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The Physiologist

A Publication for Physiologists and Physiology
Ray G. Daggs, Editor

THE AMERICAN PHYSIOLOGICAL SOCIETY

Founded in 1887 for the purpose of promoting the increase of physiological knowledge and its utilization.

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RESULTS OF MAIL VOTE ON SELECTION OF ABSTRACTS

A ballot was sent to all members asking them to vote on one of the following:

1. Retention of the present random selection with the elimination of every n^{th} abstract with the result that approximately 850 oral presentations are given. The process will be altered so that no member can be excluded in two successive years.
2. Selection by a committee on the basis of abstracts, plus one page of data for each abstract. The committee is to be relatively large, be of short term, non-renewable appointments, and be named by Council.

Of the 1730 returns received 62% were for option number one, thus it will be in effect for the 1971 Spring meeting.

INTERSOCIETY SESSIONS MEMBRANES AND TRANSPORT

At the Federation meetings in Chicago there will be at least one additional intersociety topic - Membranes and Transport. This will be indicated on the Session Topic Category List that is sent out with the abstract forms for the meeting. It is hoped that transport papers, from all societies including the biochemists who wish to attend the Chicago meetings, will be placed in these sessions.

CALL FOR APS PROGRAM SUGGESTIONS

The Program Committee of APS invites members of the Society to submit suggestions for topics and speakers for the symposia sponsored by the Society at the Spring Meetings with the Federation and for the thirty-minute introductory talks by chairmen of scientific sessions. The Committee would also welcome comments concerning the desirability and feasibility of other forms of presentation, such as, for example, invited one-hour lectures by distinguished scientists at the Spring Meetings. At the request of Council, the Program Committee will attempt long-range planning of symposia to provide continuity and balance over periods of several years. Suggestions or recommendations from members for implementing such plans will be especially appreciated.

To facilitate the submission of specific suggestions of topics and names of participants, a form will be enclosed when nominating ballots are mailed to members prior to the Spring Meeting in 1971.

H. D. Lauson, Chairman
H. M. Goodman
F. F. Jobsis
D. Kennedy
M. F. Wilson

LETTERS TO THE EDITOR

In order to better serve the members, The Physiologist is always willing to publish letters to the editor as a means of getting the views of members on various issues concerning the Society, its activities, articles in The Physiologist, etc. Letters should be sent at least six weeks before the date of publication of each issue - February, May, and November. The August issue is reserved for abstracts of the papers presented at the Fall Meeting.

TRAVEL TO MUNICH

The XXVth International Congress of Physiological Sciences will be held in Munich, Germany July 25-31, 1971. A number of satellite symposia are scheduled before the commencement of the Munich Congress (in Ireland, Italy and Switzerland) or after the termination of the Congress (in Belgium, Czechoslovakia, England, France, Holland, Poland, Switzerland and Hungary).

Heritage Travel, Inc. of Cambridge, Massachusetts will offer travel arrangements to this Congress with the approval of the Organizing Committee in Munich and the USA National Committee for the IUPS.

A charter flight will be offered for round-trip travel between New York and Munich (Departure July 23 and return August 1) for those who cannot spare time for anything but Congress attendance. Another charter flight between the same cities with departure July 22 and return August 8, is also planned.

A variety of group flights will also be offered from and back to the following gateways: New York, Boston, Chicago, Philadelphia, Washington, D. C. and Los Angeles. Some of these groups will be traveling to Munich and back, some will be traveling first to a pre-congress symposium, then to Munich and back to the USA after the termination of the Congress, and some will be traveling to Munich first, proceed afterwards to places of post-congress symposia and return to the USA.

Heritage Travel will offer group tours of total duration of two weeks, three weeks and four weeks. All trips will be offered on the basis of least expensive air fare plus guaranteed hotel accommodations in Munich, especially reserved for the Congress participants.

Travel will be on Pan American World Airways and Lufthansa German Airlines, the official airline to the Munich Congress.

The organizers (Heritage Travel) were hopeful that they would be able to present in this issue of "The Physiologist" detailed programs and cost of tours. This is not possible because transportation rates for 1971 are now being discussed by IATA (International Air Transport Association) in Honolulu. The outcome of these meetings must be approved by the various governments involved. It is expected that a new set of promotional fares will be available for 1971, to benefit the participants of the Munich Congress.

Reluctantly, therefore, the full presentation of a travel program to the Munich Congress has to be postponed until the February issue of "The Physiologist."

This involuntary delay offers the organizers the opportunity to sample opinions of those interested in traveling to the Congress and their preference of certain type of trips. It would be in the best interest of the participants and the organizers to receive as many answers as possible to the following questions:

- 1) Preferred total duration of trip - 9 Days; 2 weeks; 3 weeks; 4 weeks
- 2) Do you prefer to fly a charter plane to Munich only or do you prefer to travel in smaller groups to Munich and other places? -
Preference for charter; Preference for group.
- 3) Would you prefer to make stopovers on the way to Munich and return right after Congress termination or to travel to the Congress first and visit other places afterwards? - Munich last; Munich first.
- 4) Do you intend to participate in any satellite symposia? If answer is yes, please indicate name and place.
- 5) From which of the following gateway airports would you prefer to depart and return to the USA (please indicate two preferences) -
New York; Boston; Chicago; Philadelphia; Washington, D. C. ;
Los Angeles.

Your answer should be mailed to:

Heritage Travel, Inc.
Congress Department
238 Main Street
Cambridge, Mass. 02142

Should any of the prospective participants in the Congress desire information about alternate methods of traveling to the Congress and being accommodated in Munich, please write to Heritage Travel, Inc. which will willingly answer all individual queries.

FUTURE MEETINGS

- 1971 Spring - Federation Meeting, April 12-17 in Chicago. (The Bio-chemists are meeting separately in San Francisco June 13-18, 1971).
- 1971 Summer - XXV International Congress of Physiological Sciences, July 25-31 in Munich, West Germany.
- 1971 Summer - APS Meeting, University of Kansas, Lawrence, Kansas August 15-20.
- 1972 Spring - Federation Meeting, April 9-14 in Atlantic City.
- 1972 Summer - APS Meeting, Pennsylvania State University, University Park, Pa. August 27-September 1.
- 1973 Spring - Federation Meeting, April 15-20 in Atlantic City.
- 1973 Summer - APS Meeting, McGill University, Montreal, Canada, August 27-September 1

APS MEMBERSHIP STATUS

September 1970

Active Members	3282
Retired Members	181
Honorary Members	17
Associate Members	311
Retired Associate	1
	<hr/> 3792

DECEASED MEMBERS

The following deaths were reported since the 1970 Spring Meeting

William J. Bowen - 7/28/70	Merkel H. Jacobs - 6/27/70
Kenneth C. Fisher - 1/22/70	Alonzo M. Lands - 1/15/70
R. M. Fraps - 4/9/70	C. N. Hugh Long - 7/6/70
Maurice H. Givens - 4/19/70	Shawn Schapiro - 8/9/70
William A. Hiestand - 1/15/69	Arthur H. Steinhaus - 2/8/70
R. J. Hock - 8/28/70	James E. Toman - 5/13/70
Chester Hyman - 4/19/70	Donald M. Wilson - 5/26/70

NEWLY ELECTED MEMBERS

The following, nominated by the Council, were elected to membership in the American Physiological Society at the Fall Meeting, 1970.

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 BARCHAS, Jack D.: Asst. Prof. Psychiat., Stanford Med. Sch.
 BASSETT, Arthur L.: Asst. Prof. Pharmacol., Columbia Univ.
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- Publications Manager and Executive Editor - Sara F. Leslie
- American Journal of Physiology and Journal of Applied Physiology
- Section Editors - D. F. Bohr, T. Cooper, W. C. Randall (Circulation); L. E. Farhi, S. Permutt (Respiration); W. B. Kinter, E. E. Windhager (Renal and Electrolyte); P. F. Curran (Gastrointestinal); B. R. Landau, F. E. Yates (Endocrinology and Metabolism); J. D. Hardy (Environmental); C. L. Prosser (Comparative and General); V. B. Brooks (Neurobiology); O. D. Ratnoff (Hematology); F. N. Briggs, C. L. Prosser (Muscle)
- Journal of Neurophysiology - J. M. Brookhart, Chief Editor
- Physiological Reviews - J. R. Brobeck, Chairman Editorial Board; D. R. Wilkie, Chairman European Committee; R. G. Daggs, Associate Editor
- Handbooks of Physiology - A. P. Fishman, Chairman Editorial Committee; S. R. Geiger, Executive Editor
- The Physiologist - R. G. Daggs, Editor
- Physiology in Medicine - A. P. Fishman, Editor

PAST OFFICERS

- Presidents - 1888 H. P. Bowditch. 1889-1890 S. W. Mitchell. 1891-1895 H. P. Bowditch. 1896-1904 R. H. Chittenden. 1905-1910 W. H.

Howell. 1911-1913 S. J. Meltzer. 1914-1916 W. B. Cannon. 1917-1918 F. S. Lee. 1919-1920 W. P. Lombard. 1921-1922 J. J. R. MacLeod. 1923-1925 A. J. Carlson. 1926-1929 Joseph Erlanger. 1930-1932 W. J. Meek. 1933-1934 A. B. Luckhardt. 1935 C. W. Greene. 1936-1937 F. C. Mann. 1938-1939 W. E. Garrey. 1938 W. T. Porter Honorary President. 1940-1941 A. C. Ivy. 1942-1945 Philip Bard. 1946-1947 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. 1960 J. H. Comroe, Jr. 1961 H. W. Davenport. 1962 H. S. Mayerson. 1963 Hermann Rahn. 1964 J. R. Pappenheimer. 1965 J. M. Brookhart. 1966 R. E. Forster. 1967 R. W. Berliner. 1968 L. D. Carlson. 1969 C. L. Prosser.

Secretaries - 1888-1892 H. N. Martin. 1893-1894 W. P. Lombard. 1895-1903 F. S. Lee. 1904 W. T. Porter. 1905-1907 L. B. Mendel. 1908-1909 Reid Hunt. 1910-1914 A. J. Carlson. 1915-1923 C. W. Greene. 1924-1929 W. J. Meek. 1930 A. C. Redfield. 1931-1932 A. B. Luckhardt. 1933-1935 F. C. Mann. 1936-1939 A. C. Ivy. 1940-1941 Philip Bard. 1942 C. J. Wiggers. 1943-1946 W. O. Fenn. 1947 M. B. Visscher.

Treasurers - 1888-1892 H. N. Martin. 1893-1894 W. P. Lombard. 1895-1903 F. S. Lee. 1904 W. T. Porter. 1905-1912 W. B. Cannon. 1913-1923 Joseph Erlanger. 1924-1926 C. K. Drinker. 1927-1936 Alexander Forbes. 1937-1940 W. O. Fenn. 1941 C. J. Wiggers. 1942-1946 Hallowell Davis. 1947 D. B. Dill.

Executive Secretary-Treasurer - 1948-1956 M. O. Lee. 1956 - R. G. Dagg.

CONSTITUTION AND BYLAWS

CONSTITUTION

(Adopted at the 1953 Spring Meeting)

ARTICLE I. Name

The name of this organization is THE AMERICAN PHYSIOLOGICAL SOCIETY.

ARTICLE II. Purpose

The purpose of the Society is to promote the increase of physiological knowledge and its utilization.

BYLAWS

(Amended April 1966)

ARTICLE I. Principal Office

SECTION 1. The Society shall have its principal place of business at 9650 Rockville Pike, Bethesda, Maryland 20014. The Central Office shall house all activities delegated to the employees of the Society.

ARTICLE II. Corporate Seal

SECTION 1. The corporate seal of the Society shall be a circle surrounded by the words, THE AMERICAN PHYSIOLOGICAL SOCIETY. The seal shall also show the founding date and the date and place of incorporation.

SECTION 2. The Executive Secretary-Treasurer shall have custody of the seal. It shall be used on all official documents requiring it, and shall be placed on the documents by the Executive Secretary-Treasurer upon approval by Council.

ARTICLE III. Membership

SECTION 1. The Society shall consist of regular members, honorary members, associate members, retired members and sustaining associates.

SECTION 2. Regular Members. Any person who as conducted and published meritorious original research in physiology, who is presently engaged in physiological work, and who is a resident of North America shall be eligible for proposal for regular 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 regular membership shall be eligible for proposal for associate membership in the Society provided they are residents of North America. Associate members may later be proposed for regular membership.

SECTION 5. Retired Members. A regular or associate member who has reached the age of 65 years and/or is retired from regular employment may, upon application to Council be granted retired member status.

SECTION 6. Sustaining Associates. Individuals and organizations who have an interest in the advancement of biological investigation may be invited by the President, with approval of Council, to become sustaining associates.

SECTION 7. Nominations for Membership. Two regular members of the Society must join in proposing a person for regular membership, honorary membership or associate membership, in writing and on forms provided by the Executive Secretary-Treasurer. The Membership Committee shall investigate their qualifications and recommend nominations to Council. Council shall nominate members for election at the Spring and Fall meetings of the Society. A list of nominees shall be sent to each regular member at least one month before the Spring and Fall meetings.

SECTION 8. Election of Members. Election of regular members, honorary members and associate members shall be by secret ballot at Spring and Fall business meetings of the Society. A two-thirds majority vote of the members present and voting shall be necessary for election.

SECTION 9. Voting. Only regular members shall be voting members. Honorary, retired and associate members shall have the privilege of attending business meetings of the Society but shall have no vote.

ARTICLE IV. Officers

SECTION 1. Council. The management of the Society shall be vested in a Council consisting of the President, the President-Elect, the immediate Past-President, and four other regular members. The terms of the President and of President-Elect shall be one year. 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 quorum for conducting official business of the Society shall be five of the seven elected members of Council.

The Chairman of the Publications Committee; the Chairman of the Finance Committee; and the Executive Secretary-Treasurer are ex-officio members of the Council without vote. The Council may fill any interim vacancies in its membership. Council shall appoint members to all committees.

SECTION 2. President. A person shall 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 1. The President shall chair all sessions of the Council and business meetings of the Society and shall be an ex officio member of all committees without vote.

SECTION 3. President-Elect. The President-Elect shall serve as Vice-President of the Society and as official secretary of the Council. Should he have to function as President prematurely, the Council shall select from among its own members an official secretary.

SECTION 4. Election of Officers. Nominations and election of a President-Elect and Councilor(s) shall be by secret ballot at the Spring business meeting of the Society. They shall assume office on July 1 following their election.

SECTION 5. Executive Secretary-Treasurer. 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. He shall be responsible for management of the Central Office of the Society under general supervision of the Council.

ARTICLE V. Standing Committees

SECTION 1. Publications Committee. A Publications Committee composed of three regular members of the Society appointed by Council shall be responsible for the management of all of the publications of the Society. The term of each member of the Publications Committee shall be three years; a member may not serve more than two consecutive terms. The Council shall designate the Chairman of the Committee who shall be an ex officio member of the Council, without vote. Council is empowered to appoint and compensate a Publications Manager who shall assist in carrying out the functions of the Publications Committee under the supervision of the Executive Secretary-Treasurer. The President, Executive Secretary-Treasurer and the Publications Manager shall be ex officio members of the Publications Committee without vote. The

Committee shall have the power to appoint editorial boards for the Society's publications. The Committee shall present an annual report on publications and policies to the Council for approval and present an annual budget coordinated through the Executive Secretary-Treasurer, to the Finance Committee for its approval and recommendation to Council.

SECTION 2. Finance Committee. A Finance Committee, composed of three regular members of the Society appointed by Council, shall receive the total coordinated budget proposals annually from the Executive Secretary-Treasurer and shall determine the annual budgets, reserve funds and investments of the Society, subject to approval by the Council. The term of each member of the Finance Committee shall be three years, a member may not serve more than two consecutive terms. The Council shall designate the Chairman of the Committee who shall be an ex officio member of the Council, without vote. Council is empowered to appoint and compensate a Business Manager who shall assist in carrying out the functions of the Finance Committee under the supervision of the Executive Secretary-Treasurer. The President-Elect, Executive Secretary-Treasurer and the Business Manager shall be ex officio members of the Finance Committee, without vote.

SECTION 3. Membership Committee. A Membership Committee, composed of six or more regular members of the Society appointed by the Council, shall receive and review processed applications for membership and make recommendations for nomination to the Council. The term of each member of the Membership Committee shall be three years; a member shall not be eligible for immediate reappointment. The Chairman of the Committee shall be designated by the Council.

SECTION 4. Education Committee. An Education Committee, composed of five or more regular members of the Society and representatives of such other societies as may be designated by the Council appointed by the Council, shall conduct such educational, teaching and recruitment programs as may be required or deemed advisable. The term of each member of the Education Committee shall be three years. The Chairman of the Committee shall be designated by the Council. The Executive Secretary-Treasurer may act as Executive Director of the educational programs with approval of the Council. The Committee shall present an annual report to the Council and an annual budget through the Executive Secretary-Treasurer to the Finance Committee for its approval.

SECTION 5. The Council may appoint such special and other standing committees as it deems necessary or that are voted by the Society. The Council may name regular members of the Society as representatives to other organizations whenever it deems such action desirable.

ARTICLE VI. Dues

SECTION 1. Annual Dues. The annual dues for regular members and associate members shall be determined by the Council and shall be paid in advance of July 1. Honorary members and retired members shall pay no membership dues.

SECTION 2. Non-payment of dues. A regular or associate 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 meeting by vote of the Council. It shall be the duty of the President-Elect to notify the delin-

quent of his right to request reinstatement.

SECTION 3. Retirement. A regular or associate member who has been granted retired membership status is relieved from the payment of dues but retains the other privileges of his former membership status, except voting privileges.

ARTICLE VII. Financial

SECTION 1. Society Operating Fund. The Society Operating Fund shall consist of all funds, other than Publication Operating Funds and Publication Contingency and Reserve Funds, restricted or unrestricted, uninvested or invested, short or long term. The Executive Secretary-Treasurer shall be the responsible agent to the Council with signatory powers. Signatory powers may be delegated to the Business Manager by the Executive Secretary-Treasurer.

SECTION 2. Publications Operating Fund. The Publications Operating Fund shall consist of all funds that involve receipts, expenses, short-term investments relating to the annual receipts, disbursements and continuing operation of the Society's publications. The Executive Secretary-Treasurer shall be the responsible agent to the Council with signatory powers. Signatory powers may be delegated to the Publication Manager and/or the Business Manager by the Executive Secretary-Treasurer.

SECTION 3. Publications Contingency and Reserve Fund. The Publications Contingency and Reserve Fund shall consist of the long-term capital investments of publication earnings. The Executive Secretary-Treasurer, with advice from the Finance Committee, shall have discretionary and signatory powers, except for withdrawals. Authority for any withdrawal from this fund, shall require the following five signatures: 1) the Chairman of the Publications Committee (alternate, the senior member of the Committee); 2) the President of the Society (alternate, the President-Elect); 3) the Executive Secretary-Treasurer (alternate, the Publications Manager); 4) and 5) any two members of Council. The Finance Committee shall not recommend to Council the expenditure of any of this capital fund for non-publication purposes without the consent of the Publications Committee. The Finance Committee shall be responsible for the separate investment of the reserve fund for publications; any capital gains from such investment shall accrue to the fund (capital losses will, however, reduce its value). Any dividends, interest or income, other than capital gains, from this invested fund may be used for emergency support of any of the activities of the Society, including publications, as determined annually by the Council but the primary goal shall be to increase the investment capital.

SECTION 4. Fiscal Year. The official fiscal year shall be from January 1 through December 31.

SECTION 5. Audit. All statements of net assets and related statements of income, expenditures and fund capital shall be audited annually by an independent auditing firm.

SECTION 6. Bonding. All persons having signatory powers for the funds of the Society shall be bonded.

ARTICLE VIII. Publications

SECTION 1. The official organs of the Society shall be the American Journal of Physiology, the Journal of Applied Physiology, Physiological Reviews, the Journal of Neurophysiology, The Physiologist, and such other publications as the Society may own. All publications shall be under the jurisdiction and management of the Publications Committee unless otherwise designated by the Council. The names of the journals and publications may be changed by the Council on recommendation from the Publications Committee and any publication may be dropped by Council on recommendation from the Publications Committee.

ARTICLE IX. Meetings

SECTION 1. Spring Meeting. A meeting of the Society for transacting business, electing officers and members, presenting communications, and related activities, shall ordinarily be held in the Spring of each year.

SECTION 2. Fall Meeting. A Fall meeting of the Society shall be held at a time and place determined by the Council for presenting communications, electing members, and for transacting business except for the election of officers and adoption of amendments to the Bylaws. Under exceptional circumstances Council may cancel such a meeting.

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

SECTION 4. Quorum. At all business meetings of the Society fifty regular members shall constitute a quorum.

SECTION 5. Parliamentary Authority. The rules contained in Roberts Rules of Order, Revised 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.

ARTICLE X. Society Affiliations

SECTION 1. The Society shall maintain membership in such organizations as determined by Council.

ARTICLE XI. Regulations

SECTION 1. General Prohibitions. Notwithstanding any provision of the Constitution or Bylaws which might be susceptible to contrary interpretation:

- a. The Society is organized and operated exclusively for scientific and educational purposes.
- b. No part of the net earnings of the Society shall or may under any circumstances inure to the benefit of any member or individuals.
- c. No substantial part of the activities of the Society shall consist of carrying on propaganda, or otherwise attempt to influence local, state or national legislation. (All activities of the Society shall be determined by Council). The Society shall not participate in, or intervene in (including the

- publishing or distributing of statements) any campaign on behalf of any candidate for public office.
- d. The Society shall not be organized or operated for profit.

SECTION 2. Distribution on Dissolution. Upon lawful dissolution of the Society and after payment of all just debts and obligations of the Society, Council shall distribute all remaining assets of the Society to one or more organizations selected by the Council which have been approved by the United States Internal Revenue Service as organizations formed and dedicated to exempt purposes.

ARTICLE XII. General

SECTION 1. Records. All official records, archives and historical material shall be held in the Central Office in the custody of the Executive Secretary-Treasurer.

SECTION 2. Procedures and Customs. The Society shall maintain a current Operational Guide detailing the procedures and current customs of the Society operations as well as the duties and responsibilities of officers, committees, and major employees. The Operational Guide shall be maintained current by the Executive Secretary-Treasurer as determined by the Council.

ARTICLE XIII. Amendments

SECTION 1. Presentation. Amendments to these Bylaws may be proposed in writing, by any regular member, to Council at any time up to three months in advance of the Spring meeting, or at a business meeting of the Society. Such proposed amendments must be presented in writing at the following Spring business meeting for action by the Society.

SECTION 2. Adoption. These Bylaws may be amended at any Spring business meeting of the Society by a two-thirds majority vote of the regular members present and voting.

PAST-PRESIDENT'S ADDRESS THE JOYS OF LOCOMOTION

C. LADD PROSSER

I do not plan to entertain you this evening with a whimsical after-dinner speech; I exhausted my stock of stories at last year's dinner. Nor do I want to engage in hand-wringing about the current lack of financial support for physiology. I do wish to discuss briefly but seriously an aspect of physiology which I feel we are neglecting in our teaching and public information. I speak primarily to practicing and potential physiologists who are young in age or outlook.

My thesis is that the time is ripe to promote physiology for its intrinsic worth, not solely as an underpinning for medicine. I contend that we have been trying to sell our subject on limited promises and inadequate premises. The contributions of basic physiology to medicine, agriculture, and other technologies are great and I would not minimize the benefits of our science toward improvement of modern living. The list of diseases which have been conquered with the help of basic medical science is a long one; the list of diseases remaining to be conquered is a challenge to physiologists of the future. Unless we maintain a strong base of research we shall not provide the platform for progress by future generations. However, applications of basic research are unpredictable and the time lag between discovery and application may obscure the connection. Most of you recognize that the difficulties of extrapolation from rat or dog to man are so great as to make many investigations on these animals of more academic than practical value.

There is a clear distinction in motivation between basic and applied medical scientists; the basic scientist receives his satisfaction from learning in small steps some biological mechanism, the applied scientist is motivated by the goal of contributing to the cure of some disease. Ultimately the two approaches may merge but at the level of the working scientist they are clearly different and each deserves financial support. It is frequently possible to trace a potential relation of a basic science topic to a hoped-for application and we need more case histories of such relations. However, such subjects as the nature of nerve conduction as studied in squid giant axons, much of muscle physiology and of animal behavior are very remote from application in medicine. The question is often asked "Who cares about such things?" Relevance changes from time to time according to public fads; witness the current emphasis on environmental biology. There are different opinions as to how remote the application can be, to merit support in terms of relevance. We sorely need a national policy as to suitable level of support for that science which has a low relevance coefficient but which is of high intellectual quality.

Health is not a sufficient end in itself; rather, modern man needs more richness of life. Youth today is disillusioned with much of technology, with prolongation of living without life. Sincere students are attacking science, considering that it does more harm than good; they

seem not to admit that social evils result from the application of science rather than from discoveries by scientists. Values are changing and young people are reacting against militarism, racism, materialism and against wastage of our natural resources; they are renouncing multi-car households, color TV, families of more than two children. They seriously desire a lower material standard of living, hopefully to obtain a richer life. Most of all, they are searching for meaning in life, for ways in which they as individuals can help correct social ills. As the ratio of population to resources increases and as standards are raised for developing nations, Americans will have lower standards of living whether we like it or not.

Every man needs a "cause," a motivation. Formerly this was provided by the Judeo-Christian religion. The loss of religious motivation led to the return to Hitlerian neo-paganism, Marxist reductionism, Mao-Castroite romanticism, existential nihilism and, some would say, to Darwinian mechanism to which we as physiologists subscribe.

Science today is like the building of cathedrals in the Middle Ages - much of it may be irrelevant to immediate social problems but tremendously satisfying for personal needs. Bureaucrats and Congressmen who demand immediate social application of science are like freshmen who want only socially relevant courses. If we had to convince children of the utility of printed language, how many six-year-olds would learn to read? In contradiction to many Commencement speakers of 1970, who preached that science is dead, I assert that science is the crowning achievement of modern society, it is still the means by which humanness of life will be fulfilled, that a primary goal of mankind is to unravel the mysteries of life and the cosmos, to present a unified picture of man's place in nature. The wonders of nature revealed by modern science are as staggering, as awe-inspiring, and as beautiful as those mysteries which inspired our ancestors.

It is time for us to consider the goals of physiology in terms of esthetics and ethics. I am a physiologist, not to cure some disease - although I should be glad if some discovery of mine could be so applied - but because I want to know what makes animals tick, especially what makes man tick. I want to understand the nature of life and I am confident that life processes can be explained in terms of physics and chemistry. In presenting physiology to young students and to the public it is time for us to be honest and to describe the motives of physiological practice as it really is, not as a bundle of promises.

In the words of the contemporary Russian poet Yevtushenko -

"Telling lies to the young is wrong.
 Proving to them that lies are true is wrong.
 Telling them that God's in his heaven and all's
 well with the world is wrong.
 The young know what you mean. The young are
 people.
 Tell them the difficulties can't be counted
 and let them see not only what will be but

see with clarity these present times.
Say obstacles exist they must encounter.

Forgive no error you recognize,
it will repeat itself, increase,
and afterwards our pupils
will not forgive in us what we forgave."

Esthetics

First, consider the esthetic values in physiology, the beauty in the organization and integration of living things. Physiology may be defined as the dynamics of life, and its pursuit can give rich experiences of emotional excitement and intellectual satisfaction. Let me cite a personal experience. One evening last winter I listened to Soulima Stravinsky play a recital of Beethoven sonatas - my attention was held as I was thrilled by the beauty of the performance and of the compositions. The following evening I listened to a semi-popular lecture by the biochemist Khorana on the genetic code - with themes of the nucleotide alphabet, DNA language and its translation to protein synthesis. The second evening was an esthetic experience equal to the first. What motivated Beethoven was not very different from the motivation of William Harvey and Claude Bernard.

Knowledge for its own sake is intrinsically good. This attitude disclaims the defeatist philosophy that the end of life is reproduction, misery and death. Knowledge of life processes leads to reverence for life, to respect for human life. One need not be a specialist to have esthetic experiences in science. Before the days of television intellectual societies provided enlightenment and entertainment in combination. Those who are devoted to scientific projects have excitement without psychedelic drugs. Only a few writers and lecturers have presented physiology in all its beauty - complexity of interrelations, homeostasis of function systems, integration at different levels, evolutionary perspective on life functions. It is not necessary to use the gobbledy-gook of technical publication to present the beauty of physiology; we must find ways to communicate more meaningfully. The organization of our traditional courses often confuses more than it enlightens the students.

The scientific method is in itself esthetic. What can match the thrill of an original discovery, no matter how small? The essence of science is its tentativeness, and progress in science comes when current hypotheses prove inadequate. Some scientists use models and mathematical formulations to present their pictures of natural processes. These in themselves can be objects of beauty. We are asked for generalizations, but the more we explore the physiology of plants and animals, the more exceptions we find, and these are the clues to new discoveries. No generalization is likely to be permanent. The unknown presents a challenge to further exploration. Truly the reason most of us are physiologists is for the sheer joy of it.

Ethics

What of ethics, of a basis for moral behavior? I believe that knowledge of the dynamics of life can provide a sound basis for standards of social values. Man is the result of a long biological and a shorter cultural history, and comparative physiology puts man in his proper biological perspective. My basic philosophical tenet is the concept of emergent evolution; that at each level of biological organization new properties appear, that the whole is not equal to the sum of the parts, and that it is not possible to predict at one level those properties which emerge at a more complex level. Human behavior is the resultant of neurological and endocrine bases with superposed cultural development. Social organization is the natural emergent consequence of man's total history; people need people. Man's sense of social responsibility may have evolved along with communication by speech, with division of labor in groups and other behaviors unique to man. In emergent evolution the goal for man is not survival for its own sake but continuity and extension of the good life, survival in the sense of richness of human life, a richness due to all men.

Knowledge of the nature and history of man gives respect for humanity, a sense of responsibility for other men, in present and future generations. Knowledge of environmental biology, of the adaptations and two-way interactions of organisms with environment gives a sense of responsibility for natural resources and our earth environment. More effort needs to be put forth by those of us for whom science is a humanistic religion. We must counter the retreat to drugs, to the occult, to concepts of transmigration and predestination. Truly, biological awareness can provide a powerful basis for an ethical system, for values in human behavior. Cultivating such awareness is the best way we can combat the wave of anti-intellectualism in our country and thus recover support for science. Perhaps the most important contribution for modern science to society will be to provide a rational bases for an ethical system.

Animal movement as an example of physiological beauty

I should like to conclude with a brief survey of an example of physiological esthetics taken from an area of my own research interest - animal movement. Motility is highly adaptive and speed of movement is largely determined by muscles. The spectrum of muscle speeds and histological types covers a wide range, and muscle physiology has a very few themes on each of which many variations are played according to specific adaptations. As Sherrington stated, "All human achievement rests on muscular achievement." The mechanisms of biological movement present an example of exquisite beauty. Muscles provide for quick eye movements, for the leap of a frog or a lion, the stately flight of a flamingo, the hovering of a hummingbird, the pounce of a hawk, the vibrations of sound by a bat or toadfish, the wing beats of a locust or fly at 100 per second. Slower muscles provide for segmental and peristaltic movements of intestines, tonus of bladder, the slow rhythms of a sea anemone, for the maintained closure of a clam. Muscle speeds cover a range of some 5000-fold for contraction and up to 100,000-fold for relaxation.

The first theme common to muscles, fast or slow, is that all of them contain two proteins, one a large molecule, myosin, the other a smaller one, actin, and interaction between these in some unclear way results in contraction. These two proteins occur in most muscles in thick and thin filaments, often arranged in beautiful patterns, as in the regular arrangement in a fast insect muscle or the less regular arrangement in a slow striated muscle. The location of myosin in some smooth muscles is uncertain but the protein can be extracted from them. The two interacting proteins must have evolved before muscles as we know them, since even contractile cells of some sponges show thick and thin filaments, and related proteins provide for cell division and amoeboid movement. Associated with actin and myosin, several classes of modulating protein have evolved; one set of these (tropomyosin and troponin) facilitates interaction of myosin with actin in the presence of calcium. Another protein of large molecular weight, paramyosin, forms thick filaments with beautiful regular periodicity of 145A; it is found where tension must be maintained for long times, in the adductors of bivalve molluscs for example, as those of you who have opened an oyster can attest. Paramyosin occurs in the notochord of amphioxus (*Branchiostoma*) and in those primitive worms which form "Gordian" knots. This protein does not itself develop tension, but once it is put into a folded configuration by actin-myosin contraction, in some unknown way it makes a muscle rigid, and relaxation of it requires specific relaxing nerves.

Conformational differences in myosins account in part for differences in speed of shortening of muscles and these protein differences are modifiable by trophic influences of nerves. Also differences in the enzymatic properties of myosins permit greater energy liberation in a fast muscle than in a slow one, in the muscle of a cat compared with the same one in a sloth. Myosin is a versatile, varying protein, but the basic interaction between myosin and actin has apparently served for animal movement of all speeds for some 500 million years.

Another theme is the control of muscle by nerves. Most muscles, striated or nonstriated, are activated by signals from motor neurones, whether in jellyfish or man. Some muscle cells, as in fast skeletal fibers of vertebrates, receive only one nerve fiber, which liberates a specific excitatory transmitter of which only two are established - acetylcholine in vertebrates and glutamic acid in arthropods. The transmitter generates a local electrical response in the muscle which may then lead to a muscle impulse which resembles the nerve impulse. Some muscle cells, as in tonic skeletal fibers of frogs and fishes, receive multiple endings from one neurone in which the local response is sufficient to trigger contraction, and no muscle impulse is needed. Still other muscles, as in crustaceans and some insects, receive endings from several neurones, often two excitatory and one inhibitory. Some muscles, both striated and nonstriated, may receive one exciting and one relaxing nerve fiber, each acting by a different transmitter. Patterns of control of gradation of movement may, therefore be located either in the muscles or in the central nervous system. In at least two animals, muscle fibers send processes out to the nervous system; here the nerves do not run to the muscles. The basic theme of neural activation is an ancient one with many variations.

Some muscles have become automatically active, without triggering by nerves. Spontaneity has evolved several times, often along with sensitivity to stretch, and here the nerves modulate rather than initiate activity. The rhythmicity relates a coupling of metabolism with membrane periodicity. Modulated spontaneity permits the beating of hearts and rhythmicity of many visceral organs. A unique kind of intrinsic myogenic rhythm is that of flight muscles of some insects - bees, bugs and flies. The wing may beat faster than normal excitability cycles permit, and one motor impulse can start a train of oscillatory contractions. Even a glycerinated preparation of contractile proteins from the fast repeating muscles can be made to contract rhythmically.

A fourth theme in the comparative physiology of muscles is in the coupling between fiber membrane and contractile protein. In all muscles this appears to be by calcium ions. Even the myocytes of sponges require calcium or another divalent ion. Large striated fibers have a complex system of tubules for transmitting membrane signals inward, for releasing calcium ions for contraction and for rebinding them in relaxation. The largest such fibers occur in crustaceans - the king crab has fibers up to 4mm in diameter. Nonstriated muscles are much thinner, only a few microns thick, they lack the tubular system and apparently calcium movement in the cell membrane causes the action potential and also activates the contraction.

Finally, the interactions between muscle fibers may be mentioned. Most well-innervated striated muscle fibers are widely separated. However in sheets of smooth muscle and some cardiac muscles, low electrical resistance between cells permits some signal coupling. Between cells which are coupled electrically tight junctions occur. Another kind of interaction is mechanical, brought about by the pattern of connective tissue between fibers. A strikingly extensible muscle retracts the proboscis of a marine worm *Golfingia*; here the fibers fold and the pleats are in register across hundreds of fibers giving the appearance of herringbone tweed, particularly striking by polarized light.

Muscles do many things for animals, and they occur in a spectrum of speeds, each with its structural and biochemical adaptations. A few common features extend back to the origin of animal life and have been little changed. Variations that evolved in specific animal groups permit unique kinds of movement. A thoughtful person cannot but admire the beauty of the chemical system which makes animal movement possible and be thrilled by the adaptive variations upon the common themes of muscle activation and contraction. Yet there remain many unanswered questions, the most important of which is how tension is really developed at the molecular level, and I'll not give up my interest until more of these mysteries are solved.

I conclude that dynamic biology can provide bases not only for improvement in health care, food production, environmental quality, and population control, but it offers also esthetic joy and the foundation for an ethical personal philosophy. These latter two uses of our science are fully as practical and as relevant to society as the applied aspects. If physiology is to survive as a science we must come to view it as a broad biological discipline with social values that transcend its function as a prop to medicine.

PROSTAGLANDINS*

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The prostaglandins are naturally occurring cyclical unsaturated fatty acids with highly diverse and potent biological activities which were discovered independently in the early 1930's by Goldblatt (1) and Von Euler (2). Although biological activities attributable to prostaglandins were first discovered in human semen by Kurzrok and Lieb (3) it remained for Von Euler in 1934 to attribute this activity to fatty acids which he extracted from sheep seminal vesicles and called "prostaglandins" (4). The principal biological activities observed by these investigators were lowering of blood pressure in a variety of animal species and stimulation of non-vascular smooth muscle such as intestine to contract. Since chemical techniques for further purification, isolation and identification were not then readily available, the field remained relatively quiescent for about 25 years until 1960 when Bergström and Sjövall isolated two fatty acids from sheep prostate glands called prostaglandin E (PGE) and prostaglandin F (PGF) (5, 6).

These investigators demonstrated that the parent structure of all prostaglandins is a hypothetical compound, prostanoic acid, which is a twenty carbon compound with a cyclical 5 membered ring containing 2 aliphatic side chains one of which contains a carboxyl group (Figure 1).

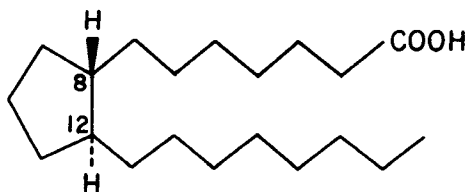


Fig.1. Prostanoic acid, the parent saturated 20 carbon fatty acid containing a cyclopentane.

All the various prostaglandins subsequently isolated and identified from a variety of tissues have this structure in common and differ only in the degree of unsaturation and substitution in the cyclopentane ring or aliphatic side chain. In 1962 Bergström and his coworkers (7, 8) succeeded in elucidating the structure of PGE and PGF compounds (Figure 2). It can be appreciated that both PGE and PGF have a hydroxyl substituent in the 15 position. Prostaglandins E differ from prostaglandins F in that they have a keto group in position 9 in the 5 membered

* Taken from introductory remarks given at a session on prostaglandins at the 1970 Federation Meetings.

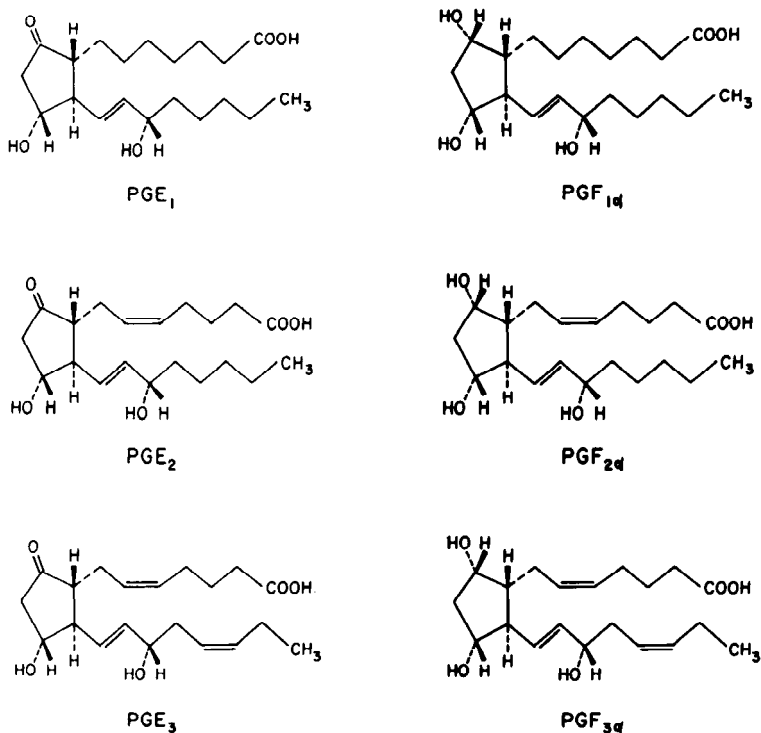


Fig.2. Chemical structures of prostaglandins E and prostaglandins F. The only difference between PGE and the corresponding PGF is reduction of the keto group in the 5 membered ring to a hydroxyl group. The numerals 1,2, and 3 refer to the number of double bonds in the aliphatic side chains.

ring whereas the prostaglandins F contain a hydroxyl substituent at this site. The degree of unsaturation in the aliphatic side chain for both groups is indicated by the numeral following the letter. Thus, PGE₁, PGE₂, and PGE₃ have identical chemical structures except that they have 1, 2 or 3 double bonds in the side chain, respectively. A similar situation exists for prostaglandins F which, however, by virtue of the hydroxyl group at position 9 may exist as the α or β series. At the present writing however, only prostaglandins of the α series are believed to be naturally occurring in compounds. All prostaglandins E have both vasodepressor and non-vascular smooth muscle stimulating activities. By virtue of the relatively simple chemical modification whereby the keto group in position 9 of the prostaglandins E is reduced to a hydroxyl, all vasodepressor activity is lost. Thus prostaglandins

F have only non-vascular smooth muscle stimulating activity. Although the chemical differences between prostaglandins E and F appear to be relatively minor it is important to note that interconversion between these prostaglandins is not believed to occur *in vivo*. It has been shown that PGE and PGF compounds are biosynthesized in various tissues from arachidonic and *cis*-eicosapentanoic acids derived from homo- γ -linoleic acid which is an essential dietary fatty acid (9, 10).

Since the original isolation and identification of prostaglandins in 1960 there has been an explosive growth in the literature dealing with these intriguing compounds (Figure 3). From virtually a single article in 1960 there has been an exponential growth in the prostaglandin literature to the extent that over 290 articles were published in 1969 while during the current year the rate of prostaglandins publications is approximately one per day. This phenomenal expansion of the prostaglandin literature is derived from the fact that they are present in virtually every tissue of many animal species and possess a myriad of biological activities in addition to their blood pressure lowering and non-vascular smooth muscle stimulating effects. The wide spread occurrence of these compounds is evident from the fact that they have been isolated and identified by full structural elucidation from sheep seminal plasma and vesicular glands, human semen, sheep, ox, human, pig and guinea pig lung, sheep iris, calf thymus, and ox brain. In addition, they have been partially characterized in human amniotic and menstrual fluid, and in the blood of

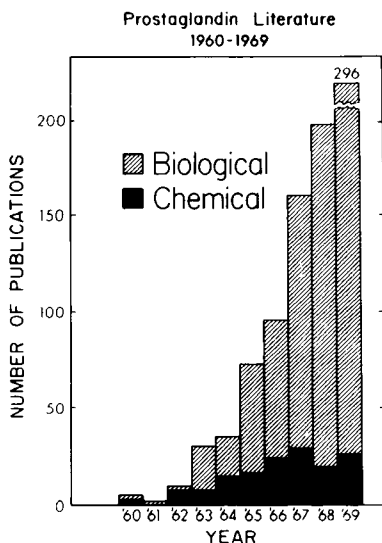


Fig.3. Growth in prostaglandin literature compiled from a bibliography on prostaglandins by Drs. John E. Pike, James R. Weeks, The Upjohn Company, Kalamazoo, Michigan.

pregnant patients during labor (11) as well as in the blood of patients with amino-peptide secreting tumors particularly medullary carcinoma of the thyroid (12), bronchogenic carcinoma, and pheochromocytoma (13). Depending on the animal species and the class of prostaglandins, their multiple biological activities include contraction of the iris of the eye, bronchiolar relaxation, inhibition of gastric hydrochloric acid secretion and experimental ulcer production, intestinal contraction, steroid synthesis, inhibition of platelet aggregation and lipid mobilization, and lowering of systemic blood pressure. They have also been implicated in central nervous system neurotransmission, placental blood flow, dysmenorrhea, sperm transport, fallopian tube function, luteolysis and nasal vasoconstriction. More recently it has been shown that prostaglandins E and F are capable of inducing abortion in primates and in pregnant humans at term by mechanisms indistinguishable from those of oxytocin. Furthermore, it has also been shown that these compounds have the capacity to induce human abortion after the sixth week of pregnancy and to be effective post-coital oral contraceptive agents.

In addition to their profound biological and clinical actions, important basic relationships are beginning to emerge between prostaglandins and cyclic AMP and with the consequent advancement of many hypothesis dealing with their biochemical mechanism of action. However the lack of a specific and sensitive assay for prostaglandins has greatly hampered our understanding of any true biochemical or physiological role for these compounds. The most current and attractive theory is that they may act as local "hormones" and, in some instances, as circulating hemorral substances as well. Because of the voluminous growth in prostaglandin literature the present paper will be limited to a brief review of the effects of these compounds on cardiovascular-renal function. For the bibliography of the sources of the aforementioned biological activities, the interested reader is referred to numerous reviews on these subjects (14-17).

Although many hypothesis have been advanced to determine the etiology of human and experimental renal vascular hypertension and essential hypertension most investigations have been devoted to studying mechanisms or agents which tend to raise the blood pressure, most notably the renal renin-angiotension system. In addition to such pro-hypertensive hypotheses there is a considerable body of evidence which suggests that, in the last analysis, hypertension is not solely the result of agents or mechanisms which raise the blood pressure but may be a deficiency disorder resulting from a lack of normally operative vasodepressor agents (Figure 4). Since most of the evidence for such a function is renal in origin the theory has been referred to as the "antihypertensive renal-endocrine function." That the kidney may exert such an antihypertensive function is derived largely from the following lines of evidence:

1. Unilateral experimental renal vascular hypertension is difficult to achieve without removal of the opposite control kidney suggesting a "protective" or antihypertensive role of the normal kidney in maintaining normotension during partial renal artery occlusion.
2. There has been a notable failure to consistently detect pressor

agents in either human essential hypertension or chronic experimental hypertension in amounts sufficient to account for the observed degree of blood pressure elevation.

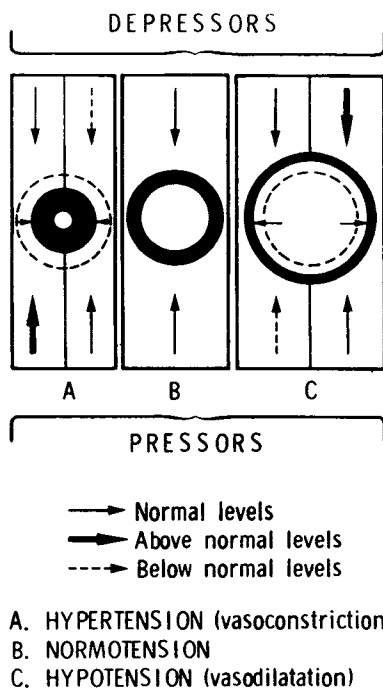


Fig.4. Schematic illustration of a possible interaction between vasodepressor and vasoconstrictor influences on blood pressure regulation. According to this hypothesis normotension (B) would result when pressor mechanisms are equally offset by depressor mechanisms. The state of hypertension (A) would be expected to occur when there was a relative or absolute deficiency of depressor mechanisms while hypotension (C) might be expected to result from an absolute or relative deficiency of pressor systems. From Lee, J.B., Prostaglandins. In: Therapeutic Grand Rounds, J.A.M.A. (in press), reproduced with permission of the publisher.

3. Removal of both kidneys in animals and humans results in a salt dependent hypertension referred to as renoprival hypertension which obviously cannot be ascribed to any renal-renin angiotension mechanism.

4. Transplantation of a normal kidney to hypertensive anephric humans or animals results in an alleviation of the renal as well as the renoprival components of the hypertension.

In 1963 aware of a possible antihypertensive role of the kidney but, unaware of the prostaglandin developments we injected extracts of rabbit

renal medulla into the anesthetized pentobarbitalized rat and observed an acute lowering of blood pressure (18), which lasted from 10 to 15 minutes following intravenous administration (Figure 5). Subsequently, three prostaglandins were isolated from large amounts of rabbit kidney medulla, two of which were responsible for the vasodepression observed in crude homogenates. These compounds were compound 1, compound 2, and medullin (19). Compound 1 appeared to belong to the prostaglandin F class since it had no effects on blood pressure but did stimulate non-vascular smooth muscle to contract; compound 2 on the other hand appeared to be a member of the prostaglandin E class since it possessed both biological activities. Medullin did not appear to be any of the hitherto described prostaglandins since it had only vasodepressor activity and lacked the non-vascular smooth muscle stimulating activities of prostaglandins E and F. All three compounds were identified by non-classical means (20) including mass spectroscopy as $\text{PGF}_2\alpha$ (compound 1), PGE_2 (compound 2) and PGA_2 (medullin). It can be seen

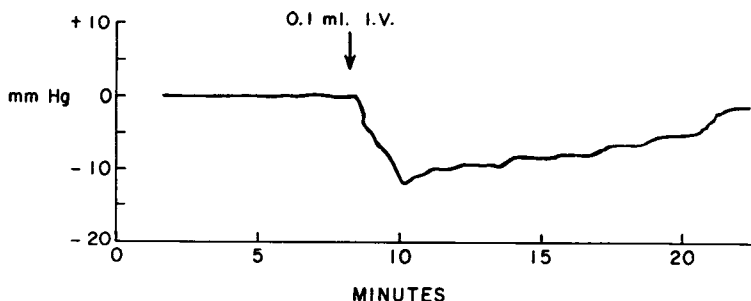
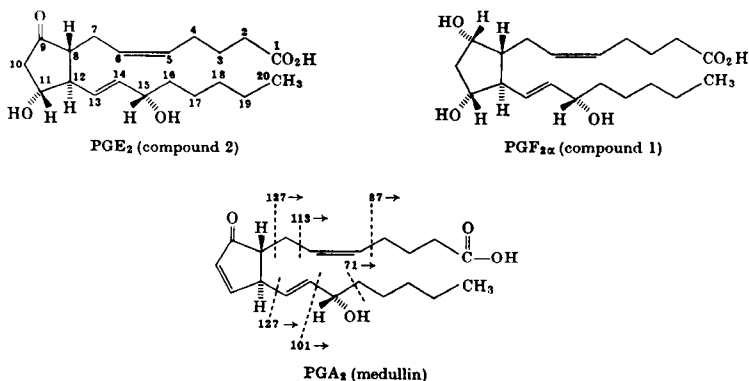


Fig.5. Depression of blood pressure in the pentolinium-treated rat by a saline homogenate of rabbit medulla. 0.1 ml of a 1 g medulla/10 ml homogenate injected intravenously. From (18), reproduced with permission of the publisher.

from Figure 6 that PGA_2 differs from PGE_2 in that it has an α - β unsaturated ketone in the five membered ring which is the result of a loss of 1 water molecule from positions 10 and 11 resulting in the introduction of a double bond at this site. This relatively simple chemical dehydration of PGE_2 results in a loss of all non-vascular smooth muscle stimulating activity with a retention of potent blood pressure lowering effects. PGA_1 and PGA_2 were also identified by Hamburg and Samuelsson in human semen (21) and were found by Daniels and his coworkers to be formed non-enzymatically by acetic acid dehydration of PGE_1 and PGE_2 to PGA_1 and PGA_2 , respectively (22). In addition, PGE_2 was also isolated from rabbit kidney medulla by Daniels et al. (23). Despite intensive efforts to isolate prostaglandins from renal cortex, this tissue was notably free from containing prostaglandins, at least those possessing biological activity.

IDENTIFICATION OF RENOMEDULLARY PROSTAGLANDINS



Structures of the isolated prostaglandins. Suggested fragmentations for all three compounds are indicated in the structure of PGA₂.

Fig.6. Structures of the rat renal medullary prostaglandins. PGA₂ differs from PGE₂ in containing a double bond with removal of 1 water molecule at position 10-11 in the five membered ring. Suggested fragmentations derived from mass spectrophotometric data are indicated in the structure of PGA₂. From (20) reproduced with permission of the publisher.

The possibility that PGE or PGF are circulating hormones appears remote since they are metabolized almost completely by the lungs at considerably greater blood levels than those at which biological activity on target organs is observed. However, more recently PGA compounds have been shown to escape degradation by pulmonary tissue and thus could at least theoretically function as a circulating hormone (24). Since PGA₂ is the only compound present in rabbit renal medulla with purely cardiovascular effects, I would like to briefly review the pharmacological mechanism of its vasodepressor, antihypertensive and natriuretic activity in animals and in patients with essential hypertension. In order to determine whether the blood pressure lowering properties of PGA₂ was central or peripheral in origin the compound was injected into the femoral, carotid, mesenteric, and renal arteries of anesthetized dogs. Figure 7 shows that there was an increase in femoral blood flow from 50 to approximately 140 ml/minute following intra arterial injection of 50 µg of PGA₂ isolated as medullin from the rabbit kidney. Similar increases in flow were observed in all other regional vascular beds studied (25, 26) the renal blood flow being particularly sensitive to injection or infusion of PGA₂ (25). Figure 8 illustrates the results of injection of PGA₂ on systemic hemodynamics in the anesthetized dog. Following injection of PGA₂ there was a significant fall in mean arterial blood pressure which was primarily the result of a fall in diastolic pressure with a resulting increase in pulse pressure. At the time of maximum vasodepression cardiac output increased significantly so there was a fall in the calculated

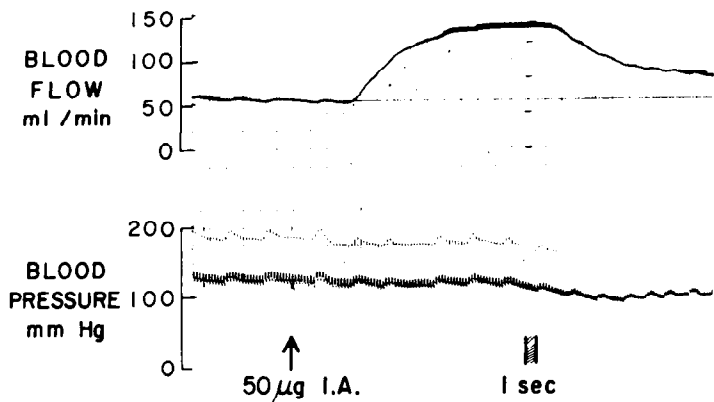


Fig.7. Effect of PGA_2 (medullin) on femoral arterial flow. There was an almost immediate increase in flow to the distribution of the femoral artery following femoral arterial injection of PGA_2 . From (19) reproduced with permission of the publisher.

total peripheral resistance. These results together with the observation that PGA_2 has no inotropic or chronotropic effects in the isolated perfused rabbit heart (19) indicate that its mechanism of action is primarily by peripheral arteriolar dilation. It has been demonstrated that the accompanying rise in cardiac output is due almost entirely to a reflex increase in heart rate probably mediated through a baroreceptor response to the fall in blood pressure. PGE compounds produce similar hemodynamic effects although the amount of PGE necessary to observe such actions are much higher than those of PGA compounds since the former are metabolized so extensively by the lung.

It has been shown by Johnston, et al. (27) and by Vander (28) that PGE_1 infused into the renal artery produced a significant natriuresis and water diuresis in the anesthetized dog. This was accompanied by a fall in the extraction ratio which has been interpreted as possibly being the result of a redistribution of blood flow for cortex to medulla (27). In fact, however, Drs. Birch and Zacheim in Dr. Clifford Barger's laboratory at Harvard Medical School have infused PGA_2 into the renal artery of unanesthetized dog at a rate between 0.07 and 0.2 $\mu\text{g}/\text{dog. min.}$ Utilizing krypton-85 disappearance, it was evident PGA_2 resulted in an increase in cortical flow with a concomitant decrease in outer medullary flow (29). This was confirmed by autoradiography and silastic injection (Figures 9, 10). The observation that a simultaneous fall in the PAH extraction ratio occurs is probably the result of the fact that prostaglandins directly inhibit PAH uptake in renal slices (30). The enhanced sodium excretion and free water excretion accompanying the redistribution of blood flow from medulla to cortex may not exclusively be the result of

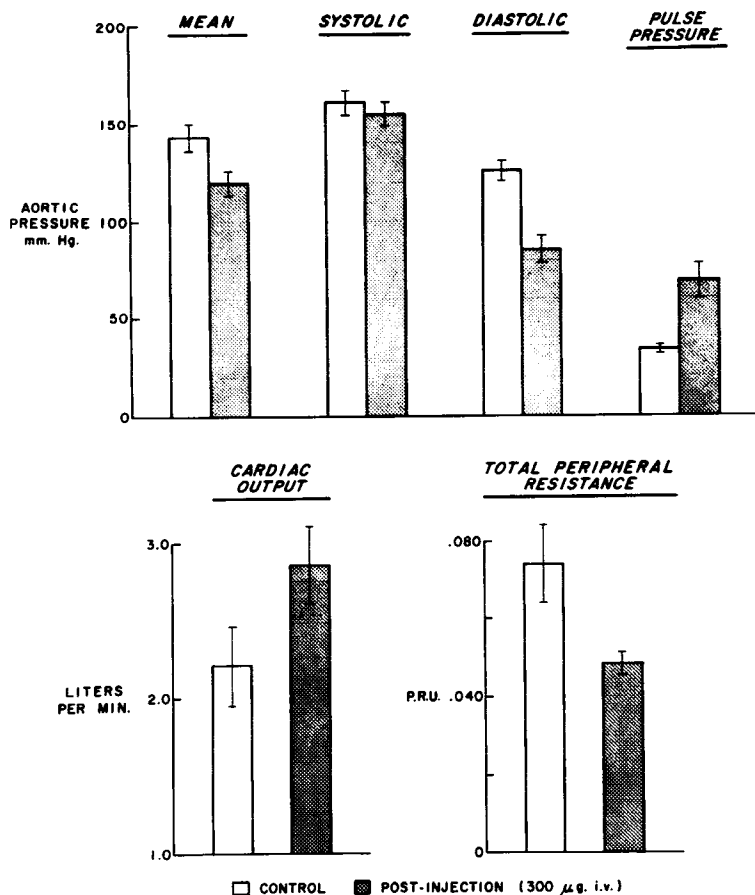


Fig.8. Hemodynamic effects of PGA_2 in the dog. Following injection of PGA_2 , mean and diastolic blood pressure fell with a concomitant rise in pulse pressure. There was an increase in cardiac output so that the calculated peripheral resistance fell. $n = 6$. From (19), reproduced with permission of the publisher.

antagonism to vasopressin activity in the medulla by adenylyl cyclase inhibition as demonstrated in rabbit collecting tubules by Orloff and Grantham (31) since a decrease in peritubular capillary medullary blood flow may in itself result in a decreased reabsorption of sodium and water from both the ascending limb of Henle and the outer medullary collecting duct. The redistribution of blood flow from outer medulla to cortex is not unique to prostaglandins but, has been observed with many vasodilators

including ethacrynic acid, furosemide, and acetylcholine (29). However, the strategic location of prostaglandins in the medulla of the kidney raises the real possibility that these compounds normally regulate distribution of blood flow between cortex and medulla thus mediating sodium and water excretion.

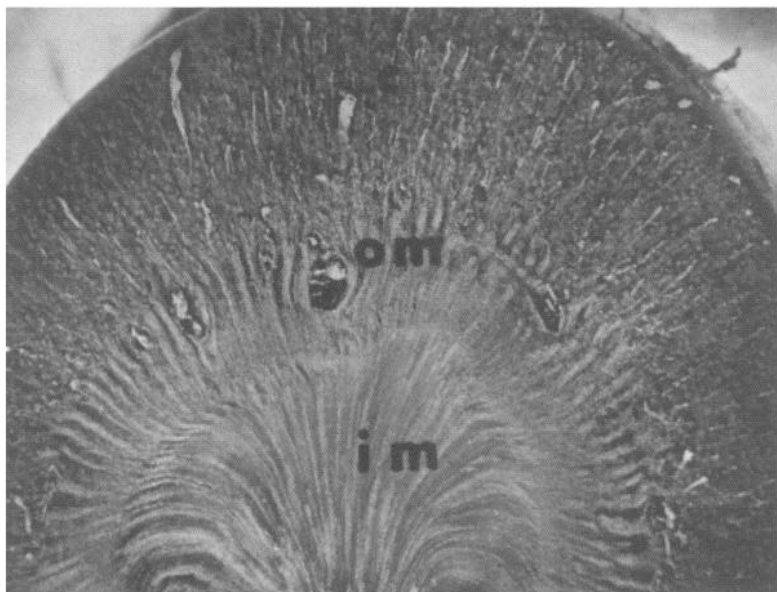


Fig.9. Silastic injected kidney from a control unanesthetized normotensive dog. C = cortex. OM = outer medulla, and IM = inner medulla. Note the bundles of vasa rectae in outer medulla surrounded by a dense peritubular capillary network extending into the inner medulla. Illustration used by kind permission of Dr. A. C. Barger. From (25), reproduced with permission of the publisher.

The mechanism whereby PGA (and PGE) compounds produce peripheral vasodilation is not well understood but it does not require the participation of cholinergic, histaminergic, or adrenergic mechanisms (32), although it has been shown that there is a requirement for the participation of calcium in the peripheral vasodilation produced by prostaglandins (33). It has recently been observed that there may be important differences in the mechanism of vasodilation between PGE and PGA compounds (34), PGE₁ (80 µg) injected into the aorta of the anesthetized cat results in an immediate 35 mm Hg fall in blood pressure (primarily the result of splanchnic dilation) with a partial return to control (50%) within 80 seconds; thereafter, there is a gradual return to preinjection values by seven minutes. PGA₁ is entirely devoid of the initial vasodilating effects of PGE₁ but produces a gradual fall in blood pressure which is maximal

at 80 seconds with a gradual return to control (coinciding with that of PGE_1) by seven minutes. These results suggest PGA_1 may act to dilate peripheral arterioles by an indirect rather than a direct action on peripheral vessels.

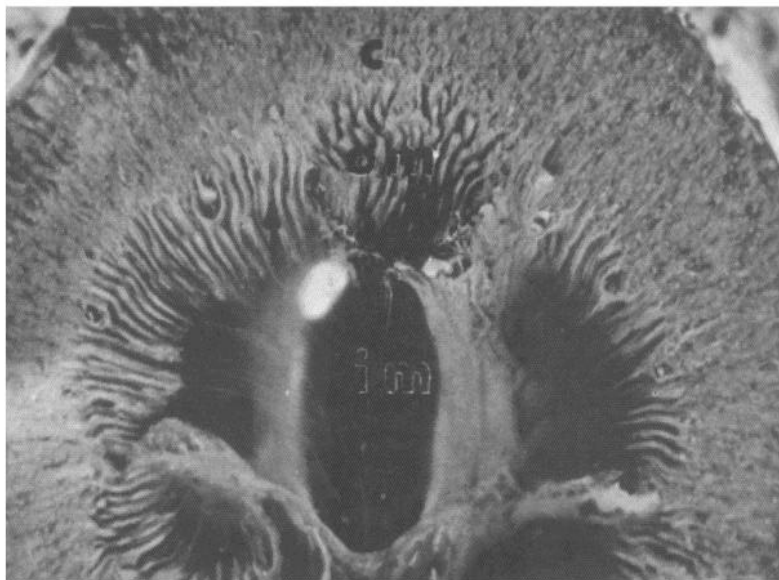


Fig.10. Silastic injected kidney from an unanesthetized normotensive dog following infusion of PGA_2 into the renal artery ($0.2 \mu\text{g}/\text{dog}/\text{min.}$) Note prominence of bundles of vasa rectae in contrast to the dark background (arrow) which was the result of a decrease in outer medullary peritubular capillary filling. The decreased filling of the peritubular capillaries in the outer medulla is also accompanied by reduction in vascular filling in the inner medulla. Illustration used by kind permission of Dr. A. C. Barger. From (25), reproduced with the permission of the publisher.

In the light of a possible antihypertensive and natriuretic role of intrarenal prostaglandins in essential hypertension, it became of interest to study the effects of PGA_2 (isolated from the kidney as medullin) in a patient with essential hypertension. PGA_2 was first infused intravenously to such a patient in 1965 and a study was made of the effects of this compound on cardiovascular hemodynamics (35). Figure 11 reveals that, at an infusion rate of $191 \mu\text{g}/\text{minute}$, there was a slight fall in arterial blood pressure from a control of $185/114$ to $180/106$ mm Hg. When the infusion rate was increased to $382 \mu\text{g}/\text{minute}$ blood pressure decreased to $165/97$ mm Hg. Accompanying the fall in blood pressure was an increased heart rate from 92 to 114 beats/minute with an increase in cardiac

output from 8.4 to 10.5 ml/minute so that calculated total peripheral resistance fell from 17.5 to 12.5 peripheral resistance units (PRU). The increase in cardiac output during PGA_2 induced hypotension could be attributed entirely to the acceleration in heart rate since stroke volume was essentially unchanged. Although it was observed that the patient underwent a marked diuresis during the infusion of this compound, the significance of this was not appreciated at the time.

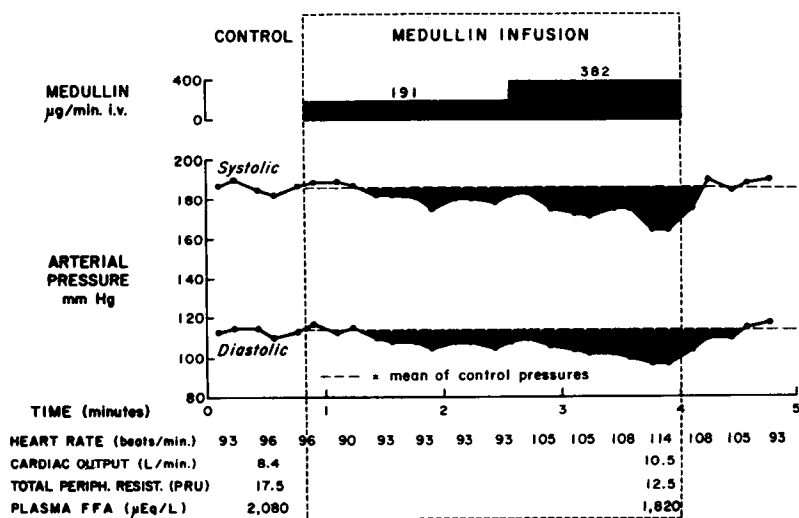


Fig. 11. Acute cardiovascular response to PGA_2 (medullin) in a patient with fixed diastolic hypertension.

With the availability of PGA_1 (a closely related analog of PGA_2) in sufficient amounts to obtain more detailed studies on the relationship between renal function and blood pressure change, a series of investigations were performed with this compound in patients with essential hypertension (36). Figure 12 illustrates that at an infusion rate of 1 $\mu\text{g/kg/minute}$ there was a progressive fall in blood pressure from a control of 200/115 mm Hg to 180/100 mm Hg during the first 15 minutes (Phase I). On increasing the infusion rate to 2.0 $\mu\text{g/kg/minute}$ there was an additional decrease to 160/100 mm Hg during the succeeding 15 minutes (Phase II). Accompanying this fall in blood pressure there was a rise in cardiac index from 2.85 ± 0.36 to 4.03 ± 0.68 L/min/ M^2 which was almost entirely due to a reflex increase in heart rate from 72 ± 2 to 96 ± 3 beats/minute. The net result was that the calculated peripheral resistance fell from 38.4 ± 5.0 to 22.0 ± 2.7 Wood units.

The most significant observation was that, at the time during which there was no change in the initially elevated blood pressure (Phase I), there was a striking increase in urinary flow which occurred within the

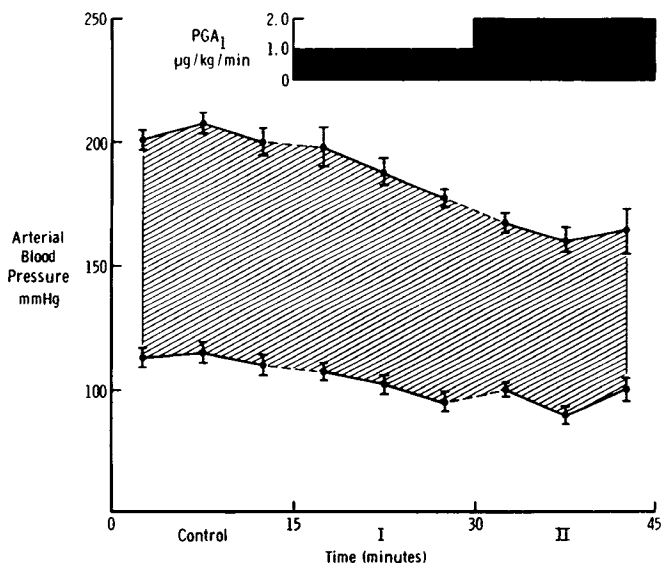


Fig.12. Effect of PGA_1 on blood pressure in patients with essential hypertension. Each result is the mean \pm SE of 12 to 18 determinations in 6 patients. The study is divided into a 15 minute control period; Phase I during which there is a progressive fall in blood pressure; and Phase II when blood pressure is stabilized at a lower level. Each phase is subdivided into three 5 minute clearance periods. Taken from (36), reproduced with permission of the publisher.

first 5 minutes following administration of PGA_1 . Figure 13 illustrates that urine flow rose from a mean control of 2.50 ± 0.39 to 13.20 ± 1.11 ml/min. Accompanying this increase in urine flow was an increase in effective renal plasma flow (ERPF) of comparable magnitude (personal observations). With the progressive fall in blood pressure over a period of 30 minutes there was a reduction in the initially elevated urine flow and ERPF to or toward preinfusion values. Figure 14 illustrates that accompanying the initial increase in urine flow there was a mean increase of urinary sodium excretion from a control of 290 ± 45 to 1320 ± 87 $\mu\text{Eq}/\text{min}$. during Phase I. As was observed with urine flow, the fall in blood pressure toward normotensive levels was accompanied by a reduction in sodium excretion to or toward control values. Osmolal clearance rose from a control of 2.90 ± 0.70 to 11.10 ± 1.00 ml/min. during Phase I, falling to 6.17 ± 1.57 ml/min. during Phase II when the blood pressure lowering effects of PGA_1 were evident. Although the free water clearance increased from -0.40 to $+2.1$ ml/min. during Phase I, the high rate of osmolal clearance at this time accounted for over 80% of the increased urine flow being primarily the result of the accelerated excretion of sodium and potassium and their accompanying anions. In essence, therefore,

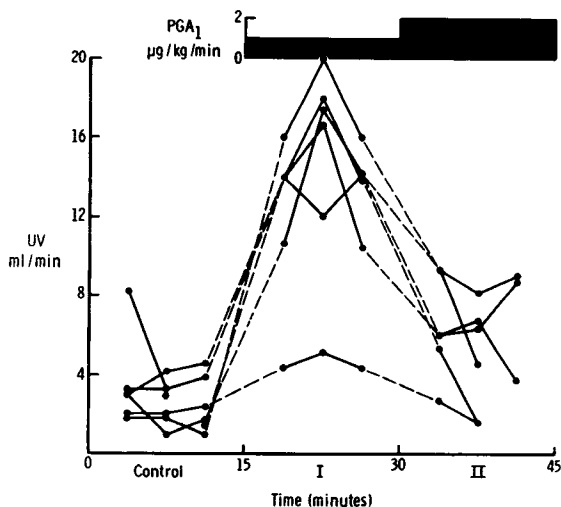


Fig.13. Effect of PGA_1 on urine flow in patients with essential hypertension. Same conditions as Figure 12. Note the rise in urine flow during Phase I when blood pressure was only minimally lowered in contrast to the fall in urine flow during Phase II at the time of maximum vasodepression. Taken from (36), reproduced with the permission of the publisher.

PGA_1 initially produced renal vasodilation with an accompanying elevation in renal plasma flow which was probably a reflection of the high renal arterial perfusion pressure associated with the hypertensive state. Subsequently there was a progressive reduction in arterial blood pressure to or toward normotensive levels which was primarily the result of extra renal peripheral arteriolar dilation. The reduction in blood pressure could also be due, in part, to a change in plasma volume which decreased by 10% in all patients studied. The reduction in blood pressure was accompanied by a parallel decrease in renal plasma flow and electrolyte and water excretion to preinfusion values. This is probably in large part the result of decreased renal arterial perfusion pressure associated with the decrease in blood pressure. Continued renal vasodilation by PGA_1 probably occurred when blood pressure was lowered since there was a fall in filtration fraction from a control of 0.24 to 0.11 when blood pressure was reduced suggesting relatively greater efferent than afferent renal arteriolar dilation. Similar changes in renal hemodynamics and electrolyte excretion have been observed by Carr in patients with essential hypertension (37).

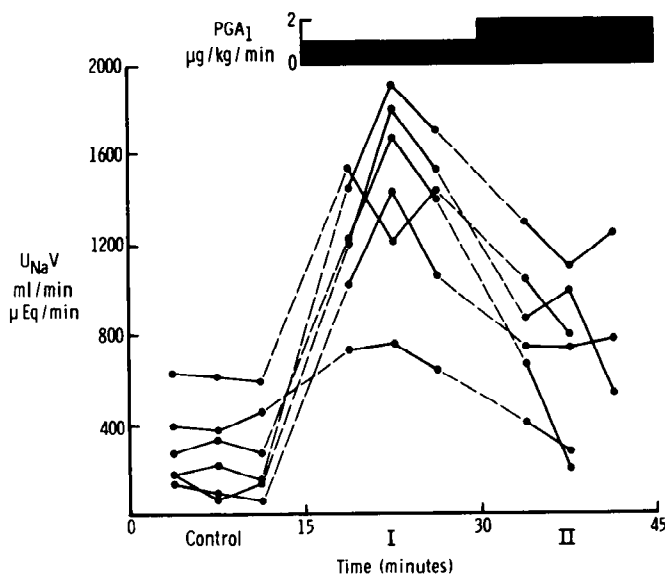


Fig.14. Effect of PGA₁ on urinary sodium excretion in patients with essential hypertension. The initial natriuresis during Phase I was followed by a return to or toward control values when blood pressure was lowered in Phase II. Taken from (36), reproduced with permission of the publisher.

Since there was greater efferent than afferent arteriolar dilation, it appears likely that an increase in hydrostatic fluid pressure would occur in peritubular capillaries surrounding proximal tubules which, in itself, has been shown to lead to inhibition of proximal tubular sodium reabsorption (38). Although a direct effect of PGA₁ on sodium reabsorption cannot be excluded, it would appear unlikely that this compound would metabolically inhibit energy sources for sodium transport since PGA₁, unlike ethacrynic acid or furosemide, does not inhibit oxidative metabolism of renal cortex *in vitro* (39).

Since most investigators believe that essential hypertension is in large part the result of an increase in peripheral resistance, the mechanism of hypotensive action of these prostaglandins is that which would be expected of a naturally occurring vasodilator. The net result of these studies was the establishment of normotension and "normal" renal blood flow and sodium and water excretion. Recently, Stricker at the Mount Sinai Hospital has observed that this steady state of normotension with well maintained renal hemodynamics can be prolonged for 24 hours by continuous PGA₁ infusion (personal communication).

If the intrarenal prostaglandins such as PGA_2 are responsible at least in part for the antihypertensive function of the kidney there are at least three mechanisms by which they might exert such a regulatory role. In the first place, PGA_2 might be elaborated into the renal venous blood under the appropriate stimulus (such as a rise in systemic blood pressure) and circulate as a peripheral vasodilating hormone (Figure 15). This is at least theoretically possible because it has been mentioned that PGA_2 , unlike PGE_2 , selectively passes through lung tissue without degradation. To date, however, because of the lack of specific and sensitive assays for this compound there is no proof that such a release of PGA_2 from kidney occurs. It has been observed by McGiff et al. (40) that PGE_2 and PGF_2 -like substances appear in the renal venous blood of dogs from both the ischemic and contralateral "protective" kidney indicating that, in fact, renal prostaglandin release can take place under certain circumstances.

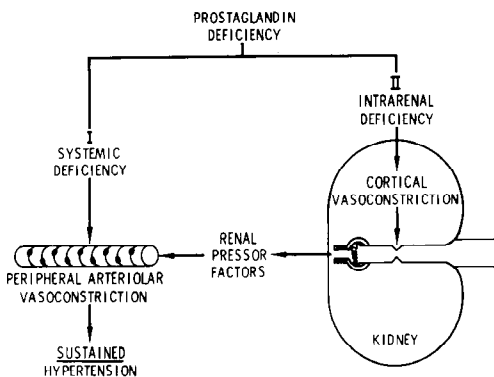


Fig.15. Hypothetical schema for a possible role of prostaglandins in the mediation of sustained hypertension. From Lee, J.B., *New Engl. J. Med.* 277: 1073-1079, 1967. Reproduced with permission of the publisher.

A second hypothesis of a possible role for prostaglandins in the regulation of systemic blood pressure is that they are synthesized at or near the peripheral arterioles where they locally vasodilate and are subsequently metabolized.

A third hypothesis, solely involving the kidney, would be that the intrarenal prostaglandins act locally to regulate the intrarenal distribution of blood flow. Since PGA_2 results in a decrease in outer medullary blood flow with a concomitant increase in cortical flow, a deficiency of such a prostaglandin might be expected to result in the reverse, that is, a diminished cortical blood flow with augmented outer medullary flow. In theory at least, sustained hypertension might result from activation of the known renal pressor mechanisms secondary

to cortical ischemia occasioned by such a reduction in renal cortical blood flow (Figure 15). According to this last hypothesis, systemic blood pressure control would reside largely within the kidney itself and renal vasodepressor substances would not necessarily have to be elaborated into the renal vein in order to exert systemic blood pressure regulating effects. A more detailed consideration of this hypothesis has been presented (41).

It has been possible to only briefly summarize some of the cardiovascular effects in human and animal studies. Although proof of a normally occurring antihypertensive renal role for the prostaglandins must await many additional studies, the fact that certain of these compounds are normally present in the kidney, reduce blood pressure in humans with essential hypertension by "physiological" mechanisms, and that they have important effects on renal resistance, peripheral resistance, plasma volume and indirectly on cardiac output, all factors known to be intimately involved in hypertensive states, raises the real possibility that these compounds may have basic and clinical applications in cardiovascular and renal homeostasis.

ACKNOWLEDGEMENT

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CO₂: CHEMICAL, BIOCHEMICAL AND PHYSIOLOGICAL ASPECTS

R. E. FORSTER

A book of this title, containing papers presented at a similarly named symposium held August 19-21, 1968 at Haverford College in conjunction with the 24th International Physiological Congress under the leadership of J. T. Edsall, A. B. Otis, F. J. W. Roughton and myself has been published by the National Aeronautics and Space Administration (NASA SP-188; available from Superintendent of Documents, U.S. Government Printing Office, Washington, D. C. 20402, \$2.75).

It was printed and distributed by the Government Printing Office, and while the cost of the book to the reader is minimal, about one-ninth the price if it had been published commercially and the authors had received royalties, it has not been promoted and many physiologists and biochemists may not be aware of its availability. Several articles for example contain the most up to date compilations of physical-chemical constants on CO₂ reactions. I have therefore taken advantage of the pages of *The Physiologist* to call the book to your attention.

The contents include articles on topics such as: distribution of CO₂ and C¹³/C¹² in nature (S. Epstein, California Institute of Technology); the physical-chemistry of CO₂, HCO₃⁻ and H₂CO₃ (J. T. Edsall, Harvard); carbamate reactions (M. B. Jensen, Copenhagen; J. C. Kernohan, Dundee; F. J. W. Roughton, Cambridge; L. Rossi-Bernardi, Milan; M. Caplow, Yale; R. E. Forster, Pennsylvania; J. V. Kilmartin, Cambridge); erythrocyte carbonic anhydrase x-ray crystal structure studies (A. Liljas Uppsala), mechanism of action (J. H. Wang, Yale), amino acid composition (P. O. Nyman, Göteborg; G. Laurent, Marseille) and active center (J. E. Coleman, Yale; S. Lindskog, Göteborg); the role of CO₂ contrasted with HCO₃⁻ in enzymatic carboxylations (T. G. Cooper, Purdue; M. D. Lane, New York University; M. C. Scrutton and A. S. Mildvan, Pennsylvania).

The final group of articles concern CO₂ exchanges in the body (F. P. Chinard, New Jersey; A. B. DuBois, R. W. Hyde and R. E. Forster, Pennsylvania; J. Piiper, Max-Planck, Göttingen) and the unexplained finding that alveolar P_{CO₂} may be found greater than arterial P_{CO₂} (E. J. M. Campbell, Royal Postgraduate Medical School, London; G. H. Gurtner, Buffalo). Pertinent discussion of all papers is included.

BEHAVIORAL REGULATION OF BODY TEMPERATURE IN POIKILOTHERMS*

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Many animals regulate their internal temperature solely by gross movement and changes in posture. Given a sufficiently diverse thermal environment, animals like lizards, moths, cicadas and snakes maintain their body temperatures to a prescribed range. In fact, they depend upon staying within this range to carry out efficiently their daily activities. Nevertheless, we frequently fail to recognize the responses of these animals as thermoregulation and insist instead upon strictly physiological criteria. This paper reviews the classifications of thermal responsiveness, summarizes control models for behavioral regulation of temperature, and draws ecological and energetic consequences of behavioral thermoregulation. In each case, behavioral responses are compared to physiological responses.

Classification of Thermal Responsiveness

Only some of the vast array of responses to temperature by animals are conventionally considered thermoregulatory. For example, withdrawal of a finger from a flame is not normally listed as a thermoregulatory response, although that reflex markedly reduces the heat gain from the environment. This observation points out that the categorization of thermoregulatory responses depends upon an observer's interpretation of the nature, circumstances and timing of the response, as well as upon the physical description of the balance of heat gain and loss.

Recognition of behavioral responses which lead to regulation of body temperature is particularly sensitive to the experimental circumstances. For example, a lizard placed in a constant temperature cabinet and subjected to a range of ambient temperatures appears only transiently to resist heat loss (1) or gain, while a mouse maintains a constant body temperature. This experiment shows that mice generate heat internally to offset heat loss while a lizard does not. The terms conformer and regulator often used in this context are inappropriate. Given a thermally diverse environment a lizard can maintain its body temperature within a narrow range. In the natural state it is a regulator. These observations led Cowles (2) to propose the terms endothermic for the responses of those animals that depend largely upon internal heat for temperature regulation, and ectothermic for those depending on external sources.

Timing is also important. A large moth treated in the same manner as the lizard and mouse proves to be ectothermic during the day and an endotherm during critical periods at night (3), (Fig. 1).

*Taken from the introductory remarks given at the session on Temperature Regulation at the 1970 Federation Meetings.

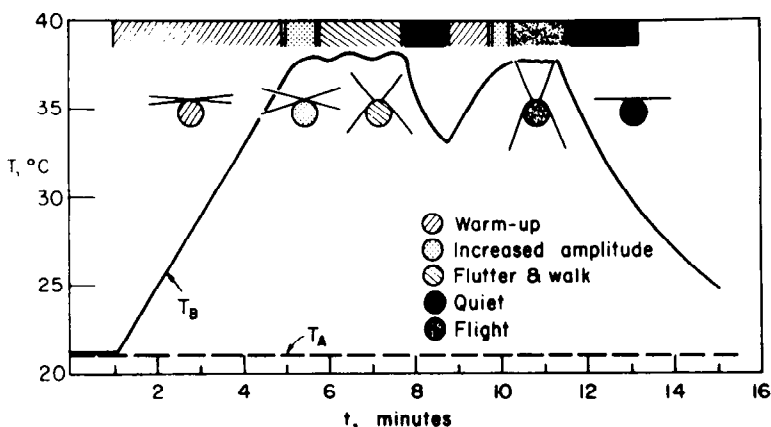


Fig.1. Thermogenic behavior of sphinx moth. The activities and wing movements are related to heat production. T_B , thoracic temperature; T_A , ambient temperature. During inactive periods the thoracic temperature equals ambient temperature as during the first minute. (After Heath and Adams, 3).

Frequently, the study of behavioral regulation of temperature requires behavioral rather than physiological methods. The behavioral patterns of thermal regulation are closely tuned to the thermal structure of the natural habitat of each organism. Even the most common patterns of behavioral temperature regulation may not be seen in an artificial environment. On the other hand, standard behavioral testing devices, such as thermal gradients, mazes and heat reinforcement in Skinner boxes may indicate usefully the range of temperatures voluntarily tolerated by an animal and the intensity of its motivation for thermal regulation.

An excessive terminology has grown up to describe or classify the responses of animals to temperature. These classifications are largely dicotomies (endothermic and ectothermic; poikilothermic and homeothermic) which are intended to distinguish the responses of birds and mammals from those of all other animals. In no case can such a distinction be drawn (4). However, the terms with the least cognates in modern language are homeothermic (homiothermic) meaning constant temperature to describe birds and mammals, and poikilothermic meaning variable temperature to describe other animals. For this reason I used the latter term in my title.

With these precautions in mind, I define behavioral regulation of temperature as a repertoire of movements and postures which, used under appropriate natural conditions, results in a relatively constant and frequently high body temperature. Such responses to temperature

have been grouped into directed and non-directed behaviors.

Non-Directed Movements

When a large number of the microorganism, *Paramecium*, are placed randomly in a thermal gradient they congregate after a time in a restricted portion of the gradient. The congregation results from behavior which is non-directed in that the individual cannot determine the direction of the temperature gradient. Each *Paramecium* is too small to encounter a significant gradient across its body. It swims too slowly and it has too small a mass to develop a gradient between core and the outside. On the other hand, this animal behaves differently at the extremes of the thermal gradient than in the middle. The change in behavior cannot be explained simply as a direct van't Hoff effect of heat on the chemistry of the organism. *Paramecium* changes swimming direction more frequently at the extremes of the gradient than at intermediate temperatures. This behavior is called klinotaxis (5). This name obscures the fact that this organism behaves in many ways as if it possesses an absolute thermometer.

The responses of most aquatic animals have been regarded to be like those of *Paramecium*. However, recent studies suggest that fish may possess unsuspected but elaborate behavioral responses to both environmental and internal temperature (6).

Similarly, many terrestrial organisms in a thermal gradient behave superficially like *Paramecium*. However, a comparatively large animal, such as a lizard, also encounters temperature gradients across its skin and along the length of its body which the nervous system translates readily into perception of the gradient.

Directed Movements

In a sufficiently complex gradient, such as the natural environment, many organisms show a complex of behavior (Fig. 2) exquisitely tuned to the available thermal diversity. This complex can be divided into gross movements involving relocation of the organism, and postural changes which alter the heat exchange with the surroundings.

An example of a thermoregulatory movement is shade-seeking. In this behavior the animal simply removes itself from direct exposure to the sun. It is not avoidance of radiant heat, since shade-seeking usually follows a long period of basking. Rather, the animal suddenly reverses preference for light at a pre-set body temperature. In nature, the result of shade-seeking is that the animal changes not only the direction of heat flux but also the arena of its behavior. After some period in the shade it may again reverse behavior and select strongly illuminated regions and avoid shade. This also occurs at a fixed range of body temperatures independent of the temperatures of shade-seeking. Between the set points of the two behaviors is a refractory temperature range. It is within the refractory range that the animal comes to rest in the thermal gradient.

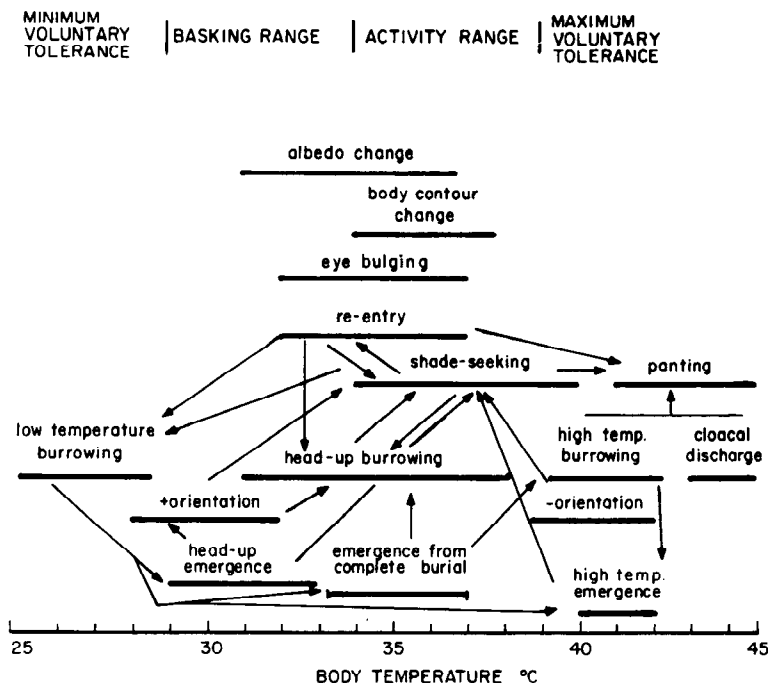


Fig.2. Thermoregulatory ethogram of *Phrynosoma coronatum* (After Heath, 7). The bars represent the range; arrows represent transitions. The sum of these activities results in regulation of body temperature to a prescribed range.

Gross movements, like shade-seeking, may force the animal from positions in its territory at inopportune times. It may have to abandon feeding or mating and retreat to shade to prevent overheating. Instead, animals may adopt postures which either conserve or facilitate loss of heat. Horned lizards orient their bodies to present maximal or minimal surfaces to direct insolation and either reduce their radiant heat load by 60% or increase exposure by 50% (7). Changes in body shape by swelling or flattening can accomplish similar changes. Alterations in posture in reptiles and insects are signaled by changes in body temperature. An appropriately timed postural change may extend the activity period of a lizard or insect by several hours per day.

Control Systems in Behavioral Thermoregulation

Directed responses can be modeled in the same way that physiological systems are modeled. Hardy's (8) categories of thermal control devices are as applicable to behavioral as to physiological regulation, particularly

on-off and proportional.

On-Off Control

In on-off control there are only two states of effector output, on and off. In Fig. 3 I have modeled the panting response of a lizard by such a system. When body temperature (T_B) exceeds a preset level (T_0) the lizard pants. Under ideal conditions of heat load and humidity, one might expect the body temperature to respond as shown in the graph. This control keeps the body temperature from greatly exceeding the pre-set level.

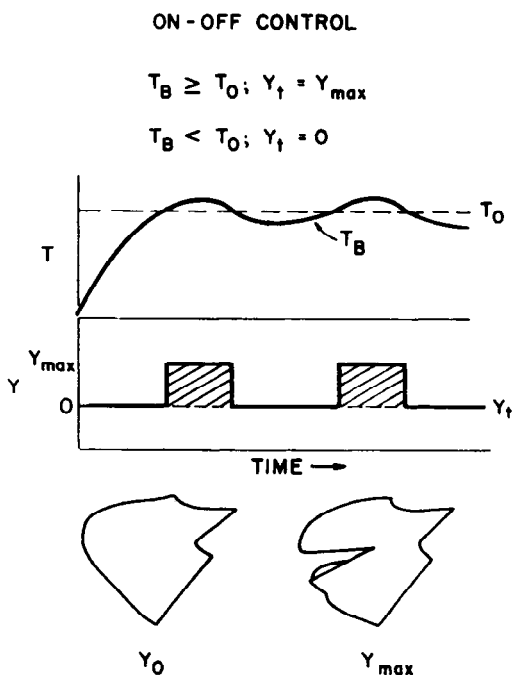


Fig.3. On-Off control: panting in a lizard. T_B , body temperature; T_0 , set-point; Y_t , output-the panting response. The body temperature rises under thermal stress. When T_B exceeds T_0 panting Y_{\max} is initiated. When T_B drops below T_0 , panting stops, Y_0 .

This form of control is very common among behavioral responses, especially because a change in behavior tends to be an all or none or on-off change. For example, the desert locust and many insects cease flight whenever their body temperature exceeds a set value. They will not begin to fly again until their body temperature has cooled below the same level. The insect either flies or does not fly, and the effector

output, heat generation by the muscular activity of flight, is either maximal or off.

Coupled On-Off Systems

More generally two or more behavioral responses are coupled to produce thermoregulation. In an earlier example, I pointed out that running into and out of shade are coupled to result in a regulated temperature range. Figure 4 considers this response as an on-off control. The heat source is the direct rays of the sun. Whenever the body temperature exceeds the high set-point, the lizard runs to shade. There it cools well below the shade-seeking temperature; at a low set-point it again returns to sunlit areas. Between the high and low set-points there is a refractory range where the lizard need do nothing about the direction of temperature change.

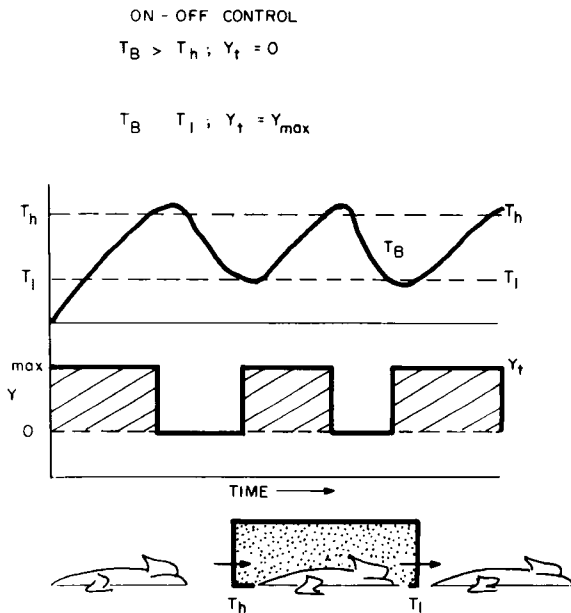


Fig.4. A bipartite behavioral regulatory system. A lizard moves from direct insolation (left) into shade (middle) at body temperature T_h , and it moves from shade to sunlight (right) at body temperature T_l . The difference in temperature, $T_h - T_l$, is a refractory range in which the lizard can operate without resorting to thermoregulatory activities. The effector output Y is here equated with the availability of insolation. $Y=0$ in the shade, and $Y = \text{maximum}$ in direct sunlight. The magnitude of Y_{max} depends upon the intensity of insolation. These relations are also shown graphically. The duration of the refractory period depends upon the heating and cooling rates of the animal. The general expression holds for insects as well as reptiles. (After Heath, 1960).

The refractory range is of great ecological importance. If a behavioral regulatory system were too tightly coupled, that is to say if the lizard both retreated to the shade and returned to sunlit areas at the same temperature, it would simply oscillate rapidly between sun and shade. As long as the sun shines it would be a very good thermo-regulator but an ineffective lizard. Table 1 shows set-points for coupled on-off systems and the refractory range for several species of lizards and insects. The coupled on-off system is the most striking feature of behavioral control systems when compared to physiological responses. It is interesting that according to Hammel's model of mammalian thermoregulation (9) the set-points for physiological responses to heat and cold by the pre-optic region are similarly separated by a refractory temperature range about 20°C wide.

Table 1. Set Points of Behavioral Temperature Regulation

Animal	Range (°C)	Set Point (°C)	Motor pattern
Ectotherms			
Iguanidae			
<u>Phrynosoma coronatum</u> California grassland	3.5	37.7 34.2	Shade-seeking Leave shade
<u>Phrynosoma cornutum</u> Texas grassland	2.7	37.5 34.8	Shade-seeking Leave shade
<u>Phrynosoma m'calli</u> Desert	5.5	40.4 34.9	Shade-seeking Leave shade
Cicadadae			
<u>Magicicada cassini</u>	6.8	31.8 25.0	Shade-seeking Leave shade
Endotherms			
Sphingidae			
<u>Celerio lineata</u>	2.9-3.2	38.0 37.7 34.8	Cessation of shivering Shade-seeking Resumption of shivering
Saturniidae			
<u>Rothschildia jacobae</u>	~ 4	36 ~ 32	Cessation of shivering Resumption of shivering

Proportional Control

In proportional control, the effector output is continuously variable and proportional to the deviation of body temperature from a pre-set level. It may be restorative. As indicated, behavior tends to be all or none in response to stress. Nevertheless, some examples of continuously variable behavior in response to thermal stress are known, notably postural changes and behavioral production of heat. In figure 5 the expression for proportional control describes the change in area of horned lizard in response to decreasing body temperature. The lizard, by altering the area exposed to direct sunlight, can adjust its radiative heat gain. It can flatten its body by extension of its ribs. As it cools its area Y enlarges, increasing the heat load and opposing the further decline of body temperature. The graph in Figure 5 details an ideal case. The horned lizard is thus able to continue its activities uninterrupted by demands of thermoregulation, save the adjustment in posture. If the sun shines at a low angle on the horizon, the lizard can tilt its flattened body toward the sun, greatly enhancing the effect of the change in posture. The lizard is also capable of presenting a very small surface to the rays of the sun in the event that it is getting too hot and is not ready to retreat to shade for biological reasons, such as courting.

PROPORTIONAL CONTROL

$$\epsilon = T_0 - T_B = -(Y_t - Y_0) \alpha$$

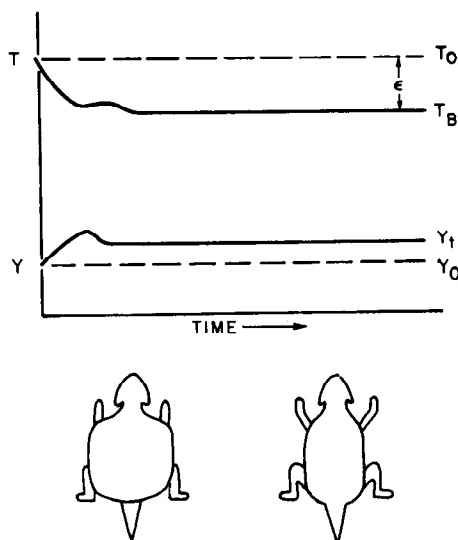


Fig.5. Proportional control: Body contour change in *Phrynosoma*. As body temperature, T_B , falls, below the set-point temperature T_0 , the lizard increases the apparent area of its body exposed to the direct rays of the sun by extending its ribs (lower drawing). The change in area ($Y_t - Y_0$) is directly proportional to deviation of T_B from T_0 .

While many kinds of animals show special postures and orientations toward the sun, these may interfere with other ongoing behavior. In a simple case, although a cicada will orient the axis of its body along the direction of the rays from the sun when it becomes too warm (10), it cannot show this behavior while in flight.

If the period of a given behavior is short compared to the duration of measurement on-off systems may appear proportional. The heat load upon an animal is proportional to the amount of time the animal spends in direct sunlight. Figure 6 shows the percent time spent by a lizard in sunlight and shade through a day (7). From morning to afternoon the ambient temperature increases and the lizard adjusts the net heat gain from the sun by adjusting its time in the sun. As the day cools the lizard spends more time in the sun to increase its heat gain. Thus, the heat gained is adjusted to the applied thermal stress. During a day in a cooler season, the percent time spent in the sunlight is greater through the day.

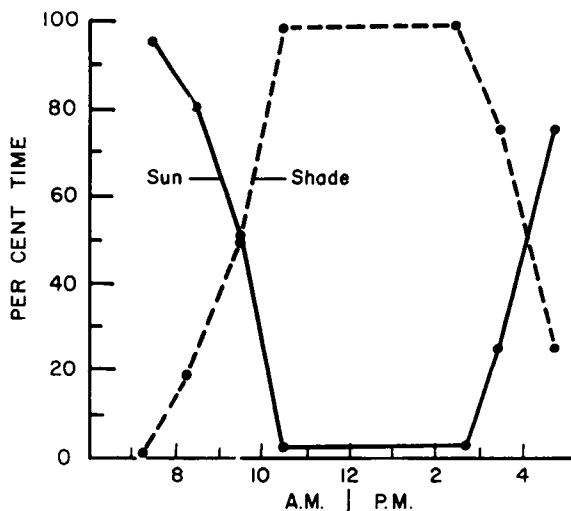


Fig.6. The percentage of time spent in the sun and the shade by a horned lizard, *P. coronatum* during August. The values are mid-points for one-hour intervals. (After Heath, 7). The control system outlined in Fig.4 appears proportional to time of day or heat stress when the unit of measurement is long compared to the period of behavior.

Another form of proportional control is found in the heat released from the flight muscles of insects. Large moths adjust their heat production to maintain a nearly constant internal temperature. The adjustment comes either as a physiological control whereby the moth adjusts the level of activity in the flight muscle to meet alterations of external

temperature, or the moth will alternate between periods of intense activity and quiescence (3). The heat production, measured over a long interval compared to the cycle of activity, is proportional to the stress upon the moth.

From these observations I conclude that the means of receptivity and controller output in behavioral responses to temperature are well-modeled by simple control systems. Indeed, they conform somewhat better to the models than do physiological responses to temperature in mammals.

Energetic Costs of Behavioral Regulation

For most behavioral patterns used in thermoregulation, the expense is only that of transporting the mass of the animal from one location to another, or the cost of maintaining a particular posture. In most cases this cost is only a small fraction of the cost of using heat production to maintain temperature (3), but it is greater than the metabolic cost of piloerecting fur or changing the course of flow in the blood vessels. Further, the expense of behavioral regulation is restricted to those parts of the day that are biologically meaningful for the animal in question; the time when it feeds, courts, mates, defends territory, etc. In the ordinary sense, behavioral regulation of temperature is efficient and well-timed.

Some animals use behavioral means of producing heat. The heat production during brooding by some giant snakes is a notable example (11). Among insects many species are dependent upon internal heat production to reach the body temperatures necessary for their activity. Large sphingid moths feed, mate, and lay eggs while on the wing. They must have body temperatures of 25-30° to fly, yet they are generally active in the evenings when ambient temperatures are much lower (3). They have developed special behaviors to warm-up and to maintain an elevated temperature by internal heat production (12). Their very small size (0.2 - 2.0 gms) means that their metabolism runs two to 10 times that of birds and mammals to maintain the same gradient. In these cases behavioral regulation is an expensive course indeed.

The most unusual case of heat production by an insect is that of the katydid, *Neoconocephalus robustus*. The males of this species must warm-up to drive their singing muscles fast enough to produce their species specific song (13). It does not use this means of temperature control at any other time. The females probably never warm-up.

Ecological Correlates of Behavioral Temperature Regulation

Just as behavioral control of temperature depends upon the thermal diversity in the environment, the expression of thermoregulatory behavior varies with the native habitat. Closely related lizards living in different habitats show distinctive thermoregulatory behavior, while those in similar but widely separated habitats show nearly identical responses. Ruibal (14) found that West Indian lizards that live in the shade on tree trunks maintain cooler body temperatures and have less

elaborate thermoregulatory behavior than those that live on exposed leaves. On the other hand, two species of horned lizards, Phrynosoma, from grasslands in Texas and California respectively, have nearly identical responses to temperature while species from deserts show higher body temperatures for the same behavioral patterns (7), (Table 1).

Because behavioral means of thermoregulation tend to be cheaper than heat production for the maintenance of body temperature, more individuals of species relying on gross movements and postures for temperature control can be supported by a unit area of habitat than those relying on heat production.

Temperature control by insects varies from insensitivity to endothermy. Insects have invaded every part of the planet and have developed appropriate thermal sensitivity and control to fit each situation. The description of the temperature regulation, and adaptation among insects has hardly begun.

Relevance

Finally, behavioral regulation by poikilotherms is a model of evolutionary stages in the development of the thermoregulation of birds and mammals. Although modern reptiles have evolved and developed their own adaptive accommodations with the environment, those features common between reptiles, birds and mammals can be presumed present in the reptilian ancestors of each group. They include pre-optic sensitivity to temperature (15), on-off and proportional integration of temperature control in the central nervous system.

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FELLOWSHIPS IN PHYSIOLOGY OF REPRODUCTION

The Training Program in the Physiology of Reproduction at the Worcester Foundation for Experimental Biology was established in 1960 under a grant from The Ford Foundation and was the first program of this type. A grant from the National Institute of Child Health & Human Development now makes available fellowships for U.S. Nationals. Support for candidates from foreign countries is provided by funds from the Ford Foundation. Fellowships are for candidates holding either the M.D., Ph.D. or D.V.M. degrees. Clinicians should have completed their residency requirements.

The program offers a three-month comprehensive presentation of reproductive physiology through lectures by Worcester Foundation and visiting scientists, demonstrations and laboratory work. Fellows then carry out independent research, in an area of interest to them, in association with staff scientists. First and second-year fellowships are awarded annually. Stipends start at \$6,000 with allowances for dependents and experience. The program starts in mid September.

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MINIMAL STANDARDS FOR GRADUATE EDUCATION IN PHYSIOLOGY

by

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During the past few years of intensive self-study by many physiology departments, as well as by many thoughtful members of the American Physiological Society, recommendations for some kind of accreditation of departments awarding graduate degrees in physiology have been considered. Advocates propose that accreditation performs a number of important functions. For example, it helps intensify efforts toward maximum educational effectiveness and requires each institution to examine its own concepts, goals, and operations, supported by the expert criticism of a visiting team. The institution is thus encouraged toward continuous self-study and improvement. In principle, general accreditation does not imply similarity of aims, uniformity of process, or comparability of graduates among institutions. Instead, it indicates that, in the judgement of responsible agencies of the academic community, an institution's own goals are soundly conceived, that its educational programs have been intelligently devised, are competently conducted, are capable of fulfilling the goals the institution seeks, and are, in fact, accomplishing them substantially; and that the institution is so organized, staffed, and supported that it should continue to merit such confidence in the foreseeable future (1).

Through its Education Committee, the Council of the APS wished to determine what recent changes in policies have actually occurred in graduate training programs, and perhaps to develop appropriate criteria or minimal standards for degree programs in physiology.

Such standards would necessarily reflect the projected role of the physiologist as scientist and teacher in the future. Herein lies a major dilemma - What are the needs and goals of physiology at the undergraduate, graduate and medical school levels? A relatively simple question to answer if values are based on our knowledge of attrition, expansion, and retirement data, but a disturbing and almost impossible question to answer when one considers current trends to lower entrance requirements, to replace basic scientists with clinicians in our medical schools and to establish a tradeschool atmosphere for the purpose of producing more physicians in less time. Graduate education must not succumb to trends to superficiality but must insist upon learning in depth as well as breadth.

The Council and the Education Committee are alert to the disturbing conclusions stated in the 1967 report by the Physiology Training Committee for NIGMS: "...there is currently a crisis in physiology training and current programs are not meeting the crisis." A primary concern of this Committee was for the impression that current training in physiology in the United States is too closely tied to the "narrow demands of medical curricula." The Committee felt that medical courses cannot deal with systems theory, and that the "training of future professionals in physiology

must present the science in its mature and most powerful form... as the science of systems biology" (2).

In an attempt to acquire definitive answers to a number of questions pertinent to this central theme, a questionnaire was formulated and sent to forty-nine departments known to have active graduate training programs in physiology and receiving support from NIGMS. These particular institutions were selected because they offered a group which had recently sustained reasonably objective, peer evaluation of faculties, policies and facilities for training. The list does not include, of course, all (perhaps not even the best) institutions offering high quality degree programs. Twenty-eight graduate program directors completed and returned the questionnaire. The selection also imposed a particular emphasis upon medical physiology with lesser attention to such areas as comparative, general or cellular, and veterinarian physiology, or to closely associated disciplines such as biophysics and bioengineering. It is possible that additional breadth and depth of information should be achieved by canvassing a large group of degree granting institutions, including these additional disciplines within physiology. One hundred sixty-one institutions are listed in the 1970 issue of *The Annual Guides to Graduate Study* as offering graduate programs (although some may offer only the MS degree) in physiology.

The questionnaire was designed also to learn something of the qualities sought in the potential graduate student in physiology, levels of performance during graduate training, and the efforts made within the department to maintain suitable self-evaluation and upgrading procedures. While the primary emphasis of this report is upon what should be considered "minimal standards," selected items of interest from the other questions will be summarized.

It is of interest that in a previous study of essential scientific background for completion of graduate work in physiology, J.H.U. Brown emphasized the growing importance of mathematics, particularly calculus, physics, and physical chemistry (3). At the time of his survey (1962), Brown found these undergraduate courses lacking in the preparation of many applicants. The present study reveals that a majority of physiology training programs now require these courses for admission. Surprisingly, a majority of departmental requirements for admission do not include undergraduate training in foreign language. Most respondents indicate great dependence upon letters of recommendation from undergraduate science teachers, with lesser reliance upon grade-point averages and performance in graduate record examinations.

There exists great diversity in mechanisms for evaluation of performance during the years of graduate training. Many departments have no formal statement of the number of didactic hours required. Nearly all stressed the importance of organ-system physiology, and many incorporate advanced (presumably referring to training beyond conventional medical courses) work in such areas as cardiovascular, neurophysiology, endocrinology, nephrology, biophysics, systems analysis, and computer techniques, among their offerings. A majority designate their graduates as physiologists in contrast to those who designate them as biologists,

biophysicists, bioengineers or other. In a majority of departments, the student selects his advisor after successful completion of the first year of graduate study. Almost all depend upon a committee (three to five members), many requiring at least one or two from outside the department, to evaluate the dissertation, research and other academic qualifications of the candidate for graduation. Of the total number of responses (28), six departments have no foreign language requirement, 13 require one, and 9 require two. French, German and Russian were the most frequently mentioned by those departments where foreign language requirements are maintained. A few cited alternative competence in other avenues of communication such as statistics or computer programming and data handling as satisfying a portion of the language requirement.

In response to the question, "Has your department carried out a systematic review of the philosophic objectives of your graduate program and its implementation during the past five years," there was almost unanimous affirmation. Many have annual reviews by the departmental faculty while others deal with the problem continuously through either special committees or the faculty as a whole. On one question there was almost unanimity in the responses. When asked, "What would be the impact of cessation of NIGMS (or other Federal) support of your training program," all stated that serious impairment would result. Many (90%) declared such action would be "very serious," "disastrous," "cause us to close up," and similar comments. Perhaps many overreacted, but there can be no question that all were greatly concerned about the consequences of such withdrawal of Federal funding. A number of pertinent and thoughtful comments warrant quotation:

"The NIGMS support provides much needed flexibility in recruitment of good students, and permits innovations which serve to enrich the program. Most important, it allows a critical mass of trainees, without which it becomes impossible to carry out didactic phases of a program effectively, and make it difficult to justify a graduate program which in itself is essential to any good department."

"Disastrous - we just have no backup funding mechanism."

"The loss of potential manpower at the national level would be the ultimate blow to academic excellence, aside from the immediate embarrassment to our teaching program. I think in our consideration of manpower problems we should consider the needs of long-term programs of excellence, not what we can get by on because of forced expediency..."

"It would reduce our training activity to less than 25% of current levels and severely curtail quality of the program."

"Our graduate training program is entirely dependent upon Federal support. The University provides support for teaching assistants only..."

"We can not afford not to have graduate students because of the stimulus which they provide. Cessation of support would disrupt current research programs..."

"It would cut our student body in half - our productivity in half. The NIGMS training grants have been extremely helpful, but society has to have scientists to support medicine.... Physiology is the pillar of basic medical science just as medicine is the matrix of clinical science."

"It would weaken the program even for those students not supported by Training Grant funds, by eliminating outside speakers and consultants, purchase of equipment, and many other functions vital to a first class program. It would lengthen the average time to the Ph.D. by forcing all students to work as teaching assistants...."

In response to the primary question, "What should be included in a 'list of minimal standards' to be met by a successful candidate for the Ph. D. in physiology", there was understandably considerable diversity. Nevertheless, there was also a consistent skein throughout the responses which reflected serious concern. The replies may be summarized as follows:

1. The candidate must acquire a good understanding of physiology (at level of a sophisticated textbook) with advanced knowledge in several different fields. He must have "in depth" knowledge in at least one field including its history, investigative techniques, primary instrumentation, modeling, workers in the field, funding procedures and agencies. He must develop technical expertise in his chosen field and he must demonstrate capabilities for creative and independent investigation. In this field at least, he should show creative imagination and initiative in his ideas and in his research.
2. He must demonstrate capability for conceptual thought as well as ability to translate his thoughts and ideas into experiments.
3. He must demonstrate primary and intelligent responsibility for a scholarly dissertation in which he reveals high competence in the acquisition, organization and presentation of scientific data.
4. He must demonstrate proficiency in, and desire to teach, to communicate information.
5. Demonstrate capability to critically and perceptively evaluate reports in scientific literature. This should be true not only in his own field, but also in other areas of physiology. He must possess an informed awareness of new technical developments.

In addition, there were many criteria which may be considered more of technical importance, and would obviously have greater application in some situations than in others. These are:

6. Possess familiarity with anatomy, ultrastructure, biochemistry, physics, pharmacology, control systems, etc.
7. Have working knowledge of computers and statistics.
8. Have working knowledge of mathematics as applied to physiology.

9. Understand elementary electronics and be able to make necessary applications to design and operation of laboratory equipment.

Considerable additional insight was encapsulated by one program director who sees it this way:

"The effectiveness of training of graduate students may be ascertained by the ability of the student to discuss, in scholarly fashion, his research. Does he clearly perceive the historical, experimental and conceptual basis upon which his studies rest? Can he cite the names of the key contributors, past and present, and can he describe the key experiments and justify their identification as key? Courses or series of courses do not usually have this as their explicit goal. None-the-less, if they are to be appropriate for graduate education this should be their most important content. If one is going to train physiologists, the problems dealt with should become the examples by which scholarship is taught. My goal is to fathom whether the student has had sufficient training in mathematics, chemistry and physics to understand physiology of today and tomorrow, and whether he understands the meaning of the term scholarship. I have never tried to answer these questions by asking a student to list the courses he has taken. I do not believe that one can prescribe a range of acquaintanceship with physiology which is minimal for all physiologists. Success is not proportional to the hours spent studying physiology in a formal didactic setting."

There were countless thoroughly refreshing and provocative comments on the philosophy of education in physiology. For instance, one respondent contributed:

"Our philosophy is to train a 'complete physiologist.' It has been disturbing to find a trend to hurry the student into a subspecialty (e.g. neurophysiology, endocrinology, membrane transport) without better mastery of the over-all field."

Most respondents revealed real intellectual concern for the present complex problems with which the profession is faced. Most seemed aware of the intimate interrelationships between research funding, research training, and the operation of the principle of supply and demand in the training of additional young physiological scientists. Most are informed about the potential need for additional teachers to staff faculties in the newly emerging junior colleges, colleges, and medical schools. They are alert to the increasing opportunities for trained physiologists in hospital, industrial and government laboratories. There was reassuring evidence of deep personal involvement on the part of these real front-line graduate teachers themselves.

It is the stated conviction of the Council of Graduate Schools in the United States, the Federation of Regional Accrediting Commissions of Higher Education, and the National Commission on Accrediting that the review and appraisal of graduate programs and work should be included as part of the over-all evaluation and general accreditation of a college or university. It is the position of the above groups that special accreditation of particular graduate programs should, in general, be avoided,

because it may tend to force narrowness and conformity in graduate student experience and to retard graduate program evolution (1). It is noteworthy that Brown, in summarizing the comments of some 50 Physiology Program Directors convened in 1962, stated the following: "It is acknowledged that the American Chemical Society has set standards for the chemistry departments and that engineering societies have set standards in engineering, and these have raised the quality of instruction. There is agreement however, that such standards should not be set in physiology, especially at the graduate level" (3). Considerable pressure was applied at that time to have APS poll the group to determine what standards are placed upon new department members, and therefore what training is considered by the majority to be acceptable.

The Education Committee is considering extending this inquiry further to include a larger segment of the graduate training programs in physiology. Thus, a survey may be prepared to search out answers to similar questions put to all institutions offering the Ph.D. in physiology. Your comments on the present report, as well as your counsel on the advisability of such a further elaboration will be appreciated.

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TWELFTH PACIFIC SCIENCE CONGRESS

The Twelfth Pacific Science Congress will be held in Canberra, Australia August 18 to September 3, 1971. Information can be obtained by writing to Organizing Secretary, Twelfth Pacific Science Congress, Australian Academy of Science, Gordon St., Canberra City, A. C. T. Australia 2601.

AN APPROACH TO UNDERGRADUATE MEDICAL PHYSIOLOGY:

"Don't kiss me, I'm trying to breathe."

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A patient-oriented approach to the presentation of basic principles of physiology to first year medical students has been developed and modified by two years' experience at the University of Missouri-Columbia School of Medicine.

The philosophy for the development of the course has been for the staff to place themselves in the position of the medical student and repeatedly ask two questions: "What concepts are essential for understanding the clinical problem under consideration?" and "What would the student want to know next?" Klausmeier and Goodwin's learning models point out that both the relating of new material to what the student already knows and the sequencing of material facilitate the learning of new material, and that the application of information develops students' problem-solving abilities (1). The application of these three principles will be briefly outlined with a sample lecture, describing a patient with emphysema.

The students are given the following introduction: "Our goal for this week is to show how physiologic evidence is drawn upon to solve clinical problems. We will spend the entire week (5 class meetings) developing an understanding of a patient with respiratory disease. We will call upon basic concepts in respiratory physiology to provide insight. Specifically, a case report has been distributed which has been extracted from the records in this hospital. We will examine each of the findings point by point and in this sense the features of the case provide the outline of our studies together." More specific objectives are then presented, in agreement with the advice of Mager who has stressed the value of clearly stating the instructional objectives to the students early in their study (2).

Two important points are worth noting. First, in contrast to the usual clinical correlation, several hours during the week are devoted to a discussion of pertinent features of a single case. This amount of time is appropriate when students are exposed to concepts and clinical problems for the first time, and is necessary to develop fully the physiologic concepts involved. Second, the case abstract is carefully edited so that the concepts presented are general and can be readily perceived by the student as an extension of previous learning, and that laboratory data are internally consistent. Extraneous historical material and data pertaining to organ systems not under consideration act as detractors

*This work was supported in part by a Public Health Service Research Career Development Award #1 KO4 HE 18518 from the National Heart Institute.

from the main goal for teaching basic concepts in physiology, although of course they will become important considerations for the students at a later stage of their development.

After the students have studied the case abstract, the patient is presented to the class. The interview is directed to emphasize particular aspects to define clearly a set of problems that could be explained by concepts in respiratory physiology. One such problem, the patient's severe limitation in developing an adequate expiratory flow, is demonstrated by her inability to blow out a candle. Furthermore, she described the compensatory mechanism of pursing her lips by stating that she pretended to whistle when walking while shopping. One of the questions posed for the students becomes how does pursing the lips provide a compensation? One student's analysis was entitled, "Don't kiss me, I'm trying to breathe."

The solution to the question involves a thorough understanding of the mechanics of respiration. Towards this end, the factors contributing to the development of pressure to move air out of the lungs are considered, such as the elastic recoil of the lungs and thorax, alveolar surface tension (including the role of surfactant), and the development of positive intrapleural pressure in forced expiration. The relative roles of these factors are considered in a summary example using approximate pressures calculated from factors considered in the discussion. Continuing with the logical organization of the forces coming into play as the rationale for sequencing, the movement of air in the airway is next considered with utilization of Poiseuille's and Bernoulli's laws as they relate to airflow in normal lungs and in lungs of patients with emphysema. It is noted that pressure becomes less in the airway than in the alveoli because of the frictional resistance to air flow. The change in pressure follows Poiseuille's law where

$$\text{change in pressure} = \frac{8 \times \text{flow} \times \text{viscosity} \times \text{length of airway}}{\pi (\text{radius of airway})^4}$$

(Note that abbreviations are avoided so that the meaning intended is not lost in translation from symbols where, for the example, the symbol r might become rate instead of radius in a student's notes). In the emphysematous patient, the pressure drop along the airway becomes considerably larger than normal due to a decreased radius of the bronchioles. Students are reminded that they had previously encountered one result of the loss of elastic tissue, which was a loss of elastic recoil, but are told that this elastic tissue serves another potentially more important function. The mesh of elastic tissue attached to the small airways tends to hold the airways open in opposition to the positive intrapleural pressure. When the elastic tissue is destroyed by the disease process the radii of the airways are not maintained. The decrease in radii of the fine tubes results in an increased pressure drop across this part of the airway. At this point Poiseuille's law is recalled from previous learning and the fact that the radius is taken to the 4th power in this relationship takes on a meaningful significance for the student.

The pressure-flow relationships are then extended to considerations of flow in flacid tubes. The narrowing of the airway will create a second effect that will increase the pressure drop - the Bernoulli effect. It is

worth repeating the frequently made observation, emphasized by John Carroll, that students require differing amounts of time to learn the same material (3). For the case being described, material on the Bernoulli effect is repeated and summarized more frequently than would seem intuitively necessary, simply because some students generate questions about this concept long after other students have demonstrated an understanding of it. Students are now in a position to reconstruct by themselves the series of events in forced expiration that results in the collapse of the airway. Thus the solution to the first question, why the patient was unable to blow out a candle, is detailed in the lecture. The second question, why the patient pretends to whistle while shopping, was left to the students to unravel as a problem-solving exercise. References are provided to aid them in problem-solving to a solution that describes the compensatory mechanisms involved in pursing the lips (4, 5).

Considerable effort has been made in the development of the course to make the material meaningful. The example of increasing the mathematical readability in the equation in Poiseuille's law has already been given. In addition, terms that would be new to most students are carefully defined and are illustrated by the example of the patient. The student is expected to bring a sufficient understanding of some terms from anatomy. Other terms, like "bleb," are defined in the context of presentation. To aid retention, and to assist students in organizing the material, repetition, advance organizers, and summaries are made throughout. Finally, the staff shows a sensitivity to the problems faced by the students in terms of the demands of learning large amounts of material and at the same time developing a thorough grounding by the application of this material in problem-solving situations.

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REPLIES FROM SENIOR PHYSIOLOGISTS

Received by Drs. Bruce Dill, Eugene Landis,
Hiram Essex, and Hal Davis
(Continued from May issue of The Physiologist)

Born in 1900

Arturo Rosenblueth remains active in research but primarily in administration. In 1962 he organized a research and graduate teaching scientific center, of which he is Director. The center includes seven departments. In addition, every year he gives some lectures at the National College (El Colegio Nacional). His most recent book "Mind and Brain: A Philosophy of Science" was published by Technology Press of the Massachusetts Institute of Technology.

Albert H. Hegnauer wrote Gene that he is due to retire soon from civil service with the Army Research Institute of Environmental Medicine. He plans no further scientific activities except possibly in some voluntary capacity such as Vista.

Caroline tum Suden will retire in July. Besides attending to personal affairs she is prepared to do what she can for the support of the American Physiological Society and its members. "I am looking forward to the next issue of The Physiologist and the delightful and appreciated reports of your Committee."

Hymen Mayerson who is Associate Director of Professional Services and Education of the Touro Infirmary is working harder than in years, but is enjoying himself. The Research Institute is in his jurisdiction so he is involved in the various laboratory activities and in a broad educational program. "We moved into a new home about 18 months ago, smaller garden, but still enough to keep me relaxed. Our son, Peter, is a successful psychiatrist in Denver. I feel strongly that one should get out of the place on retirement in all fairness to the new chairman and the staff. One should not be the ghost in the back room."

E. S. Nasset decided on a complete change of scene on retirement and is now research physiologist and lecturer in the Department of Nutritional Science, Berkeley.

H. A. Blair officially retired in 1965 and will discontinue part-time teaching and administrative work this year. He plans to continue research on effects of ionizing radiation in fruit flies and on carcinogenesis by radioactive materials in animals and man.

J. C. Scott continues in teaching and research. Dr. E. T. Angelakos, the new chairman of the department, has appointed him professor of physiology and gave him laboratory space and teaching assignments. He is happy with his work and grateful to have a place where he continues to be useful.

Kacy Cole may remain at Berkeley one more year or may return to

NIH for a year. He might consider other possibilities.

Dave Rioch will retire from government employment the end of June. He hopes to work (at least part time) in the Institute for Behavioral Research, Silver Spring, Maryland. The Institute was founded in 1957 by Dr. Joseph V. Brady, who has been at Walter Reed since 1951, is now a Colonel, MSC, but will probably go full time to the Department of Psychiatry at Hopkins, where he is professor of behavioral science. Dave thinks it will be more fun to continue work with less responsibility than to "go to Florida."

R. C. Herrin writes, "Your letter made my spirits rise. Thank you for your inquiry." He retired at Wisconsin July 1st of this year but he does not wish to move to another area; he is considering volunteering for some teaching in his state. He advises those nearing retirement to squeeze out of every day all the personal satisfaction in your work that is possible. "Quickly forget all the disappointments."

Born in 1901

Leon K. Saul is continuing scientific activities; he thinks the best plan for retirement is "a light routine, but staying busy and useful."

Howard Bartley's comments to Bruce Dill shed light on his pioneering in the field of physiology-psychology: "One of my main endeavors, these many years has been to understand sensory mechanisms. While originally trained as a psychologist, I have been first, a biologist. For me, psychology must be a form of biology wherein organismic behavior is accounted for through body mechanisms. The eleven years I spent in Washington University Medical School in St. Louis with George Bishop focused my attention on the optic pathway. The information and concepts formed there have been the basis for most of my work in the psycho-physics of vision. Dozens of experimental papers have borne testimony to the continued interest by my associates and me. This spring my revision of "Principles of Perception" came out. The first edition was in 1958. I am involved in an attempt at a paperback regarding body mechanisms in perception to go along with the Principles to show how perception works in active early life and in the early development of the child. For the past 12 years I've had research grants from Washington to help carry on the work I have indicated. I now have an NIH student training grant, the purpose of which is to develop a few students for careers in sensory research. As you will remember, several years ago I wrote a brief book on Fatigue which I dedicated to you. The article on fatigue in the new addition to Encyclopedia Britannica will be mine. I am having more genuine fun and satisfaction with my graduate classes than ever before. This is partly because I feel I am getting closer to the students in them than ever before. I seem to elicit more active response each year."

Jacob Sacks became professor emeritus June 30, 1969 and has relinquished the chairmanship of the Premedical Advisory Committee, but remains as "expert consultant" to the Committee. He is interested in a possible position involving teaching, research or administration. It would need to be where the age 70 limitation would not apply. He

advises approaching retirement with equanimity, realizing that there are others capable of doing the job one has been doing, and that the other person's ways will be somewhat different. There is no barrier to keeping up one's interest in things outside his immediate field.

Joseph C. Hinsey writes: "Last July, I closed my office at the New York Hospital-Cornell Medical Center on whose staff I had been for 33 years. I have moved all my activities to Scarsdale. I have continued some of my board memberships and still serve as Chairman of the China Medical Board of New York. As a director of the American Hospital Supply Corporation, I have been interested in many of their activities involving better patient care. As a member of the Advisory Board of Wood and Tower, I am called upon for advice regarding the construction of medical and academic institutions. I find that I am kept busy enough and am not looking for any additional responsibility.

Chalmers Gemmill is continuing his scientific activities. He has an NIH grant on thyroxine mechanisms and another grant for the History of Medicine which involves visits to the National Medical Library or the Library of Congress once a week.

John Bean will not retire for two years. His research has been reduced this year incident to moving to new quarters in the new Medical Sciences Building.

Gene Landis spends three days a week in his small lab in the Biology Department at Lehigh with a small NHI grant that makes it possible to take up slowly and thoroughly much unfinished business on capillary permeability, with the help of new devices and methods nonexistent when he tried the same experiments hastily and unsuccessfully before. Chief pleasure - working with one's own hands in the lab again. Other days are spent tailoring their small plot of woods, sawing wood (a nice wood pile makes a good "security blanket" for winter and the hearth), gardening (outdoors in summer; indoors propagations in winter with help of Gro-lamps, growth hormones and hydroponics), home shop, birds, a little fishing, and reading widely again.

Maurice Visscher is continuing scientific work on excitation - contraction problems in the myocardium. He is President of the Board, National Society for Medical Research, and has a library search under way on the world literature on the subject of legal and ethical aspects of animal experimentation. "I have visited several foreign countries recently in connection with scientific cooperation with, and assistance to, developing countries. I am impressed with the need to stress economic and social (educational) assistance to such countries. One cannot expect to see peaceful and democratic societies built on a base of ignorance, illiteracy, poverty, hunger, and over-population. The time for constructive change is now. Tomorrow may be too late."

Alexander Sandow continues in his pattern of the last ten years at the Institute for Muscle Disease as a full-time member, in charge of the Division of Physiology, and at the graduate school of New York University, as an adjunct professor of biology. He gives a course in

biophysics and sponsors students for advanced degrees.

D. C. Smith is spending the winter with his wife in Hilo, Hawaii, where his son lives. This gives them a chance to get acquainted with their grandsons. He has been secretary for the past 20 years of the Maryland Society for Medical Research and edits the Society's Bulletin. The Maryland Society has been one of the most active in the nation. "If you are the type who enjoys his freedom and enjoys travel, my only advice is don't wait too long."

H. T. Ricketts is practicing part-time.

Tom Cureton, dean of physical fitness programs, retired in August but is as busy as ever. He has quarters in the U.S. Armory, almost adjacent to the Tartan track on which he has 300 adults (men and women) running daily, a program he began 25 years ago. He lectures and directs Physical Fitness Clinics across the country, applying what he knows in the physiology of exercise area. He believes physical educators should apply their work to people, educate them and consult with them, mainly about programs they might follow.

Allen D. Keller enjoys farming but would be available only in case of a dire need for administrative personnel in teaching and/or research in a two-year medical school or in the pre-clinical sciences of a four-year school.

Ted Koppanyi appreciates our interest in him: "I am delighted and grateful to you and your Committee of Senior Physiologists to take an interest in me although I am not as active in the Society as I would like to be.... I always considered myself as a physiologist with special interest in drugs as tools to study function." While professor emeritus of pharmacology since July 1, 1969, he pursues scientific activities and helps teach the major medical course in pharmacology. As to retirement he advises: "Look forward to it and think how many projects (academic or nonacademic) you can undertake freed from routine duties. Economically, take advantage of tax sheltered annuities offered to university people up to 1/6 of their gross earnings. This always helps and supplements one's retirement pay."

A. A. Luisada is continuing his scientific activities full-time. "Try to find some other work that will help you keep busy and interested."

Irvine Page writes a characteristic letter: "Naturally, I continue my scientific activities, I suppose, because I know nothing else - not even fishing, golf, or retiring on \$250 a month pension. The Cleveland Clinic, Jim McCubbin and Merlin Bumpus still put up with me as an old habit hard to break. My medical practice seems largely limited to visiting my friends' friends, old patients or greasing the portal of entry to what is now known as the Medical Establishment; this is my 'involvement'. We built a home in Hyannis Port very near the Kennedy Compound and you see how far this is getting us! My interest in the Marine Biological Laboratory is limited to old friends. Starfish, sea urchin eggs and sea water analysis no longer thrill me; their artificial parthenogenic way of

life, the same. I should be interested in moving away from a Cleveland that has something euphemistically called a climate, but I know I won't. I hate everyone who is warm and comfortable in the South while we freeze, which accounts in some measure for a certain sprinkling of vitriol which appears in my editorials for Modern Medicine. It is pleasant to be the editor so no one can edit me. There are two things I am not interested in: 1) serving on committees, 2) giving speeches to county medical societies in the northern zone. My only word of advice to those approaching retirement is to do it only when you must, which frees you to say No to things you never wanted to do, without having to make excuses. Remember your time is your own, even if your money isn't. Do anything not to quit being the nuisance you always have been. Say what you really believe because it is likely to be your only, and last chance. I must admit to being pleased with both the pharmacologists and the physiologists with their willingness to discard the rigidities of only slightly post-Victorian custom. Reminding our older friends that they are still viable is good!"

M. H. Seevers will not retire before 1971. "I spend about half of my time charging around the country on all kinds of Committees and other activities. Judging by the history of other retired individuals one never gets rid of this business especially if it does not cost these agencies any money. My outside activities include taking care of three greenhouses and about 125 bonsai, Japanese dwarf trees, in which I became interested 20 years ago on one of my many trips to Japan."

Abraham Cantarow since retirement from academia has been in the Office of the Director, National Cancer Institute, as "Research Planning Officer." He enjoys his work thoroughly. "There's nothing wrong with retirement as long as you don't let it interfere with your work."

Sarah Town wrote Hal that she is continuing her scientific activities, now in the field of psychoanalysis. With the close of the second World War she ceased to work in the field of experimental neurology and moved into psychiatry, both practice and teaching. This is one of her busiest years ever; she is retiring at the end of this year from teaching at the Johns Hopkins Medical School but will continue teaching in the Baltimore-District of Columbia Psychoanalytic Institute. "You will see from the above that I have no time to be interested in another position of any sort. The only words of wisdom I would have for those who are approaching retirement is to cultivate their connections with the young. Happily, having had my children as late in life as I did, this comes naturally, even though the children are distributed - one on each of the two coasts of the country. I may say I still receive The Physiologist and glean from its pages concerning my one-time companions, but it is good to hear directly from one of them, yourself."

Victor Hall, although retired, has been "recalled" to full-time duty, not in the department of physiology, but to three other jobs: 1) a physiological consultant in the training program in pediatric cardiology; 2) co-principal investigator in the UCLA Brain Information Service (a NINDS offshoot); and 3) editor of the UCLA Forum in the Medical Sciences. He is in his last year as editor of the Annual Review of

Physiology, a job held for almost thirty years. "These activities keep me happily busy and in contact with my colleagues and students. Truly my cup runneth over."

John Welsh replied to Hal: "Your Committee on Senior Physiologists certainly does a fine job of keeping in touch with retired members of the Physiological Society. I have read the replies of members past 80 years of age in the past *Physiologist* and I must say that most of them remain very active. Noting their ages makes me feel rather youthful." John retired in 1968; the past two years long summers have been spent on the old family farm in Boothbay, Maine and winters in Cambridge. He is finishing an article on "catecholamines in the Invertebrates" for a forth-coming volume of the *Handbook of Experimental Pharmacology* and has two more papers under way. "By June we expect to have moved to Maine to make it our legal residence. There we have a nice old farm house built in the early 1800's. We have a woodlot of about 150 acres where I plan to do tree-farming and I shall continue gardening, which is my favorite avocation. There are three marine laboratories in the immediate vicinity (Federal, State, and Univ. of Maine). I have good friends working in these labs and may, if I can find the time, continue some work in one of these. The general atmosphere of the Biol. Labs is very different from that of your day as chairman of the board of tutors. There has been extensive physical renovation and updating and the majority of occupants are of the newer type - molecular biologists, biochemists, and the like. Some of these are only housed here temporarily, waiting for their new building. It is a good time to depart and stop worrying about the future of biology. I am sure it will have a future but it is certain to be very different from the past."

Born in 1902

Ronald V. Christie replied from Australia. He is not active in scientific affairs but is enjoying travel, writing, and trout fishing.

Allan Hemingway replied to Bruce that he retired from UCLA in June 1969 and is now Chief of Cardiopulmonary Laboratory at the San Fernando Veterans Administration Hospital. This laboratory makes the routine tests of electrocardiography, resting and exercise, pulmonary function tests, blood gas analyses and exercise tolerance tests. A research program is in progress on exercise tolerance in the older individual. Oxygen debt is measured in an attempt to find a better exercise tolerance test than simply walking on a treadmill until fatigued. "We use your famous hemoglobin oxygen saturation curves."

James Irving is an active editor of one journal and on the editorial board of another. He finds it keeps him abreast of many aspects that he wouldn't otherwise see. Last year he was Chairman of the Gordon Conference on Bones and Teeth, and then went to the International Nutrition Conference in Prague, where he was a session chairman. He will be head of the section of histochemistry for another 3 or 4 years, and had the interesting fun of planning the new lay-out in the Forsyth Dental Center of about 5500 feet. He is still very active in research working together with two to three post doctoral fellows as well as two

staff members. His wife is a professional singer; he often accompanies her pupils.

Ray Zwemer is continuing scientific activities as Project Director and Executive Editor of Neuroscience Translations and is Chairman of the Finance Subcommittee of the International Anatomical Nomenclature Committee. Also he is preparing a report for the Council on Library Resources on identification of journal characteristics useful in improving input and output of retrieval systems, and is preparing a definitive list of Biological Periodicals for the Council of Biological Sciences Information. "Keep on doing something productive, change fields when the new job seems interesting and stop meeting deadlines."

Oscar Richards in 1967 reached the age for mandatory retirement from the American Optical Corporation. He and his wife moved back to Oregon where he teaches a one-semester course in Environmental Vision for the sixth year graduating class of optometrists. He has one or two graduate students and good research facilities at Pacific University. He is continuing his measurements of acuity and contrast vision of humans from 10fL to moonlight luminance and is writing and completing former projects. "Time at the mountains or the sea coast is pleasant. This year the frogs started their spring sing the 3rd week of January and our spring flowers are coming into bloom."

Gordon Marsh is retiring by degrees, but is continuing his scientific activities. Facilities will be available to continue research and writing.

John Field, after retirement on June 30, 1969 was reappointed as professor of medical history and assistant dean. As professor of medical history, he is engaged in teaching and research in that field. He feels that previous professional and administrative experience have broadened his field of vision and ripened his judgment. His research is focused upon the history of medical education in the United States from the opening of Johns Hopkins Medical School (1893) to the present. He is preparing a monograph to be entitled, "History of Medical Education in the United States: Late Nineteenth and Twentieth Centuries," which was the title of the paper he presented at a symposium at UCLA early in 1968. "After retirement it is a pleasure to have an opportunity to do scholarly work in line with one's prior interests and knowledge and which one deems of use to others."

Irving Blank's appointment at the Massachusetts General Hospital will continue until at least September 1971. Robert Scheuplein came from Edgewood to join their staff. His sound physical chemical knowledge has advanced their work immeasurably. Irving and he have been invited to prepare a manuscript for Physiological Reviews on the permeability of the skin. They hope that this paper will get the membrane transport physiologists interested in the stratum corneum, a unique biological membrane.

Ashton Graybiel is continuing his scientific activities, dividing his time about equally between administration and research. He and his associates continue to report on experiments dealing with the vestibular

organs. As a clinician-physiologist he advises as follows: "First, I believe it is important to carry out some sort of work representing an intellectual challenge, whether this is accomplished at home or elsewhere. The second bit of advice reflects my clinical background. Approaching 68 years of age, health problems have arisen which have intrigued me. Up till now anyhow I have tackled them objectively and, in some instances, with much success. The regimen I follow takes little time, is tailored to my needs and has taught me much."

Otis O. Benson enjoys his responsibilities in the Southwest Research Institute as Staff Director - Bioscience and Bioengineering. He advises those approaching retirement to seek an appropriate position immediately. A gradual transition is neither desirable nor necessary. He sees the evils in myriads of retired military officers in his locality who become dormant and preoccupied.

Louis Flexner writes: "I'm busy as the very devil and glad that my administrative responsibilities are a thing of the past. I'm still doing my stint with the students and still getting a big kick out of the lab. All in all it adds up to one of the most gratifying times I've ever had."

A. A. McIntyre advises that in retiring one should prepare to relinquish authority, keep working and keep out of the youngsters' long hair.

Born in 1903

Wright Adams has resigned from his position as Coordinator of the Illinois Regional Medical Program. He plans to take about six months to get resettled and to do some traveling and will then decide what he wants to do. Then he will seek some employment in an administrative position. "I very much appreciate your interest in maintaining contact with older members of the Society."

A. Sidney Harris has three years left on the active faculty; he may retire from the chairmanship two years hence. The present development of a dental school, expansions in nursing school, graduate school and residency training all conspire against relaxation by the chairman. He advises preparing for the pursuit of happiness in leisure, or in the freedom of choice of activities that retirement brings. "Thanks for the service that you are rendering to all of us."

James Pinkston is still active in teaching and research in Chandler Brooks' department. He expects to retire in August 1973, at age 70, and is looking forward to gardening and related activities at their country place in the Pocono Mountains.

F. O. Schmidt thinks it is a fine custom for society officers to send along a friendly word to those who have become emeriti. He continues to chair and guide the activities of MIT's Neurosciences Research Program which is growing constantly in its program and interest to others. The worldwide interest in the neurosciences, which was little when NRP was founded in 1962, is growing to a ground swell and is culminating in

the formation of a large and active Society of the Neurosciences. Those approaching retirement age and who are blessed with good health should plan to continue full speed and full interest, preferably in different circumstances - maybe even a different field - than those to which they have become accustomed. "If you ever come our way, we would like to welcome you at the NRP Center in Brookline or at our home in Weston."

Edward S. Castle writes: "For me retirement is the greatest excitement since the 1920's I am now at liberty.... My heart is really in Vermont's green hills, from whose seasonally white slopes I'm only temporarily exiled."

Walter Redisch is continuing his scientific activities, and hopes to do so for some time. He is interested in the positions that come to the attention of the committee and might be willing to move to another area. He advises senior physiologists not to retire but to continue their activities as long as possible.

Eszter Kokas writes: "I am continuing my scientific activities, teaching and research, and hope to continue my work as long as the laws of North Carolina or my health permit."

Fred Gibbs and Erna "have not discovered the electroencephalographic Rossetta Stone, but ... are gradually learning the significance of numerous specific patterns and types of spread." He will be emeritus next year. "Whether they still will want me to read brain waves remains to be seen. They won't find anyone who will do it as cheaply. I am consultant for a fair number of hospitals in the Chicago area and elsewhere, reading their EEG's and supervising their EEG laboratories; they seem pleased with my services. If I have any spare time I can fill it up by taking on another hospital or two. Erna and I have been organizing and reorganizing our collection of 200,000 electroencephalograms that are stored in a barn on our farm at Valparaiso, Indiana. It is a goldmine that we can work on for years. Records are kept on the ground floor and what was the hayloft has been converted into a brain-wave library."

L. A. Crandall in 1962 left his position as director of research for Miles Laboratories and entered on a residency in psychiatry at Southeast Louisiana State Hospital. He is now a staff psychiatrist at the hospital, four days a week and spends one day at the Bogalusa Mental Health Center 40 miles away. "I could not have tolerated psychiatry in the pre-drug days when there was little to offer but custodial care but now it seems to me to be the most rewarding work I have ever done. Southeast is an exceptionally well staffed acute treatment hospital and we return almost all uncomplicated schizophrenics to the outside world within 10 weeks and often in 6 weeks, and refer only a fraction of one percent to the large state hospital for long term hospitalization." The Crandalls enjoy sailing, they are patron members of the local Little Theatre and enjoy a rather wide circle of friends in Mandeville, Covington, and other nearby communities.

Eric Ogden is Division Chief of Environmental Biology, NASA - Ames Research Center. He supervises 47 full time personnel and a

large floating crowd of guest scientists, fellows, contract employees and the like. He finds some time for laboratory research. He and Max Anliker are making an onslaught into the physical properties of large (later hopefully small) bloodvessels and the neurohumoral control of distensibility, especially of the veins.

Walter Kempner maintains his usual pace as professor of medicine at Duke Medical School.

George B. Jerzy Glass is working full speed with the help of various Public Health Service Research and Training Grants. He has relinquished clinical duties at the Hospital. He recommends continuing at full speed if God and health permit.

S. R. M. Reynolds became emeritus at Illinois last September. There he was busy for several years, intensively last year, in revamping medical education in state-supported schools aimed at shortening the time two years. Those involved in such an effort may wish to write him at 933 Olde Hickory Road, Lancaster, Pa. 17601. He is a lecturer at the University of Pennsylvania, shares in some of their research and uses the library. He is catching up on writing delayed by administrative tasks. This included a chapter for the endocrinology section of the Handbook of Physiology. He has in view a monograph on developmental cardiovascular physiology. He describes his desired research environment. "I require only close contact with younger research workers whose interests are developing and who have, usually, very great technical capacity, adequate to excellent intellectual resources, but whose acquaintance with the literature of their area of interest and capacity for conceptual thinking with respect to it is not yet highly developed. In this way, I learn much from them, and it is frequently mutual. Is there a message in this for some men looking forward to retirement? For me, I could not get to it soon enough!"

F. R. Steggerda continues to teach and conduct research at the University of Illinois. He will retire September 1, 1971. He would be interested in some sort of part time job as a teacher and some chance of remaining scientifically active. He considers himself a member of a fast-disappearing group, one who likes to lecture to the elementary student and give dog demonstrations on blood pressure, secretions, respiration, etc. He particularly enjoys directing each summer an NSF research participation program for postdoctoral school teachers from colleges and small universities. He would consider a position on a yearly basis provided he could feel needed. His research continues to deal with gas production in the gastrointestinal tract. Also, he is research consultant for the local Carle Hospital clinic. He took leave for two months beginning January 15, 1970 to be associated with the project Hope in Tunisia, North Africa.

Ted Stier has retired at Indiana University. By September 1971 he expects to be available for a teaching or research position.

A. B. Taylor with two more years at University of Illinois before mandatory retirement would like to continue scientific activities after

retirement and would consider moving to another area. He advises keeping interested in scientific research or some other activity.

John L. Nickerson has not retired. In addition to continuing as Chairman of the Department of Physiology and Biophysics, awaiting the appointment of a successor, he is Acting Dean developing a School of Graduate and Post-Doctoral studies. His scientific work has been reduced to a low level because of the administrative responsibilities. He continues his interest in computers and computer processing of data accumulated over the past years, with several publications in prospect. When the new Chairman of the Physiology and Biophysics Department is selected, he will take up full time duties as Dean of the Graduate School.

Arnold Lieberman reminded Bruce Dill of some meetings in post-war years and of the letters they wrote on the occasion of the 75th birthday of Ajax Carlson. Lieberman's Ph.D. thesis was on Ca^{++} ; Luckhardt and Ajax encouraged him to follow that line of research. While he has written more than 100 papers, he now keeps busy practicing medicine and consulting at hospitals. He recalls a wise-crack of Chauncey Leake's: "I've been going to funerals of recently retired colleagues."

Konrad J. K. Buettner is still fully active teaching and researching. He has been offered and has accepted a sabbatical stay for the academic year 1970-71 with Jim Hardy at Yale. He hopes to be able to build up over there his long neglected work on skin permeance. As to retirement, "Keep busy and have contact with young students."

Born in 1904

Leigh Chadwick does a fair amount of reading, functions on the editorial board of *Entomol. Exp. & Appl.*, criticizes a few other manuscripts on request, and from time to time does some translation of scientific works from German to English. He and Maria have a summer place on the shore of Blue Hill bay, and an all-year house nearby. Leigh had a coronary attack early in November but got off lightly and now leads an essentially normal life. Maria became ill before Leigh recovered; Mrs. Chambers (widow of Bill) who lives nearby came over and ran the household for ten days.

Paul C. Bucy is continuing his scientific activities.

J. D. Hardy writes that he has retired from the U.S. Navy and Civil Service but is continuing his scientific activities as Director and Professor of Environmental Physiology, John B. Pierce Foundation Laboratory, New Haven, Conn. To those approaching senior citizenship he advises, "Be sure to join Medicare!"

Hugh Montgomery feels that what he is doing in any field of biology is a continuation of scientific activity, and that the means chosen to new ends are sound and logically interpreted. The practice of medicine can benefit from a number of years of researches that dealt with animals, with normal human beings and to an increasing degree with ill people. "I welcome your questions regarding retirement or interest in a new position that would enable continuing scientific activities. The pressing problems of pollution of water are increasingly exciting. I think I should

like to work in laboratory and field, along that line, without taking on any heavy administrative responsibilities. To be effective this would necessitate giving up the practice of medicine and to do so would require a steady, though modest, means of financial support. Perhaps anti-pollution planning, federal, state or city, is now advancing at such a rate that scientificis in various fields, and in many localities, will be in considerable demand. If this is so one might even hope to continue to live in his present home and hold a position with some financial stability."

R. K. Richards has a part-time appointment as Visiting Professor in the Departments of Anesthesia and of Pharmacology. He is doing research in the former field and teaching in the latter. He is part-time consultant for the Syntex Corporation in Palo Alto and in clinical pharmacology at the Palo Alto Veterans Administration Hospital which is connected with Stanford University.

Evelyn Howard wrote Hal Davis that she is continuing research on the effect of corticosteroids on brain development. "I am full of the feeling that I have had all my life, that in a few weeks or months I am really going to achieve something tremendous."

John M. Bruhn, Division of Health Service Facilities, plans to retire in June of this year. He expects to serve as a part-time consultant in recruiting minority group students for the Health Professions.

Harry Grundfest is "still working away. Relaxing is too difficult."

Alan Burton will retire in July 1970. He writes, "I certainly hope to continue my scientific activities. I want to see if I can still get back to the bench and do research myself, and plan to work for the first year at least without having any graduate student, until I know that my projects are worthwhile. I want to enter a field of research in which I have no experience, and this will be quite different from anything else I have done, but in which I have a great many wild ideas. This is the field of the control of cell division, in which I hope that someone who is simple-minded, and has not been brainwashed by the cancer research people, might start some new line of attack along the lines of biophysics. I expect to continue on pension plus up to 1/3 salary for continued undergraduate teaching, particularly in the Honours Biophysics course we have been running for the last three years. My department certainly needs my help still on this. My difficulty at the moment is to find some place, preferably in another department, where I can hang my hat. Everybody seems impossibly crowded at the moment."

A. Van Harreveld plans to continue his usual activities until age 68.

R. A. Cleghorn plans to continue his scientific activities for another three years. Then he hopes to have a half-time job in teaching and consultation work after his retirement in August 1970. He anticipates McGill University will provide opportunities for scientific activities.

Mary Brazier is Professor of Anatomy and Physiology in the School

of Medicine at UCLA. She has a Career Research Award from NIH, which is supplemented by salary from the University. She has an active research unit in the Brain Research Institute with help from people including a computer programmer and a full Professor. Her research grants from NIH and ONR cover research in neurophysiology in man and animal, specializing in electrophysiology and biomedical computing.

Henry Beecher reports: "I am indeed continuing my scientific activities. Work on pain continues. I have been one of the severist critics of the experimental pain methods as employed in the past, but we have devised our own method which works very well. This doesn't hold for threshold pain. All of the earlier methods depended on threshold pain. The thrust of our work over the last 25 years has been to make it abundantly clear that one can deal in quantitative terms with the effects of drugs on the mind. A number of people have been kind enough to say that this puts a solid foundation under much of psychopharmacology. In the last 15 years I have been also much interested in ethical problems associated with experimentation in man. I am afraid that this has been to the annoyance of some, but the work has received robust support from many quarters and I am grateful for this. In mid-January my book, "Research and the Individual: Human Studies" will be published by Little, Brown and Company."

N. R. Brewer, Executive Secretary, Illinois Society for Medical Research, keeps members informed about State and Federal legislation and potential legislation that may effect the use of animals in teaching and research; aids in keeping the public informed about the value, the necessity and the humane use of animals in teaching and research; represents the deans of the medical institutions in the distribution of animals from the local pound to approved research and teaching institutions. In addition he is trying to finish a book, aimed at veterinarians on "Laboratory Animal Physiology."

Ancel Keys has given up almost all teaching in order to concentrate on his research primarily concerned with the epidemiology and possible prevention of coronary heart disease. He has continuing studies in progress in Italy, Greece, Yugoslavia, Finland, and the Netherlands. Those follow-up studies are planned to continue for at least another four years and the analyses will go on long after then. He and Margret have built a house in Italy and they find it makes a good headquarters abroad. He will be busy with reexaminations and working up data for a long time to come, with lots of sea and sun bathing as accompaniment. He wishes he could move the computer and statistical machines to their Italian home, thus saving "carfare" between Minnesota and Europe.

M. H. Knisely retired as Chairman a year ago in order to give the place to W. Curtis Worthington, Jr. who had a very fine offer from another school. For some five years he has been cooperating with chemical engineers developing equations with which to predict the limitations on the distribution of oxygen from red cells into plasma, thence out through the endothelial wall to the cells of tissues and organs. Some of this has been published; a large paper will be out some time this month giving an introduction to the mathematics and an extensive portion showing

how the mathematics can be used. He plans to continue with this research as full professor in the department.

Samuel Soskin has given up his laboratory and is happily devoted to clinical practice which he looks upon as applying physiological principles to the treatment of individuals. As to retirement his answer is "Don't until you absolutely have to by reason of infirmity. Continue to work at something that interests you if possible, but at any rate work at something!"

Hayden C. Nicholson has been in administration full time for twenty years. He would like to retire next July but may continue in his present position beyond that time. He would consider a part-time position but would prefer not to leave Chicago.

Evan W. McChesney retired after 30 years with Sterling Winthrop Research Institute and joined the staff of the Institute of Experimental Pathology and Toxicology where he is continuing his research. He advises those facing retirement to keep up contacts and start looking and planning before the separation date has arrived.

Hurley Motley is now Director of the Cardio-Respiratory Laboratory, Good Samaritan Hospital, Los Angeles, as well as Director of Inhalation Therapy and Research. Last summer he and his wife enjoyed a boating trip to the Rainbow Bridge, Lake Powell.

AMERICAN PSYCHOSOMATIC SOCIETY

The twenty-eighth annual meeting of the American Psychosomatic Society will meet in Denver, April 2 -4, 1971. Abstracts of original work are invited. Abstracts are limited to 500 words and are to be submitted in 12 copies. The Society maintains a broad interdisciplinary representation within the basic central nervous system sciences, autonomic and endocrine regulatory physiology, as well as psychiatry, internal medicine and related clinical sciences. Abstracts should be submitted by November 15, 1970 to Peter H. Knapp, M.D., 265 Nassau Road, Roosevelt, N. Y. 11575.