Baltimore
G. Canby Robinson (R) - Greenport, N.Y.
L. G. Rowntree (R) - Miami, Florida
Carl Voegtlin (R) - Washington, D.C.
Homer Wheelon - The Polyclinic, Washington
Russell M. Wilder (R) - Mayo Clinic, Rochester, Minn.

NEWLY ELECTED MEMBERS

The following, nominated by the Council, were elected to membership in the American Physiological Society at the Fall meeting, 1960.

FULL MEMBERS

ALPERN, Mathew: Assoc. Prof. Physiol. & Ophthal., Univ. Mich.
ASERINSKY, Eugene: Asst. Prof. Physiol., Jefferson Med. Coll.
BATTS, Adrienne A.: Asst. Prof. Physiol., Univ. Calif. Med. Ctr.
BECK, Edward C.: Asst. Res. Prof. Neurol. & Psych., Univ. Utah
BIEGELMAN, Paul M.: Asst. Prof. Med., Univ. S. Calif.
BONDURANT, Stuart O.: Asst. Prof. Med., Indiana Univ. Med. Ctr.

BOYLAN, John W.: Asst. Prof. Physiol. & Med., Univ. Buffalo
BREWSTER, William R. Jr.: Asst. Prof. Surg., Univ. Florida
BRYANT, Shirley H.: Asst. Prof. Pharmacol., Univ. Cincinnati
BULLARD, Robert W.: Asst. Prof. Physiol., Indiana Univ. Sch. Med.
CAHILL, George F. Jr.: Assoc. in Med., Harvard Med. Sch.
CHART, Jerome J.: Senior Endocrinologist, CIBA
CHERNIACK, Reuben M.: Asst. Prof. Med., Manitoba Med. Coll.
CHEW, Robert M.: Asst. Prof. Biol., Univ. S. Calif.
COHEN, Bennett J.: Asst. Prof. Physiol., Univ. Calif., L.A.
CONTOPOULOS, Alexander: Asst. Prof. Anat., Univ. Calif. Med. Ctr.
COOK, Charles D.: Asst. Prof. Pediat., Harvard Med. Sch.
DAVIS, George D.: Assoc. Prof. Physiol., Louisiana State Univ.
DeBIAS, Domenic A.: Instr. Physiol., Jefferson Med. Coll.
DESSAUER, Herbert C.: Assoc. Prof. Biochem., Louisiana State Univ.
DIAMOND, Irving T.: Assoc. Prof. Psychol., Duke Univ.
DIECKE, Friedrich P. J.: Assoc. Prof. Physiol., George Washington Univ.
DONALD, David E.: Instr. Physiol., Mayo Foundation
DORCHESTER, John E.C.: Asst. Prof. Physiol., Jefferson Med. Coll.
DOWLING, James T.: Assoc. Metabol. & Endocrinol., VA Ctr., Los Angeles
DUNN, Arnold S.: Asst. Prof. Pharmacol., New York Univ. Coll. Med.
ECKSTEIN, John W. : Asst. Prof. Int. Med., State Univ. Iowa Hosps.
EIDELBERG, Eduardo: Asst. Res. Prof. Anat., VA Hosp., Long Beach, Calif.
ERULKAR, Solomon D.: Asst. Prof. Otol. & Physiol., Temple Univ.
FARHI, Leon E.: Asst. Prof. Physiol., Univ. Buffalo
FRANK, Charles W.: Assoc. Prof. Med., Albert Einstein Coll.
GAMBLE, James L. Jr.: Asst. Prof. Pediat., Johns Hopkins Sch. Med.
GANLEY, Oswald H.: Res. Assoc., Merck Inst. for Therapeutic Res.
GOLD, Jay J.: Dir., Dept. Human Reproduction, Michael Reese Hosp.
GOLDFIEN, Alan: Res. Assoc. Physiol., Univ. Calif.
GONZALES, Federico: Asst. Prof. Anat., Univ. Texas Dental Br.
GOODMAN, Joan W.: Biologist, Oak Ridge Natl. Lab.
GRAFSTEIN, Bernice: Asst. Prof. Physiol., McGill Univ.
GREENE, David G.: Asst. Clin. Prof. Physiol., Univ. Buffalo
GUTH, Lloyd: Neuroanatomist, Natl. Inst. Neurol. Dis. & Blindness
HARRIS, John B.: Adv. Fell., Am. Heart Assoc., Instr. Med., Univ. Calif., S.F.
HIRSCHOWITZ, Basil I.: Assoc. Prof. Med., Univ. Ala. Med. Ctr.
HONIG, Carl R.: Asst. Prof. Physiol. & Med., Univ. Rochester
JONES, Jack C.: Assoc. Prof. Entomol., Univ. Md.
KIANG, Nelson Y-s: Staff member, Res. Lab. Electronics, M.I.T.
KNOEBEL, Leon K.: Asst. Prof. Physiol., Indiana Univ. Med. Sch.
KOBLICK, Daniel C.: USPHS Post Doct. Fell., Univ. Calif., Berkeley
KRAUS, Shirley R.: Assoc. Prof. Pharmacol., Long Island Univ.
KREBS, John S.: Biologist, Biol. & Med. Sci. Div., US Naval Radiol. Def. Lab.
LANGFORD, Herbert G.: Assoc. Prof. Med., Univ. Miss.
LeBRIE, Stephen J.: Asst. Prof. Physiol., Tulane Univ.
LEE, Jui Shuan: Res. Assoc. Physiol., Univ. Minn.
LEE, Y. Chiung P.: Estab. Invest. Am. Heart Assoc., Univ. Minn.
LeVEEN, Harry H.: Assoc. Prof. Surg., State Univ. New York
LEVEY, Harold A.: Asst. Prof. Physiol., State Univ. New York

LEVINSKY, Norman G.: Instr. Med., Boston Univ.
LIEBMAN, Frederick M.: Asst. Prof. Physiol. & Biophys., New York Univ.
LINCICOME, David R.: Assoc. Prof. Zool., Howard Univ.
MALAMED, Sasha: Asst. Prof. Anat., Albert Einstein Coll. Med.
MARSHALL, Robert J.: Res. Assoc. Physiol., Mayo Clinic
MATTHEWS, James L.: Assoc. Prof. Physiol., Baylor Univ.
MENGUY, Rene: Asst. Prof. Surg., Univ. Okla.
MERRILL, Joseph M.: Chief, Clin. Physiol., VA Hosp., Nashville
MILLAR, Florence K.: Biol. Lab. Physiol., Natl. Insts. Health
MONTOYE, Henry J.: Prof. Phy. Ed., Mich. State Univ.
MOORE, Ward W.: Assoc. Prof. Physiol., Ind. Univ. Sch. Med.
MYERS, Ronald E.: Res. Officer, US Army Med. Ctr., Walter Reed Hosp.
NACE, Paul F.: Assoc. Prof. Biol. & Med. Res., McMaster Univ.
NEELY, William A.: Asst. Prof. Surg. & Biochem., Univ. Miss. Med. Ctr.
NEPTUNE, Edgar McC. Jr.: Div. Physiol., Exper. Med. Br., Naval Med. Res. Inst.
PINTER, Gabriel G.: Asst. Prof. Physiol., Univ. Tenn.
PLOUGH, Irvin C.: Comm. Off. US Army Med. Res. Lab., Fitzsimons Army Hosp.
PODOLSKY, Richard J.: Biophysicist, Naval Med. Res. Inst.
POOL, Judith G.: Res. Assoc. Med., Stanford Univ.
POPOVIC, Vojin: Post Doct. Fell., NRC, Ottawa, Canada
POTTER, Gilbert D.: Asst. Res. Physiol., Univ. Calif., Berkeley
RAPATZ, Gabriel L.: Res. Assoc., Am. Foundation Biol. Res.
RAPELA, Carlos E.: Assoc. Prof. Physiol. & Pharmacol., Bowman Gray Sch. Med.
REES, Earl D.: Instr., Res. Assoc., Ben May Lab. Cancer Res., Univ. Chicago
REGAN, Timothy J.: Asst. Prof. Med., Wayne State Univ.
ROBERTS, James E.: Chief, Pharmacol-Biochem. Br., Brooks AFB
ROTHBALLER, Alan B.: Asst. Prof. Anat. & Neurosurg., Albert Einstein Coll.
SCHNEIDER, Robert A.: Assoc. Prof. Med. & Psych., Univ. Okla. Hosps.
SHELLABARGER, Claire J.: Scientist, Asst. Chmn. Med. Dept., Brookhaven Natl. Lab.
SMITH, Arthur H.: Assoc. Physiol., Exper. Sta., Univ. Calif., Davis
SMITH, Orville A.Jr.: Asst. Prof. Anat., Physiol. & Biophys., Univ. Wash.
SOLOMON, Sidney: Asst. Prof. Physiol., Med. Coll. Virginia
SPAZIANI, Eugene: Instr. Zool., State Univ. Iowa
SPERELAKIS, Nick: Asst. Prof. Physiol., Western Reserve Univ.
SRETER, Frank A.: Instr. Anat., Univ. British Columbia
SUTHERLAND, Gerald B.: Asst. Prof. Physiol., Univ. Kansas
THOMPSON, Alan M.: Asst. Prof. Physiol., Iowa State Univ.
TONNA, Edgar A.: Head, Histo-Cytochem. Res. Sect., Brookhaven Natl. Lab.
TURNER, Manson D.: Asst. Prof. Biochem., Univ. Miss.
VAN der KLOOT, William G.: Prof., Chmn. Pharmacol., New York Univ., Bellevue Med. Ctr.
WAITZMAN, Morton B.: Asst. Prof. Pharmacol., Western Reserve Univ.

WALSH, Raymond R.: Asst. Prof. Physiol., Univ. Colo.
WERMAN, Robert: Spec. Trainee, NINDB, USPHS, Dept. Neurol., Columbia Univ.
WHALEN, William J.: Assoc. Prof. Physiol., Univ. Iowa
WHITE, John I.: Assoc. Prof. Physiol., Univ. Md.
WILSON, Thomas H.: Asst. Prof. Physiol., Harvard Med. Sch.
WOODS, James W.: Asst. Prof. Physiol., Johns Hopkins Hosp.
YONCE, Lloyd R.: Asst. Prof. Physiol., Univ. N.C.
YOUNG, Ho L.: Asst. Res. Physiol., Univ. Calif., Berkeley

ASSOCIATE MEMBERS

ARENDT, Kenneth A.: Asst. Prof. Physiol., Coll. Med. Evangelists
AUSTIN, Louis: Prof. Biol., Maryland State Coll.
BAKER, Robert D.: Instr. Physiol., Univ. Texas
BERGMAN, Emmett N.: Asst. Prof. Vet. Physiol., Univ. Minn.
BRADLEY, Arthur F. Jr.: Grad. Res. Physiol., Univ. Calif. Med. Ctr.
BRUMLEVE, Stanley J.: Asst. Prof. Physiol., Univ. N.D.
CONRAD, Margaret L.: Res. Assoc., Bowman Gray Sch. Med.
CONSTANTINE, Jay W.: Asst. Prof. Zool. & Physiol., N.D. State Coll.
CRITZ, Jerry B.: Grad. Asst. Physiol., Univ. Missouri Med. Ctr.
DANFORTH, Charles G.: Pre-med. Sci. Teacher, Glendale Coll.
DIMOND, Sister Marie T.: Assoc. Prof. Biol., Trinity Coll., Washington, D.C.
DZIUK, Harold E.: Instr., Univ. Minn.
FRANTZ, William L.: Asst. Prof. Biol., Drake Univ.
GOE, Don R.: Instr. Physiol., Coll. Med. Evangelists
GOOD, Archie L.: Assoc. Prof. Vet. Physiol. & Pharmacol., Univ. Minn.
GOODMAN, Henry M.: Grad. Student Physiol., Harvard Med. Sch.
GOTTLIEB, Sheldon F.: Res. Physiol., Linde Co., Tonawanda, N.Y.
HELMENDACH, Roger H.: Instr. Physiol., Coll. Med. Evangelists
HIMMELFARB, Sylvia: Instr. Physiol., Univ. Md.
KANDEL, Eric R.: Neurophysiologist, Sr. Asst. Surg., Natl. Insts. Health
KELLOGG, Kenneth E.: Prof. Physiol., Coll. Med. Evangelists
LANGE, Gertrude: Instr. Physiol., State Univ. New York
LANGSTON, Jimmy B.: PHS Res. Fell., Natl. Insts. Health
McILREATH, Fred J.: Sr. Pharmacologist, R. J. Strasenburgh Co., Rochester, N.Y.
McKENZIE, Jess M.: Physiologist, Fed. Aviation Agency, Oklahoma City
MICHAELIS, Bryan A.: Asst. Prof. Physiol., Coll. Med. Evangelists
MOON, Richard C.: Asst. Prof. Physiol., Univ. Tenn.
MOORE, George P.: Grad. Res. Physiologist, Univ. Calif., L.A.
MORGANE, Peter J.: Instr. Physiol., Univ. Tenn.
NADEL, Jay A.: NHI Res. Trainee, Univ. Calif., S.F.
NEWTON, Joseph E. O'N.: Fell. Psych. Res., Johns Hopkins Univ.
PANUSKA, Joseph A.: Divinity Student, Woodstock Coll., Md.
PEARSON, Robert B.: Asst. Prof. Physiol., Coll. Med. Evangelists
PETERSEN, Jo Ann C.: Med. Res. Assoc., Galesburg State Res. Hosp.
ROSENBERG, Edith E.: Res. Fell. Physiol., Grad. Sch. Univ. Pa.
SMITH, Edward E.: Post-doct. Fell. Physiol., Univ. Miss. Med. Ctr.
SPENCER, William A.: Neurophysiol. Sr. Asst. Surg., Natl. Insts. Health

STALING, Leah M. P.: Sr. Instr. Physiol., Univ. Md. Dent. Sch.
STEINBERGER, William W.: Instr. Med. Sch., Univ. Michigan
STEVENS, Charles E.: Res. Assoc. Vet. Physiol. & Pharmacol., Univ. Minn.
SWANN, Henry E. Jr.: Res. Assoc. Occupational Health, Univ. Pittsburgh
TOOLE, James F.: Assoc. Neurol., Univ. Pa.
WALKER, James F.: Chrmn. Dept. Biol., Southern Coll.
WOOD, William B.: Instr. Pharmacol., Univ. Tenn.

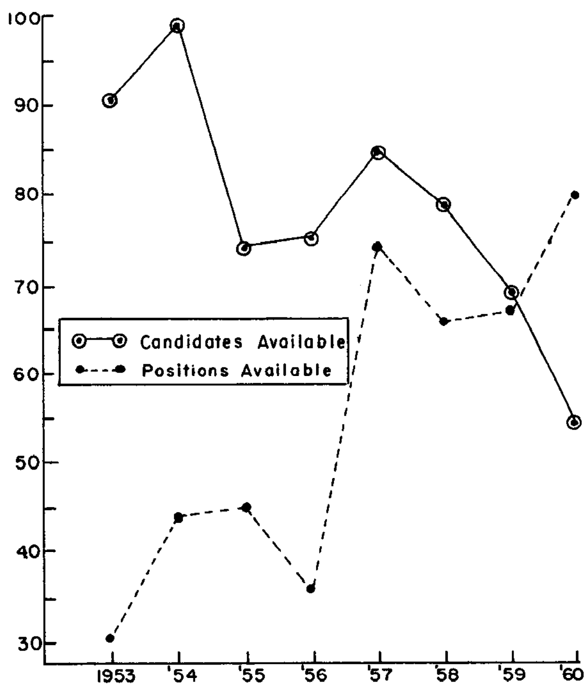
INTERNATIONAL CONGRESS OF BIOPHYSICS

An International Congress of Biophysics will be held in Stockholm from July 31 to August 4, 1961. The purpose of the meeting is to provide a forum for international communication in the field of biophysics. Participants may include members of national societies of biophysics, medical physics, and related fields; and other scientists interested in pure and applied biophysics. The meeting will be divided between a series of symposia devoted to special topics in biophysics and to presentations of a number of contributed papers in pure and applied biophysics submitted by participants. Further information can be obtained from Dr. Bo Lindstrom at the Department of Medical Physics, Karolinska Institutet, Stockholm 60, Sweden.

SUPPLY AND DEMAND

In checking the records of the Federation Placement Service for the last several years some very interesting facts were revealed. The number of available positions in physiology listed with the Placement Service were checked against the number of candidates trained in physiology. In 1953-56 the number of available candidates far outnumbered the number of available positions. In 1959 the number of positions and candidates were about equal, whereas in 1960 there were almost twice as many available positions as candidates. (See chart).

Of course this may not be a true picture of the over-all market for trained physiologists but it is a sample and does show the beginning of an alarming trend. We are not training enough physiologists to meet the demand. Do we need to increase our recruiting efforts among biology students? What can we do to interest young men and women in a career in physiology? Are widely distributed Career Brochures enough or should other means of recruitment be tried?



PAST-PRESIDENT'S ADDRESS*

ROBERT F. PITTS

THE TEACHER AND THE FERMENT IN EDUCATION

Few would deny that a general ferment is stirring our educational system to its depths. Much soul searching is directed toward the aims and scope of education, the proportion of the population which can profit from and hence should receive an education of any given level, and the specific questions of course content, pedagogical methods, and efficiency of the educational program. Strangely, the teacher, who along with the student constitute the two most significant elements of the educational process, has received the least attention. What is the origin of this ferment?

A glib answer would be to assign it to the recent spectacular demonstrations of the advanced state of Soviet technology. Perhaps this is the most significant element in the ferment affecting our primary and secondary schools. However, it is certainly not the only cause, and in the realm of higher education, by no means the most important one.

There is more to this ferment than a desire for survival and for maintenance of our relative position in a technologically complex world. Over the years, the average man has developed an increasing appreciation of the long range monetary value of an education. According to the 1950 census, the life earnings of a college graduate averaged \$268,000, of a high school graduate, \$165,000, and of a grade school graduate, \$116,000. Coldly calculated, a college education in 1950 was worth \$100,000 to a high school graduate. The 1960 census will no doubt demonstrate an even greater dollar premium. More immediately evident to the young job seeker is the competitive advantage which a college education confers on its recipient. Furthermore, there is increasing acceptance by the general public of the need for the services of the skilled professional man in economics, business administration, labor relations, personnel management and many other fields, no less than in law, engineering, science and medicine. The day of the self-made man is drawing to a close. Finally, the social prestige of a college education is firmly rooted in middle class consciousness. Unfortunately, public emphasis is largely on the materialistic values of education with little appreciation of such intellectual and spiritual values as the satisfactions of being a producer of, or a contributor to civilization and not merely a consumer of its fruits.

The ferment in higher education is not new nor was it inspired by the impact of Soviet technological advances. None of us teaches the same material, nor do we teach in the same fashion that we did a quarter century ago. We have changed, and I hope for the better. Progress was slow in the 1930's, nearly impossible during the war,

---

*Due to Dr. Pitt's illness this address was read by Dr. Julius Comroe at the 1960 Fall Meeting.

but has been occurring at an accelerating pace since 1945. In medical education we have been stimulated by the various experimental curricula, if not to copy them, at least to examine carefully what we are doing. The teaching institutes of the Association of American Medical Colleges, our own Society's teaching sessions at the fall meetings and even the Handbook Series of our Society reflect our interest in trying to do our job in the best way we can. Increasing funds from governmental and private sources have enabled us individually to increase our teaching staffs, improve our teaching facilities and discuss and exchange views with teachers in other institutions. Surveys in progress will help us plan for the future.

My premises are these. First, in the educational process the teacher and the student are supreme. Physical facilities, visual aids and laboratory equipment are necessary for the best instruction, but no abundance of these appurtenances can substitute for the informed and inspired teacher and for the intelligent and receptive student. Second, with increasing population and increasing need for more highly educated members of our society, more and more teachers will be needed, and unless some positive steps are taken to accelerate the production of teachers, the shortages and deficiencies which now exist will become critical within the next decade. As Dr. Visscher points out, an even greater threat to education than insufficient numbers of teachers is deterioration of quality. I quote: "When a position cannot be filled with a candidate of calibre, the institution lowers its sights and appoints someone of less than optimal ability and training."

Much of the emphasis of the present educational ferment is on course content, methodology and means of substituting for inadequacies in teaching, rather than on increasing numbers and improving quality of teachers. Some cynic stated that man is the only complicated machine that can be mass produced by unskilled labor. However, the production of a competent teacher is a demanding and time consuming process, the lead time is long, and shortages cannot be rapidly corrected. Teaching, to be done well, demands years of training and experience.

Let us consider the over-all magnitude of the problem. Last fall Dr. Davis discussed the broad implications of the population explosion. I would like to consider briefly its impact on education. Our population is now nearly 180 million; it is increasing at the rate of 3 million per year and will double by the year 2000. However, the school population will double by 1973. If in the next 13 years every primary and secondary school and institution of higher learning were duplicated, we would just about keep abreast of need. It is evident that we are building toward a greater and greater proportion of more highly educated individuals in an expanding population. We will certainly need double the number of teachers we now have in 1973. If we are to improve education and not merely do more of what we are already doing, those teachers must be better qualified than are we.

A second factor of significance is the explosion of knowledge which is occurring in basic and applied science. This leads to the rapid obsolescence of science teachers, especially at the secondary school level where the stimulus of research to keep abreast of the times is lacking. It demands periodic intellectual refreshment. It also leads to the rapid obsolescence of textbooks, which in primary and secondary schools are often superficial and inadequate when first published.

At the present time significant shortages of teachers exist at all levels of education. A recent report of Ohio State University disclosed that over 3000 notices of teaching vacancies at a collegiate level had been received within the past year. The University was able to supply candidates for only 180 positions. Six years ago, the Federation Employment Service received twice the number of applications for positions from individuals seeking employment as notices of job openings. In 1960, the figures were exactly reversed. Nearly every college and university biology department and medical school physiology department has one or more budgeted staff vacancies. Why does this relative teacher famine exist? Why is the status of teaching at a low ebb despite obvious need?

One of the major factors is economic. Pay scales are relatively low in comparison with other careers and in relation to time of training. Compensations has been rising as a result of unfilled demands, but at primary and secondary school levels is not competitive with any but the lower echelons of industry and business. In colleges and universities pay scales have been rising. The American Association of University Professors reports that compensation of 63,152 full-time staff in 323 institutions averaged $8,000 in 1959-60, ranging from a mean of $5,600 for instructors to $10,800 for professors. This represents a gain of 6 to 7% over the previous year. However, if one considers operating budgets, over-all college and university expenditures other than those for research have increased 37% over the past 4 years. Costs of instruction have increased only 22.9%. Apparently teaching is not considered as significant as certain other non-research activities of the university. Of course research expenditures have increased far more.

A second factor of importance is the relatively low social prestige or status of the teacher in his community. This is in sharp contrast to his European counterpart, who though he may enjoy no greater relative economic advantages, at least enjoys a position of eminence in his community. Again this is partly economic in origin, for in our materialistic society, status symbols of home, car, club membership, maid, and private schooling weigh heavily in the thinking of our youth in the choice of a career.

But prestige or lack of it has more than materialistic implications. Were this all, the problem would not be so serious. Ingrained in the public mind is the adage: "He who can, does; he who can't, teaches." Professor is almost a term of derision. The television quiz shows, which occupied for a time the choice evening hours, served to equate, in the public mind, education with rapid recall of endless detail and trivia, not with logical thought processes and understanding based on accumulated wisdom. Even this myth of the educated man was exploded by the rigging of the quiz shows. Furthermore, in the New York area, most of the really significant educational experiences on television are scheduled between 6 and 7 a.m.

However, of greatest import is the down grading of teaching within the teacher's own academic environment. The able and forward looking teacher in primary and secondary schools goes into administrative work. At the college, university and professional school level, he looks toward full-time research or high level administration. Promotion is always to less teaching, not to more.

In the pre-war era, full-time research posts were few in number. Most research was carried out in our colleges, universities and professional schools by teachers. One made do with limited research budgets derived from departmental funds, supplemented by an occasional small foundation grant to purchase a bit of needed apparatus. Technical assistance was available only to the chief; one performed one's own technical work and never questioned the propriety of doing so. When one went to scientific meetings, one paid one's own way, and that perforce limited travel. I do not look back on this era with any nostalgia, only to remind you that research was once almost inseparably linked with teaching. The man who was interested in research prior to 1940, of necessity, developed some interest and capacity as a teacher and was the better investigator for it. The real research genius, unable or unwilling to communicate at the level of the student, could find opportunity and sanctuary in one of the few ivory towers of research.

Times have changed. Research is the magic word of today, and to question anything done in the name of research is to be profane. However, research has a number of different meanings: to industrial management, it means increased numbers and diversification of products and increased profit; to labor, it means vistas of ease and leisure; to the public in general, it means a place of pre-eminence in world society, refinements of living, and an increased span of a disease-free happy life; and unfortunately, to the academician, it is beginning to mean an escape from the classroom, from one of the basic responsibilities of academic life namely, the synthesis of new knowledge with the old and the imparting of that knowledge to the younger generation. Please understand me. I am not saying that research, in the sense of pushing ahead the frontiers of knowledge, is not a prime responsibility of a University faculty. Indeed it is; but it is not the sole responsibility, nor should it be the sole responsibility of anyone enjoying the full benefits of the academic environment. Furthermore, I decry the developing practice of creating a University society with two classes of citizens, the research elite or nobility and the teaching proletariat.

Let me quote from an article in the New York Times of February 21, 1960, by John Q. Academesis. "Once the odd man in the faculty group, included as it were by courtesy, the full-time research worker today in most academic centers, is the top man on the totem pole. Clad in robes of financial ermine, he is the Prince Charming of the faculty, the darling (and at times the spoiled brat) of the administration, and the pride of his department. Although a member of the teaching staff, he does not teach. His research activity is the key to his academic advancement."

Caplow and McGee in their book on the Academic Marketplace have introduced a character called the Academic Adventurer. They describe him in the following terms: "A carefree and somewhat irresponsible sort, the adventurer is a late comer on the academic scene and wanders from realm to realm singing, telling stories and doing well-sponsored contract research. When his record of being able to secure foundation support is sufficiently gaudy to emblazon on his shield, he becomes a chairman."

Still a third character to hold faculty rank is the Academic Beachcomber. By devoting only modest time and thought to the problem, he finds it possible to schedule a series of lectures, symposia, colloquia and conferences in distant spots, spaced in such a way as to permit a return home on week ends to replenish his linen and to accept the invitations which have been received in the previous week's mail. Jet travel and a liberal foreign travel policy permit tighter scheduling of engagements and a choice of more exotic places for meetings. A century and a quarter ago a doubting conservative asked an admirer of Andrew Jackson if he thought that Jackson would go to heaven when he died. The answer, "Yes, if he wants to," might be paraphrased for the investigator of today, "Yes, if his travel grant was approved." Dean Deitrick of our medical college says that he can tell the difference between a full-time and a half-time staff member by the fact that the full-time man is away half time.

Not long ago the king of one of the more primitive tribes of the Congo experienced his first taste of civilization. On his return to his native capitol he was unhappy and deeply depressed. True, he had six wives and twenty head of cattle, which befitted a man of his station, but the royal palace was only a one room grass hut and he had no throne. He called in two of his most skilled artisans and assigned them the task of carving an ebony throne. Six others he commanded to build a split-level thatched palace: dining room, living room and bedroom below, throne room above. When all was finished and he and his six wives moved in, he was supremely happy. Each morning he spent in the throne room, sitting on his massive ebony throne draped with lion skins, receiving his supplicants in royal splendor. One noon while sitting at lunch, a sharp and ominous crack came from the throne room above. A second later the ceiling collapsed. The king was crushed by the massive throne. Now the moral to this story is that people who live in grass houses shouldn't stow thrones. I tell this story largely for the benefit of my close colleagues who know that I am not averse to traveling, and who also know that I enjoy research far more than I do the administrative detail required of a departmental chairman.

I am entirely in favor of expansion of scientific research and for the dispersal of the increasing private and governmental funds which will make it possible. Our place in the sun demands it, as a service to world society, our own society and ourselves. To the dedicated individual, research is as much a creative art as painting, sculpture or music. Unless he has an outlet for his creative research talents, he will meet his teaching and administrative responsibilities with less than adequate enthusiasm. I am convinced that the performance of research improves the teacher both intellectually and emotionally. It encourages him to keep abreast of the times, it forces him to analyze and synthesize new knowledge, and it engenders in him a healthy skepticism and sense of humility. I am no less convinced that some teaching experience will make any investigator more intelligible to his colleagues. However, I am concerned that the very emphasis which is being placed on research, its direction, and its rapid expansion to the exclusion of considerations of general educational needs of the university and professional school, may in the end strangle research or at least emasculate it. Much of the excitement of research comes in the experiment by experiment pitting of one's wits against the unknown. However, the making of some significant contribution to knowledge, small though it may be, is the aspect of research which gives us lasting satisfaction. Yet the attainment of this goal should not be at the expense of the teaching of our students today, for from these students will come the teachers and investigators of tomorrow.

For the remainder of my time, I shall concentrate on a consideration of problems of teaching and research in basic and medical physiology. I shall draw heavily on the thought-provoking Boisfeuillet Jones report on Federal Support of Medical Research prepared for the Subcommittee on the Department of Health, Education and Welfare of the Senate Appropriations Committee.

In 1940, total expenditures for medical research in the United States totaled $45 million; $42 million from non-federal sources, $3 million from federal sources. In 1960, total expenditures will amount to $715 million; $335 million, non-federal; $380 million, federal. Predicted expenditures for 1970 are $3 billion total; $1 billion, non-federal, $2 billion, federal. If this money is to be spent even as wisely as it is today, and I would hope more wisely, there must be a very substantial increase in trained and experienced professional research personnel. I do not subscribe to the philosophy that a relatively unlimited supply of technical help and modern equipment and techniques have so magnified the productivity of the individual investigator that trained manpower is not and will not be a limiting factor. Brain power, not money is in short supply today and will be even more a factor limiting research productivity in 1970.

The Jones report recommends an increase in the appropriation for the National Institutes of Health for fiscal 1961 from the budgeted figure of $400 million to $664 million. These funds would be spent for the following purposes: expansion of the research grants program; increase in the indirect cost allowances on such grants from 15% to a more realistic 25%; expansion of the training grant and fellowship programs; a modest increase in the intramural research program; an increase in construction funds for health and education facilities; and finally funds for the initiation of a series of new general and categorical federal research centers.

The recommendation which poses one of the greatest teaching challenges is that relating to the construction of health education facilities. In 1960, medical schools in the United States graduated 7,400 physicians. At present there are in this country 141 physicians per 100,000 population. As our population grows from 180 million in 1960 to 215 million in 1970, we will have to increase our medical graduates to keep the ratio constant. This means that by 1970, 9,600 physicians must be graduated each year, an increase of 2,200 over present numbers. The Jones report proposes that this can be most economically accomplished: first, by an average increase in the enrollment of existing schools by 15%; second, by establishing 16 new two-year basic science medical schools to replenish losses in four-year schools and to fully utilize existing clinical teaching facilities; and third, by building 18 new four-year schools. The total facilities cost of roughly $1 billion, distributed over 10 years, would require the annual expenditure of $100 million.

As I mentioned earlier, the two most significant elements in the educational process are the informed, inspired teacher and the intelligent receptive student. Throughout the country, numbers of applicants for admission to medical schools have dropped each year for the past five years or so. Some of those schools which restrict their admissions to state residents are now finding it difficult to fill their freshman classes with qualified applicants. All schools have been forced to lower their sights somewhat. There are no doubt many causes for this disenchantment of the younger generation with medicine, including greater glamor of other professions and the universally bad press which medicine has received in recent years with its resultant lowering of the prestige of the physician in his community, but certainly a major factor is the high cost in both time and money of a medical education. The Jones report recommends that fellowship support be provided for the student of medicine on much the same terms and in the same way that it is now provided for the Ph.D. candidate in the physical and biological sciences. This would no doubt improve the competitive position of the medical school relative to the graduate school, but it might well reduce the number of Ph.D. candidates in basic biology. Let us hope that it will provide us with 2,200 more promising candidates each year for medical training by 1970, and not do so at the expense of Ph.D. training programs. Assuming we have the educational facilities and the students to meet the demands of the future, what about the teachers to instruct them; namely, teachers to staff 16 new two-year schools and 18 new four-year schools, as well as to fill present staff vacancies and provide 15% more staff for all medical schools in the United States? The problem does not end there for more teachers will be needed for the increased numbers of students in premedical courses in our colleges and universities.

According to the Jones report, more Ph.D. students in basic sciences are in training today than ever before. The expectation is that numbers will increase in proportion to the increase in population. In addition, a proportion of physicians in the future as in the past will embark on basic science careers. The implication is that if more fellowships are provided, if postdoctoral training programs are expanded, adequate teaching personnel will be forthcoming. I am by no means sure that this is necessarily correct. Perhaps it would be if we had not loaded our dice so strongly against the teacher and in favor of the full-time investigator.

Indeed the final phase of the Jones report recommends not only the fuller exploitation of existing research facilities but also the establishment of a series of new research centers around the country. These should include general and categorical clinical research centers; primate and other animal resource centers; centers for communications research, data processing, and biophysical instrumentation. To me this appears to impose an additional strain on highly trained and capable personnel. If these centers are to be productive, they must be staffed by those who in years past might have embraced a combined career of teaching and research. This view is strengthened by the recommendation in the Jones report that salary ceilings for top level administrative and scientific personnel of the National Institutes of Health be raised to make them once again competitive with industry. From a selfish point of view, I welcome such competitive bidding. Furthermore such increases are no doubt richly deserved. However, the game of musical chairs in top level positions will improve the economic station of the average teacher rather slowly. Even more slowly will it operate to increase the supply of teachers. If we are to meet the challenge of the next 10 years, more active steps should be taken now.

I have presented you with a problem. I will briefly sketch what I feel to be avenues which may lead toward a partial solution. My only qualification for expressing an opinion resides in the fact that I have been occupied with teaching and research for about 30 years, during which time I have made certain observations about my chosen career. The situation is somewhat akin to that which faced the de Haviland company a few years ago. You recall that they were the first to produce a commercial jet passenger liner. For a brief interval, the Comet I was phenomenally successful, setting records on passenger runs all over the world. Then in rapid succession, two planes disintegrated in mid-air. Not only was the good name of the company at stake, but a tremendous investment as well. Parts of these planes were collected and painstakingly reassembled. It became evident that the difficulty was the result of structural failure at the junction of wing and fuselage due to metal fatigue, much like that which recently afflicted the Lockheed Electras. The de Haviland engineers recalculated wing loading, beefed up structural elements, and placed a modified plane on the vibration rack, which rapidly flexes the wings and simulates in a short while the stresses of hundreds of hours of flight. Failure occurred exactly as before. Time and again they recalculated and redesigned to no avail. Finally in desperation they threw the problem open to engineering consultants. One day a young free-lance engineer walked in, took a long look at the data and the plane, put his slide rule back in his pocket, and made the following recommendation: drill a series of quarter inch holes, spaced one inch center to center around each wing at its junction with the fuselage. He was greeted with hoots of derision and forceably ejected from the factory. Months went past without a solution. Finally the chief engineer in a moment of desperation decided to follow the young upstart's recommendation. What was there to lose? To everyone's surprise, the modified plane withstood the rigors of the vibration rack for a period three times the maximum of the standard model. Another plane was modified and again the result was the same. They called in the young engineer and asked him, "Just what is the engineering principle upon which you based your recommendation." "No principle at all," he answered, "just an observation I made long ago and have repeatedly confirmed. A sheet of toilet paper never tears along the perforations."

I rather doubt that the problems of inadequate numbers and of deterioration of quality of teachers can or will be solved on the basis of my observations and recommendations. In fact I believe the problem of teaching and the teacher justifies a study as thorough as that which the Boisfeuillet Jones Committee made of Medical Research. True, that committee has considered problems of teaching personnel in the health sciences, but not in an entirely unbiased fashion, for their charge was to assess the research potential and needs of the country. The Survey of Manpower Needs in the Basic Health Sciences, sponsored by the Federation, supported by the National Institutes of Health, and in progress under the guidance of Dr. Cowles at the University of Pittsburgh will provide valuable data, but again in a limited area. Perhaps the National Science Foundation might sponsor a Study of Problems of Numbers and Quality of Teachers of Science throughout our educational system. It is probable that whatever can be done in science will spill over and benefit the humanities, and their problems are scarcely less critical than are those of the sciences.

I believe that steps should be taken at once:

1. to improve the economic status of the teacher;
2. to restore his prestige in the academic world and to heighten it in the eyes of the general public; and
3. to recruit teachers actively with the same vigor with which industry recruits personnel.

No one of these ideas is original; hence my view that a critical study might lead to a fresh and more productive approach to the problem. Furthermore at the present time, some attention is being devoted to each of these means for increasing the supply of teachers. For the most part, if they are to be effective, they must be carried out on a large scale on the recommendation and under the sponsorship of a national organization such as the National Science Foundation. In the remaining few minutes of my time, I prefer to discuss a simple approach whereby individually we can each make a significant contribution to the over-all solution of the problem.

Interviewing applicants for a variety of postdoctoral fellowships has convinced me that the cream of the graduate student crop are today carefully insulated and isolated from any teaching contact or experience. When I was a graduate student at Hopkins, the most promising Ph.D. candidates held graduate teaching assistantships. From the beginning of graduate work, the student of 30 years ago had at least minor teaching responsibilities. Fortunately these responsibilities were light and the graduate assistants earned their degrees as rapidly as those who received no stipend and did no teaching. Graduate assistants were a select group. Graduate fellowships were essentially non-existent.

Today, the best of the graduate students are supported on fellowships. They devote their time exclusively to course work and to their thesis. They waste no time on teaching and receive their degrees after fulfilling the minimum residence requirements. They are the select group and in consequence receive first consideration for postdoctoral fellowships.

The graduate in medicine who applies for a postdoctoral fellowship has led a similarly sheltered existence so far as teaching is concerned. His orientation, like that of the graduate student, is strictly toward research. The postdoctoral fellowship which he receives may specifically prohibit teaching or more commonly limit it to 10 to 15% of his fellowship time. I would not argue that it should be more, only that such limitation implies that to devote any time to teaching is fundamentally wasteful. Is there any wonder after two years of postdoctoral training that the fellow looks toward a senior fellowship, toward a full-time research post, or if he is a medical graduate, toward a clinical post rather than toward an academic position which combines teaching and research. Teaching is an unknown career, a bit awesome and frightening. Furthermore, it would be a bit degrading to teach, for he who is one of the select, has been so carefully shielded from it for so long.

My thesis is very simple. Ph.D. training should not be all course work and thesis. It should be training for a rounded academic career and hence should include some teaching experience. Postdoctoral fellowship training for either the Ph.D. or medical graduate should be an extension of training in preparation for an academic career. It should not be research training alone. The sooner one is indoctrinated into some of the simpler responsibilities of the teacher, the more naturally will one fit into an academic career at the completion of the training period.

In shepherding our graduate students and our postdoctoral fellows through their training programs, each of us can and should provide some training and experience in teaching. By so doing we can develop in the coming generation of biological scientists a realistic attitude toward the two elements of an academic career, namely research and teaching. My advice is somewhat akin to that of the father who cautioned his son. "Don't marry for money. Go where the money is and marry for love."

REPORT OF SPOT ANALYSIS OF UNIVAC PROGRAMS

The following letter was sent to 100 APS members, including session chairmen, heads of departments and volunteers. There were 44 replies.

Dear APS Member:

As you know the Federation conducted an experiment, under a grant, using the UNIVAC service as a means of programing the papers presented at the Spring Meeting. The only parts of the UNIVAC service actually used were the Subject Index and the arrangement of the printed abstracts in Part I of the March issue of Federation Proceedings. The actual program that was used, and printed in Part II of the March issue, was made up by the Society Secretaries as has been the custom in the past.

In order to evaluate the full experiment a comparative analysis of the handmade and the machine-made programs must be made. The APS Council is submitting copies of the UNIVAC completely integrated program and the UNIVAC physiology program (made up from abstracts submitted by APS members) to 100 selected members of the Society. The Council requests that each of you seriously analyze the programs and submit your comments to the Central Office of the Society on or before May 30 so that a decision can be made as to how much mechanization might be used next year.

The Federation realizes that the subject categories listed on Form B were not completely adequate so that your suggested revision would be appreciated. A separate subject category list for each Society of the Federation is being considered.

You are asked to go over the printed Physiology program (Secretary-made program, Part II of Proceedings); compare it with the mimeographed UNIVAC Physiology program; and with the way the same physiology papers that are integrated in the UNIVAC Federation-wide mimeographed program.

Which of the three programs is best? Cite specific examples to support your answer and state why you like one best. It is to be remembered that due to time limitation each session can only include 8 to 12 papers. This leaves some few sessions with dual categories.

The Council appreciates the time and effort involved in this spot analysis and hopes you will give serious thought to the matter and supply the Council with constructive criticism on or before May 30, 1960. It is by such surveys as this that the Council can best serve the desires and interests of the members.

Incl. Form B - please revise or submit one of your own.
UNIVAC Physiology Program
UNIVAC Federation Integrated Program

Several replies were short and narrative. A few were given in considerable detail with constructive criticism. The majority dealt with only the area of their immediate interest.

Comments have been abstracted and generalized for the purpose of this report.

Abstracts and Index

Those who did comment indicated that this method of listing abstracts in systematic order was good and should be retained. One comment was that IBM probably could do it cheaper. Another commented that having one number for each abstract would be a further improvement.

All comments on the index were favorable.

Integrated UNIVAC Federation Program

Comments on the general idea of integration were about equally divided with a very few more for integration than against. Those for integration recommended continuation of Intersociety Sessions. Sessions on the following were considered to be "hodgepodges" with little meaning: Renal; Endocrines; Biological Regulation; and Environmental. Many stated that papers were misplaced. One analyst stated that several papers were misplaced but, "I am damned if I know where I would put them in the program."

Many suggested that after general sorting the human touch is needed in arranging papers into properly titled sessions and sequence within sessions. It was felt that no one person could do this. Several suggested, relative to all programing, that a small group of 5 or 6 persons versed in different disciplines should sit with the Secretary for a day in setting up the final program.

UNIVAC APS Program

A very few stated this program was better than the Federation UNIVAC and just about as good as the Secretary's Program, but the great majority felt this program was the worst of the three. Sessions on the following general areas were particularly noted for poor organization: Pulmonary Blood Flow; Energy Metabolism; Nervous System; Special Senses; Circulation; Respiration (except Respiration Mechanics); Sex Hormones; Pituitary and Muscle.

The general statement of the majority was, "An awful mess."

Secretary's Program
(The one actually used in 1960)

The general comment of all but two analysts was that this program was best of all three. The two negative comments were that the Federation UNIVAC program was better.

Emphasis was again placed on the importance of having a few experts in different fields work with the Secretary in the final arrangement of papers.

It was also stated by some that it was impossible to have absolutely perfect sessions since much depends on the number of papers received, the number of rooms available and the number of days and one must combine some categories to fill out a session. Much blame was placed on the authors, they should improve the titles to their papers to really indicate the contents.

Form B

There was not one single comment in favor of the present Form B. The kindest comment was one that stated it was fairly good but needed some few additions.

There were many suggestions for revisions but the majority were biased in favor of detailed revisions and additions in the categories of their special interest. Many particularly objected to the categories: Biological Regulation; and Cells.

Some of the constructive suggestions are listed below:

1. Should be revised every year to account for new fields.
2. Need more categories and sub-categories.
3. More definition needed in terms used.
4. Should use functional terms, not anatomical categories for physiologists.
5. Should be like a library classification.
6. Does not give machine enough information to place papers properly.
7. Can never please everybody but a committee of experts could devise a fairly acceptable form.

Summary

1. Listing of abstracts in systematic order should be retained.
2. Indexing method should be retained.
3. Form B must be radically revised. Continue author indication of a category.
4. Machine might be used for first sorting but the human element must be involved in the final programing.

FINANCES OF THE AMERICAN PHYSIOLOGICAL SOCIETY

The finances of the Society are divided into two separate categories, the General Fund and the Publication Fund. The General Fund is administered by Council and is the fund for running the Society's activities other than publications. Grants controlled by the Council and administered by the Education Committee are handled as separate restricted funds in accordance with the terms of the grants. The only part of these funds appearing in the General Fund is the "overhead" (the reimbursement of expenses for administering the grants).

The other category of finances is the restricted Publication Fund administered by the Board of Publication Trustees. In accordance with Section 2 of Article V of the Bylaws the Board of Publication Trustees "control all publication funds, none of which may be diverted from support of the publications of the Society."

The income and expenses for 1959 are shown for both the General Fund and the Publication Fund. To give a clear picture of the changing finances of the General Fund between now and 1961 "pies" are drawn of the income and expense dollars. These changes are due to the discontinuance of large education grants (approximately $90,000 a year) which provided some direct cost funds as well as "overhead," and to the expanding activities of the Society. Parts of the Central Office salaries were provided as direct cost in the grants; parts have been and will continue to be paid from Publication Funds for services on publications.

It will be noted that by 1961 the General Fund estimated expenses will exceed the expected income. Funds must be found to take up this deficit if we are to maintain at least one year's operating reserve. The refund from the Federation Meeting, based on the number of members registered at the meeting, is the Federation's way of reimbursing the Society for its efforts in arranging the program, etc. This is a yearly decision and is based on the Federation finances, therefore cannot be considered a secure yearly income.

The President-Elect Tour in the past has netted some income over expense due to honoraria paid the President-Elect for lectures. Now that a Councilman as well as the President-Elect makes tours and honoraria are not solicited this item may prove to be an expense rather than income.

It has always been the policy that the Fall Meeting should pay for itself but not necessarily make money, therefore, this item cannot be considered as a definite income.

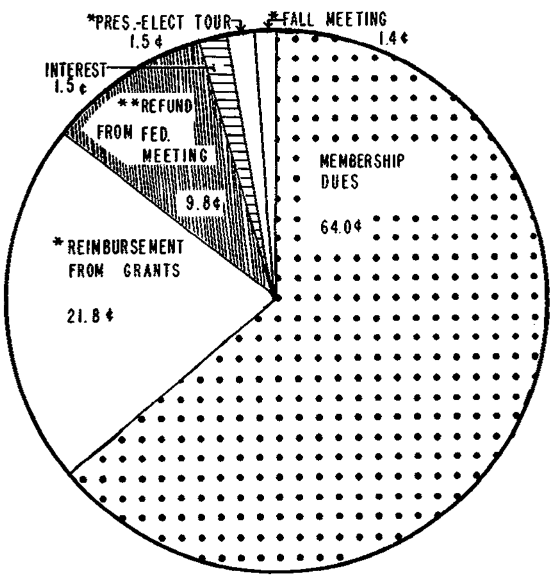
1959 INCOME

GENERAL FUND

Membership Dues ($10 per member)	$16,383 *
President-Elect Tour, net	394 **
Fall Meeting, net	335 **
Interest on Savings Accounts	374
Reimbursements for Expenses for Administering Grants	5,579 **
Refund from Federation Meeting	2,510 ***
	$25,575

* On accrual basis
** Non-recurring income
*** Determined yearly by Federation Board

1959 INCOME DOLLAR



* 24.7¢ NON-RECURRING
** 9.8¢ SUBJECT TO CHANGE YEARLY

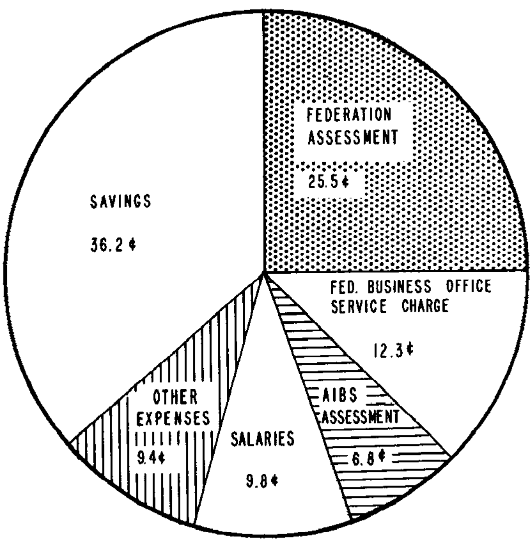
1959 EXPENSES

GENERAL FUND

Federation Assessment ($4 per member per year)	$ 6,514
AIBS Assessment ($1 per member per year)	1,736
Expenses of Education Committee	210
Partial Salaries for Executive Secretary and his Secretary	2,504
Partial Travel Expenses of Exec. Secy.	208
Mailing	477
Telephone	62
Supplies and Duplicating	853
Depreciation and Maintenance of Office Equipment	224
Past-Presidents' Pictures	189
Honorary Member Certificates	77
Officers' Secretarial Expenses	100
Federation Business Office Service Charge	3,144 *
	$16,298

* Overhead charged for bookkeeping, banking, auditing, billing members, etc.

UTILIZATION OF 1959 INCOME DOLLAR



1959 BALANCE

GENERAL FUND

Income	$25,575
Expenses	16,298
Excess of Income over Expenses	9,277
On Hand in Savings and Cash, Jan. 1959	13,311
Total in Savings and Cash, Jan. 1960	$22,588

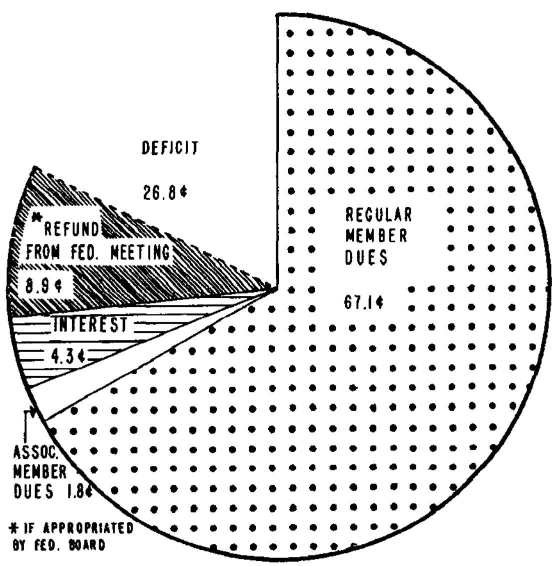
1961 ESTIMATED INCOME

GENERAL FUND

Membership Dues ($10)	$18,750
Assoc. Membership Dues ($5)	500
President-Elect Tour	--- *
Fall Meeting	--- *
Interest on Savings Accounts (approx. $30,000)	1,200
Reimbursements for Expenses for Administering Grants	--- **
Refund from Federation Meeting	(2,500)***
Total	$20,450

* Uncertain, not required to show a profit. May show a deficit.
** Major grants being discontinued in 1960.
*** If Federation Board votes to make a refund.

1961 ESTIMATED INCOME TO SUPPLY 1961 ESTIMATED EXPENSE DOLLAR



1961 ESTIMATED EXPENSES

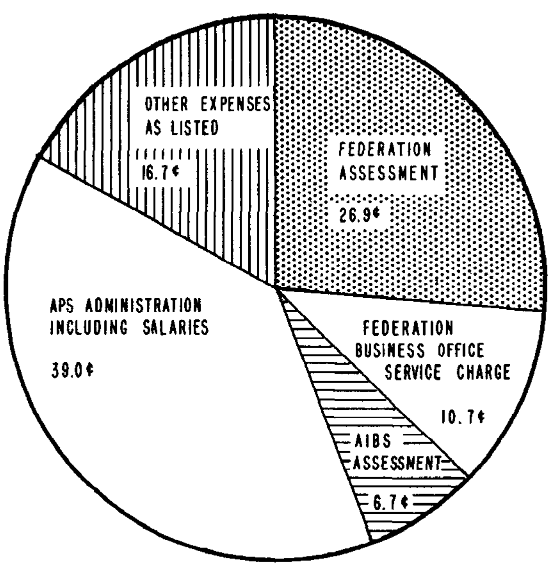
GENERAL FUND

Federation Assessment ($4)	$ 7,500
AIBS Assessment ($1)	1,875
Expenses of Education Committee	1,000
Partial Salaries for Executive Secretary and his Secretary	10,900 *
APS Office Supplies, Duplicating, Mailing and Telephone, Etc.	2,000
Depreciation and Maintenance of Office Equipment	250
Miscellaneous Expenses (Officers' Secretarial Expenses, Committee Expenses, Etc.)	1,400
Federation Business Office Service Charge	3,000
Total	$27,925

* Difference between '59 and '61 due to no grants in '61 to which part of salaries could be charged as direct expense.

Excess of Estimated Expenses over Estimated Income ($7,475)

1961 ESTIMATED EXPENSE DOLLAR



RESTRICTED PUBLICATION FUND
1959

INCOME		
Journal Operations (See Schedule 1 for details)		$284,272
Handbook of Physiology -		
Sale to Members	$ 4,851	
Royalties on Non-member Sales	15,510	
Sale of Reprints	1,848	22,209
Monographs and Supplements -		
Grants and Government Contracts	$20,054	
Sales	3,992	
Sale of Reprints	559	
Royalties	1,180	25,785
Other Sources -		
Dividends & Interest on Investments	$26,049	
Share of Net Income from Annual Reviews	772	26,821
Total Income		$359,087
EXPENSES		
Journal Operations (See Schedule 1)		$273,893
Handbook of Physiology -		
Cost of Books Sold	$25,308	
Manufacturing Cost of Reprints Sold	683	
Overhead Costs (Indirect Expenses)	1,806	27,797
Monographs and Supplements -		
Cost of Books Sold	$10,510	
Manufacturing Cost of Reprints Sold	274	
Printing and Engraving Costs Subsidized by Grants and Contracts	17,996	
Editorial Salaries and Office Expense	652	
Overhead Costs (Indirect Expenses)	2,790	32,222
Total Expenses		$333,912
EXCESS OF INCOME OVER EXPENSES		$ 25,175
Capital, Jan. 1959		552,335
Net Gains on Sales of Investment Securities in 1959		32,407
CAPITAL, Jan. 1960		$609,917
Consisting of -		
Investments at cost (market value, $712,400)	$570,282	
Operating funds (working capital)	39,635	$609,917

APS PUBLICATIONS
1959
Schedule 1

	Total	Amer. Jour. of Physiol.	Physiol. Revs.	Jour. Appl. Physiol.	The Physiologist
Number of Member Subscriptions	3972	410	1314	323	1925
Number of Non-Member Subscriptions	7522	2391	3380	1543	208
INCOME					
Subscriptions	$187,220	$105,245	$45,809	$35,485	$ 681
Sale of Reprints	64,972	41,798	6,373	15,488	1,313
Sale of Back & Single Issues	8,124	3,491	2,884	1,345	404
Advertising Income	4,708	2,886	123	539	1,160
Author Charges	8,605	13,140	290	5,175	---
Royalties	643	129	513	1	---
Total Income	$284,272	$166,689	$55,992	$58,033	$ 3,558
EXPENSES					
Printing & Engraving	$149,564	$90,641	$21,395	$33,758	$ 3,770
Manufacturing Cost of Reprints	18,812	11,810	2,444	4,313	245
Postage & Distribution Cost	11,909	5,870	3,520	1,782	737
Advertising & Promotion	1,583	949	58	197	379
Editorial Salaries & Office Expenses	55,826	29,100	10,829	11,368	4,529
Business Services & Office Facilities	36,199	21,073	5,824	7,831	1,471
Total Expenses	$273,893	$159,443	$44,070	$59,249	$11,131
EXCESS OF INCOME OVER EXPENSES	$ 10,379	$ 7,246	$11,922	($ 1,216)	($ 7,573)

( ) Denotes Deficit

REPORT ON MEETING OF THE COMMITTEE TO STUDY THE RELATIONSHIPS OF MEDICINE WITH ALLIED HEALTH PROFESSIONS AND SERVICES

ROBERT F. PITTS

In April 1959 and again in March 1960, representatives of the American Physiological Society met in Chicago with a committee of the American Medical Association at their invitation to discuss interprofessional relationships in the health sciences. As initially constituted, the A.M.A. group was known as the Committee to Study Paramedical Areas in Relation to Medicine. Paramedical personnel was defined to include two major groups: 1) a so-called Ph.D. group concentrated in the basic medical sciences, including physiology; and 2) some 50 or more assorted groups of lesser academic attainment, including therapists and technologists of all descriptions. The initial premise was that all paramedical personnel assisted and "served as the hands of" the physician in the care of the patient, and that their sole "raison d'etre" was to provide the increasingly complex services required by the physician in the diagnosis and treatment of disease. Possible teaching and research activities of basic medical scientists were completely overlooked. The second premise was that the tendency of the various groups to organize national societies and to look to governmental licensure and registration of their several specialties and to governmental certification of educational standards could only serve to weaken the traditional control of the physician over all aspects of the diagnosis and care of his patient. Therefore the A.M.A. committee proposed to bring representatives of the several groups together, exerting their leadership in defining areas of activity and responsibility, in promoting professional recognition and economic security, and in setting voluntary rather than statutory criteria of professional competence.

Dr. Hallowell Davis and Dr. John Gray represented the Physiological Society in 1959 and Dr. Gray and I represented the Society in 1960. The following organizations were also represented by one or more individuals: American Academy of Microbiology, American Association of Bioanalysts, American Association of Clinical Chemists, American Board of Clinical Chemists, American Chemical Society, American Institute of Chemists, American Psychological Association, American Public Health Association, American Society of Biological Chemists, American Society of Professional Biologists, Federation of American Societies for Experimental Biology, American Association for the Advancement of Science and the Intersociety Committee of Laboratory Services Related to Health.

The first meeting in 1959 served to educate the A.M.A. Committee as evidenced by a change in its name to the Committee to Study the Relationships of Medicine with Allied Health Professions and Services and by a very real alteration in the tone of its pronouncements from one of patronizing omniscience to one of open-minded inquiry. The second meeting, which I attended, served to convince me of two points: 1) problems exist which the A.M.A. committee may be able to solve;

2) the American Physiological Society is not involved in these problems and further representation at meetings, if such are held, would be of no profit to the Society or to the A.M.A. The problems could be defined as basically jurisdictional with marked overtones in the realms of professional status and economics. Examples of these problems are the following. Should clinical chemists be eligible to become directors of clinical chemical laboratories in approved hospitals or should such posts be restricted to graduates of medicine certified as clinical pathologists? The latter view is championed by the American Society of Clinical Pathologists and the College of American Pathologists and the former by the clinical chemists. To what extent should clinical psychologists engage in psychotherapy and how closely should such psychotherapy be supervised by psychiatrists? What constitutes the proper therapeutic realm of the podiatrists and the chiropodists and where does it begin to impinge on that of the orthopedic surgeons? Equally sticky are the problems which face the radiological technicians and the radiologists, physiotherapists and persons engaged in rehabilitation medicine and numerous other fields where technical service personnel and physicians should be working in close harmony for the benefit of the patient.

Dr. Davis, Dr. Gray and I have each made the point that relationships between physiologists and practicing physicians are amicable, if for no other reason than that the physiologist does not compete economically with the practicing physician nor does he seek recognition in the eyes of the patient in competition with the physician. By long tradition, the physiologist does not render direct service to patients. If he does render direct service, he does so as a physiologically oriented physician, not as a physiologist. There is no question of the non-physician professional physiologist practicing medicine, usurping the rights of the physician, or coming between the practicing physician and his patient. Such are the basic causes of discord between physicians and groups of non-physicians who render direct service to patients

The following 5 questions were posed by the A.M.A. Committee for consideration at the meeting in March 1960.

1. What have been, what are, and what can be projected to be the contributions to medicine and the care of patients by your group?

2. What are the currently recognized needs for scientists in your field, the projected needs to promote better care of patients; and what is the current supply and adequacy of numbers of persons entering the field?

3. Give a resume of physician-medical scientist relationships that have been or can be expected to promote better care of the patient.

4. What pattern of academic preparation is necessary, where is it provided, and how might it be better provided?

5. What approaches to develop more effective relationships with physicians do you recommend? What are the suggested mechanisms?

Dr. Gray considered these questions from the point of view of the teacher and investigator in physiology. I considered them from the viewpoints of the American Physiological Society. Our preliminary statements follow.

John S. Gray, Ph.D., M.D.
Representative of the American Physiological Society
Professor of Physiology, Northwestern University Medical School

Physiologists have not, and probably will not, participate directly in the care of, or service to, patients. As a result, the relationships between physiologists and the medical profession are beset with comparatively few problems or sources of friction.

1. But physiology, as one of the basic medical sciences, has made, and will continue to make, major contributions to medicine in three distinct ways:

a) by the instruction of medical students in basic science,
b) by the education of researchers in both basic and clinical fields,
c) by fundamental contributions to the scientific knowledge upon which the practice of medicine is based.

It is perhaps unfortunate that the pre-eminent role of the basic sciences in these endeavors is so little known to the layman, and sometimes even to the physician.

2. Physiologists are in short supply; schools the nation over are concerned at the shortage of qualified graduate students in the basic medical sciences. At the same time the demand for physiologists is increasing. The expansion of old and the establishment of new medical schools, the proliferation of governmental and commercial research activities, and the growth of clinical research facilities, are all contributing to this demand. The widening gap between supply and demand is a serious problem.

3. The physiologist and the physician rarely meet at the bedside or in the presence of the patient. But the physiologist is the colleague of that portion of the medical profession which is engaged in education and research. There are, of course, intramural problems in medical education, specifically the challenging one of improving the correlation of basic science and clinical teaching. But it is probably true to say that no group of educators is more active today than the medical in soul-searching, experimenting, and exploring the means of improving their performance.

4. Physiologists are now largely trained by graduate Ph.D. programs in physiology departments, either in medical, or liberal arts colleges. A minority already have, or subsequently earn, the M.D. degree in addition, but this is far less relevant to their standing as physiologists. This is the result of inevitable specialization. It is popular to inveigh against specialization, but this is as futile as complaining about the law of gravity. Competence demands specialization, although it is

reasonable to ask that the pattern of specialization be suited to the job at hand.

5. The immediate interests of physiologists and of the general membership of the medical profession do not naturally bring them much together, and I see no profit in maneuvering so as to bring about personal contacts. But there is much to be gained by promoting contact between the basic science and clinical faculties within the medical school. After all, each is contributing an indispensable part to an over-all plan of medical education; the better each sees and understands the full program, the better he can make his own contribution fit.

In summary, physiologists and physicians meet primarily in the ivory towers of education and research, rather than in the marts of competition. Accordingly, relative harmony prevails.

Robert F. Pitts, Ph.D., M.D.
President (1959-60) American Physiological Society
Professor of Physiology and Biophysics,
Cornell University Medical College

The American Physiological Society includes among its associate members, graduate students, beginning investigators, and college teachers of functional biology and among its members, established investigators in research institutes and government laboratories, and persons who combine teaching with research in universities and medical colleges. A major requirement of membership is that the individual be engaged in and have published meritorious original research in physiology. At least half of our members are physicians, many of whom hold appointments in clinical departments of medical schools. A minority are full-time members of departments of physiology in medical schools. Although our membership is less than 2000, the roots of our society extend broadly in the field of functional biology and are by no means restricted to the medical field. Our society is composed of individuals who, because of common interests in teaching and research in physiology, find it profitable to band together for the purposes of exchanging information and rendering service to science. I shall confine my remarks to a brief resume of activities of the American Physiological Society, insofar as they bear on the five questions posed in the agenda.

The American Physiological Society publishes four journals, three of which are high standard scientific journals, including the American Journal of Physiology, the Journal of Applied Physiology and Physiological Reviews. These journals provide an outlet for much of the good physiological literature of this country; hence render a direct service to medicine. The fourth journal is a house organ of the Society, and of greatest interest to the man professionally involved in the teaching of physiology. The Society is presently engaged in the publication of a multivolume Handbook of Physiology which is a modern day Bethe or Roger. The first two volumes on Neurophysiology have just been completed. This will be a monumental reference work, again of direct service to medicine, and will be revised and up-dated on a five to ten year schedule.

The American Physiological Society holds two scientific meetings each year. These meetings provide a means of exchanging information with one's colleagues and obtaining prepublication criticism of one's peers. A number of papers deal with applied clinical physiology; many are related in some basic fashion to medical problems.

The American Physiological Society has long been concerned with the improvement of the teaching of physiology. Each year at the Fall Meetings, the first day is devoted to a discussion of the teaching of some phase of physiology, such as circulation, respiration, acid base balance, or excretion. The Society is compiling a manual of laboratory experiments, not in any sense for a recommended or approved course, but to provide help to our teaching colleagues in organizing their courses in the way they deem best.

The Society recognizes its responsibility for the continued education of the practicing physician and this April is jointly sponsoring with the University of California a Course on the Physiological Basis of Diagnosis and Treatment. This course has been organized by Dr. Julius Comroe and will be given just preceding the meetings of the American College of Physicians in San Francisco. However, we feel no less an educational responsibility toward college teachers of physiology, who instruct and I hope inspire each succeeding generation of premedical and pregraduate students. Along these lines the American Physiological Society has conducted a five year pilot program involving more than $50,000 per year for summer laboratory research guidance for college teachers who have had little time and no encouragement to engage in research. The National Science Foundation has financed the program. As a follow up, the Executive Secretary of our Society has helped the trainees prepare foundation grant requests to continue their research endeavors in their home institutions. This program has been so successful that the National Science Foundation proposes to take it over on a science-wide basis after the completion of this summer's term. The Society also sponsors and organizes two workshops for college teachers of biology each summer and during the winter provides a limited guest lecture program. Probably the greatest need for improvement in the teaching of physiology, or more properly functional biology, is at the high school level. However, the problem is so vast that a small society such as ours would be lost in its immensity. However, here is where the greatest gains can be made in the improvement of basic medical science and medical practice 15 to 20 years hence.

The American Physiological Society recognizes the fact that the teacher and investigator of physiology is not reproducing his kind in numbers adequate to supply either present or future needs. The pharmacologists have pioneered in the field of recruitment and the physiologists, recognizing their priority, have frankly plagiarized the idea. We are producing two brochures, one at a high school level, one for college students and high school guidance personnel, describing career opportunities in physiology, what physiologists do, how to become a physiologist, what such a career offers, what fellowships are available, how to choose a graduate school.

The American Physiological Society recognizes no necessary conflict of interests between physiologists on the one hand and practitioners of medicine or the American Medical Association which represents the practitioners on the other. We would not question the responsibility of the practitioner for the medical care of his patients. By long tradition, the physiologist does not render direct medical service to patients. Those members of the American Physiological Society who do practice medicine, do so as physicians, not as physiologists or as members of our society. As physiologists, we do not recognize a man by the degree label he happens to bear. We are not a Ph.D. group or an M.D. group. We are a group of teachers and investigators. We recognize teaching ability, scientific competence and research excellence. We do not look to the American Medical Association and certainly not to the practitioner of medicine for leadership in the field of physiology. We will, however, welcome cooperation in solving common problems on a basis of mutual respect for competence, not on the basis of degree held nor on the basis of any inferred omniscience of either group. However, I must, with some pride, point out that our Society has for many years been concerned with problems which the American Medical Association seems only recently to recognize as existing.

TEMPERATURE SYMPOSIUM

The American Institute of Physics plans to hold a four-day symposium on "Temperature, Its Measurement and Control in Science and Industry" at Columbus, Ohio in March, 1961. The part of the program dealing with Physiology, Biophysics and Medicine is under the chairmanship of Dr. James D. Hardy, U.S. Naval Air Development Center, Johnsville, Pa.

THE NATIONAL ACADEMY - NATIONAL RESEARCH COUNCIL

R. W. GERARD

Last year the National Academy of Sciences - National Research Council operated on a budget of over $12 million. Since thousands of top flight scientists have contributed their time to Academy-Council business without remuneration, the total effort is fully equivalent to that of a major university. This effort, moreover, is restricted to the science area and overwhelmingly to the promotion of research and of its effective use; so the impact on American science is unparalleled among agencies expending (in contrast to those supplying) research funds.

The National Research Council is the main operating agency of the National Academy of Sciences. It is organized at present into eight subject matter divisions, including chemistry, mathematics, anthropology and psychology, engineering, etc.; two offices, of International Relations and Scientific Personnel; and several unassigned activities, such as education, biological effects of radiation, and space science. Division members are appointed by the President of the Academy, from men nominated by member societies of the division or as members-at-large. In either case, the division members function as individuals; society nominees serve for liaison with, rather than as representatives of their societies. Members-at-large are chosen to round out otherwise unrepresented areas and because of special experience and service in Council affairs. Each division operates under a chairman and executive committee.

The Academy-Council while not a federal agency with a line budget, is intimately related to government. It gives extensive advisory services to, and receives much financial support from, executive bodies concerned with the development or utilization of science -- the military arms, public health, agriculture, Atomic Energy Commission, National Science Foundation, and many others -- and liaison members sit in appropriate divisions. Ties are also close with many industrial groups.

The American Physiological Society has always been a strong adherent to the Council. It is a member society of both the Division of Medicine, Keith Cannan, Chairman, and the Division of Biology and Agriculture, Burr Steinbach, Chairman and its nominees have regularly been appointed. John O. Hutchens is the Biology and R. W. Gerard the Medicine appointee. Milton O. Lee is a member-at-large of the Biology division, as is Gerard, who serves on the Executive Committees of both divisions and also represents biology on the Committee on Behavioral Sciences in the Division of Anthropology and Psychology. Many other Society members serve on the many committees and boards of the life science divisions, on interdivisional groups, and in administrative posts. In fact, since Detlev W. Bronk, now in an unprecedented third term, has guided the Academy-Council as its vigorous President for the past decade, our Society has indeed played a large role in Council affairs.

The Council, large, quiet, with an aura of power and perhaps privilege, functioning at high levels, has often seemed remote, even ominous, to the individual scientist. The investigator may have had contact with a research proposal review committee, or a fellowship award committee, or other selecting or standard-setting groups, and so thinks of the Council, at best, as some impersonal road block and, at worst, as some highly personal agents awarding the plums to their favorites. Such an impression has never been a valid one and now, with more government agencies doing their selecting through intramural or other special panels, the vast creative program of the Council is coming into better focus.

Even at the individual level, moreover, the Council is active in many ways. It helps scientific societies raise funds (and itself is active in this), as for travel grants to international meetings. It facilitates exchanges of scientists at all levels -- students, fellows, lecturers, administrators -- including the overcoming of visa and other political barriers. It helps in much informal job placement. It sponsors many small working groups which pool the experiences of the participants, often resolve conflicting views, and make available to all the resulting understanding and often specific recommendations. It offers young scientists with a bent for administration opportunities for rich experience within its own organization.

The main contributions of the Academy-Council, however, are above the individual level. They are concerned with the support of scientists, in funds and facilities and materials, and with the supply and training and employment of scientists; with the illumination of the lacunae in scientific knowledge and with the use of available knowledge to solve the imminent problems of mankind. Its publications alone, approaching a thousand items issued mainly by its own Printing and Publishing Office (catalogue on request to 2101 Constitution Ave., Washington 25, D.C.), are a valuable array of documents and an eloquent reminder of its wide-flung activities. Physiologists will be directly interested in such items as: Biological Effects of Atomic Radiation; Animals for Research; Concepts of Biology; Handbook of Biological Data; Career Opportunities in Biology; Biological Education; Biology Code of the Chemical-Biological Coordination Center; Proceedings of the International Conference on Scientific Information; Evaluation of Protein Nutrition; Doctorate Production in United States Universities; Index-Handbook of Cardiovascular Agents; Psychopharmacology; Status of Research in Underwater Physiology; Basic Mechanisms in Radiobiology; University Patent Policies and Practices; Scientific and Technical Societies of the United States and Canada; Symposium on Biomolecular Organization and Life Processes.

Our Society members are active in, and affected by, many organs of the Academy-Council, but the focus of interest for the Society is, of course, the life science group. The Division of Biology and Agriculture, with 36 member societies and over 400 scientists on its various committees, has carried responsibilities for: Fulbright and postdoctoral fellowships, the United States national committees to two International Unions, research programs in developmental biology and in photobiology; and for three major boards or institutes, each with its own committee structure -- the Agricultural Board, the Food and Nutrition Board, and the Institute of Laboratory Animal Resources. This latter includes committees dealing with such matters as: animal care, animal diseases, primates, production standards, and technical guidance.

The Division of Medicine, with 25 member societies and over 300 participating scientists, has committees dealing with: the Atomic Bomb Casualty Commission in Japan, anesthesia, blood and transfusion, cardiovascular system, drug addiction, nervous system, pathology, radiology, sex, shock, trauma, the International Union of Physiological Sciences, several aspects of environment control and sanitary engineering, and a number of others. The Division is also active in committees on bioastronautics, computers, bioacoustics, fellowships, etc.

In recent years the several divisions of the Council have been brought together at the Annual meeting to consider collectively the less parochial aspects of science that cut across all disciplines. Such sessions, and much Council activity continuing on a year-round basis, is of great value to all scientists. The Biology Council, created by the Biology division under the leadership of Paul Weiss, initiated important activities in relation to science education, research support and supplies, public attitudes toward science, publications, and like cross-disciplinary matters. This body unfortunately was suspended for lack of support, but not before the National Research Council as a whole became active in such areas. Its Advisory Board on Education has fostered industry-education cooperation at the state level, promoted teacher education, participated in development of visual aids and of a general science television program, supported extensive programs in science curriculum revision, and in like ways worked to improve science education. Excellent presentations at recent annual meetings of the National Research Council covered: education in science, international science, the future of IGY, information and documentation in science, interdisciplinary research, fellowship programs in science, science in foreign aid, behavioral science, and support of scientific research.

A listing, even with some annotation, of aspects of the structure and activities of a large and many-faceted institution gradually comes to resemble the string of stations rattled off by a train announcer. Only to the traveller who has visited some of the "stations stops" do the empty words come to life. During the war years, the call "Edgewood, Aberdeen, Havre de Grace, and Perryville" became a bit of poetry to many scientists. Likewise, those who have had the opportunity to travel with the Academy-Council have enjoyed rich experiences as well as given valuable service.

Officers of the Council are continuously concerned that the march of time ages the group of participants and grooves the use of men into familiar channels. There are continued requests, almost supplications, to the scientific societies for the names of young oncoming scientists who may be brought into committee work, even onto the operating staff. Our Society, for example, has responded to a request to the Council with a fine list of such names, prepared by Ray Daggs. But the direct approach is also open.

The Academy-Council occupies a beautiful building on Constitution Avenue. On the door hangs a sign, "Not open to the public"; but Society members are not public -- push in courageously and be greeted by an attractive hostess who will help you find the information or person you seek. If you come with an idea or specific offer you will be especially welcome. The Society's emissaries to the two divisions of the National Research Council have submitted regular reports to Society's Council. They are available to members interested in exploring further, as are all the official documents of the Academy-Council. I have found my long contact with this focus of American science most rewarding; "the water's fine"; I invite fellow members of the American Physiological Society to "come on in."

THE TWENTY-THIRD PSALM FOR RESPIRATION STUDENTS

D. K. FREEMAN, JR.

The Respiratory Center is my shepherd; I shall remain in a steady state.

It maketh me to maintain proper gas tension gradients; it leadeth me past mild respiratory stresses.

It restoreth my acid-base equilibrium; it leadeth me along the blood dissociation curve for my tissue pH's sake.

Yea, though I climb to the peak of an 18,000-foot mountain, with a P_{IO_2} of 66 mm Hg, I will fear no acapnea; for thou art inside me, thy built-in Fenn-Rahn diagram and thy Nature's own slide-rule, they comfort me.

Thou preparest a set of optimum $\dot{V}_A$'s in the presence of my moderate physical exercise; thou saturateth my inspired air with 47 mm Hg of water vapor at 37^oC; my excess CO_2 runneth over.

Surely tidal volume and respiratory rate adjustments shall govern my P_{AO_2} and P_{ACO_2} all the days of my life; and I will dwell on the .8 R-line forever.

EVALUATION OF APPARATUS FOR USE IN THE TEACHING LABORATORY

A. B. DuBOIS, S. Y. BOTELHO AND G. POLGAR

Although simple apparatus formerly sufficed for both research and teaching in physiology, current research equipment used by physiologists and diagnostic equipment used by physicians have become both complicated and expensive. Consequently, physicians are no longer expected to understand the internal intricacies of electrocardiographs, fluoroscopes, strain gauges, or other "black boxes" which supply them with useful physiological information about the patient. One may ask whether the complexity of this new equipment prohibits its use in student laboratories.

At the autumn meetings of the American Physiological Society in 1959, there were demonstrations of experiments which were supposedly suitable for use in teaching physiology to medical students. Little information was presented to indicate whether the students were capable of using the apparatus, or whether they learned any physiological principles during its use. Medical educators are reluctant to let medical students perform student experiments while using electronic apparatus for two reasons; first, because the physiology students may not be able to operate electronic equipment during these experiments in physiology, and second, because the results of the physiological experiment might be misunderstood if the internal circuits of the analytical apparatus were not fully comprehended by the student. Methods for testing these assumptions will be described in this paper.

The student experiment which we chose was one which demonstrates the effect of breathing increased concentrations of carbon dioxide on the minute volume of ventilation. A closed circuit spirometer system flushed with oxygen and containing a soda lime cannister was used. After a control experiment in which the soda lime cannister was in the circuit, a second experiment was done with the cannister removed. In each case, gas samples were withdrawn from the spirometer and analyzed for carbon dioxide concentration. Thus, the relationship between the concentration of carbon dioxide in the inspired air and the rate and depth of breathing was established.

We decided to compare an infra-red carbon dioxide analyzer against a simple chemical gas absorption method for determining CO_2, namely a modified Scholander 5 ml carbon dioxide analyzer. In the latter, the sample, delivered from a 5 ml syringe, is bubbled through KOH solution into a 5 ml burette, the difference in volume readings being due to the volume of CO_2 absorbed by the KOH. The teaching experiment was done as a part of a laboratory course in physiology for a class of 18 physiotherapy students at the University of Pennsylvania. The students were not aware that they were being used as "guinea pigs." Two identical spirometer systems were arranged in the same laboratory room. The burette gas analysis method was used with one, and the infra-red gas analysis method with the other. Simple instructions, including a description of the principle of the method, were placed beside each analyzer. The same instructor served for both. Students worked in pairs. Each pair of students used first one method, and on another day, the other method. Some pairs of students used the burette method first, and other pairs used the infra-red method first.

To evaluate the success or failure of the two teaching methods, observations were made on the ability of the students to obtain reasonable results using each analyzer, the length of time using each method, and the questions asked of the instructor. Student laboratory notebooks were examined a few days after each laboratory period. The final examination included questions regarding the physiological principle demonstrated and the principle of operation of one method for analysis of CO_2 (choice of either method).

The students were allowed as much time as necessary to complete the experiment. Nine pairs of students completed the experiment using the infra-red gas analyzer, and eight pairs of students completed the experiment using the burette method. The average time for the experiment using the infra-red analyzer was 40 minutes, whereas the average time to complete the experiment using the burette analyzer was 60 minutes. There was little doubt that the chemical method required more time both during practice and during each subsequent analysis of a gas sample. Reasonable results were obtained with the infra-red gas analyzer only if there was no change in the calibration of the instrument. If a change in sensitivity did occur, the instructor had to interpret the data using the new and old calibration curves. On the other hand, once the student did a correct blank analysis with the burette method, he was able to obtain reasonable results in succeeding analyses without requiring the aid of the instructor. On the final written examination at the end of the course, 83% of the students understood the physiological principle being demonstrated by the experiment (increase of ventilation with increased inspired CO_2), 61% chose to describe the infra-red method of gas analysis, 28% chose to describe the burette method of gas analysis, and 11% described neither method. Of those students who described the infra-red method, 64% grasped its basic principle, and of those students who described the burette method, 80% grasped its basic principle.

From these findings, we concluded that it was possible to evaluate newer apparatus used in student laboratories by comparing it with older equipment. There were indications that the use of electrical methods does not interfere with the learning process, although different types of apparatus would have to be tested in student hands to see whether weak points, such as changes in calibration, interfere with their use. The observation that a comprehension of the principle of operation of an infra-red gas analyzer was within the grasp of an average physiotherapy student was surprising and encouraging. Perhaps we overestimated the difficulty of explaining the principles of such instruments.

The method described for comparing the effectiveness of particular pieces of equipment may well be applied to testing other apparatus used in student laboratories. This form of research in teaching lends new interest to old laboratory exercises.

ON FEEDING FLAMINGOS

The following poem, by Denis L. Fox, Professor of Marine Biochemistry at Scripps Institute of Oceanography, was inspired by research and study of the diet of the flamingos in the San Diego Zoo. Dr. Fox has been investigating the dietary control of biochromy in this interesting species. The bright color of the birds' feathers and naked skin areas can be maintained with a daily diet rich in astaxanthin, a red carotenoid pigment which the birds store unchanged. The poem suggests the birds' natural habitat, their general manner, appearance, gestures and manner of feeding. It incorporates the idea that carotenoid-rich food is absolutely necessary. Dr. Fox states that it does contain one or two speculations, e.g. that reducing mud and the microflora therein, and/or resident in their alimentary tracts, may have a biochemical role in the chemical alteration of dietary carotenoids, known to occur in the birds' metabolism. Dr. Fox also states that Bill Conway, Curator of Birds in the New York Zoo has had success on supplying his flamingos with carradeen, an oil derived from extraction of carrot-root and incorporated in alfalfa meal. Dr. Holgar Poulsen, Curator of Birds at the Copenhagen Zoo gives his flamingos paprika with similar gratifying results.

THE FLAMINGO

D. L. Fox

With apologies to Lewis Carroll: "A-sitting on a Gate".

1.

I'll tell thee everything I can;
There's little to relate.
I saw a pale flamingo standing
Just beyond a gate.
"Whence come you, noble bird," I asked,
And how is it you live?"
The creature merely stared at me,
Twas all she had to give.

2.

She seemed to say, "We live in swamps,
Hot river-mouths and lakes,
And shores, where foes are few, and food
(for all who'll pay the stakes)
Is plentiful and varied, and,
Though salty and quite muddy,
And mixed with copecods and sand,
Keeps our complexions ruddy."

3.

Then I stood, thinking of a plan
To dye their feathers red,
By offering them so large a pan
That they might all be fed
On copecods and shrimps and shells
Of lobsters from the sea,
That they might strut once more, as swells
In gorgeous livery.

4.

And so we fed them all such meals,
And waited days and weeks
To see them redden up their heels,
Their leg-skin, plumes and beaks.
The birds blushed fairly well, indeed,
When some few months had passed.
But wild kin spoke of better feed
Within their recent past.

5.

I then sought out my special bird
Of pale and spindly frame,
And drew her to one side. She heard
My query without shame:
"These new-comers of crimson hue;
What is there in the diet
They find somewhere outside the Zoo?
Pray tell me, Blanche, we'll try it."

6.

The pale flamingo looked at me,
But never a word she said.
She fixed me with a jaundiced eye,
Then turned away her head;
She stalked away with hindward kick,
A very rude salute
As if to say, "Some skulls are thick."
Her scorn had left me mute.

7.

Next morning, though, she sought me out;
She gently plucked my sleeve.
And spake, without cold glance or pout,
"Our keeper, I believe?"
Beside her stood a taller bird
Of bright vermillion hue.
"My beau," she said, "He has a word
Of sound advice for you."

8.

His accents mild took up the cue;
He bent a blushing knee;
"Good sir, may I be frank with you
On bio-chemis-tree?
These polyenes that you provide
Are wanted, yes indeed,
But we have enzymes down inside
Which magnify our need."

9.

"Now I've come from a land of sun,
And mud and salt and ooze
That other birds and people shun,
But we are loath to lose.
Endemic microflora there
Have de-hy-DRO gen-ases
That poise pee-aitch and ee-aitch fair
Throughout our feeding places."

10.

"Keep this in mind: we like that feed,
That stinking mud; we need it!
Your spoonbills, ducks and storks have need
Of mud; and those you feed it!
If we're to keep our lipochromes
From air-free oxidation
Within our guts, provide our homes
With fully balanced ration!"

11.

"If that you'll do (he gave a wink),
Perhaps my Blanche her name
Will change to Ruby when she's pink
Throughout her slender frame.
Provide us with a stagnant pond
Of such redox potential
As will preserve our double bond-
ed beauty so essential."

12.

I've told thee everything I can;
There's little more to state.
I woke to see those two birds standing
Just beyond the gate.
They glanced and croaked, one pink, one pale;
I promised I'd provide
Much lipochrome, and, without fail,
Black mud for their inside.

13.

And now, if e'er by chance I dip
   My fingers into goo,
Or introduce a single bond
   Which really should be two,
Or if I drop upon the floor
   A yield of measured weight,
I weep, for it reminds me so
   Of that pale bird I used to know,
Whose glance so cold, suggested zo-
   ologic disapproval so;
With feathers whiter than the snow;
   Whose face was solemn like a crow,
With eyes pale amber, full of woe,
   With long curved neck, and head
     hung low
In water, sweeping to and fro;
   Who croaked disconsolately low
As though her beak were full of dough,
   (Whose gentle mien I envied though),
That summer day so long ago,
   A-standing by a gate.

MOVEMENT OF MATERIAL ACROSS CELL MEMBRANES*

C. ADRIAN M. HOGBEN

Interest in many areas of physiology, secretion and absorption, maintenance of the internal homeostasis of the cell, excitation and conduction, has contributed to a renewed interest in the transfer of material across cell membranes. The broadening scope of investigation has led to an increasing recognition of the complexity of the problem. In turn, there has come into use, special terms the meaning of which is not always easily accessible. The following brief commentary is an attempt to bring together the more important terms.

In suggesting that movement across a cell membrane can occur in several of eight different ways, it is hoped that the reader will appreciate that movement will ordinarily occur in more than one fashion. Thus it is not unexpected that, for a single membrane, movement can occur at the same time by simple diffusion, active transport and exchange diffusion. It should be equally apparent that there is no simple dichotomy between passive diffusion and active transport. We recognize that these two terms alone do not serve to characterize movement through cell membranes.

While the contention may not gain universal acceptance, the description of movement across cell membranes must be clearly formulated in terms of the net movement of a particle, its two unidirectional fluxes and the electrochemical potential gradient.

In the past, emphasis has been placed upon the temperature coefficient or activation energy of a process. Unfortunately, the activation energy does not distinguish between a "passive" and "active" process. In simple physical systems involving highly restricted diffusion the activation energies may be of the same magnitude as those customarily associated with a chemical reaction. Conversely in a complicated chain of chemical reactions, it is by no means obvious that the over-all process should have high activation energy. In fact, there is no reason why it should not have a negative temperature coefficient as it frequently does in biological systems.

Just as it is necessary to emphasize that the temperature coefficient gives us no sure clue to the nature of a process, it is equally important to stress that a change in response to exposure to a metabolic poison does not provide an unambiguous answer to the hazardous question: whether a process is "passive" or "active". If the transfer of material is characterized, then the use of metabolic poisons may allow the opportunity to profitably manipulate an experimental preparation.

*Taken from the introductory talk given at the session on Active Transport at the Federation Meetings in Chicago, April 11-15, 1960.

1. Simple unrestricted passive diffusion.

The concept of simple unrestricted passive diffusion is reasonably simple and one that is widely accepted. It results from the random movement of a particle due to its thermal energy without there being a significant interaction with other molecules moving through the membrane; either of the same or of another species.

Simple unrestricted passive diffusion is exactly defined by Ussing's flux ratio equation (Acta Physiol. Scand. 19: 43-56, 1949):

$$M/M' = (c/c')\ (f/f')\ e^{(P.D.)} = F/RT$$

where M and M′ refer to the two unidirectional fluxes between two bulk solutions bathing a membrane that are accessible to analysis. The flux ratio is equal to the product of the concentration ratio (c), activity ratio (f) and the exponential function of the electrical potential difference across the membrane (P.D.). The constants z, F, R and T have their conventional physical chemical meaning. When an uncharged species is being considered the balance (z) is zero and the term involving the difference in electrical potential drops out. It is noteworthy, that this equation exactly defines simple unrestricted diffusion without making any a priori assumption regarding the nature of the membrane structure.

Most of us have been prepared to think of passive diffusion in terms of the Fick equation. However, there are two substantial restrictions to the application of the Fick equation to transport across the biological membranes. All too frequently it is difficult to stipulate the boundary conditions which permit use of the differential equation. More importantly, the inclusion of the permeability coefficient (D) predisposes to treating it as a constant rather than a complex function of the other variables of the equation. Use of the Fick equation does imply some a priori assumptions regarding the nature of the membrane.

While it is an obvious outgrowth of classical general physiology it is important to emphasize that simple diffusion through a membrane can occur by either of two quite dissimilar routes.

A. Via aqueous pores.

B. Via lipoid matrix.

2. Active Transport.

The introduction of this term marks a change in the approach to the study of movement of material across the cell membrane. It is an admission that knowledge of physical chemistry of the two solutions bathing a membrane is often not sufficient to account for movement of a particular molecular species. Often there is a transfer of energy from the cell or membrane to the moving species. In this sense, active transport can be unambiguously defined as the net transfer of a molecular species from a lower to a higher electrochemical potential ($\bar{\mu}$). The electrochemical potential difference between two solutions is given by

$$\bar{\mu} - \bar{\mu}' = RT \ \ln\left\{\frac{c}{c'} \cdot \frac{f}{f'}\right\} + zF \quad (P.D.)$$

the symbols having the meanings cited above.

While this is an unambiguous and I believe useful definition of active transport, it has been objected to on the grounds that it is too restricted and also because it is too general. It is restricted in the sense that we recognize that active transport must be invoked in many steady state situations, particularly that obtaining between the inside and the outside of the cell, where there is no net movement. It would be appropriate to expand the definition to such steady state situations, if further evidence establishes that there must be a continuous passive permeation that can only be counteracted by active transport in the opposite direction. The above definition can be modified, without doing undue violence to it, so that it will apply to the experimental situation where there is a net movement across a membrane in the absence of an electrochemical potential difference between the two solutions bathing the membrane. In this situation, energy must be expended to overcome the inherent resistance of the membrane.

I would not choose to characterize as active transport, a net movement that is brought about by the net movement of another species flowing through the membrane. This type of movement has been placed in a separate category of interaction noted below. The distinction between active transport due to a "drag" effect may pose a challenge in experimental design.

The above definition of active transport has been objected to by some as being too general because it is not committed to any molecular model. My personal reaction is that when we can approach a more explicit hypothesis or molecular model we should abandon the term active transport in favor of one that is more explicit. In the meantime, we can subdivide active transport into:

A. Specific. This type of active transport, and the one most frequently considered, is believed to be "carrier" mediated. It is characterized by structural specificity, saturation kinetics and analogue competition as well as being subject to metabolic poisoning.

B. Nonspecific. At this juncture, this is no more than a catch-all for those situations where there is active transport in the sense defined above, but is not necessarily attributed to a fixed membrane carrier. It includes, what may be considered a trivial example, the active transport of weak electrolytes across the gastrointestinal epithelium (J. Pharmacol. Exptl. Therap. 119: 361-369, 1957). Until we better understand the phenomenon, it also provides for the apparent active transport across the intestinal epithelium of water from a lower to a higher activity (Biochim. et Biophys. Acta 30: 666-667, 1958).

3. Facilitated diffusion.

This mode of transfer which accounts for the entry of important water-soluble substrates into cells, such as glucose into skeletal muscle, is similar to specific active transport but the net movement is from a higher to a lower electrochemical potential or in other words, the molecules only move downhill. In the absence of an electrochemical potential gradient there is no net movement. It is distinguishable from simple diffusion by a rate of transfer that is greater than would be predicted on the basis of molecular weight and lipid solubility. Like specific active transport, it is believed to be carrier mediated and is characterized by structural specificity, saturation kinetics and analogue competition. It is often, though not necessarily, inhibited by metabolic poisons.

4. Exchange diffusion.

This aspect of exchange across membranes is the one that is most confusing to a person who is not familiar with this field. Some of the confusion arises from the unfortunate choice of the term which has frequently been used in the past in an entirely different sense. In the strict sense this is not a route for the net transfer of material. It only provides for a one for one exchange of isotopically distinguishable particles. This "exchange diffusion" is visualized as being mediated by a membrane carrier. To the extent that this carrier gives rise to "exchange diffusion" it is always complexed with the exchanging particle. At the membrane-solution interfaces, one exchanging particle can be displaced from the complex by a similar particle. If isotopically labeled particles are introduced into one solution bathing a membrane, they will be able to pass into the solution on the other side of the membrane by virtue of the complex formed with the exchange diffusion carrier. While exchange diffusion does not contribute to the net movement of a particle, when it is present it does contribute equally to the magnitude of the two unidirectional fluxes across a membrane since these unidirectional fluxes are measured by the use of isotopes. Consequently, recognition of the process is crucial to an intelligent interpretation of unidirectional fluxes. If there is simultaneously both simple diffusion and exchange diffusion, the flux ratio will be less than that predicted by Ussing's flux ratio equation. The process of exchange diffusion was initially proposed to explain the apparently excessive expenditure of energy that would otherwise be necessary to account for the flux of sodium across the skeletal muscle fiber membrane (Nature 160: 262, 1947). It has also been evoked when a partial conductance of an ion calculated from flux data exceeds the total membrane conductance (Am. J. Physiol. 180: 641-649, 1955). The presence of exchange diffusion is also suggested, but not established, when a flux rate is dependent on the concentration of a particle in the solution into which its isotope is deposited or on the transconcentration (J. Biol. Chem. 41: 101, 1957).

There are instances where exchange diffusion is sensitive to metabolic inhibition and other instances where it is not.

While the above commentary on facilitated diffusion and exchange diffusion serves to outline the principle contribution to exchange across a membrane a somewhat especial circumstance may be noted. If a carrier, responsible for either process, complexes with closely related but chemically different species, it is possible that one of the chemical species may approximate being a tracer of the other. In such a situation, a gradient for one species would be capable of driving the movement of its close relative through the carrier.

5. Restricted diffusion of a solute.

In certain instances where movement is thought to occur by passive diffusion, the observed flux ratio exceeds that predicted by Ussing's flux ratio equation. As in simple unrestricted passive diffusion there is no net movement of solute in the absence of an electrochemical potential gradient between the two solutions bathing a membrane. The departure of the observed flux ratio from that predicted for simple unrestricted passive diffusion has been attributed to the restraint imposed upon simple diffusion by pores whose radii restrict free movement so that the diffusing molecules interact with molecules of the same species (J. Physiol. 128: 61-88, 1955). The conditions for movement approach 'single-file' progression through the pore.

6. Hydraulic flow of solvent.

This mode of transfer is similar to the foregoing in that the diffusing molecules interact with molecules of the same kind but it is sufficiently important to warrant the emphasis obtained by placing it in a separate category. The interaction is not imposed by the restriction of the pore, but occurs because the solvent, water, constitutes a continuous phase. Again, due to interaction with molecules of the same species, the flux ratio is greater than that predicted for simple diffusion (Acta Physiol. Scand. 28: 60-76, 1952).

The movement of water through cell membranes is generally characterized by a greater net movement in response to a gradient of activity of water than would be predicted from the diffusion coefficient of water estimated from isotopic transfer. This is accepted by many as evidence that net water movement occurs by hydraulic flow rather than by uncomplicated diffusion.

7. Interaction with another species of moving particle.

When the two solutions bathing a membrane are not identical, we have to deal with complicated situations. Circumstances can be such that there is a gradient for a particular species leading to its diffusion from a higher to a lower potential. The diffusion of this particular species may not significantly influence the movement of other species or the interaction may be significant. If the diffusion of one species does significantly influence the movement of another, I would not choose to label the departure of the movement from that which would otherwise be expected as 'active transport'.

It is easier to draw attention to the nature of the problem than to lay down criteria which permit its inclusion or exclusion. In part, clarification can be sought with a suitable experimental design that eliminates the diffusion of the particle that is not of primary interest. While it is clear that this is a type of problem that should be treated by irreversible thermodynamics, it is not yet obvious that we are ready to apply irreversible thermodynamics with unqualified success to complex membranes of unknown structure.

It may or may not be appropriate to distinguish between two categories:

A. Solvent drag.

B. Solute drag.

8. Pinocytosis.

This is a mode of transfer that enjoys particular favor among anatomists but is less favored by physiologists because it does not account for the extraordinary specificity of some of the mechanisms of transport. The concept of a cell 'drinking' its environment has been modified by some to such an extent that the engulfing of fluid becomes a specific process that only certain solutes are taken into the cell. When the original concept of pinocytosis is so drastically modified it no longer is clear whether it is importantly different from the physiologist's concept of a membrane carrier.

Pinocytosis has certainly been observed. But until appropriate experimental criteria are established for pinocytosis, it will remain the last refuge of the intellectually bankrupt. I do not reject the occurrence of pinocytosis out of hand. It is possible that it will serve to explain anomalies such as the intestinal absorption of intact protein in the gestating and newborn mammal. I am not aware that the process of pinocytosis can yet be deduced from the static picture of the electron micrograph.

GENERAL REFERENCES

1. A Textbook of General Physiology. (2nd ed.) Davson, H., Boston: Little, Brown & Co., 1959.
2. Symposium of ionic transmission across membranes. XXI Internat. Cong. Physiol. Sci. Symposia and Special Lectures. p. 162-175, 1959.
3. Principles of General Physiology. (vol. 1) Bayliss, L. E., New York: Longmans, 1959.
4. Method of isotopic tracers applied to the study of active ion transport. New York: Coursaget, J. Pergamin Press, 1959.
5. Metabolic aspects of transport across cell membranes. Q. R. Murphy (editor). Madison: Univ. of Wis. Press, 1957.
6. Transport and accumulation in biological systems. Harris, E. J. Jr., New York: Acad. Press, 1956.
7. Bacterial permeases. Cohen, G. N. and Monod, J., Bacteriol. Rev. 21: 169-194, 1957.
8. Electrolytes in biological systems. A. M. Shanes (editor). Washington, D.C.: Am. Physiol. Soc., 1955.
9. Electrochemistry in biology and medicine. T. Shedlovsky (editor). New York: Wiley, 1955.
10. Active transport through animal cell membranes. Le Fevre, P.G., Protoplasmatologia 8: 1-123, 1955.

11. Active transport and secretion. Brown, R. and Danielli, J. F. (editors). Soc. Exptl. Biol. Symposium No. 8, New York: Acad. Press, 1954.
12. Ion transport across membranes. H. T. Clarke (editor). New York: Acad. Press, 1954.
13. Annual Reviews of Physiology. (vols. 13, 15, 17, 19, 21).
14. Active and passive exchange of inorganic ions through the surfaces of living cells and through living membranes generally. Krogh, A., Proc. Roy. Soc. (series B) 133: 140-200, 1946.
15. Physical chemistry of cells and tissues. Höber, R., Philadelphia: Blakiston, 1945.
16. Permeability of natural membranes. Davson, H. and Danielli, J. F., Cambridge, England: Cambridge Univ. Press, 1943.

EXPERIMENTAL PROCEDURES FOR ESTABLISHING RELIABILITY OF THERMISTORS FOR MEASURING INTRAVASCULAR TEMPERATURES

SKODA AFONSO AND J. F. HERRICK

The application of thermistors (thermally sensitive resistors) in medical research is proving to be particularly convenient. Two important applications of rather general interest are in thermometry, and in observations of blood flow. The primary purpose of this report is to describe techniques for testing thermistor-thermometers in order to obtain reliable and accurate measurement of small temperature variations which may occur within the cardiovascular system and which must be independent of the flow of blood.

The thermistor-thermometer is a resistance thermometer. Like any other resistance thermometer a measuring current is required for the Wheatstone Bridge or for other resistance-measuring circuits employed. To avoid error in measuring the temperature of the surrounding medium (the ambient temperature) this measuring current must be small enough to prevent significant heating of the temperature-sensing element. Unlike the metal resistance thermometers the presently available thermistors have a high negative temperature coefficient (values ranging from one to five per cent per degree centigrade near room temperature) thus permitting greater sensitivity. The resistance-temperature characteristics over the wide range of temperatures from -100 to +400 degrees centigrade are non-linear. However, an acceptable approximation to linearity does exist over the narrow range of temperatures which occur naturally within the cardiovascular system.

The tests described in this report were made on only one type of thermistor, the bead type. The small bead, 0.01 inches in diameter, was enclosed in a glass envelope and had a resistance of approximately 2000 ohms at room temperature. Such a high resistance makes the lead-resistance errors negligible and hence measurements can be made at remote distances if so desired. Furthermore, temperature measurements may be recorded by wireless methods (by electric telemetering systems).

Every thermistor-thermometer for use within the cardiovascular system should be tested for the following properties:

A. Response time

B. Negligible heating by the measuring current

C. Insensitivity to blood flow

Any thermistor-thermometer possessing optimally the above-mentioned properties can be used with confidence for measuring intravascular temperatures in vivo after a careful calibration has been made.

A. Test of Response Time

"The response time or the thermal time constant is the time required for the temperature of the thermistor to change 63% of the difference between its initial value and that of the surroundings when no electric power is dissipated in it."(1)

More than one method was used for determining the response time of thermistor-thermometers. The method we preferred employed the technique of dipping the thermistor (which had attained equilibrium in air) into a water bath of uniform temperature at a suitable level. A signal photographically recorded indicated the instant that the thermistor touched the surface of the water.* This signal gave an unequivocal indication of the time at which the temperature sensing element began its response to the temperature of the bath. This response was recorded photographically (fig. 1).

The response time for each of two thermistors was recorded on Sanborn equipment. One thermistor showed a response time of approximately 0.65 seconds (fig. 1a) while the other showed a response time

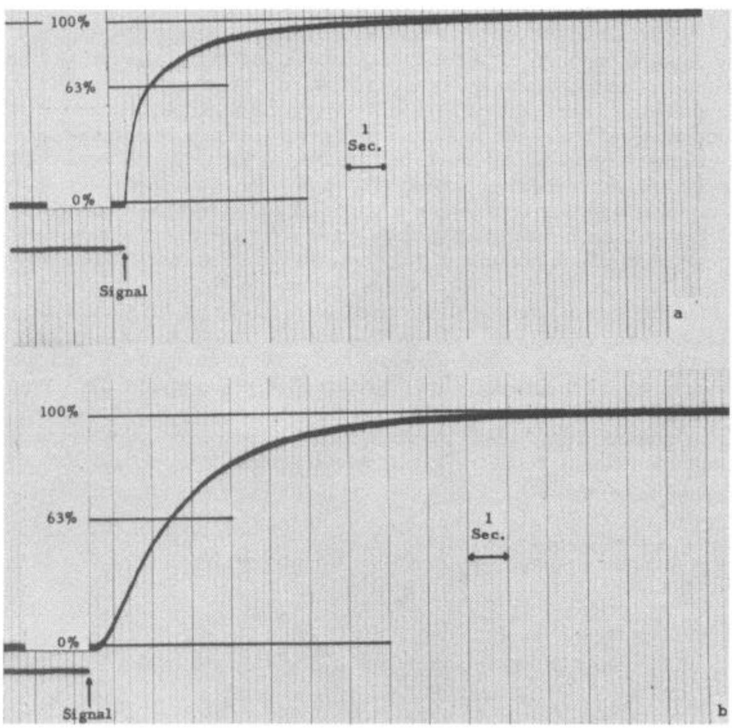


Fig. 1. Records of Response Times (thermal time constants) of Thermistors.
a. Response time: approximately 0.65 seconds.
b. Response time: approximately 2.0 seconds.

---

*The circuit consisted of a fine copper wire (placed adjacent to the thermistor bead) which completed a direct current at the instant of contact with the water.

of approximately 2.0 seconds (fig. 1b). Types of thermistors are available which possess response times as brief as a few milliseconds. If longer response times are desired, they may be obtained by increasing the thermal capacity with suitable material in which to imbed the thermistor.

B. Test for Detecting Direct Heating of a Thermistor

Any reliable resistance thermometer demands that the measuring current be negligible. A negligible current is one which will not change the resistance of the temperature sensing element significantly.

As stated previously, the thermistors have a relatively large negative temperature coefficient which gives them greater sensitivity than other available resistance thermometers. This characteristic demands that particular attention be given to avoid heating the thermistor directly. To repeat: the measuring current must be negligible.

The direct heating of a thermistor by the measuring current can be detected easily. Any direct heating causes a decrease in resistance and consequently introduces an error in the measurement of the temperature of the medium in which the thermistor is placed.

A procedure for detecting the thermistor that is being heated directly is as follows:

Place the thermistor in a constant temperature bath. Preferably, the temperature of the bath should be lower than the arbitrary temperature at which the resistance-measuring circuit is balanced. The temperature-indicator in the measuring circuit should assume a position corresponding to the true temperature of the bath almost instantaneously and should remain at this position indefinitely (fig. 2a). However, if the measuring current is causing direct heating the temperature-indicator will move initially in the direction for indicating that the bath is at a lower temperature, but it will remain at the lower position only momentarily before proceeding in the opposite direction. The motion in the opposite direction is the key for the detection of a directly heated thermistor (fig. 2b). Significant direct heating can be eliminated simply by reducing the voltage imposed on the associated measuring circuit.

C. Test for Insensitivity to Flow

Directly heated thermistors are sensitive to flow.

It is this property which is utilized when measuring blood flow, an application which is simple and interesting.

However, when the thermistor is to be used as a reliable temperature-sensing element within the vascular system every precaution must be taken to make the thermistor insensitive to flow. The test must show convincingly that the temperature-indicator remains undisturbed when the surrounding medium begins to move. The procedure for this test follows:

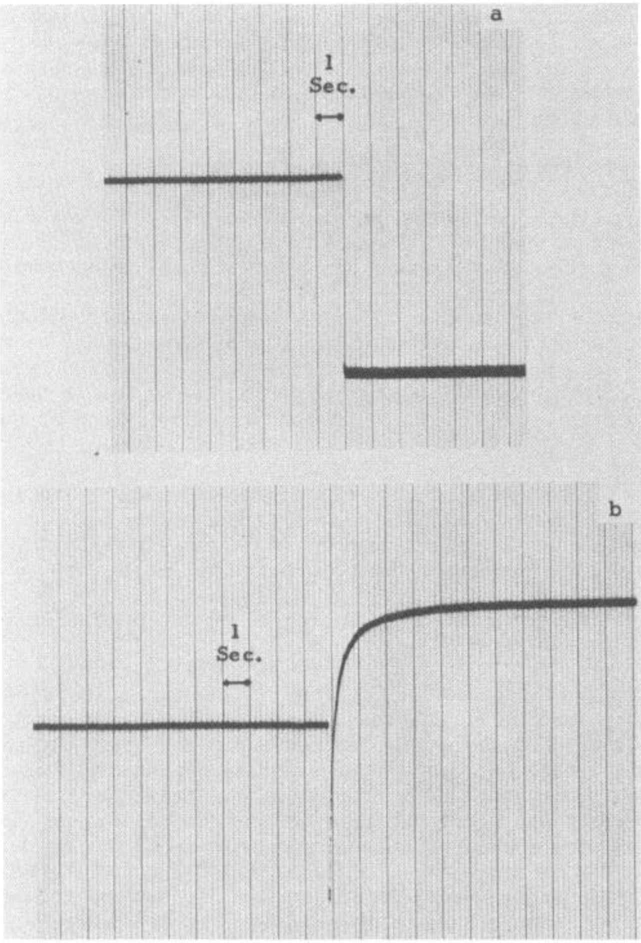


Fig. 2. Records Demonstrating no Direct Heating (a) and Direct Heating (b).
a. Deflection of temperature-indicator remains indefinitely at the position for indicating the temperature of the bath.
b. The temperature-indicator attempts to proceed to the position for indicating the temperature of the bath but the measuring current causes direct heating whereupon the deflection is reversed.

The thermistor was placed at the center of a glass tube through which flows as large as 6 liters per minute could be obtained. The glass tube with the thermistor in proper position was filled with water from the constant temperature bath. The temperature of the water at rest was recorded. Suddenly a flow of the water up to 6 liters per minute was produced. When the conditions for insignificant heating of the thermistor obtained (described above in section B.) the thermistor was insensitive to this flow (fig. 3a). When the voltage imposed on the measuring circuit was increased deliberately so as to cause direct heating of the thermistor, the temperature-indicator showed a sensitivity to flow (fig. 3b).

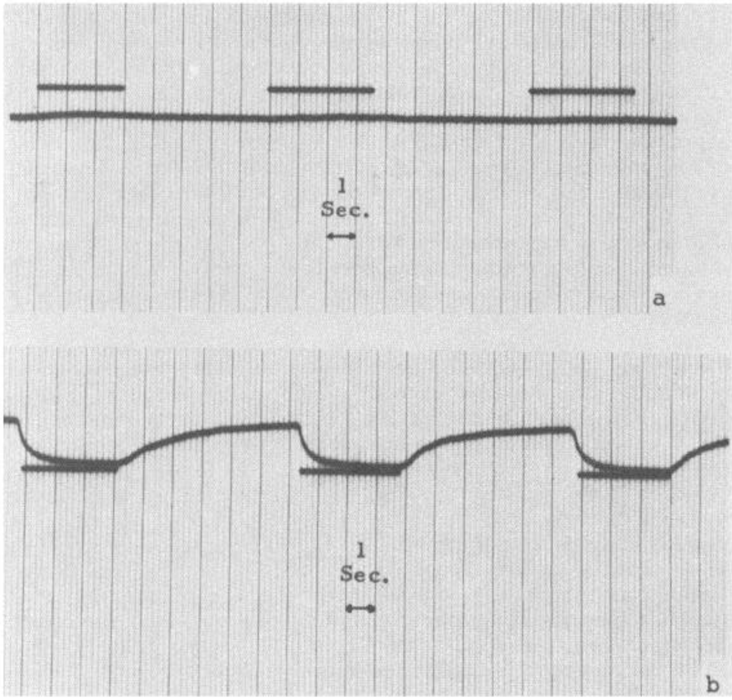


Fig. 3. Records of a Thermistor-Thermometer Demonstrating Insensitivity to Flow (a) and Sensitivity to Flow (b).

a. The measuring current heats the thermistor insignificantly. The short horizontal bars are signals during which the water flows about the thermistor up to a rate of approximately 6 liters per minute. Please note that no change occurs in the record of the temperature (the continuous horizontal line).

b. Except for a measuring current to cause direct heating of the thermistor, the conditions are the same as in (a). Note that the thermistor is sensitive to flow, i.e., change in resistance is caused by the flowing water which cools the thermistor.

The flowing liquid cools the directly heated thermistor because it carries away the heat, thus increasing the resistance. Such an increase in resistance may be interpreted as a fall in temperature of the blood thus introducing an error when measuring temperatures.

Figure 3 indicates clearly how a thermistor responds to flow. Figures 3a and 3b demonstrate clearly the fundamental difference between the thermistor as a temperature measuring device and the thermistor as a flowmetering device. There should be no confusion between these two distinctly different applications. When used for measuring flow the thermistor is heated directly intentionally by a constant current of suitable magnitude. The magnitude of the deviations from the constant current indicate the magnitude of blood flow. When measuring intravascular temperatures every precaution must be taken to avoid heating the thermistor directly so that changes in the resistance will be due only to the changes in temperature of the surrounding medium.

The proposed use of thermistor-thermometers by the authors is to obtain information on certain dynamic regulatory mechanisms which require reliable measurements of small but significant variations in the temperature of the flowing blood in vivo.

After the above tests have demonstrated the reliability of a thermistor-thermometer, a careful calibration is made. Calibration consists of the well-known procedure of placing the thermistor in a suitable bath where any desired temperature may be attained and maintained long enough for recording the various positions of the temperature-indicator corresponding to the true temperature of the bath. The true temperature of the bath is determined by a standard mercury thermometer.

Finally we wish to cite an instance where incorrect temperature measurements were made with an unreliable thermistor, i.e., a thermistor which was being heated directly by the measuring current (fig. 4). A directly heated thermistor showed that the wedge temperature in the pulmonary artery was higher than the temperature of the blood flowing in the same artery (fig. 4a). Making the same measurements with a thermistor in which the measuring current caused negligible heating, it was shown that no appreciable temperature variation occurred between the wedge and the mid-stream positions in the pulmonary artery (fig. 4b). The incorrect conclusion that a significant differential temperature existed between wedge and blood in this instance was owing to the cooling of the directly heated thermistor by the flowing blood. The technique used for measuring wedge temperature prevented the blood from flowing.

This report emphasizes the fundamental importance of a thorough understanding of the performance of instruments. It emphasizes in particular the possibility of introducing false physiological data through errors in the measurement of temperature when tests for reliability are not made.

REFERENCE

1. Green, C.B. Thermistors as primary temperature elements. In: Process Instruments and Controls Handbook. Douglas M. Considine (editor). New York: McGraw-Hill, pp. 2-61.

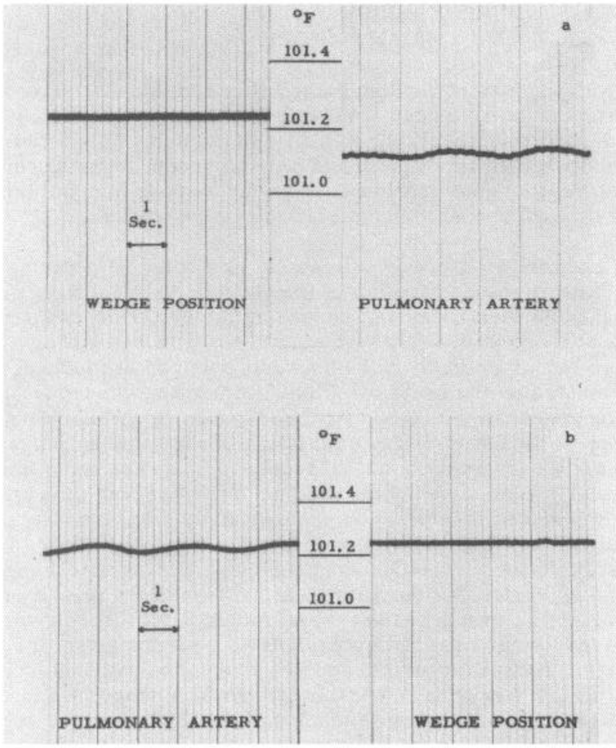


Fig. 4. Demonstration of error caused by an unreliable thermistor-thermometer. Measurements were made in the wedge position and in the pulmonary artery of the dog.

a. The unreliable thermistor-thermometer (one in which the measuring current heated the thermistor directly) showed a higher temperature in the wedge position.

b. The reliable thermistor-thermometer showed no appreciable difference in the temperature at these two sites.

CARDIAC EXCITABILITY*

BRIAN F. HOFFMAN

Various aspects of cardiac excitability and the electrophysiology of cardiac muscle have been reviewed in considerable detail in numerous publications (2,8,11,14,15,16); I will consider only a few of the problems presented by a number of old and recent investigations and attempt to relate these problems, in so far as possible, to information acquired through use of intracellular microelectrodes.

The excitability of the heart usually is studied by applying electrical stimuli to the epicardium of the atria or ventricles through non-polarizable electrodes and recording the electrical response of the heart to these stimuli through electrodes attached either to the same chamber or to another chamber. If only one stimulating electrode is located on the heart, or if one stimulating electrode is much greater in area than the other (4), the stimulus is called unipolar or monopolar. If two stimulating electrodes of the same size are placed on the heart the stimulus is called bipolar. Since the recording electrodes usually are located some distance from the site of stimulation, they are influenced primarily by propagated activity and thus give little or no indication of local responses to the testing stimuli (5). When bipolar stimulating electrodes are employed, appropriate location of the recording electrodes permits identification of the site of origin of the propagated response to the test stimulus (8,13). This can be determined by noting changes in polarity of the electrogram or in the time interval between stimulus and response. In most instances the test stimuli are rectangular current pulses which may be varied with respect to strength, duration, and time of application in the cardiac cycle and polarity. It is possible, however, to use stimuli other than rectangular pulses or to vary the voltage-time course of the stimulus.

The excitability of resting cardiac muscle can be determined by applying stimuli late in diastole and thus, presumably, after the completion of all recovery processes. If the threshold for stimuli of different durations is measured at the same interval of the cardiac cycle, it is possible to construct a strength-duration curve. In form, the strength-duration curve of cardiac muscle is much the same as that obtained for other excitable tissues. Stimuli of 10-20 msec duration are rheobasic and stimuli of less than 0.1 msec duration are effective only if very high current strengths are used. In a given heart, the strength-duration curves of the atria and ventricles are much the same (2). When the resting excitability is altered, the strength-duration curve may shift en bloc or may reveal a more marked change in the threshold for stimuli of one duration than another.

The recovery of excitability after activity can be studied by applying stimuli at selected intervals after activation and measuring the change in threshold as a function of time. The curve obtained in this manner has been termed a strength-interval curve. A typical strength-

*Taken from the introductory talk given at the session on Cardiac Excitability at the Federation Meetings in Chicago, April 11-15, 1960.

interval curve for dog ventricle is shown in figure 1. In this experiment, bipolar stimulating electrodes were employed and the recording electrodes were located far from the stimulus site. For an interval of 150 msec after the onset of activity, the stimuli failed to elicit any propagated response. Subsequently, the stimulus strength required to reach threshold decreased in an irregular fashion until finally a steady level of excitability was obtained. The interval following activity during which stimuli elicit no propagated response is the effective refractory period, sometimes called the absolute refractory period (2). The interval during which the stimulus requirement is greater than the resting threshold is called the relative refractory period.

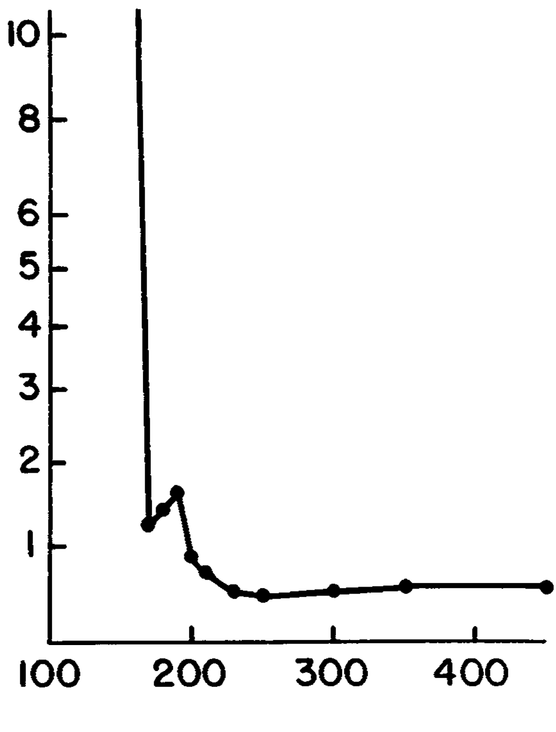


Fig. 1. Typical strength-interval curve for dog ventricle. Ordinate stimulus strength in mA; abcissa, time in cardiac cycle in msec after onset of electrical activity.

A great deal of interest has centered on the transient changes in excitability noted during and immediately after the relative refractory period. The interval just prior to the end of the refractory period during which the threshold is lower than later on during diastole has been called the supernormal period (1,7). The cause of this enhancement in excitability has been explained by studies to be discussed subsequently. Earlier in the relative refractory period there is another transient alteration in excitability which appears as a dip in the bipolar strength-interval curve (2). The cause of this dip has been determined only recently. If the recovery of excitability is studied with unipolar stimulating electrodes two discrete strength-interval curves are obtained (fig. 2). The "cathodal" curve shows a low threshold late in diastole, a supernormal period and a rather smooth change in excitability during the relative refractory period. The "anodal" curve shows a high threshold during diastole; however, during the relative refractory period the anodal threshold becomes lower than the threshold to cathodal stimulation. Also, a clear dip is apparent in the anodal strength-interval curve. These results suggest that, if bipolar stimulation is employed, during part of the relative refractory period threshold stimulation actually occurs at the anodal electrode. That this is the case has been demonstrated directly by noting changes in the latency and form of the electrogram recorded close to each stimulating electrode (4,13). However, the cause of the transient anodal supernormality is not shown by this type of study.

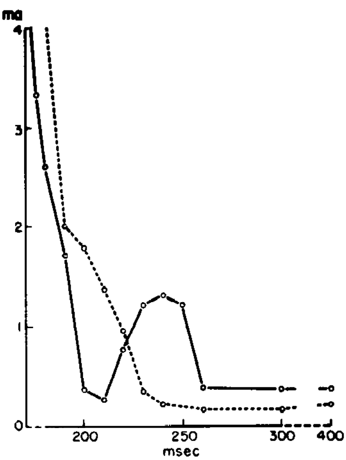


Fig. 2. Strength-interval curves for dog ventricle obtained with unipolar cathode (dashed line) and unipolar anode (solid line). Ordinate, stimulus strength in mA; abcissa, interval of cardiac cycle in msec.

Another phenomenon of considerable interest is associated with stimulation during the relative refractory period. Only during a brief interval during the recovery of excitability will a single suprathreshold stimulus elicit multiple responses or fibrillation. This interval, called the vulnerable period, occupies a similar position in the strength-interval curves of atrium and ventricle. It is possible to measure the "threshold" for fibrillation at several intervals during the vulnerable period and to evaluate changes in vulnerability in terms of changes in the fibrillation threshold (9,20). Although the cause of vulnerability at a particular interval of the cardiac cycle is not certain, it has been demonstrated that simultaneous activation at both the cathode and anode does not necessarily cause any arrhythmia (4). This statement is based on the fact that, if bipolar electrodes are used, both during diastole and the greater part of the relative refractory period suprathreshold stimuli elicit responses at both stimulating electrodes without causing fibrillation. Also, a vulnerable period is demonstrated when monopolar stimulation is employed.

Use of the intracellular microelectrodes has supplied information which helps in the interpretation of some of these observations. Such microelectrodes are glass capillaries with a tip diameter of less than one micron (8,16). One or more of these electrodes can be inserted through the membrane of a single cardiac fiber and used either to record the transmembrane potential or to pass stimulating current.

When a microelectrode is inserted through the membrane, the inside of the resting fiber is found to be negative with respect to the outside by about 90 mv. The transmembrane action potential consists of a rapid depolarization and reversal of polarity, so that the inside of the fiber is positive by about 20 mv, and then a slower repolarization. Depolarization is simultaneous with the intrinsic deflection of the local electrogram. The voltage-time course of repolarization differs in fibers of atrium, ventricle and specialized tissues; however, in each case repolarization of the membrane corresponds in time to the T wave of the surface electrogram. In ventricular fibers from large mammalian hearts, and in Purkinje fibers, depolarization and repolarization are separated by an interval during which the transmembrane potential remains near the zero level; this phase of the action potential, which corresponds in time to the S-T segment of the surface electrogram, has been called a plateau.

If the stimulating and recording electrodes are located quite close together in the same fiber, it is possible to make a more quantitative determination of factors which change excitability than can be accomplished with the usual surface electrodes. This is so because it is possible to measure the stimulus current which actually crosses the fiber membrane and at the same time to record the change in transmembrane potential caused by this current. When this sort of experiment is carried out, one obtains a somewhat different concept of threshold than formerly held. If a rectangular pulse of depolarizing current too weak to cause a propagated response is applied through one intracellular electrode, during passage of the current the transmembrane potential recorded through another similar electrode changes in a characteristic manner. After the onset of current flow, the membrane potential slowly decreases to reach a steady level; after the end of the stimulus, the membrane potential returns to the resting value. The rate of change of membrane potential depends on the time constant of the membrane. If the stimulus current is increased by equal increments, there is a non-linear change in the transmembrane potential. This is a result of a local response which adds to the depolarization caused by the stimulus current. When the depolarization lowers the transmembrane potential to a certain value, the local response is superseded by the all-or-none depolarization of the action potential. The level of membrane potential at which the all-or-none response is elicited has been called the threshold potential (10).

Records of this sort show that excitation occurs whenever the transmembrane potential is lowered to a critical value; excitation does not depend on changing the membrane potential by a fixed amount and thus the usual concept of a threshold is misleading. This type of experiment also indicates several factors which may change the stimulus requirement. The threshold current requirement may change if the level of the threshold potential is increased or decreased, if the level of the resting potential is increased or decreased or if the current-voltage characteristics of the membrane are changed. If other factors remain constant, a lower threshold potential corresponds to a greater stimulus requirement and vice versa. It also should be noted that an electrode which behaves as a "cathode" when extracellular will, if inserted inside the fiber, cause hyperpolarization and thus act as an "anode". For this reason if an intracellular stimulating electrode is used it is more convenient to designate stimulus polarity in terms of the direction of current flow across the membrane or the effect of the stimulus current on transmembrane potential.

If the excitability of a single cardiac fiber is tested at selected intervals during and after the end of repolarization through intracellular stimulating and recording electrodes, the nature of the supernormal phase is shown quite clearly (19). During the latter part of repolarization the transmembrane potential is less tham the resting potential; at the same time, the threshold potential has its normal value. A stimulus applied at this time need cause less displacement of the membrane potential to reach the critical threshold level than after repolarization is complete. For this reason, the stimulus current requirement is less just before the end of repolarization than later on in the cycle; therefore, in terms of the threshold stimulus requirement, there is a phase of supernormal excitability immediately after the relative refractory period.

Inspection of the records of transmembrane potential obtained when stimuli are applied at progressively longer intervals after the onset of depolarization reveals several other points of interest. During the plateau of the action potential and until repolarization has restored the transmembrane potential to a value of about 50 mv, even very strong depolarizing stimuli elicit no appreciable active response. At membrane potentials between 50 and 70 mv, strong stimuli cause local depolarizations which are graded in relation to the strength of the stimulus. At levels of membrane potential higher than 70 mv, the response to stimuli of threshold intensity is all-or-none and is propagated. However, even though propagated, these action potentials are of less than normal amplitude and show a greatly reduced rate of depolarization. Not until the full resting membrane potential has been restored does the action potential regain its normal configuration and amplitude.

These findings suggest that the terms commonly used to describe the recovery of excitability may be misleading. The absolute refractory period should refer to that interval during which depolarizing stimuli cause no active response. This period is followed by an interval during which stimuli cause local responses; the first propagated response thus signals the end of the effective refractory period and the beginning of the relative refractory period. During the supernormal period, even though the stimulus requirement is less than after completion of repolarization, the response of the heart is abnormal in terms of the shape and amplitude of the action potential and the velocity of propagation. The end of the supernormal period corresponds to the completion of repolarization and is best referred to as the full recovery time. This usage is in general agreement with earlier definitions (12). An additional method of describing the recovery of excitability is suggested by the records obtained through intracellular microelectrodes. Even though the duration of the action potential may vary greatly, the relationship between the level of membrane potential and the character of the response may be unaltered; conversely, even in the absence of a change in the duration of the action potential, a higher or lower level of membrane potential may be necessary for the appearance of a propagated response. It is of some value, therefore, to describe the recovery of excitability not only in terms of time after the onset of depolarization but also in terms of the levels of membrane potential at which a given type of response is obtained.

If microelectrodes are used to study the effects of "anodal" stimuli, i.e., hyperpolarizing currents, several interesting findings are encountered. In the first place, the results obtained with surface electrodes are largely confirmed. During the latter part of repolarization, corresponding to the relative refractory period, the threshold current requirement for depolarizing ("cathodal") stimuli is greater than for hyperpolarizing ("anodal") stimuli. Also, the threshold current requirement for hyperpolarizing stimuli at this time is lower than after the end of repolarization. Furthermore, if hyperpolarizing stimuli of adequate strength and duration are applied at any time after the upstroke of the action potential, on the break of the stimulus a new action potential appears. These action potentials are graded in amplitude in relation to the degree of repolarization produced by the flow of stimulus current and demonstrate again the relationship between the level of membrane potential and the response to stimulation (17). Still another effect can be brought about by hyperpolarizing currents applied during the action potential. At a certain current strength, on the break of the stimulus the membrane remains fully polarized (18). Moreover, this premature repolarization may propagate for a considerable distance along the fiber (18) and throughout other fibers (3). These observations show that, although cardiac muscle may be refractory to cathodal stimuli throughout much of the action potential, at any time after the upstroke of the action potential anodal stimuli of adequate strength and duration can elicit either a new action potential or a premature repolarization. For this reason the terms usually employed to describe the recovery of excitability can be used to describe that recovery only as it is indicated by the effects of cathodal stimulation.

Some but not all of the effects of anodal stimulation seem to have been explained by the studies carried out using intracellular electrodes. Perhaps the most important of these is the demonstration that in cardiac muscle (17), as in nerve (6), there is an S-shaped relationship between the magnitude of the resting potential and the rate of rise and amplitude of the action potential. At low levels of resting potential inactivation (6) of the mechanism permitting an inward sodium current is assumed to occur; if the membrane potential is returned to the resting value, there is a prompt reactivation of the sodium carrying system and a rapid regenerative response to a threshold stimulus. If anodal stimuli are applied during the relative refractory period, during the flow of current the membrane in the vicinity of the anodal electrode is repolarized or even hyperpolarized and excitability of this area of membrane is restored. On the "off" of the stimulus, current flows from the repolarized region near the electrode into the adjacent, still depolarized parts of the membrane. If this current flow lowers the membrane potential in the vicinity of the anode to the threshold potential, excitation occurs. The rate of rise and amplitude of this break response depend on the level of membrane potential or degree of repolarization caused by the anodal stimulus.

The observation that the threshold for anodal stimulation is lower during the relative refractory period than after the end of repolarization may result from the fact that, in diastole, the entire heart is fully polarized. Unless an anodal stimulus applied at this time causes a marked local hyperpolarization, current flow between the hyperpolarized and normally polarized areas of the membrane may not be sufficient to cause excitation. It should be noted, however, that even though it is relatively easy to elicit an anodal break response during the relative refractory period, and even though this response may be relatively normal in amplitude and configuration at its site of origin, propagation may not take place. This is so because areas at some distance from the anodal electrode have not yet repolarized. If the local spread of the anodal break response is slow enough to permit adequate repolarization in adjacent membrane, propagation will take place. Otherwise, the anodal break response will remain a local response or show decremental conduction.

Studies of the transmembrane potential of single fibers have not contributed greatly to our understanding of the nature of the vulnerable period. Since anodal stimuli can elicit a local action potential at a time when propagation throughout the adjacent muscle is impossible, it is certain that local disorganization can be produced in this manner. However, fibrillation of the intact ventricle can be brought about by single suprathreshold stimuli which are either anodal or cathodal and thus the interesting effects of hyperpolarizing currents on the fiber membrane do not seem to be directly implicated. Also, fibrillation is a phenomenon of the intact heart and thus other contributory factors should be considered. One of the most important of these is the lack of homogeneity of fibers in each chamber. The duration of the refractory period of fibers in the specialized conducting system is longer than that in ventricular muscle; during the vulnerable period the ventricular fibers can develop a propagated response but the Purkinje system may not be able to do so. The creation and persistence of fibrillation requires a certain mass of muscle; if a fibrillating dog ventricle is cut into smaller and smaller bits, when a given piece is reduced in size by a sufficient amount the arrhythmia ceases and subsequent stimulation usually fails to induce a new fibrillation. Finally, when electrical stimuli are applied to the intact ventricle it is not certain that the stimulus current acts only on the myocardial fibers; during part of the cardiac cycle threshold stimulation may involve direct activation of the specialized conducting system. These observations suggest that studies of cardiac excitability should consider gross and microscopic structure as well as function and that studies of electrical activity might well consider the transmembrane potentials of the several fiber types as well as the electrical response of the entire syncytium. In spite of the numerous experiments which have been carried out, this approach is certain to yield new information about the excitability of the heart and may answer some of the problems which are yet unsolved.

GENERAL REFERENCES

1. Adrian, E. D. J. Physiol. 55:193, 1921.
2. Brooks, C.McC., B. F. Hoffman, E. E. Suckling, and O. Orias, "Excitability of the Heart". New York: Grune, 1955.
3. Cranefield, P. F. and B. F. Hoffman. J. Gen. Physiol. 41:633, 1958.
4. Cranefield, P. F., B. F. Hoffman, and A. A. Siebens. Am. J. Physiol. 190:383, 1957.
5. Drury, A. N. and E. C. Andrus. Heart 11:389, 1924.
6. Hodgkin, A. L. Proc. Roy. Soc. (series B) 148:1, 1957.
7. Hoff, H. E. and L. H. Nahum. Am. J. Physiol. 124:591, 1938.
8. Hoffman, B. F. and P. F. Cranefield. "Electrophysiology of the Heart". New York: McGraw-Hill, 1960.
9. Hoffman. B. F., E. E. Suckling, and C. McC. Brooks. Circulation Research 3:147, 1955.
10. Jenerick, H. P. and R. W. Gerard. J. Cell. Comp. Physiol. 42:79, 1953.
11. Lewis, T. "The Mechanism and Graphic Registration of the Heart Beat". London: Shaw, 1925.
12. Lewis, T. and A. N. Drury. Heart 13:95, 1926.
13. Orias, O., C. McC. Brooks, E. E. Suckling, J. L. Gilbert, and A. A. Siebens. Am. J. Physiol. 163:2, 1950.
14. Schutz, E. Ergeb. Physiol. Exptl. Pharmakol. 38:493, 1936.
15. Van Dam, R. Th. "Experimenteel Onderzoek Naar Het Prikkelbaabheidsverloop Van de Hartspier". Klein Offsetdrukkerij Poortpers N.V.
16. Weidmann, S. "Elektrophysiologie der Herzmuskelfaser". Bern: Hüber, 1956.
17. Weidmann, S. J. Physiol. 127:213, 1955.
18. Weidmann, S. J. Physiol. 115:227, 1951.
19. Weidmann, S. J. Physiol. 129:568, 1955.
20. Wiggers, C. J. and R. Wegria. Am. J. Physiol. 131:296, 1940.