

# *Editor's Page*

The Society will celebrate its 75th anniversary in 1962. It is contemplated that a special history will be published at that time. This volume will be similar to the one published in 1938 on the occasion of the fiftieth anniversary. Copies of this volume are scarce. The American Physiological Society office would like to obtain one or two copies of this volume for the archives of the Society. If any member has a copy and would be willing to donate it to the Society it would be appreciated. We are also interested in any pertinent letters, programs, etc. pertaining to the Society or the International Physiological Congresses that would be suitable for the archives and/or history of the Society.

Again we appeal to members to send us material for publication in THE PHYSIOLOGIST that might be of interest to fellow physiologists. We would also like to develop a "Letters to the Editor" section in which members can discuss policy matters as suggested in the President-Elect Tour report, matters of general interest, unique experimental procedures, etc.

## SUMMARY REPORT OF SPRING MEETING

The forty-third annual meeting of the Federation in Atlantic City, April 13-17, 1959 was the largest ever held. A total of 10,356 registered: 8,871 scientists; 539 visitors and guests; and 946 exhibitors.

There were 2,485 scientific papers presented in addition to the Joint Session of the Federation and the Motion Picture Session.

Physiology had 61 sessions programmed including 2 Symposia, a Teaching Session and 8 Special Sessions introduced by a 30-minute review. These Special Sessions again proved to be popular.

The two largest interest areas were neurophysiology and cardiovascular physiology. There was a total of 28 sessions at the Federation meetings that dealt with neurophysiology and its related aspects and 29 sessions devoted to cardiovascular aspects. These were scheduled in the Inter-Society Sessions, the Physiology Sessions and the Pharmacology Sessions.

The Physiology Society elected Dr. Julius H. Comroe, Jr. as President-Elect. Dr. Theodore C. Ruch was reelected to Council for a 4-year term, having previously filled the 1-year unexpired term of Dr. Pitts. Dr. Horrace W. Davenport was elected to Council to fill the 3-year unexpired term of Dr. Comroe. Dr. Philip Bard was appointed Chairman of the Board of Publication Trustees, replacing Dr. Maurice Visscher who resigned because of ill health, and Dr. Hermann Rahn was appointed to the Board. Other appointments to Committees, etc. will be reported later.

## NEWLY ELECTED MEMBERS

The following, nominated by Council, were elected to membership in the American Physiological Society at the Spring Meeting, 1959.

### Regular Members

|                         |                          |
|-------------------------|--------------------------|
| ANGELAKOS, Evangelos T. | KORY, Ross C.            |
| BENJAMIN, Robert M.     | LEAF, Alexander          |
| BERNSTEIN, Leon         | LILIENFIELD, Lawrence S. |
| BEYER, Robert E.        | LOEWENSTEIN, Werner R.   |
| BOWMAN, Roger H.        | MCGREGOR, Maurice        |
| BRANDT, J. Leonard      | MENSCHIK, Zygmunt        |
| COHN, Stanton H.        | METCALFE, James          |
| CRAIG, Albert B., Jr.   | MITHOEFER, John C.       |
| ECKEL, Robert E.        | NELSON, Don H.           |
| ELIASSON, Sven G.       | NIEMER, William T.       |
| ENGLE, Ralph L., Jr.    | PRINCIOTTO, Joseph V.    |
| FRUMIN, M. Jack         | RENNICK, Barbara R.      |
| GIEBISCH, Gerhard H.    | RODRIGUEZ, Maria I.      |
| GILBERT, Daniel L.      | ROGERS, Terence A.       |
| HALMI, Nicholas S.      | RUDOLPH, Abraham M.      |
| HAVEL, Richard J.       | RUSSELL, Findlay E.      |
| HEINEMANN, Henry O.     | SMITH, Lawton H.         |
| HEMPLING, Harold G.     | STAINSBY, Wendell N.     |
| HIND, Joseph E., Jr.    | TEODORU, Constantin V.   |
| HILL, Robert            | THOMAS, Price E.         |
| HOLADAY, Duncan A.      | THOMSON, Ashley E.       |
| HUBEL, David H.         | TIMIRAS, Paola S.        |
| HUCKABEE, William E.    | WAUGH, William H.        |
| JACOBSON, Frank H.      | WELKER, Wallace I.       |
| JACQUEZ, John A.        | WESSLER, Stanford        |

### Associate Members

|                   |                        |
|-------------------|------------------------|
| CAIN, Stephen M.  | REED, Donal J.         |
| CASSIN, Sidney    | REEVES, Robert B.      |
| HANSEN, Julius T. | REUBEN, John P.        |
| KARLER, Ralph     | ROVICK, Allen A.       |
| KELSO, Albert F.  | SANUI, Hisashi         |
| KRUM, Alvin A.    | SECKENDORF, Russell C. |
| LEVY, Alan C.     | TOLBERG, Adelaide B.   |
| MANNING, John W.  | VCELLA, Carl L.        |

### Honorary Members

|   |                         |
|---|-------------------------|
| BRAUN-MENENDEZ, Eduardo (deceased January 1959) - Argentina |                         |
| HURTADO, Alberto - Peru                                     |                         |
| KUNO, Yas - Japan   | USSING, H. H. - Denmark |
| MORUZZI, Guiseppe - Italy                                   | WEBER, H. H. - Germany  |

# FINANCIAL STATEMENT OF APS GENERAL OPERATING FUND FOR 1958\*

Capital Balance December 31, 1957 \$ 7,538

Income:

|                                   |                 |
|-----------------------------------|-----------------|
| Membership dues (\$10 per member) | \$15,382        |
| President Elect tour, net         | 1,034           |
| Fall Meeting, net                 | 849             |
| Interest                          | 100             |
| Contributions                     | 500             |
| Total Income                      | <u>\$17,865</u> |

Expenses:

|                                     |                 |
|-------------------------------------|-----------------|
| Salaries and employee benefits      | \$ 5,489        |
| Central office expenses             | 1,066           |
| Fed. Business Office service charge | 3,835           |
| Fed. Assessment (\$4 per member)    | 6,294           |
| Dues to AIBS                        | 1,000           |
| Miscellaneous expenses              | 143             |
|                                     | <u>\$17,827</u> |

|   |                 |
|---|-----------------|
| Deduct expenses reimbursed by<br>overhead charged to grants and<br>other restricted funds | 4,228           |
|   | <u>\$13,599</u> |

|                                   |                 |
|-----------------------------------|-----------------|
| Excess of Income over Expenses    | 4,266           |
| Capital Balance December 31, 1958 | <u>\$11,804</u> |

\*Does not include publication funds and other restricted funds secured from granting agencies, etc. These restricted funds support Society publications, the Porter Fellowship, Bowditch Lectureship and the Education Committee activities.

## PORTER FELLOWSHIP

The Harvard Apparatus Company grants the APS funds to support the Porter Fellowship which pays \$3,600 for the last year of pre-doctoral training.

## BOWDITCH LECTURESHIP

An anonymous donor provides funds for an honorarium of \$250 for the Bowditch lecturer each year.

## EDUCATION COMMITTEE GRANTS, 1958

National Science Foundation - \$50,000 for summer training program.  
National Heart Institute       \$20,000 for summer training program.  
National Science Foundation - \$ 8,155 for summer workshop.

# AN INVITATION TO THE FALL MEETINGS OF THE AMERICAN PHYSIOLOGICAL SOCIETY

University of Illinois, Urbana, Illinois

September 8-11, 1959

The Department of Physiology, University of Illinois, Urbana-Champaign, extends a cordial invitation to all members of the American Physiological Society and their friends to attend the Fall Meetings. The Society of General Physiologists will also be meeting on the Urbana-Champaign campus, September 7-9. The subject of the symposium of the General Physiologists will be "Molecular Morphology in Relation to Differentiation." On September 9, the two Societies will jointly sponsor a symposium entitled "Cellular Approaches to Mammalian Physiology." The refresher course will be on Tuesday, September 8, in the new first unit of the Biology Building which will house the Physiology and Bacteriology Departments. This building is to be officially dedicated at the time of the meetings. The general topic of the refresher course will be "Teaching Demonstrations of New Laboratory Methods." The scientific sessions will be from Wednesday morning until Friday noon, September 11. Thursday afternoon is being reserved for Open House, movies, and demonstrations by members of the Society. The annual dinner of the Society, with the address of the Retiring President, will be on Thursday evening. The fourth annual Bowditch Lecture will be given by Dr. Lloyd M. Beidler of Florida State University, Tallahassee. A "Smoker" and "Chicken Barbecue Picnic" are also being arranged.

Arrangements are being made to have a program of organized entertainment for the ladies on both the campus and at Allerton Park, a garden spot owned and operated by the University. Supervised play and care facilities will also be available for small children. Plans are in progress to offer an all-day bus trip to Springfield to visit the Lincoln Memorials and New Salem, a small village, now preserved as a state park where Lincoln lived as a young man. This trip will depend on interest shown by advanced registration.

The Local Committee has made arrangements to lodge the guests in a University residence hall. The facilities are adequate to accommodate guests in either single or double rooms. Meals will be served at the same residence hall in which the guests are housed. Hotel and motel accommodations are also available in the area and will be listed for the benefit of those who may wish to take advantage of them.

Urbana-Champaign is a twin-city community of approximately 60,000 people. It is approximately 130 miles south of Chicago. It is on the main line of the Illinois Central Railroad. The Ozark Airlines also connects St. Louis, Indianapolis and Chicago with the local University Airport. Urbana-Champaign is very accessible by

main highways in Central Illinois and it is the hope of the Committee that many members and guests will see fit to make the trip by automobile. Adequate parking facilities are available on the campus.

Further announcements and reservation forms will be mailed to the membership. The deadline for receiving abstracts of 10-minute papers will be June 21. This is necessary in order to have them appear in THE PHYSIOLOGIST sent to the members in August.

The Local Committee and the University authorities are very happy to extend a personal invitation to visit our campus on this occasion.

THE STEERING COMMITTEE

# THE GAVEL OF THE AMERICAN PHYSIOLOGICAL SOCIETY

HALLOWELL DAVIS

The gavel of the American Physiological Society was made by President Eugene M. Landis from wood that belonged, part of it, to our first president, Henry P. Bowditch, and part to another very eminent president, Walter B. Cannon. The wood of the anvil and of the box that contains the gavel and its anvil belonged part to Anton J. Carlson and the remainder to another past president, Carl J. Wiggers. The box was designed by President Louis N. Katz. Presidents Landis and Katz have explained their choices of past presidents to honor partly on the basis of their eminence and because of the relation of teacher to pupil, because of a common scientific interest or because of association with the same academic institution.

In turn President Hallowell Davis honors another of his most eminent predecessors, Joseph Erlanger. To the top of the box has now been attached a metal disc made from a medallion given to Professor Erlanger on the 50th Anniversary of his graduation from The Johns Hopkins School of Medicine. Beneath this and forming a background for it is a larger but thinner split brass disc. This second disc was originally the circular scale that indicated time intervals on the stimulator of the original Erlanger and Gasser cathode ray oscilloscope assembly. It was for work done with this apparatus that Erlanger and Gasser were awarded the Nobel Prize in Medicine in 1944. On the heavier disc is engraved the inscription: THE GAVEL OF THE AMERICAN PHYSIOLOGICAL SOCIETY.

The choice of Joseph Erlanger is appropriate for President Davis in several ways. First, Erlanger is eminent as the second ex-president of our society to receive a Nobel Prize.\* Secondly, Davis is a devoted follower of Erlanger as an electrophysiologist and a user of the now ubiquitous oscilloscope. Thirdly, Erlanger was the first and Davis is the latest president of the American Physiological Society from Missouri, and both are presently associated with Washington University. Finally, both Erlanger and Davis have been treasurers of the Society, and it was Treasurer Joseph Erlanger who, in 1923, handled the incorporation of the American Physiological Society. Our Society is a corporation under the laws of the State of Missouri and Joseph Erlanger was the first signer of our documents of incorporation.

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\*The first was J. J. R. Macleod with F. G. Banting in 1923.

## HENRY NEWELL MARTIN



The American Physiological Society was originally conceived by a group of three men, H. P. Bowditch, S. W. Mitchell and H. N. Martin. Bowditch and Mitchell became presidents of the new Society. Although Martin never became president he was very active and influential in the early days of the Society. It was thought that present-day members would like to know something about Martin so the following is taken from the material appearing in the History of the American Physiological Society.

Professor Martin was born at Newry, County Down, Ireland, on July 1, 1848. He died on October 27, 1896 at Burley in Wharfedale, Yorkshire, England. Both of his parents were Irish, his father, at the time of his birth, being a congregational minister. Martin's early education was acquired mainly at home. At the age of 16 years he entered University College, London, to begin his medical studies. Here he came under the influence of Michael Foster, who doubtless was responsible for directing his interests toward physiology. Martin and Schafer (Sir Edward Sharpey-Schafer) were fellow students under Foster, doing special work in his courses. When Foster was made Praelector of Physiology at Trinity College, Cambridge, he invited both of the young men to go with him. Martin accepted, having meanwhile won a scholarship at Christ's College. At Cambridge he assisted Foster in his physiological and biological courses, and as a student made an exceptionally brilliant record. He won first place, for example, in the Natural Science Tripos, the second place falling to Francis M. Balfour who later, in spite of his early death -- he was killed in an Alpine accident in Switzerland at the age of 31 -- acquired the highest distinction in embryology.

Martin also assisted Huxley in his courses in biology at South Kensington, London. Together they published a laboratory guide in general biology, "A Course of Elementary Instruction in Practical Biology." This little book was famous in its day as the forerunner and model of many similar laboratory manuals. It was used widely in England and the United States to introduce courses in the newly conceived science of biology.

In 1876 Martin, when only 28 years old, was called to the chair of Biology at The Johns Hopkins University which was then in process of organization. His selection by President Gilman for this important post was made doubtless on the recommendations of Huxley and Foster. Martin undertook his new work with great zeal and energy. He arranged graduate and undergraduate courses in general biology, animal morphology and physiology and, to a less complete extent, in botany. He himself gave the introductory courses in general biology and physiology and took direct charge of the advanced work and research in the latter subject. For a period of about 15 years Martin was actively engaged in physiological research, and gathered round him a number of graduate students, so that the laboratory soon became recognized as a center for research and for the training of specialists in animal physiology. Physiology in his laboratory was treated not as a branch of medicine but as a biological science. This was the point of view that Martin had inherited from Huxley and Foster and which, in turn, he passed on to his pupils. Moreover at that time there was no medical school at The Johns Hopkins and hence no need to correlate instruction in physiology with other branches of the medical curriculum. It was accepted by the University as one of the principal or subordinate subjects that might be offered for the degree of Doctor of Philosophy. As a matter of fact a number of students took this degree in physiology under Martin, and other students, graduates in medicine, took special courses or carried on research under his direction. At the time of the founding of the Physiological Society six of his pupils had acquired sufficient reputation in the subject to be included among those asked to the organization meeting.

As an investigator Martin showed marked originality. He was not especially skillful in constructing new apparatus, but he was ingenious and original in devising new methods of attacking physiological problems. His most noteworthy contribution, probably, was his method of isolating the mammalian heart. With this method, which was entirely new, he and his pupils carried out a number of important researches upon cardiovascular physiology. One of these investigations, "The direct influence of gradual variations of temperature upon the rate of beat of the mammalian heart" (Phil. Trans. Royal Society, London, 1883, 174, 663) won for him the Croonian Lectureship of the Royal Society. After his retirement in 1893 his researches and addresses were reprinted by his friends and pupils as a memorial volume, "Physiological Papers by H. Newell Martin - Memoirs from the Biological Laboratory of The Johns Hopkins University, III, Baltimore, 1895."

Martin was one of the principal founders of the Physiological Society and was deeply interested in its work. He served as Secretary and Treasurer until the fifth annual meeting. The minutes of the first six meetings, annual and special are in his writing. He was prevented by illness from attending the annual meeting at Princeton, December 1892, and shortly thereafter his physical condition became so poor that he resigned his position at The Johns Hopkins and returned



to London. He was then only 45 years old, and it was hoped that rest and medical care would restore his health. He had this hope himself. In a letter dated January 6, 1895, he spoke of having just completed a revision of his college textbook, "The Human Body," and outlined a new theory of muscle contraction which he expected to work upon in Schafer's laboratory. But an attack of pneumonia left him in a much weakened condition and led him to leave London to seek rest and recuperation in Yorkshire, where a second attack proved fatal.

During his 17 years in Baltimore, Martin changed little in appearance. Physically he was somewhat under average size with a rather slender although athletic figure, so that he gave an impression of youthfulness. He was distinctly good looking with attractive blue eyes that could light up with rare humor and cordiality, or, on occasions, when he felt that he was being bored, could convey quite the opposite impression. His pupils were warmly attached to him for he never assumed with them the attitude of a master, but rather that of a companion and fellow student. He was fond of having his men at his home, at a sort of social seminary, at which beer and ale were dispensed and some physiological classic was read and discussed. The part that he took in the organization and development of the Physiological Society was appreciated by his contemporaries as is indicated by the resolution of the Council adopted at the Princeton meeting, 1892, as follows: "Deeply regretting the necessity which deprives the American Physiological Society of the services of Professor Martin as Secretary and Treasurer, the Council desires to record its grateful appreciation of the value of his service in past years, and to express the hope that he may, when fully restored to health, once more take an active part in the management of the Society which owes its origin in great measure to his energy and enthusiasm." At the ninth annual meeting, Boston, December 1896, his death was announced to the Society by President Chittenden and a resolution offered by Doctor Howell was adopted and placed in the minutes, as follows:

"In the death of Professor Martin the Society has lost a member to whom it owes an especial debt of gratitude. He was actively concerned in its foundation and organization, and during the critical period of its early history he gave much time and thought to its interests. He served for six years as its secretary and treasurer, and strove always with enthusiasm to make a successful beginning of an enterprise which he believed would foster the spirit of scientific research in physiology and bring its active workers into stimulating fellowship. For its present prosperous condition and its prospects of future usefulness the Society feels that it is largely indebted to his wisdom and energy. In a broader field his influence upon the science of physiology has been deeply felt. His own splendid contributions to experimental physiology will have an enduring value, while the stimulus given by him to others has been and will continue to be an influential factor in the development of physiological instruction and research in this country. As an investigator and teacher he was distinguished not only by his originality and ability, but by

many noble traits of character. His modesty, his genuine interest in all kinds of biological work, his steady insistence upon the highest ideals of scientific enquiry, his chivalrous conception of the credit due to his fellow workers, and the generous sympathy and appreciation always felt and shown by him for the work of younger investigators, are some of the qualities which will endear his memory to those who were so fortunate as to be brought into intimate association with him as teacher or as friend."

The resolution was seconded by Doctor Bowditch in the following words:

"Probably few of the younger members of the Society are aware of the great debt which we owe to Doctor Martin for establishing the high standard which the Society has always maintained with regard to the qualifications of the members. It was always Doctor Martin's contention that a candidate for admission to our ranks should be required to demonstrate his power to enlarge the bounds of our chosen science and not merely to display an interest in the subject and an ability to teach text-book physiology to medical students. To his wise counsel in this matter the present prosperity of the Society is, I think, largely to be attributed. I trust that the resolution will be adopted and spread upon the records of the Society."

## AVAILABLE RUSSIAN TRANSLATIONS

List prepared by WILLIAMINA HIMWICH

Photostat or microfilm copies of English translations of the following Russian articles are available from the Translation Center of the John Crerar Library in Chicago, Illinois.

1. Angarskaya, Sokolova and Khadzhai. "On the Effect of Strophanthin and Corglycon on the Speed with which Phosphorus Compounds are Replaced in the Animal Organism," 141-7.
2. Asatiani, V. S. (Tbilisi). "Concerning the Biochemistry of Men and Apes." *Uspekhi Sovremennoi Biologii* (Progress in Contemporary Biology), Vol. XLIV, 1957, Issue 3 (6).
3. Babenko, G. A. "Age Changes in the Quantity of Copper, Manganese and Zinc in the Human Brain". *Ukrainian Biochemical Journal*, Vol. 30, No. 1, 1958.
4. Baranov, M. N. "The Distribution and Specific Activity of Labile Phosphorus Compounds in Different Layers of the Cerebellum." *Biokhimiya*, 22: 830-837, 1957.
5. Barbashova, Z. I. "Tissue Processes Occurring during Acclimatization to Oxygen Deficiency". AN, SSSR, Laboratory of Evolutionary Physiology, Moscow-Leningrad, Vorposy med. shimi, 2, p. 128-132, 1956.
6. Belenkii, N. G. and Meshcheriakova, M. F. "Protein Metabolism in Animal Organisms Under Various Functional Conditions of the Central Nervous System". Issue II, Reports of the Lenin State Academy of Agricultural Sciences, 1956.
7. Belik, Ya. V. "Scientific Convention on the Problems of Biochemistry of the Nervous System, 2nd Scientific Conference, Fourth Coordinated Meeting on Biochemistry of the Nervous System." *Naukova Khronika*: 252-257, 1957.
8. Budanova, A. M. "Biochemical Shifts in the Blood of Dogs in Cases of Conditioned Epilepsy." *Zhurnal vysshei nerv. deiat.* (Journal of Highest Nervous Activity), 7, pp. 554-559, 4, 1957.
9. Butom, M. L. and Vartapetov, V. A. "The Change in the Content of Adrenaline and Adrenaline-like Compounds in the Tissues of Castrated Rabbits at Different Functional Conditions of the Central Nervous System" (The Biochemical and Physiological Dept. of the Ukrainian Institute of Experimental Endocrinology, Kharkov). *Biokhimiya*, Moskva, 5: 807-12, 1957.
10. Chetverikova, E. P. "Tissue Respiration During Sleep Caused by Chloralhydrate". Laboratory of Pharmacology of Metabolism in the Institute of Pharmacology and Chemical Therapy, ANN, SSSR, No. 3, p. 42-49, May 3, 1956.
11. Dikovenko, E. A. "Changes in Metabolism of Nucleic Acids in Internal Organs Following X-ray Irradiation of the Brain". *Med. radiol.* Moskva, 2: p. 42-46, 1958.
12. Gershenovich and Krichevskaya. "Activity of Glutamin Synthetase on the Brain and Liver on Animals under Increased Oxygen Pressure", *Biokhimiya*, Vol. 21: 715-721, 1956.

13. Goncharova, E. E. "Effect of Insulin and Adrenaline on the Polysaccharide Metabolism in the Brain". Reports of the Academy of Sciences of the Ukrainian USSR, No. 2, 183-185, 1957.
14. Gracheva, N. D. "A Study on Radioactive Sulphur (S35) Inclusion in Nerve Cells". Doklady SSSR, 113: 688-691, 1957.
15. Gracheva, N. D. "Autoradiographic Study of Radioactive Phosphorus (P32) Distribution in Some Parts of the Nervous System." Doklady, Akademii Nauk SSSR, 113: 436-439, 1957.
16. Graevskii, E. A. and Korchak, L. I. "Effect of X-ray Radiation upon the Distribution of Coloring Substances Injected into the Tissues of Mice". Doklady Akademii Nauk, SSR 115: 702-705, 1957.
17. Ivanov, V. I., Rosenberg, P. A. and Tolgskaya. "How Glutamic Acid Effects the Course of Some Biochemical Reactions in the Brain and Other Organs During Carbon Bisulfide Intoxication." Annotations of Scientific Research at the Academy of Medical Sciences, SSSR, 1956-1955, Moscow, p. 784, 785.
18. Kassil, G. N. "The Problem of Hemato-Encephalitic Barrier in Physiology and the Clinic". Zh. nevropat. psikiat., Moscow, 12: 1537-1542, 1957.
19. Khaikina, B. O. "Carbohydrate Metabolism in Brain Tissue in Excitation of the Central Nervous System". From the Institute of Biochemistry of the Ukrainian SSR Academy of Sciences, Kiev Ukrainskii biokhim zhurnal, 29: 275-284, 1957.
20. Kometiani, P. A. and Klein, E. E. "Reamination Paths of the Adenylic System in Nerve and Muscle Tissues". Biochemistry, Vol. 21, No. 3, p. 393-400, 1956.
21. Kreindler, A. and Misson-Kriguel, N. "Biochemical Research with Experimental and Clinical Epilepsy". Journal for Neuro-pathology and Psychiatry in Honor of Korsakob, Vol. 37, Issue 10, p. 1205-1209, 1957.
22. Kreps, E. M. "Concerning the Biochemical Properties of the Activity in the Cortex of the Large Hemispheres of the Brain". Zhurnal Vyshei Deiatelnosti (Journal of Highest Nervous Activity), Vol. VII, Issue 1, p. 75-82, 1957.
23. Koshtoyants, K. S. "Chemistry of Metabolism, Structure of Proteins and Nervous Regulation". Physiol. Bohemislov (in English), Vol. 3, p. 382-393, 1954.
24. Kukhtina, A. P. "Effect of Sodium Bromide on the Copper Content of the Brain". (From the Department of Biology and Biochemistry of the Medical Institute, Staline) Ukrainskii biokhimichnyi zhurnal, 29: 285-91, 1957.
25. Levina, E. N. "Accumulation of Manganese Oxides in the Organs and Tissues of Animals with Different Methods of its Administration". Gig. truda. i. prof. zabol. 3: 29-34, 1957.
26. Lipovetskaya, E. I. "Effects of Narcosis on the Ascorbic Acid and Adrenaline Content of the Adrenals, Brain and Liver in Animals". Ukrainskii Biokhim, Zhurnal, 29: 131-141, 1957.
27. Lisovskaya, N. P. "The Role of the Glycolytic and Oxidative Mechanisms in Phosphoprotein Metabolism Biochemistry. Vol. 21: No. 3, p. 439-444, 1956.

28. Lodin, Z., and Kolousek, J. "Metabolism of Methionine and Methionine Sulfoximine in Relation to Function of the Central Nervous System. *Physiol. Bohemoslov* (in English), Vol. 5, p. 43-46, 1956.
29. Lusenko, V. S. "Effect of X-rays on the Quantities of Ammonia, Glutamine, ATP, and Glycogen in Rabbit Brain Tissue. *Fiziolog, Zhurn. AN, Ukrain, SSSR*, 1957, Vol. 3, No. 3.
30. Malinskaya and Yanovskaya. "Pharmacology, Effect of Dichloroethan on Vitamin C. Metabolism." *Bull. Exp. Biol. Med.* (in English). Transl. 1957, No. 9, p. 1100-2.
31. Manykian, K. G. "Nucleic Acids and Phospholipides in the Brain of Rabbits During Ontogenesis". *Biokhimiya, Doklady Adademii Nauk SSSR*, Vol. 101, N. 6, 1955.
32. Mayevskaya, I. P. "Effect of Total X-ray Irradiation on Certain Aspects of Carbohydrate Metabolism in the Brain". *Fixollog. Zhurnal Akademii Nauk, Ukrainskii, RSR*, 3: 101-5, 1957.
33. Nasonov, D. N. and Ravdonik, K. S. "Direct Effect of Audible Sounds on the Nerve Cells of Isolated Spinal Ganglia of the Rabbit". *DAN, SSSR*, 71: No. 5, Physiology, 1950.
34. Nechaeva, G. A. "The Course of Renovation of Protein Sulphur Gluthathione and Sulphatids of the Rat Cerebrum in Narcotic Sleep and upon Excitation of the Central Nervous System". *Biok. 22*: 546-553, 1957.
35. Ossinskaya, V. O. "A Study of Adrenaline and Noradrenaline Metabolism in Animal Tissues". 22: No. 3, *Biokhimiia*, 1957.
36. Palladin, A. V., Belik, Ya. V., and Krachko, L. I. "The Rate of Protein Renovation in the Brain Upon Excitation and Inhibition with Reference to Age". *Institute of Biochemistry, Academy of Sciences of Ukrainian SSR, Kiev*, p. 359-368, 1957.
37. Palladin, A. V. and Vladimirov, G. E. "Use of Radioactive Isotopes in the Study of Functional Biochemistry of the Brain." Reports given by USSR at the international conference for peaceful use of atomic energy, Moscow, 1955.
38. Panchenko, L. F. "The Effect of Sodium Amytal Inhibition on Inclusion of Sulphur Methionine into the Proteins of Various Portions of the Central Nervous System and Other Organs During Oxygen Deficiency". *Pharmacology and Toxicology (Moscow)* No. 1, p. 53-57, 1958.
39. Panchenko, L. F. "Protein Turnover at Various Levels of the Central Nervous System and in the Liver in Growing and Full-Grown Animals." *Fiziologicheskii Zhurnal SSSR (The Journal Physiology of USSR)* 44: 243-248, 1958.
40. Petrov, Raiko and Kudritskaia. "Comparative Characteristics of Functional Variations and Certain Indices of Carbohydrate-Phosphorus Metabolism in Brain Tissue During the Agonal Period, at the Time of Clinical Death, and in Resuscitated Animals." *Sechenov Physiological Journal of the USSR*, 43: 98-107, 1957.
41. Petrov, I. P., Raido, Z. A. and Kudritskaya, T. E. "Comparative Characteristics of Functional Changes and of Some Indicators Concerning the Carbohydrate". *Physiology of USSR*, XLIII: 107-116, 1957.

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# HETEROTHERMOUS OPERATION OF WARM-BLOODED ANIMALS\*

LAURENCE IRVING

It would seem that the development of travel and communications would have provided a good acquaintance with the geographical variations in physiological processes but during the last forty years the expansion of physiological laboratories and the development of technical facilities have occupied American physiologists in the enlargement of institutions for research and teaching. Except for unplanned experiences in war only a few physiologists have found it expedient to operate in the natural conditions surrounding human and animal populations away from urban laboratories. In spite of the speed of modern transportation most travel and communications pass from city to city within only a few of the many cultural perimeters of the world. We would like to believe that the vast wordage carried by the American system of communication brings to us knowledge of the world and so we are surprised to learn that people in other societies often act contrary to our understanding of how the world should operate.

It is hard to appreciate the capabilities of the great human populations which dwell in arctic, tropical and desert lands for which the common American and his culture are not suited, and that most animals live where our domestic kinds could not exist. A broad view of the geographical variation in forms and processes of life is necessary for comprehension of our own relation to the living part of the universe.

In addition to the reference of reactions to location in space, if physiology is to be a biological science it must also refer its observations to time, not only for the determination of the immediate velocity and sequence of physiological reactions but in order to provide for them a chronological position relative to the long past in which organisms of the present were molded by and for adaptation. The influence of the past persists in the structures and processes by which organisms have been adaptively shaped. Types which evolved in the past determine that each adjustment of an animal to an external circumstance must also continue the line from its own origins. When they are related to geographical distribution and evolutionary development, physiological processes acquire two physical dimensions of a sample of the universe. Information which refers only to a single locality and time is unrelated to the general system of science.

Comparative study of the thermal reactions of animals has attracted much attention from physiologists because temperature and sometimes heat are rather easily measured. They are common

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\*Editor's note. This article was solicited to illustrate the effectiveness of comparative physiological studies.

physical measurements and our own sensations clearly indicate the important bearing of temperature and heat upon existence. But the conditions surrounding organic thermal reactions vary greatly in the various climates, seasons and daily weather of the world.

I have been interested in surveying physiological reactions to cold as they appeared among the few species which inhabit the small extent of the arctic region. That some progress has been made in understanding adaptation to cold is the result of fortunate association with colleagues who realized that only animals living as natural populations in cold climates could demonstrate adaptive physiological reactions to cold. Exposure of a laboratory bred rat, city dog and urban man reveals the suffering which the arctic lemming, sled dog and Eskimo escape by their trained use of all their means for adaptation. Populations naturally adapted to cold have provided remarkably clear illustrations of the general process of adaptation to cold in a wide variety of special cases. So I venture to present some views of thermal relations which the experimental procedures of comparative physiology are developing by choosing suitable examples of natural populations in appropriate situations.

#### Relation of warm-blooded metabolism to climate

In winter, caribou run over arctic tundra and mountains as swiftly as deer in southern climates. Speed, agility and endurance are common to the deer family regardless of the climate which they inhabit. The wolves which would prey upon deer are not their equals in speed but in all climates resort to similar individual or socially organized stratagems to supplement the effectiveness of their lesser speed, which is that of wolves regardless of climate and weather. In winter air the arctic gyrfalcon is a swift flyer which may still be unable to overtake the strong flying ptarmigan in level flight. But by diving at about the highest speed attainable by animals and under perfect control a falcon in any climate can strike down the swiftest flying bird. Speed, agility and precision of performance is that of each species regardless of the environmental temperature in which it operates.

By experimentation at Point Barrow and Panama we have found that arctic birds and mammals need spend no more for the metabolic cost of maintaining warm bodies than tropical birds and mammals, for natural adaptive gradation of insulation makes it possible to maintain heat expenditure within the normal range for the species (Scholander, Hock, Walters, Johnson and Irving, 1950). It has long been apparent that the basal metabolic rate which maintains the proper operating temperature of warm-blooded animals is related to their size, one of the many internally determined physiological characters. Appreciation for the significance of this important generalization was developed from comparative measurements of the insulation and metabolism of animal species known to be adapted either to arctic cold or to tropical warmth by their normal residence in those climatic extremes.

I was once repaid for expressing these generalizations, which still require much explanation, by the thanks of a compassionate lady for relieving her concern for the arctic animals and people who she had supposed must live in constant suffering from cold. Arctic animals and people are not only as swift, strong and sensitive as others, but the test of their adaptation to their climate is provided by the stability of their populations and societies. The long existence of the Eskimo people is a good example of human adaptation to an environment in which we would think life would be precarious. The ancestry of modern Eskimos can be traced in historical records to the time when the first Norse settlers described them in Greenland 1000 years ago. From Greenland to Alaska Knud Rasmussen (1927) found similar views in spiritual and social attitudes expressed in a common Eskimo language. Sir John Richardson (1852, p. 203) remarked that the difference of speech among the several tribes did not exceed in amount the provincialisms of English counties, and (p. 214) that "the Eskimo language does not materially vary throughout a line of coast longer than that which any aboriginal people possesses." The long continuous sequence of Eskimo occupation of one third of the arctic perimeter is a good record for stability among human populations. In the case of the Eskimos they have suited their physiological adaptability to arctic cold by an ingenious and highly developed material and social culture which has secured their racial existence during ten centuries which have seen the disappearance of most of the societies and many of the populations living in milder lands.

#### Stability of body temperature at rest

The consistency of basal metabolic rates with size is further related to the regularity of the temperatures at rest of all warm-blooded animals. The universal regularity of body temperatures appears conspicuously to be free from climatic influence among arctic animals (Irving and Krog, 1954). The average internal warmth of 21 species of arctic mammals did not differ from the average reported by Peter Morrison (Morrison & Ryser, 1952) in 56 species living in temperate and tropical climates. The average body temperature of arctic species of birds also did not differ significantly from that of the many species in 50 families which Alexander Wetmore (1921) examined in temperate regions. Nevertheless, only a few mammals are as warm as some of the cooler birds, and the difference between the two classes may be related to the long separate evolutionary development of their different forms and habits.

In spite of the long separate evolution and diverse modification of birds and mammals their average operating temperatures differ only about 3 degrees. As a matter of fact the musculature, circulatory and respiratory processes of birds and mammals are essentially homologous and the chemical reactions in their operation are similar. The differentiation of the two classes into strikingly different forms which are able to expend metabolic energy in excess of any cold-blooded animals has retained essential reptilian morpho-

logical patterns and physiological chemistry. In fact many organic and more cellular functions of warm-blooded animals are comparable even to those in the invertebrate phyla. While they were evolving systems for warm-blooded operation, birds and mammals had to utilize pre-existing living material and reactions in which thermal characteristics were already established. So it is not surprising to find that along with their high operating temperatures both the birds and mammals also have made adaptive use of some of the ability of cold-blooded animals for operating at various temperatures.

### Variation in temperature of body

The remarkably stable specifically constant temperature at rest is a characteristic of the state of the warm-blooded metabolic mechanism. The temperature of the individual animal is not constant, however, for, as a few examples will demonstrate, the central temperature of the body is variable with predictable relations. During sleep the rectal temperature of man declines about 1 degree. In many species of birds the nocturnal decline is about 3 degrees, and as W. R. Dawson (1954) has shown the decline can be quickly elicited by experimental darkness and the return to normal resting temperature quickly follows the restoration of light.

The familiar heating of the body in exercise is not normally a result of inadequacy of heat dissipation, for in August Krogh's famous laboratory Marius Nielsen (1938) showed that men trained for exercise increased their body temperature to levels accurately related to the metabolic rate. The greatest elevations of temperature in man were recorded by Sid Robinson (in Newburgh, 1949, p. 226) as the surprising warmth of 41 degrees in champion long distance runners in whom the hyperthermia by resting standards accompanied about the greatest sustained metabolic ability that man can have.

Knut and Bodil Schmidt-Nielsen (1957) have shown that during hot days on the African desert in the dry season camels dehydrated by scarcity of water warmed to 41 degrees in the hot desert day and cooled during the chilly nights to 34 degrees. In this surprising way camels can accumulate the heat of several hours of daytime metabolism and by dissipating it to the cool night reduce the evaporation of water which would be dangerous in their dehydrated condition.

Hibernation is normal for some species in several of the orders of mammals. In the arctic ground squirrel (*Citellus*) hibernating at Point Barrow, Harold Erikson (1956) measured temperatures as low as 2 degrees, from which the animal awakened apparently normal. Although the circumstances are quite different from hibernation, man can be artificially cooled to a hypothermic state and restored. Audrey Smith (1956) and her colleagues have restored mammals, which had been cooled to freezing without derangement of conditioned reflexes learned before the cooling. In the same laboratory of the National Institute of Health in London, sperm which had been stored at -79 degrees were found to be effective in

fertilization (Polge, Smith and Parkes, 1949). Banks of frozen semen have been used to preserve the sperm of selected sire bulls beyond their own life time. The surviving sperm is used to transmit their valuable characters all over the world while selection from their progeny can be continued during many generations.

Variations in body temperature are both normal and adaptive in the sense that they bring about better economy in the animal heat machine and fit animals to exploit special situations which would be otherwise unutilized. It is of great practical and theoretical importance to note that under artificially arranged circumstances some avian and mammalian cells have the faculty of surviving degrees of cold which arctic plants and cold-blooded animals normally endure each winter. Although the arctic organisms contained ice their regularly reduced oxygen consumption indicated that cellular life was sustained rather than suspended at the lowest occurring natural temperatures (Scholander, Flagg, Hock and Irving, 1953).

#### Variations of temperature in peripheral tissues

The bare feet of arctic birds and mammals cool to near freezing while at rest in arctic winter (Irving, 1951). On their bodies under thick fur and feathers, as on the bodies of clothed men, the skin did not normally cool to 30 degrees (Irving and Krog, 1955). Fur and feathers provided most of the insulation over the body but on the bare extremities only cooling tissues could serve as an insulator, and one which by rapid warming during activity could effectively increase the dissipation of heat when its escape through thick fur would be harder to manage. The long slender limbs of reindeer expose a considerable extent of skin which is cool where it is only thinly insulated by fur, but the large webbed feet of such arctic birds as gulls immersed in ice water are exposed to a medium with twenty times the cooling power of air. Yet comparatively little heat escaped from the feet of gulls during calorimetric measurements in cold water (Scholander, Walters, Hock and Irving, 1950). John Krog and I have watched through the microscope the active circulation of blood through the fine vessels in the web of the gull's foot while the temperature of the tissues measured 0 degrees by adjacent thermocouples.

Hairless mammals like swine live outside in the Alaskan winter. I found that while they rested during cold winter days the skin over much of their bodies might be as cold as 5 degrees (Irving, 1956) and yet they appeared as comfortable as only a hog can be. That the cool skin served for insulation was shown by the normal resting value of metabolism in freezing air of young boars weighing only 50 kg (Irving, Peyton and Monson, 1956). J. S. Hart and I (Irving and Hart, 1957) found that hair seals (*Phoca vitulina*) provided an even more emphatic demonstration of the insulative effectiveness of cool skin, for in winter even small seals could lie in ice water with only 20% elevation of their resting metabolism. Young harp seals (*Phoca groenlandica*) of equal size did not increase their metabolic heat

production even in ice water. Exposed to the most extreme cooling found in any natural situation, the insulative protection provided by cooling superficial tissues of arctic bare-skinned aquatic mammals is the most effective yet demonstrated.

Human skin finds its only natural means of insulation in its cooling. Although this ability is small in comparison with that of the feet of arctic animals and the entire surface of swine and seals, its variability is nevertheless of great importance. People of our economic status and habits in temperate climates cannot comfortably stand cooling of skin or our normally clothed bodies below 32 degrees. Our hands and feet tolerate a little more cooling, but our natural insulation is scarcely adequate even for a tropical climate (Erikson, Krog, Andersen, Scholander, 1956). It is now evident that we do not well represent the ability of the human species, for, continuing from the pioneer observations of Sir Stanton Hicks, Scholander and his colleagues (1959) examined the Australian aborigines who slept naked during the frosty winter weather of their natural desert habitat. Their skin and most noticeably their feet cooled below the limits tolerable for white scientists without causing elevation of metabolism. There is a significant variability in human capacity for insulation by superficial cooling which is clearly utilized adaptively by people in certain conditions. The best natural examples of human physiological insulation yet measured have only been found suitable for a cool climate. Although human physiological insulation is small it is the only natural and hence indispensable means for regulating heat loss in cool air where evaporation is no longer an important heat regulator.

Bare skin which can conserve heat by cooling can also increase heat dissipation by warming when exercise produces more heat. Thus the changing temperature of bare skin gives a measure of the remarkable variability of the insulation around the warm-blooded heat machine which provides for temperature regulation in varying weather and activity (Irving and Krog, 1955, Irving and Hart, 1957). In its morphological complexity and by the differentiation of insulating devices and their variable control on different surfaces, the control of the animal radiator is more elaborate than the simple thermostatically controlled valves which regulate the operating temperature of artificial heat machines. But for all the difference in complexity of structure, material and reactants the animal and artificial mechanisms abide by the physical laws of transfer of heat.

#### Behavioral adaptations for temperature regulation

Animals are not physiologically able to withstand exposure to the cold or heat of their environment without at times protecting their thermal situation by well-chosen behavior. To physiologists behavior may appear to be governed by individual choice. But some examples will show the remarkable regularity of behavior by which animals modify their exposure in order to keep within the limits tolerable for warm-blooded operation.

In referring to the warmth requisite for the development of avian and mammalian embryos Claude Bernard (1876, p. 403) remarked upon the nicety of temperature regulation by the behavior of incubating parent birds. He particularly referred to the incubating behavior of the Australian mound building birds (*Megapodiidae*) which deposit their eggs in a mound prepared of mingled earth and vegetation which by fermentation provides the proper temperature for incubation. The fermentative and solar heat being variable, the parent birds daily open the mound to vary its insulation and replace the covering in a manner suitable to maintain the right temperature for incubation. H. J. Frith (1956) has recently demonstrated that by its daily parental care of the mound the Australian mallee fowl (*Leipoa ocellata*) preserves a steady temperature about 35 degrees around the eggs by working over the fermentable material and by modifying the conductivity of the cover to suit the diurnal changes in temperature.

John Krog and I found (Irving and Krog, 1956) that in the arctic nesting season of birds, when the air might vary from -10 degrees to 30 degrees, incubation kept the eggs in nests of seven species of birds as evenly about 35 degrees as has been observed in nests of similar species in a temperate climate, and incidentally at the same temperature as is maintained by the remarkable control of fermentation and insulation in the incubation mounds of the Australian mallee fowl. In the hot sun of the southern California desert, white pelicans shade their young under their outspread wings to prevent overheating (Bartholomew, Dawson, O'Neill, 1953). It is evident that the embryos and young of birds and mammals, while perhaps capable of enduring brief cooling, require regular and near adult warmth for development, and since the power of their heat regulation is small it must be supplemented by parental care which is applied with extraordinary sensitivity and skill. Although the embryos and young have not the means for regulating their warmth in ordinary conditions, as Claude Bernard (1876) remarked, their reproductive cells are produced in warm bodies and the embryos require warmth like the adults. Their ontogenetic course does not help to indicate in what ancestor the warm-blooded requirement of birds and mammals originated.

Arctic sled dogs curl up when resting in cold weather. Obviously the shape assumed reduces the amount of surface exposed to cold. At Barrow, John Krog and I have inserted thermometers into the center about which the dogs were curled and the air to which that portion of the fur was exposed recorded 32 degrees to 35 degrees when the surrounding air was -20 degrees to -30 degrees. By placing a grid of thermocouples under sleeping dogs we observed by the steady temperatures that the dogs seldom changed position while asleep in very cold weather. The temperature at the interface between dog and snow was about freezing in air that was 30 degrees colder. Not only was the underlying warmth maintained by the dog's quiet curled posture a measure of heat conservation, but the snow bed must be kept below freezing, for if it occasionally melted the dog's hair would become frozen in the ice. The beds of arctic animals in the snow contain only a few shed hairs to show that in

changing weather freezing of the hairs to the snow on which they lie is avoided by heat dissipation which is also regulated to avoid melting the snow.

The variety of thermal conditions at the surface of animals which Scholander (1955) has discussed demonstrates the extraordinary variability of the geometric extent and patterns of regulated superficial temperatures. Manifestly it is absurd to regard the thermal surface of an animal as a measurable geometric entity and the physiologists' custom of referring the dissipation of an animal's heat to a fictitious geometrical surface has been a major source of confusion in descriptions of the transfer of animal heat. The method of estimating the surface area of animals is so arbitrary that when their heat production is reported in relation to surface area it is difficult to discover the metabolic rates that were actually measured.

#### Heterothermous character of warm- and cold-blooded animals

Variation of internal body temperature is actually considerable and is not alone concerned with the economy of heat. Variation in surface temperature is much greater and is an indicator of variability in transfer of heat to the environment. It is satisfactory to call these animals warm-blooded but they can only be called homoiothermous with such reservations as impair the meaning of the word and conceal the nature of the animal heat machine. In fact, unqualified reference to homeostasis of any kind refers to a scheme which would be inoperable and unadaptable. Reference to the heterothermous operation of animals and their tissues describes many conditions but no single characteristic in a formula for the operation of the system. I do not wish to add heterothermism as the name of a process, for physiological nomenclature is already overloaded with unscientific terms.

In his interesting investigations of the natural preference of reptiles for warmth, Charles M. Bogert (1949) has found that many lizards resort for their activities to areas which provide for them a somewhat regular warm operating temperature. There is a wide difference among the temperatures which the various species choose and some select a rather narrow range of temperature which is apparently their elected preference. The elective behavior of these cold-blooded animals is apparently directed to obtain temperature conducive to their most effective activity. Some of these warmth-seeking reptiles elect operation at temperatures about as high as those of birds. The northern range of reptiles scarcely passes into the cool temperate parts of southern Canada and as a class they seem to be rather inadaptable to operating effectively when cold.

Various species of fishes on the other hand and many invertebrate species live over the entire range from tropical to arctic waters, which incidentally do not differ in temperature as much as the normal variations observed in the tissues of arctic warm-blooded animals. Some common tropical fishes die in water as cold as



15 degrees or 20 degrees (Scholander, Flagg, Walters, and Irving, 1953). Aquatic forms which are accustomed to small daily and seasonal changes in temperature are able to tolerate only a fraction of the change through which the feet of herring gulls and the entire skin of swine and seals can rapidly pass in the regulation of their heat exchange. Even the interior tissues of the camel can pass through diurnal changes in temperature which many aquatic animals cannot endure.

The temperature range for normal operation of some tissues in arctic mammals is from 0 degrees to 41 degrees, while for birds the upper limit is about 45 degrees. Thus some tissues of many species of birds and mammals have retained ability to operate normally in about the full range of temperatures to which the complete list of cold-blooded species are suited. Although fishes inhabit springs as warm as 60 degrees (Sumner and Lanham, 1942) only a few species among poikilothermous animals can even survive seasonal changes in temperature as great as some peripheral tissues of many arctic birds and mammals repeatedly go through in a few minutes.

#### Climatic adaptation in cold- and warm-blooded animals

From the curve showing the decrease in metabolic rate with cold among poikilothermous animals, August Krogh (1916) indicated that the metabolic rate of poikilothermous animals in arctic waters might be so low as to be ineffective if their metabolism declined with temperature as it did in species from temperate climates. Since arctic waters are richly inhabited by active cold-blooded animals, Krogh suggested that some modification of the relation between metabolism and temperature observed in warm waters might occur to provide the abundant and active life of the arctic waters. If you fish for arctic trout and grayling you will see that they are as strong and active as trout in warmer waters. Looking through holes cut in several feet of ice on arctic lakes or sea shows a crustacean fauna swimming about as actively as is the manner of their related species in a warm climate. Perhaps the longest seasonal migrations of fishes pass through the great cold rivers of Siberia and Alaska. Dog salmon (Onchorhynchus keta) and shee fish (Stenodus leucichthys) annually migrate over 2000 miles up the swift Yukon River to spawn in its large arctic tributary, the Porcupine. Neither in visible speed or ability to travel are arctic poikilothermous animals as slow as would be inferred from their temperature dependence in the tropics. Conversely tropical species do not live at the rapid pace extrapolated from arctic to tropical temperatures.

The adaptation of metabolism which can free some species of poikilothermous animals from complete temperature dependence was foreshadowed by winter observations in temperate regions, but the general situation was clarified by comparisons of metabolism made in the arctic and tropics (Scholander, Flagg, Walters, Irving, 1953). Naturally the arctic aquatic poikilotherms lived in ice water but they were killed at 10 degrees to 20 degrees, while those of the tropics

perished in water colder than 20 degrees. It is also apparent that arctic metabolism exceeds the rate expected from the tropical point of view. In attempting a comparison, using the Q<sub>10</sub> for metabolism found by Krogh (1914) for extrapolation of tropical rates from 30 degrees to 0 degrees would diminish them to less than one thirtieth. Actually the metabolic rates of arctic forms in their usual temperature were only two or three times less than in their tropical relatives. If it is supposed that a common level of metabolism is needed by similar animals, the arctic ones are considerably, but not completely adapted toward maintaining the tropical metabolic pace. Or if we start from an arctic standard, the tropical forms do not operate at the violent pace which would result from a thirty-fold increase of the arctic rate.

We are not sure that our samples of species were completely representative nor do we know how efficiently the application of oxidative energy produces useful activity at various temperatures. But observation indicates that in arctic and tropical waters animals do not differ so radically in speed and endurance as would be inferred from the effects of temperature observed in the opposite climate. It appears that climatic adaptation of poikilotherms is effected by the approximation of their metabolic rates. For want of a better description the adaptation of poikilotherms appears to involve modifications in the physical chemistry of their working systems. This kind of adaptation we have not observed in the heterothermous tissues of warm-blooded animals, but neither has it been sought.

The form, size and general habits of systematically related animals seem to permit their populations to live only with similar activity and metabolism in all climates. A systematic and probably evolutionary relationship determines the activity and speed of animals, requires a corresponding metabolism and transcends the influence of climate in determining the speed of living processes. In activity as well as in form animals are the product of their phylogeny and the kinds which adapt to various thermal environments must modify the relation between metabolism and temperature in order to operate their inherited set of mechanisms and habits at a certain speed which is intrinsically rather than environmentally determined.

The adaptation of poikilothermous metabolic rates toward uniformity in all climates is slow in comparison with the quick changes of temperature through which avian and mammalian superficial tissues must pass while still keeping their integration with the warm center of the body. An arctic dog's feet can warm almost instantly from near freezing to near body temperature when it is suddenly aroused to intense activity and the extremities can cool about as rapidly as the activity slows down and reduces the elimination of heat to resting level.

T. H. Bullock (1955) presented reasons for considering that temperature coefficients of metabolic oxidations could be adaptively reduced so that activity of poikilotherms might proceed at a fairly

steady rate over wide changes in temperature. In Scholander's laboratory, Eva Valen (1958) recently reexamined the metabolism of four common species of poikilotherms which in older reports had been said not to vary with temperature. She found  $Q_{10}$ 's from 2 to 3, as had been the usual observation. The evidence which I can see does not permit animals to take the liberty of modifying the constants of physical chemistry by which metabolic reactions vary with temperature, and I doubt if temperature coefficients near unity can explain either climatic adaptation or the integrated action of heterothermously operating tissues in warm-blooded animals.

#### Adaptation to cold in warm-blooded tissues

The cold peripheral tissues of birds and mammals are visibly sensitive, blood can be seen to circulate through them and in spite of their frequent coldness they grow, maintain and repair themselves adequately (Irving, 1951). Any of these functions operates inadequately in the cool tissues of animals unaccustomed to cold. Upon examining the situation in a typical example, the cold adapted northern herring gull (*Larus argentatus*), we found that the metatarsal part of the peroneal nerve registered conducted impulses when as cold as 5 degrees. The tibial part of the same nerve, which lies in the warmer part of the leg under thick feathers, ceased at about 10 degrees (Chatfield, Lyman, Irving, 1953). After the gulls had been kept in warm surroundings for two weeks the distal part of the nerve had lost its adaptation to conduct while cold. The measurable changes in excitation and conduction provide a clue as to the modifications of physiological processes which are involved in adaptation to cold.

Many properties of tissue substances are much altered by small changes in temperature. Taking the hardness of fat as an example of a thermolabile property, we found that fat from the phalanges of several species of arctic herbivorous and carnivorous animals was still soft near freezing temperature which made the fat from the head of the femur and body so hard that it was brittle (Irving, Schmidt-Nielsen, Abrahamsen, 1957). This variation in a physical property of a substance according to its exposure to cold illustrates how tissues must modify their components to make them suitable for operation in heterothermous circumstances.

#### Integration of thermolabile organisms

These are examples of heterothermously operating tissues which indicate variations necessary in adaptation to external conditions. The illustrations of the adaptations of functional processes of separate tissues fail to demonstrate one very important condition for the heterothermous operation of an organism. The distal part of the herring gull's nerve adapted to cold still declined in velocity of conduction with cooling at about the same rate as the unadapted central part of the nerve, its conduction being about 25 meters per second at 40 degrees and about 5 meters per second at 10 degrees. Impulses traveling from the foot with four-fold variation in speed conveyed to

the gull's brain appropriate information about the surfaces over which it walked and for the irregularity of which it must adjust its locomotion. In fact all receptors dealing with dimensions of space and time must provide the organism with constant or absolute measures through a receiving and transmitting system in which velocity characteristics differ many fold in heterothermous tissues.

Animals with uniform body temperature do not present the same problem of internal integration as appears in those with heterothermously operating tissues. Nevertheless every organism has to live in an external environment with varying temperature but with reference to constant physical dimensions of time and space. Von Frisch (1950) has demonstrated the accuracy with which honey bees repeatedly return to the location of honey-bearing flowers over distances of several miles. Not only can the individual bee which has found the distant flowers remember how to return but it can communicate by signals to its fellow workers the location which it has discovered so that they in turn can proceed over the right measured course and direction. As the air cools and warms the memory of the bee provides it with a constant scale for distance and temporal regularity of action. Senses, integrated actions and even desires for movement and memory in poikilothermous animals keep each individual in absolute relation to the spatial and temporal dimensions of its whole existence. If this were not so, activity would be promiscuously related to the social and physical environment and to the memory of the past. Adaptation and consequently life could not exist. And yet, this stable entity of individual behavior is maintained in changing temperatures by reacting systems in which the components are thermolabile.

Integrated relation with environmental conditions and maintenance of its own identity as an evolutionary product appear in a more complicated system in warm-blooded animals. But in all organisms entity is maintained in an ordered system by its use of reactions applying energy derived from the environment. I have not the ability to speculate upon how individuality is maintained and is still adaptable to changing temperatures by means of thermolabile processes, but a statement of the problem in this manner suggests some interesting analytical studies of adaptation.

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## ANTON JULIUS CARLSON

A. C. IVY



**"...behind his scornful frown and pointed criticism there was a kind heart and abundant generosity."**

Dr. Anton Julius Carlson (1875-1956) was a great man, a "scientist's scientist" and the "common-man's scientist." He was a preeminent leader in physiological, educational and civic activities. The influence of a zeal for the truth, a critical judgment, a colorful personality and dynamic teaching has nowhere been better exemplified than in the life of Dr. Carlson. He began at the bottom of the hill; and by his industry, his tenacity of purpose and his talents, he climbed the rugged path which leads to the top of the hill where repose those who have served mankind well.

Dr. Carlson was born in the hill country near Goteborg, Sweden. At seven he was hired by a neighboring farmer for whom he herded sheep and goats in the hills. He observed the shining granite hilltops and wondered who had climbed there to polish them. From a wise and affectionate mother and a teacher of manual training he developed an ambition to know. In 1891, as an orphan of 16 years of age, he followed his brother Gust to the U.S.A. where he worked as a carpenter in Chicago. Within several months his Swedish Lutheran pastor recognized the abilities of the youth and urged him to attend Augustana Academy and College. He entered the Academy in 1892 and as a result of his industry and talents received the B.S. degree in 1898, and the M.S. degree in philosophy in 1899. Not long thereafter his goal of becoming a minister was abandoned, even though it is said that he was a good preacher. He could not rid his mind of his love for Nature and his curiosity regarding living things he had acquired as a boy shepherd. It was only in the field of biological science that his boyhood hunger for learning could be gratified.

He attended the graduate school at Stanford University in 1900, and became an Assistant in Physiology in 1901. He received the Ph.D. degree in 1902. He received a Carnegie fellowship and worked at Woods Hole, Mass., in 1903-04. In 1904 he moved to the University of Chicago to join Jacques Loeb, G. N. Stewart and A. P. Mathews in physiology, pharmacology and biochemistry. In those days it has been said that when Prof. A. P. Mathews proposed a brilliant theory



or explanation, Loeb said "Let me have some paramacia," Carlson said, "Bring me a dog," and Stewart said, "Yes, let's do an experiment." Dr. Carlson became Professor and Head of the Department of Physiology in 1914. He retired in 1940, but remained active in lecturing, research and civic affairs until about 1955.

Besides teaching some 5,000 medical students, he took part in graduating 151 students with the degree of M.S., and 112 students with the degree of Ph.D. in Physiology. Between 1910 and 1940 he probably gave post-graduate lectures to some 100,000 physicians.

In 1905 he married his college-days sweetheart, Esther Naioma Sjogren, a splendid woman and an affectionate mother. They had three children. The older son, Robert, is a businessman in California, the younger son, Alvin, is a chest surgeon in California. The daughter, Alice, married Professor Hough of the University of Illinois.

In World War I Carlson served as a Lt. Col. in the Sanitary Corps of the A.E.F. He was assigned the task of reorganizing the diet of the fighting soldiers at the front and the methods of handling food. On one occasion he said that "if it is true that soldiers fight on their stomachs, then to win the war you had better keep their stomachs adequately filled with good food. Good food and ammunition are on the par." The dietary allotment was increased. After the War he worked with the American Relief Commission in charge of food relief for the war stricken peoples of Europe. This experience along with his observations of the European politicians at Versailles embittered him against war. Prior to World War II he said: "War is futile. One war serves only as the basis for another war." On another occasion he said: "The dictator screams: 'We think with our blood!' and men cheer. New faith, new formulae, new fetishes, new saviours via the sword spring up over night from troubled soils, and with the same old clay in their feet, and with the same old sawdust in their skulls. Science and violence are incompatible."

Dr. Carlson served the American Physiological Society in numerous capacities. He was elected a member of the Society in 1904. He was Secretary from 1910 to 1914, and a member of the Council from 1921 to 1922 and again from 1928 to 1932. He served as President from 1923 to 1925. He was Chairman of the Board of Editors of Physiological Reviews from 1932 to 1950. He was primarily instrumental in persuading the International Committee of Physiologists to hold the International Congress in Boston in 1929.

When he was the President of the Society two very amusing incidents occurred. In 1923, Herr Geheimrath Professor Biedl visited the United States and attended the annual meetings of the Society. At this period of the Society's history the adrenals were stirring the emotions of many physiologists and there was no time limit on discussion. Carlson was having great difficulty in controlling the discussion. After a half-hour of discussion Prof. Biedl arose and spoke for twenty more minutes. Then a physiologist of the

opposition insisted on speaking. Then Biedl rose again and after speaking for about two minutes, Professor Carlson, said: "Biedl you haf said dot vunce; sit down." In 1924, the meetings of the Society were held in a High School in Washington, D.C., where smoking was prohibited. Carlson and Macleod were inveterate pipe smokers. In the midst of the meeting a policeman entered the scientific session and arrested Carlson and Macleod for smoking, and when Dr. Meek, the Secretary of the Society, intervened he was arrested for permitting Carlson and Macleod to smoke. The members of the Society who were present and witnessed this comedy and farce had "pain in the sides" from laughing so much. And, the more they laughed the greater the anger of the policeman and the perplexity of Carlson, Macleod and Meek. The policeman asked Carlson to speak English; he told Macleod that a physiologist should know better than to use tobacco; and then he walked away with these three masters of debate in custody after telling them that "ignorance of the law is not a defense."

Dr. Carlson served as president of several other scientific and educational organizations, such as the Union of American Biological Societies (1940-43), Society of Experimental Biology and Medicine (1943), National Society for Medical Research (1945-53), American Association for the Advancement of Science (1944).

When he was President of the American Association of University Professors (1937), his activities were referred to as "Carlson in the Den of Deans." At one of the many meetings of Professors he addressed, he said: "I don't look up to Deans; I don't look down on Deans; I yust look at 'em." On another occasion he was invited to take part in a discussion of the place of science in liberal education. The representatives of the humanities predominated in number and had spoken for two hours. When his turn came he arose and said, "To listen to some of the palaver of you sobersides of academic sophistication yust give me the yim yams." At many such meetings he created consternation by rising to inquire: "Vot is de effidence?" When a former President of the University of Chicago, Robert M. Hutchins, very provocatively proposed that all academic tenure be eliminated because "it would keep all the professors on their toes," Dr. Carlson arose and said: "Mr. President, you made a mistake. Vot you mean is dot it vill keep dem on der knees."

He frequently spoke to lay audiences on almost any subject. At a large civic gathering in Kansas City he was debating the subject of mental telepathy with a practitioner of the art. The telepathist said: "Now, I shall give you an example of an actual occurrence of mental telepathy which occurred this morning. My mother lives in New York City and this morning exactly at 9:00 a.m. I felt that she urgently needed me. Later today I received a telegram stating that exactly at 9:00 a.m. this morning my mother fell and broke her leg. Now, Dr. Carlson, what do you think of that?" Carlson replied: "What about the one hour difference in Eastern and Central Standard time?"

A class period rarely passed without Carlson making some pungent but amusing critical remark to a student. On one such occasion a girl held an electric wire in her hand trying to stimulate a frog's muscle lying in a pool of salt solution. Carlson said to her: "Vake up! You might as vell try to stick your electrode in the Atlantic Ocean and stimulate Ireland." A student with a bibliographic memory was asked a question by Dr. Carlson. The student responded. Carlson said: "Vare did you read dot? In de Sunday fiction sheet?" The student started to defend himself with vigor. Carlson said: "Vell you should have been a lawyer." The student responded with still greater vigor. Carlson said: "I made a mistake. You should have been a Captain of Industry." In another case a second-year medical student who had really studied the relation of the vagus nerves to the stomach questioned a statement made by Dr. Carlson, and proceeded to present his supporting evidence. Dr. Carlson listened intently, took the student to a research laboratory, said that the space was vacant and that the student could start to experiment on the vagus nerves in his spare time. He further informed the student that there was a scholarship waiting for him at the office of the Dean of the Graduate School, if he needed it. The student is now a well-known physiologist.

Dr. Carlson inspired his students more than most teachers to know the truth by the keenness with which he separated fact from fancy and the vigor with which he sought "de effidence." Students soon learned that behind his scornful frown and pointed criticism there was a kind heart and an abundant generosity for those who were intellectually honest and willing to work.

In medical meetings his rugged aggressive method of criticism was convincing and amusing to all. He frequently arose to criticize when others present desired to criticize but did not have the courage to do so. An illustration of such an occasion occurred at the meetings of the International Congress in Stockholm in 1926. Dr. Serge Voronoff, a surgeon and a famous specialist in monkey-gland transplantation, presented a paper on rejuvenation. He was the last on the program, but many out of curiosity remained to see the show. After Dr. Voronoff's presentation ended, you could have heard a pin drop. Everyone present was waiting for his neighbor to arise and offer criticism. Several looked at Carlson who arose and said: "I know of the case of a man in the United States who had a monkey-gland transplant by a surgeon. After the operation this man felt very young until he received the surgeon's bill. Dot vas so high he suddenly felt old again." The meeting ended in an uproar. A bearded French physiologist rushed up to Carlson, embraced and kissed him.

Dr. Carlson's technique of criticism, his wit and humor amplified by a Swedish accent left indelible imprints on the minds of those in his audience. The remarkable fact is that less than ten percent of those whom he criticized and at whose expense he created laughter resented his criticism; and few were embittered.

In his criticism, he rarely meant to hurt. He meant to hurt only the bluffer, the sophisticated and the ostentatious. Even after he had criticized Dr. Voronoff, he asked a colleague whether he had been too severe. In the "privacy" of his laboratory or classroom he was often amusingly severe when some manifestation of stupidity occurred. But, when the mistake was an honest one or the student or colleague rationally explained the mistake, Dr. Carlson would apologize by his facial and bodily expressions, rarely with words. On occasion he would severely criticize some laboratory assistant who had made a mistake because of lack of sleep due to working to make his financial ends meet. Then a few hours later he would loan the student a hundred dollars or more.

His granite-like outspoken intellectual honesty, however, had an Achilles heel. On very rare occasions he was known, when human relations only were involved, to tell a "white lie" to protect a colleague, for whom he had great affection, from embarrassment and humiliation. This was so out-of-character and unartistic that the truth soon caught up with the matter. On one such occasion tears appeared.

No field of physiology escaped Dr. Carlson's investigative skill. This was due to his breadth of interest in biology, the fact that he did not deter a student from investigating his own ideas, and the fact that he had to teach the entire subject of physiology to medical students.

The results of his first major research revealed that the velocity of transmission in a nerve is correlated with the rate of contraction of the muscle it innervates. In a study of the nature of the conducting mechanism in the nerve fiber, he used a nerve-muscle preparation with a nerve which in normal life underwent considerable lengthening and shortening. He found that when the nerve trunk was shortened less time was required for a nerve impulse to pass from the point of excitation to the muscle than when the nerve trunk was elongated. His interest in the nerve impulse led him into the polemic on the origin of the heart beat, a problem which received much attention during the first two decades of this century. Using the horse-shoe crab (*Limulus*) in which animal a collection of nerve cells are located near to but outside the heart and sends axones into the heart, he found that after the removal of these nerve cells the heart would not spontaneously or automatically contract and relax. Though the crustacean heart muscle more closely resembles skeletal muscle physiologically than that of mammalian heart muscle, Dr. Carlson's discovery provided an outstanding example of automatic rhythmicity in nerve tissue, and provided strong support of the neurogenic theory of the origin of the heart beat. His study of lymph formation and flow during salivary secretion represents a classical contribution to the physiology of the secretory process. He early entered the field of endocrinology and became interested in the thyroid because prior to 1925 about 98% of the dogs in Chicago had goiter. He and his students rechecked much of the literature on all the endocrine glands,

separating fact from fancy. In a study of extirpation diabetes, he found that the foetal pancreas near term can apparently function in part for the diabetic pregnant dog. In 1912 a student in his laboratory had insulin in a test tube, and in 1919 another student again had it in a test tube. A spirit of a too rigid self-criticism prevented the development of these discoveries. His largest series of investigations culminated in "The Control of Hunger in Health and Disease," which today remains a classic contribution to the subject. Every student of the visceral sensory nervous system is acquainted with his contributions to this basic area in physiology. In later years he made contributions to the subject of ageing and alcoholism.

Dr. Carlson was a critic of the character of our more recent educational process in the home and at school. He complained that our young folks have no "granite in their bread." "Science in schools and colleges is a quiz-kid program. Our young children have a wise stage during their development -- the stage when they are everlastingly asking why that is so, and why this is so, and how this or that thing happens. And we drown them with facts and more facts. The result is that we educate out of them the fund of mental curiosity with which they are born." He said: "Medical students and physicians become robots or IBM machines which can regurgitate complicated information but cannot think originally or creatively or digest and absorb new ideas unless such ideas are taught to them as a fact by some authoritative source. Thoughtless conformity and to-always-please are the major sins of today."

At the Fiftieth Anniversary of the American Physiological Society, Dr. Carlson said: "Some of my colleagues, particularly those of advancing years, see clouds ahead on the score of the number and the caliber of men and women we train annually in our laboratories for service in physiology.... Some even propose a control of recruits on the principle ... of the guilds of the middle ages. I think this would be as weateful and unfortunate as it is undemocratic.... In the first place, none of us can neither pick nor train genius.... I am reasoning on the ancient and formerly biologically sound and acceptable theory that we must create our own opportunities, that we must scratch for our living.... As I read history, all great achievements in science have come through the individual endeavors of relatively free men.... A regimented science is science in eclipse.... Is it not true that when men have bartered freedom for security, they have lost freedom without gaining a security worth having?"

Dr. Carlson never became bored or discouraged with life. He loved to work and work. He always was helping to carry several crosses for good causes, causes which would produce a better life for others and future generations.

His students called him Ajax. This appellation did not arise from signature A.J.C. Neither was it used as a witticism, but with respect and sometimes awe. This name was used as though Carlson was

“AJAX,” the only heroic figure from the past who never called on man or God for aid, but always fought his own way out of trouble. Ajax was a man of great physical stamina and strength of character, who was devoid of and an enemy of the shrewdness and intellectual dishonesty of a Ulysses.

# EXCERPTS FROM "MIRROR TO PHYSIOLOGY"

## DEFINING PHYSIOLOGY AND PHYSIOLOGISTS

Physiology is today more meaningfully defined by what physiologists say than by what they do. The field has become so varied and extensive that no a priori definition effectively distinguishes physiologists from non-physiologists, and an operational approach, based on self-classification, mainly on a questionnaire, was used by the Survey. In October, 1953, there was an estimated total of 5750 physiological scientists in the United States and Canada, about a third of 'pure' biological scientists, a tenth of all biologists. Approximately one third of the questionnaire respondents are primary or "central" physiologists, two-thirds are secondary or "peripheral" physiologists. Nearly two-thirds of both central and peripheral groups are animal physiologists, one-fourth are plant physiologists, and one-eighth are bacterial physiologists. Nearly a third of the peripheral physiologists are biochemists - roughly one-sixth of the biochemists in the United States - and three-fourths of all physiologists are interested in two to four specialties. Central animal physiologists are concentrated in zoology and biochemistry, roughly one-seventh each, and in medicine, pharmacology, and biophysics, one-tenth each; plant physiologists, in botany, two-fourths, and agriculture and biochemistry, one-fifth each; bacterial physiologists, in microbiology, one-half, and biochemistry, one-third. Peripheral animal physiologists are mostly in metabolism and nutrition, one-third (endocrines, one-twelfth, and physiological psychology, one-twentieth, are next); and this specialty absorbs one-fourth of all animal, one-third of all plant, and two-fifths of all bacterial physiologists.

Over three decades, the population of physiologists has increased some eight-fold, as compared with seven-fold for all Ph.D.'s or those in biology, four-fold for all scientists, and two-fold for the total labor force. From "American Men of Science" listings, there were about 100 in 1905, 300 in 1925, 1000 in 1945, and 2000 in 1955 - a good exponential growth curve. Nonetheless, there are many signs that physiology as a whole, and central animal physiology in particular is lagging.

From 1915-44, 3.5% to 5% of all Ph.D. degrees, and 10% to 14% of those in biology, were in physiology; from 1945 to the present, the proportion has been only one-third as much, 1.5% and 5%, respectively. The central animal physiologists, nearly half of all in 1945, are now a third; and the authors of papers in physiological journals were one-fourth central in the 1900's, one-third in the 'twenties, but below one-fourth in the 'forties. Finally, while the age level of the total population of physiologists has risen slightly in the past fifty years, at present men under forty constitute three-fourths of the bacterial, three-fifths of the plant, but only two-fifths of the animal

physiologists. Such burgeoning fields as microbiology and physiological psychology are manned about seven-tenths with men under forty; industry about two-thirds, as compared to little over half in academia and government.

Not only in subjects but in geography, have there been shifts over recent decades. In most areas of the United States about as many physiologists are now employed as were born or educated there. But an important influx of foreign-born physiologists has supplied 10% of our pool, and the South Atlantic region employs (many in the Washington area) over twice as many as it generates. The East North Central region has educated a disproportionately large fraction of physiologists; the Pacific region has educated and now employs over twice as many physiologists as were born there. Many of these shifts apply to the population as a whole or to large segments thereof - as the trek to the Southwest, especially of older persons - but other evidence, as the high proportion of elite physiologists in California, shows that particular factors are operating for physiologists, or scientists as a whole.

Physiologists are medium people. They tend to come from moderate-size communities, moderate income and status homes (many fathers in professional or managerial occupations), and half from large, half from small universities or colleges. In personality they are not strikingly different from their colleagues.

In sum, physiology though growing, is lagging. Whether the relative shrinkage of physiology and its most traditional sub-areas is to be viewed with alarm, in terms of the encroachment of other disciplines (especially the more chemical ones) upon it; or with pride, in terms of the infiltration of physiological attitudes and methods into other disciplines (including microbiology and psychology), is perhaps a matter of taste. Certainly young scientists, especially the abler ones, are attracted into those topics which are intellectually exciting during their formative years.

#### PROFESSIONAL TRAINING AND RECRUITMENT

Tracing the flow of students into physiology or of physiology into students, through the courses, departments, and schools that contribute to undergraduate, graduate, and technical or professional education, is as confused as is tracing precursors and products through a metabolic pool.

With a wide view of physiological content, there were in the Survey period over 4300 courses containing physiology taught to over 74,000 students in 1800 departments (only one quarter called "physiology") in 1300 colleges and universities (omitting those with an enrollment under 200), mostly liberal arts institutions with professional schools. Undergraduates can enter four-fifths of the courses - 72% are specifically for them - and 54,000 (73%) do so. Graduate students in biology (6000) are served by 8% of the courses;



professional students (medicine 9000, veterinary medicine 4000, dentistry 1200) by 13%. The 80% undergraduate courses include: one-fourth (of 100%) directed to majors in biology (rarely does one called "physiology" exist); one-third, to students in the semi-professions (medical technology, nursing, pharmacy, agriculture); and one-sixth, to education students (including home economics, nutrition, and coaching). Less than half of all physiologists (two-thirds of the plant group) teach undergraduate courses with physiological content, and 70% of peripheral physiologists (43% of all physiologists) teach no course containing physiology. Most biology courses for teachers, who train future citizens as well as scientists, are taught by men and women who have had no reasonable exposure to physiology. Only 9% of present physiologists were influenced toward their career by high school teachers; 40% by a college teacher, usually some biologist.

More narrowly, 3200 courses are taught by 1800 central and peripheral physiologists. Of these courses, 1900 are for undergraduates, 700 for graduate students in biology, 500 for professional students, and 100 unassigned. Higher level courses divide between 1 mammalian physiology to 2 plant physiology to 2.5 cellular physiology. The mammalian courses are mostly professional and, on the average, devote one-third of their time to neurophysiology and one-fourth to circulation. Opinion is strong that general physiology should be required in Ph.D. training, probably in the undergraduate years.

Nearly a thousand graduate students, half of them in physiology departments, are working on physiological theses for a Ph.D.; and, of the fourth-year medical students doing research (39% of those sampled in 1955) the largest groups, some one-third, were working on clearly physiological problems. Other estimates place in physiology departments, of all those in physiological science, only 37% of Ph.D. candidates, and 7% to 18% of completed theses. Half of all Ph.D. candidates are judged "good" by their department chairmen; and half also rate, on an ability test, in the top 10% of the whole college student body. (A small sample of professional physiologists scored on this test with the physical science group rather than with other biologists. Survey respondents placed their undergraduate grades almost entirely at the A, 38%, or B, 55% levels.)

Teachers mostly (68%) feel that teaching conditions are propitious, space limitations being most troublesome; and 180 schools give a Ph.D. in physiology. But so far as the present professional physiologists are concerned, a dozen or so institutions - mostly the large liberal arts universities - account for over half. Despite such good opportunities, many physiologists feel defects in their own training and see such in current Ph.D. programs. Poor skill in English is seen far more than felt; inadequate basic science is more felt than seen. Few physiologists mention a deficiency in biology; about half wish their mathematics, physics, or chemistry were better. Animal physiologists crave mostly mathematics and physics; plant and bacterial physiologists, mostly chemistry and biochemistry.

Perceived deficiencies obviously do not represent failures in training - bacterial physiologists have strong roots in chemistry - but rather reveal the directions of advance of the science. Plant physiology is moving into a strong biochemical development, beyond the training of older professionals; and animal physiology, having split off biochemistry, is now similarly tugging its devotees towards biophysics.

The non-congruence of physiology as a subject matter and as an administrative area is also clear from the multiple streams into and out of graduate training in physiology. This is rarely an undergraduate major, so most students enter from biology (22% of the central group) or chemistry (23% of the peripheral group). By areas, the sources are: for animal, plant, and bacterial physiologists respectively, 40% biology-zoology and 15% chemistry; 37% botany and 23% agriculture-horticulture; and 32% bacteriology and 23% chemistry. On the output side, while two-thirds of the central animal physiologists received their doctorate in a department of physiology, only one-third of the Ph.D.'s in physiology have become central animal physiologists. Indeed, over two-thirds of present professional physiologists at one time considered another career - as medicine by one-third of the animal group and chemistry by one-sixth of the bacterial group - and over 10% were even headed away from science. Physiology has, of course, also lost potential or actual workers; but it seems clear that the profession and the science would gain greatly if the subject were better recognized in course offerings and departmental organization and in course content and teacher training.

#### THE PUBLIC AND PHYSIOLOGY

The term "physiology" means little to the public. In contrast, "chemist" or "surgeon" or "psychiatrist" immediately conjure up readily recognizable figures - scientists with test tubes, men in white with scalpels, or graybeards with couches. But physiology and physiologists are indistinct: in definition and in function they merely "have something to do with the body," meaning - almost without exception - the human body. Public recognition of physiology in terms resembling Claude Barnard's classic view, as the study of the physical and chemical processes of all living organisms, is practically non-existent.

This situation stems from the historical vicissitudes of physiology in relation to hygiene and from the habit of journalists of attributing anything physiological to the "doctor," so that such concepts are "tied to the tail of the medical disease kite." A century and a half ago, physiology was regarded, in learned circles, as part of natural philosophy and of natural history. At first this primitive biology reflected the preoccupation of scientists with systematic botany and ecological and taxonomic zoology; later, in the mid-nineteenth century, it emphasized the morphological aspect of zoology. Physiology for the layman became entirely related to

human anatomy and shifted gradually toward hygienic considerations. This view merged easily with a growing popular concern about the practical and social aspects of community health and welfare, and also served as a convenient platform for temperance evangelists and reformers. After World War I, popular demand led to legislation requiring school courses in physiology, health and physical education. Such measures, while perhaps raising national standards of health information and practices, have reinforced the popular notion limiting physiology to its application relative to the functioning human body. The public's image of physiology is important; - it influences the appreciation of, interest in, and support for the work done by physiologists as scientists.

This view of physiology is naturally the one utilized by science writers and editors. The term is only occasionally used, but the concept of physiology mostly underlies the presentation of medical news items. With simple language and ideas, the "sine qua non" of all newswriting, it is difficult to present the intellectual significance of a finding; so the layman is given a new test or treatment for cancer or heart disease as a tidbit relating to his personal or national life. Furthermore, the backgrounds of editors and science writers are those of reporters and writers in general and rarely contain much science; indeed, it is a recognized policy of some publications to keep their science writers innocent in this field. And when the writers do become knowledgeable, they are often thwarted, in turn, by the copy desk. Of course, scientific discovery is rarely proper spot news; and the magazines usually do a better job than the newspapers - occasionally a superb one.

The Survey attempted to gauge the effectiveness of the public presentation of physiology and to detect factors operating against public awareness of this field and its workers. A brief questionnaire was prepared for circulation to members of the National Association of Science Writers; but pretesting it showed that personal interviews with even a few representatives would be more productive, since orientation to the area of interest are so individual. Furthermore, it was necessary first to clarify with the respondents what physiology is and then to learn the extent of their interest and competence in the field as reporters.

The science writers and editors were questioned as to: their concept of physiology and use of the terms physiology and physiologist; the requirements for presenting their sort of news; the factors influencing their judgment of news items as important and valuable; the nature of their sources; their own backgrounds; the factors influencing the inclusion of physiological material in their news articles, such as source, appropriateness, and public acceptance or awareness; and finally their own reactions, suggestions, and comments concerning the effect of publicity on scientists and scientific efforts. All those interviewed felt that medical news appeals to the public because the layman easily personalizes the content, and be-

cause the several health fund drives emphasize special areas of disease and medical progress. A newspaper science editor estimated that 65% to 85% - the larger figure during medical conventions - of his coverage is medical, and the greater portion of the balance is physics and chemistry; with plant science and agriculture receiving rare attention. The medical editor of a news magazine estimated that the rank order of appearance of content material was medicine, disease, physiology, biochemistry, and anatomy. Physiological phenomena are presented as "medicine"; if the term "physiology" or "physiologist" is used at all, it is mainly because of the source of the news lead. Science writers and editors are primarily concerned with timeliness and newsworthiness, their sources are often personal, and their leads are either articles in technical journals or press releases from professional, governmental, or commercial bodies. Some sources provide press releases of high accuracy and pertinency, which may be used almost verbatim; many do not.

All journalists interviewed strongly urged the establishment of public relations machinery to ensure the vigorous and extensive presentation of physiology in lay media. They urged, in short, "If you have something to say, say it!", but cautioned against assuming that the public will read or understand technical terms. A central clearinghouse, or rewrite service, is required for this purpose. The American Chemical Society, as an example, has had such an organ in operation for years and, by indicating the role of chemistry in everyday industrial, agricultural, medical, and other scientific fields, it has given the public a friendly awareness of the importance and attractiveness of the chemical field. This program has resulted in increases in industrial support of basic research and teaching, and the establishment of weekly television and radio programs, both national and local. The Society supplies speakers in the field of chemistry to a variety of organizations and searches the literature for new items to put in releases for press and radio. As with other sciences, the principal difficulty is in translating technical terminology into common terms.

Good public relations for science develop only when scientists themselves are active in establishing them. The situation in other countries, as to public knowledge of physiology and efforts to improve it, was explored in essays contributed by participants in a symposium at the 1953 International Congress of Physiology. In general, these further emphasized the limited impact of physiological science upon the general public; but in Sweden a public campaign for betterment, launched by physiologists and other medical scientists, has greatly advanced research. Through this appeal for popular interest and support, members of Parliament were led to establish a Medical Research Council and provide research funds for medical science. New professorships and staff positions were created, and physiological research in Sweden was greatly strengthened. Physiology now receives 13% of all medical research grants, undoubtedly the result of this campaign by the profession for its support.

Few American physiologists volunteered comment on the need of public understanding of physiology, but the topic was not included in the Survey questionnaire. In interviews with physiologists, there were frequent remarks to the effect that "physiology" means nothing to the public and that the position of physiologists would be improved if a different term were used to describe their work (biophysics and bio-mechanics were explicitly suggested); but physiologists are overwhelmingly disinterested in the problem of public relations, however alert they become on the matter of public support. Such a depersonalized attitude helps make physiologists diffident about publicizing their work or their profession. It is rather significant that only 4% of the Survey respondents indicated that the prestige of physiology was a factor influencing them to enter this field. Disinterest of physiologists in the public image of their profession implies poor public relations, future recruitment, and support.

## INTERNATIONAL MEETINGS -- 1959 and 1960

### 1959

- June 2-6 -- Washington, D.C.  
SECOND PAN AMERICAN CONGRESS ON RHEUMATIC DISEASES. Dr. R. T. Smith, West Point, Pa.
- June 3-5 -- Royaumont (near Paris), France  
CIBA SYMPOSIUM ON CELLULAR ASPECTS OF IMMUNITY (by invitation). Dr. G. E. W. Wolstenholme, 41 Portland Place, London, W. 1., England
- June 4-8 -- Trieste, Italy  
INTERNATIONAL SYMPOSIUM ON ELECTROLYTES. Societa Italiana per il Progresso delle Scienze, Piazzale delle Scienze 7, Rome, Italy
- June 7-13 -- Amsterdam, Netherlands  
THIRD WORLD CONGRESS ON FERTILITY AND STERILITY. Dr. W. W. Williams, 20 Magnolia Terrace, Springfield, Mass.
- June 10-12 -- East Lansing, Michigan  
SECOND INTERNATIONAL SYMPOSIUM ON GAS CHROMATOGRAPHY. Mr. H. S. Kindler, 313 Sixth Ave., Pittsburgh 22, Pennsylvania
- June 15-17 -- Stockholm, Sweden  
SECOND INTERNATIONAL SYMPOSIUM ON X-RAY MICROSCOPY AND X-RAY MICROANALYSIS. Dr. G. Hoglund, Institutionen for Medicinsk Fysik, Kraolinska Institutet, Stockholm 60, Sweden
- June 15-20 -- Paris, France  
INTERNATIONAL CONFERENCE ON INFORMATION PROCESSING (UNESCO). Dr. I. L. Auerbach, Box 4999, Washington, D.C.
- June 23-30 -- Munich, Germany  
NINTH INTERNATIONAL CONGRESS OF RADIOLOGY. Sekretariat des 9, Internationalen Kongresses fur Radiologie, Reitmorstrasse 29, Munich 22, Germany
- June 24-26 -- London, England  
CIBA SYMPOSIUM ON SIGNIFICANT TRENDS IN MEDICAL RESEARCH (by invitation). Dr. G. E. W. Wolstenholme, 41 Portland Place, London, W. 1., England
- June 30-July 10 -- New York City  
INTERNATIONAL CONFERENCE ON MEDICAL ELECTRONICS (CIOMS). Dr. Maurice Marchal, 12, Rue Jacques-Bingen, Paris 17e, France
- July 19-25 -- Montreal, Canada  
NINTH INTERNATIONAL CONGRESS OF PEDIATRICS. Dr. R. L. Denton, P.O. Box 215 Westmount, Montreal 6, Canada
- August 6-8 -- Buenos Aires, Argentina  
CIBA COLLOQUIUM ON HUMAN PITUITARY HARMONES (by invitation). Dr. G. E. W. Wolstenholme, 41 Portland Place, London, W. 1, England

- August 9-15 -- Buenos Aires, Argentina  
 TWENTY-FIRST INTERNATIONAL CONGRESS OF PHYSIOLOGICAL SCIENCES. Prof. A.O.M. Stoppani, Facultad de Ciencias Medicas. Paraguay 2155, Buenos Aires, Argentina
- August 20-September 2 -- Vienna and Salzburg, Austria  
 FOURTEENTH INTERNATIONAL LIMNOLOGICAL CONGRESS, (IUBS). The Secretary, 14th International Limnological Congress, Biologische Station, Lunz am See, Austria
- August 23-27 -- Kansas City, Missouri  
 THIRD PAN AMERICAN CONGRESS ON VETERINARY MEDICINE. Dr. B. D. Blood, P.O. Box 99, Azul, Buenos Aires Province, Argentina
- August 30-September 4 -- Chicago, Illinois  
 SECOND WORLD CONFERENCE ON MEDICAL EDUCATION. World Medical Assoc., 10 Columbus Circle, New York 19, N.Y.
- August 30-September 6 -- Barcelona and Madrid, Spain  
 NINTH INTERNATIONAL CONGRESS ON HISTORY OF SCIENCE. Prof. Jean Vernet, Via Layetona 141, Barcelona, Spain.
- September 1-8 -- Stuttgart, Germany  
 THIRD INTERNATIONAL CONGRESS ON ACOUSTICS. Dr. Eberhard Zwicker, Breitscheidstrasse 3, Stuttgart N, Germany
- Sept. 20-25 -- Lyon, France  
 FIFTH INTERNATIONAL MEETING ON BIOLOGICAL STANDARDIZATION. Dr. Charles Merieux, 17 rue Bourgelat, Lyon, France
- September 21-October 3 -- Munich, Germany  
 FOURTH INTERNATIONAL CONGRESS OF THE INTERNATIONAL CARDIO-VASCULAR SOCIETY. Dr. H. Haimovici, 105 E. 90th St., New York 28, N.Y.
- October 3-5 -- Geneva, Switzerland and Evian, France  
 FIRST INTERNATIONAL CONGRESS OF NEPHROLOGY. Dr. G. Richet, Hospital Necker, 149 rue de Sevres, Paris 7e, France
- October 11-18 -- Istanbul, Turkey  
 FIFTEENTH INTERNATIONAL TUBERCULOSIS CONFERENCE. Dr. T. I. Gokce, Salime Hatun, Mezarlik Sokak, Taksim, Istanbul, Turkey
- October 13-20 -- Munich, Germany  
 INTERNATIONAL SOCIETY OF SURGERY, EIGHTEENTH CONGRESS. Prof. P. Martin, 141 rue Belliard, Brussels, Belgium

### 1960

- January 31-February 7 -- Caracas, Venezuela  
 SIXTH PAN AMERICAN CONGRESS OF OPHTHALMOLOGY. Dr. Moacyr E. Alvaro, 1151 Consolacao, Sao Paulo, Brazil
- April 11-16 -- New York City  
 SEVENTH INTERNATIONAL CONGRESS OF ANATOMY. Prof. Louis Flexner, University of Pennsylvania School of Medicine, Philadelphia
- June 13-17 -- Madrid, Spain  
 FOURTH INTERNATIONAL CONGRESS OF CLINICAL PATHOLOGY. Dr. J. Aparicio, Sandoval 7, Madrid, Spain

- June 13-17 -- Amsterdam, Netherlands  
FOURTH INTERNATIONAL CONGRESS OF PHYSIO-PATHOLOGY OF ANIMAL REPRODUCTION AND ARTIFICIAL INSEMINATION. Dr. J. Edwards, Milk Marketing Board, Thames Ditton, Surrey, England
- July 5-9 -- London, England  
FOURTH INTERNATIONAL GOITRE CONFERENCE. Dr. S. Taylor, 3 Roedean Crescent, London, S.W. 15, England
- July 18-23 -- Copenhagen, Denmark  
FIRST INTERNATIONAL CONGRESS OF ENDOCRINOLOGY. Dr. S. G. Johnsen, Hormone Dept. Statens Seruminstitut, Copenhagen, Denmark
- July 25-29 -- New York City  
THIRTEENTH INTERNATIONAL CONGRESS ON OCCUPATIONAL HEALTH. Dr. Leonard Greenburg, 44 West 77th St., New York 24, N.Y.
- August 7-14 -- San Francisco, California  
FIFTH INTERNATIONAL CONGRESS OF GERONTOLOGY. International Assoc. of Gerontology, 741 Brady St., Davenport, Iowa
- August 21-26 -- Washington, D.C.  
THIRD INTERNATIONAL CONGRESS OF PHYSICAL MEDICINE. Dr. W. J. Zeiter, Cleveland Clinic, 2020 E. 93rd St., Cleveland, Ohio
- August 25 -- Tokyo, Japan  
INTERNATIONAL SOCIETY OF HEMATOLOGY, EIGHTH CONGRESS. Dr. Sol Haberman, 3500 Gaston Ave., Dallas, Texas
- August 29-September 1 -- Paris, France  
INTERNATIONAL CONGRESS OF HISTOCHEMISTRY. Dr. Wegmann, 45 rue des Saints, Peres, Paris 6, France
- September 1-7 -- Washington, D.C.  
FIFTH INTERNATIONAL CONGRESS ON NUTRITION. Dr. M. O. Lee, 9650 Wisconsin Ave., Washington 14, D.C.
- September 3-8 -- Paris, France  
TENTH INTERNATIONAL CONGRESS FOR CELL BIOLOGY. Prof. Chevrement, 20, rue de Pitteurs, Liege, Belgium
- September 4-10 -- Toronto, Canada  
SECOND WORLD CONGRESS OF ANESTHESIOLOGISTS. Dr. R.A. Gordon, 516 Medical Arts Bldg., Toronto 5, Canada
- September 4-10 -- New York City  
INTERNATIONAL SOCIETY OF ORTHOPAEDIC SURGERY AND TRAUMATOLOGY, EIGHTH CONGRESS. Societe internationale de Chirurgie orthopedique et de Traumatologie, 34, rue Montoyer, Brussels, Belgium



# EVOLUTION, PHYSIOLOGY AND FINALITY

Reflections on the absence of physiologists  
from symposia on evolution

JOSEPH SCHILLER

The concept of evolution is the greatest contribution that biology has made to the advancement of sciences both natural and social. Many branches of scientific inquiry have participated in its establishment. These include paleontology, comparative anatomy, ecology, embryology and genetics. Symposia on evolution are being held periodically and the number of books written on the subject keep librarians quite busy. Although rudiments of the idea of organic evolution can be traced as far back as Ancient Greece - its official date of birth has been conventionally but deservedly established as of November 24, 1859 the date of publication of Darwin's "Origin of Species." Its centenary will be celebrated next year the world over.

It is distressing to see that physiology as an organized system of inquiry into nature does not lay any claim to playing a role in the foundation of the concept of evolution, while a newcomer like biological chemistry, the direct offspring of physiology, tries to make up for time lost. This appears even more paradoxical when a perusal of biology textbooks shows that living matter is defined in terms of its physiological properties such as assimilation, growth, reproduction. In Darwin's memorial volume published in England on the occasion of the fiftieth anniversary of his "Origin" (1) the only contribution by a physiologist is that of Jacques Loeb then professor of physiology at the University of California on "Experimental Study of the Influence of Environment on Animals." His treatment of the problem is mechanistic, his method one of changes in the environment to the neglect of the study of mechanism of action. As a result his observations are more valuable to the embryologist than to the physiologist. No address was delivered by a physiologist at the fiftieth anniversary of Darwinism organized by the AAAS in Baltimore the same year - 1909 (2). This was the year when Kocher received the Nobel prize "for his work on the physiology, pathology and surgery of the thyroid gland" (3), five years after Pavlov received the same award and three years after the publication of Sherrington's classic "The Integrative Action of the Nervous System" (4). More recently (1946) the Princeton University Bicentennial Conference dealt with "Genetics, Paleontology and Evolution" and, again, with no participation by physiology. The same absence is noticeable in books on evolution, some of which have become classics, e.g., the works of Haldane, Fisher, Huxley, Dobzhanski and Mayr among others. In the chapter dealing with "Forces of Evolution and Their Integration" Simpson (5), through no fault of his own, ignores physiology which might lead one to believe that evolution could take place independently of physiological actions and reactions. Still, appeals for collaboration

are voiced by students of evolution. Simpson states: "The key to the adaptive nature of any characteristic of an organism is its usefulness under the conditions in which the organism lives." In the recently published "A Hundred Years of Evolution"(6) only one page is devoted to physiology. However, hopes for future studies are expressed with the awareness that too few are available at present.

How can the absence of the physiologist from the forum of evolution be accounted for? Is it true that the physiologist -- in the classical meaning of the word with no adjective attached -- is addicted to the doctrine of finality, that his investigations reveal that mechanisms of natural phenomena are purposeful? Since the philosophical background of such a doctrine is man, the mammal becomes by necessity its physiological counterpart and homeostasis the almost single object worth investigating. Evolution seen in this perspective has little to offer to the investigator. Undoubtedly, some celebrated books reflect both by title and vocabulary such an ideology: Cannon's "Wisdom of the Body," Henderson's "Fitness of the Environment" and some of J. S. Haldane's writings are examples of this approach. The phrasing by which physiological phenomena as expressed frequently are more reminiscent of the Aristotelian final causes than of Claude Bernard's "causes prochaines." However, this is superficial and the analysis must go deeper and reflect the methodology of classical physiology and its applicability to the understanding of the facts of evolution. Before any further discussion becomes fruitful a brief mention of the main materials serving in the study of evolution is necessary.

The paleontologist who is also a comparative anatomist deals with organic structures (usually bony material or imprints on rocks) in terms of geological eras. The infra- and inter-species transitions are recorded but the active process of change is beyond the reach of experimentation; the science of the paleontologist is observational. Still, he is aware of the existence of "living fossils," that is of animal species which have remained unchanged for millions of years. The ways in which these species function and meet the challenge of their environment is within the realm of physiology. In addition, at one time these species were the most advanced living forms and could serve as physiological landmarks. The opossum is a case in point. Except for a few experiments in connection with reproduction little is known about this animal functionally. Physiological investigation of species has reached such a high degree of specialization today that the dog is almost synonymous with cardio-pulmonary experimentation, the cat with that of the nervous system, and the rat with reproduction. Still, the functional features of the opossum are representative of an evolutionary step 60 million years old and this may account for the peculiarities in the distribution of electrolytes in this animal after adrenalectomy which is unlike anything known in other mammals. The patterns set by Homer Smith who studied the evolutionary significance of the kidney which, paradoxically, more than any other organ in the body, assures the stability of the internal environment has not been followed by others.

The materials used by the geneticist are the gene-controlled mutations, which differ from those of the paleontologist because they can be produced experimentally by X-ray radiation, U.V. rays or temperature changes. Between the cytological and biochemical changes taking place in the chromosome and the morphological changes that become apparent in the animal, as a whole, the long realm organ actions and reactions and their integration remains an uncharted land. To the physiologist the result of gene action is an end-product which escapes the experimental procedures to which he subjects a system "in the becoming." Genetic changes do not explain the transition from water to land, from tadpole to frog with all that it implies in the respiratory and circulatory systems. Consequently, the physiologist has to rely on techniques which are different from those used by either paleontologist or geneticist.

The physiologist deals with a large number of functions each with its own regulatory mechanism and all integrated into organized systems. In order to gain an insight into the working mechanism he must dissociate one functional system from another and study each one in isolation. Also the logic of the experiment compels him to deal with one variable while keeping the other components constant, or to assume that they are so. For instance, the secretion of the parathyroid glands is immaterial while studying circulation time. In addition, the physiologist is not merely contemplating the phenomena under study but intervenes actively in altering their natural course, a "frame-up" as G. B. Shaw called it in his antivivisection campaign (7). The magic of physiology is such that one can study the effect of running on the muscular system while the animal is sound asleep. Contraction, relaxation, myosin and ATP changes proceed, without displacement of the animal. The result of his investigation is that mechanisms are self-regulatory, that for each disturbing action there is a compensatory reaction which reestablishes the lost equilibrium: hypertension calls for hypotension, expiration for inspiration, hyperglycemia for hypoglycemia, FSH in excess defeats itself since the secretion of its target organ will inhibit it, the product of enzyme activity inhibits the enzyme, etc. Everywhere there is a limiting factor which acts like a stabilizer and imparts a notion of finality. From a finalistic viewpoint for every "good" mechanism a better one is conceivable. The brain uses glucose as a source of energy the supply of which is limited and the rapid exhaustion of which results in irreversible damage to the organ while the utilization of lipids would save the situation and respiration could conceivably be less dependent upon the partial pressure of  $O_2$ , etc. However, without transcending factual physiology, the constancy of the self-regulatory mechanisms for which the comprehensive term homeostasis was coined by Cannon has become the cannon of all valid physiology. It stands firmly on the foundations constructed by mammalian physiology as practiced in medical schools. Hence, a reproach coming from other scientific disciplines: not even the mammal is interesting per se, it is merely a means for the understanding of functions in man and for finding the road to the cure of his ills. Was it not Claude Bernard who conceived physiology as

scientific medicine intended "to conserve health and to cure disease"?<sup>(8)</sup> Here lies "the economic determinism" for confining physiological investigation to mammals, it is "utilitarian." Fulton<sup>(9)</sup> has rightly emphasized that historically physiology "came into the academic curriculum in response to the needs of the clinic," but he also reminds us that "it is now a subject in its own right" and it is not Claude Bernard's fault if his "Introduction to the Study of Experimental Medicine" is better known than his "Lecons sur les Phenomenes de la Vie Commune aux Animaux et aux Vegetaux." He also stated "Everything is Evolution."<sup>(10)</sup>

The physiologist has definite advantages over other students of evolution. He enjoys a freedom of inquiry which is the result of the versatility of the functions he studies. He is not limited by either structures or species boundaries and does not have to account for their discontinuity. From the complexity of a lung he can go to the comparative simplicity of a respiratory pigment. For him the hemoglobin concentrated in the erythrocyte, the chlorocruorin dissolved in the plasma of annelids and the universal cytochrom all reflect the basic problem of respiratory function. Epinephrin and estrogens occur in many species from infusoria to mammal and the problem of their integration into organs involving specific functions as they ascend the zoological scale is a physiological one.

The physiologist differs from the geneticist in his attitude toward environment. Far from being inhibited by it, the physiologist is the stage director of the play in which the internal and external environments are the actors and their integration is the action. No inquirer is in a better position to study the mechanism of adaptation, the common ground of physiology and Darwinism. It is true that the mechanism of adaptation as conceived historically by Darwinism is that of the survival of the fittest. Geneticists appraise it as the effect of natural selection on the genetics of various populations with no cannibalistic or exclusively sexual implications. Modern ideas have broadened the concept of species fitness by linking the classical notion of an expanding surviving progeny with that of their better adaptation. Still, the meaning of such a mechanism acceptable as it is to both geneticist and paleontologist is too inclusive for minute devices of physiological experimentation. A gap is left between the occurrence of a mutation and the change it causes in the animal as a whole. The effects on functional parts are different in their immediate determinism from the long range Darwinian causation and belongs to the realm of physiology. Physiology alone can answer the long debated question as to whether evolution results in the animal's progressive adaptation to the environment in which it lives or whether the animal is preadapted and searches for the environment which is most propitious for its survival. The development, dispersion and potential increase in mutation rate depends on the establishment of the interrelationship of function to environment, in which the physiologist does not have to fear to be accused of neo-Lamarckism.

The success of any given organism cannot only be accounted for by physiology but it can be "fractionated" as well, since the success

is not equal in all of its parts. For instance, fishes are osmotically independent of the environment, but are dependent thermically. Such lack of direct temperature regulation in poikilotherms does not remain uncompensated for and the counteraction results from changes in the metabolic rate and in fluid shifts (11,12). A similar situation exists partly for hibernating mammals. There is, therefore, a hierarchy of mechanisms of various degrees of efficiency in their adaptive ability to the environment. Such variability in function from one species to another, and within the same species from one functional system to another, points to a basic difference between the geneticist and the physiologist. While the former finds in gene mutation the unifying mechanism of evolutionary changes, the latter deals with the many functional mechanisms that influence evolution and that which in turn are subjected to a process of evolution of their own. In Lillie's words: "The mystery of mysteries is not the mechanism of evolution, but the evolution of different mechanisms."

The most universal law is that of change and evolution is recognized today as a property of living matter. This property is as material as the physical, chemical and organic properties from which it originates. Evolution is the "broad unifying concept" (13) able to answer the call for "a larger physiology" (14).

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# MUST WE FAIL IN SCIENCE EDUCATION?

OSCAR RIDDLE

Americans need not be told that more than our crushingly expensive military effort is required to win the Cold War that powerful Russia and menacing China now wages against us. For fifteen months our leadership in practically all fields has recognized that to win that contest we must quickly begin to train many more scientists and engineers than we now do. Too, since Sputnik, the general public has heard so much discussion of this need for more scientists that surely most of us assume that our schools are now arranging to provide that obligatory additional training in science. My purpose here is to question that assumption. Indeed, I must do more than question it. During many years I have given much attention to the place accorded the sciences in our high schools, and I have followed recent educational discussions and events with much care and interest. Like most others, I can think that several new developments enable current college teaching and very vital scientific research to carry on in a manner worthy of our nation. Again, one admits that many of our high schools are now teaching science and mathematics to a somewhat higher percentage of pupils than they did a year ago. But, the high school is the precise place where a very substantial change in climate and emphasis was and is essential, and that change has neither occurred nor is it in prospect. This failure at the all-important high school level thus becomes, in my opinion, another way of saying that we are fast losing the Cold War.

It should be said at once that the real reason for wide and deep change in the secondary school curriculum is based on other grounds than that the Russians were first with Sputnik and the ICBM. These latter merely invited a laggard nation to look at a fact that for long it had refused to see and acknowledge -- namely, that we have already entered an age of science which has been suitably recognized neither in the thinking of our people nor in the curriculum of our elementary and secondary schools. In those schools the sciences have never had a status other than that of step-children; and, though we have become a rich and smug nation, we have been unable to become a genuinely modern society. That lower status was tolerable -- at least it did not threaten our survival -- as long as we were not challenged by a powerful, unscrupulous and aggressive enemy who had the wits and found the opportunity, to shed the skins of tradition and accept science for what it is. And by that I mean that science is the foe of supernaturalism, the father of technology, and the foundation of industrial, economic, and political supremacy in this new age.

Others have urged the importance of greater emphasis on the sciences in our high schools. More than a year before Sputnik, the thoughtful Cole report (1956) asked that increased amounts of mathematics and science be required of all able students, regardless of

their careers. That study also quoted George Harrison as authority for the conclusion that the schools should be turning out twice the 50,000 students well oriented toward science they now do. And Dr. James R. Killian, the President's science adviser, recently said: "Science and mathematics are more than tool subjects; they are basic cultural subjects -- liberal arts in the true sense. Science in the secondary schools should be basic, fundamental and versatile."

Still others have told the entire nation that the outcome of our struggle with Russia may depend upon an extraordinary effort in science education. Thirteen months ago the President's committee on scientists and engineers reported: "There is ample evidence that the Soviet Union is bending every effort to achieve its goal of world domination by leading the way in the scientific revolution.... Today Russia has more scientists and engineers than the United States and is graduating more than twice as many each year. The education program of the (this) committee is largely directed to the secondary schools." Again, in March 1958, Mr. Khrushchev clearly stated that Russia intends to defeat the West through education, industrial production and other non-military means.

Space here does not permit a survey of the several productive efforts of the past three years to improve our science education at the secondary level; nor may we consider the weighty evidence that unless far more extensive changes in the high school climate and curriculum are made soon we shall attain no better than second place even if our society exhausts itself in doing every other useful thing.

Instead, I now want to refer to two adverse, usually ignored, but highly persuasive conditions now prevalent in our high schools which prevent adequate recruits to courses in science and mathematics. These relate to psychological hurdles to that choice. Pupil opinion provides one hurdle, teacher opinion provides the other.

Nation-wide polls of opinion of high school pupils have shown their mixed though usually favorable image of science and of scientists, but an overwhelmingly unfavorable view of science as a career for themselves or for their husbands. An excerpt from a quite recent note to the press from the Purdue Opinion Panel is even less comforting. It stated: "The students (almost 90 per cent) think engineers are the bastion of our strength but that the scientist is an incompetent radical."

Next we note that a fair percentage of non-science high school teachers exhibit an anti-science attitude towards science -- or perhaps when probed, it is towards the naturalism that inheres in science. Only several months ago (Science, April 26, 1957) did we acquire a documented account of the pre-scientific -- and effectively anti-scientific -- nature of much current high school instruction in history and literature. For that illuminating material we are indebted to Joseph Gallant, head of the department of literature in the

Roosevelt High School, New York City. We quote him: "Not to apprehend this world from the standpoint of science is, therefore, to belie the very process of seeing. To speak in any idiom other than that which incorporates the scientific outlook is to speak the language of the dead. The writer has no choice. The cultural gap which leads him to stand with one foot in the present and one in a pre-scientific past must be closed if his message is not to consist of arbitrary and falsified symbols.... History can mold and reenforce the scientific outlook of students. It can attract them to science as a way of life or as a prospective career.... Meanwhile the courses in the humanities, on the secondary school level, hold the key to the future of our country and of our society. But the humanities sweepingly ignore the role played by scientific insight and thinking in the ideology of our times and disdainfully march on their archaic way as though the atomic and electronic age had not arrived." Next, a mere word from Manson Van B. Jennings, associate professor of history at Teachers College, Columbia University (NEA Journal, May 1957): "However, many social-studies teachers are unable to answer elemental questions (about science). Back of this lack of understanding one often finds a strong distaste for science." Here is place and time for the keen scholars and the fine scholarship of our better universities to contemplate the slender measure of their success in communicating their modern thought to some tens of thousands of those now teaching the humanities and social studies in our high schools.

A third item that is too comprehensive to discuss and too disastrous and shameful to ignore confronts the youth who finally enrolls for a course of instruction in biology. Though that is the science that best illuminates the social creations of peoples, and most affects the philosophic thought of persons, those gripping and society-transforming aspects of this revealing subject will usually be effectively screened from him or her. Since the anti-evolution laws and the Scopes trial of the twenties -- all born of religious fervor -- the high school textbook will omit, disguise, or soften the word, evolution; and the informed teacher will well know that he walks on eggs when that word is mentioned.

In conclusion. Is softness in our secondary school curriculum justifiable in the light of the present threat, mode of attack, and strength of our opponent? Starting 40 years ago with a poor and war-crushed people 70 per cent illiterate, it now annually graduates more than twice as many scientists and engineers as does the United States. That nation now happens to be our dangerous and aggressive enemy. How much longer dare we gamble the fortunes of Western civilization on the proposition that the scientific age is still remote?



# NATIONAL DEFENSE EDUCATION ACT OF 1958

Two provisions of this act are of interest to those involved in graduate training. A brief summary of their provisions is given below.

## Loans to Students in Institutions of Higher Education (Title II)

Purpose: To provide Federal assistance in the establishment, at institutions of higher education, of students loan funds for making low-interest loans to students to pursue their education at such institutions. Generally, the Federal Government will contribute 90 percent of the capital of these funds and the institutions 10 percent.

Applications: Applications by institutions for Federal capital contributions are filed with the Commissioner of Education.

Students eligible: To be eligible for a loan, a student must (a) be in need of the amount of the loan to pursue a course of study at the institution; (b) be capable of maintaining good standing in such course; and (c) have been accepted for enrollment as a full-time student, or, if already attending the institution, be in good standing and in full-time attendance as an undergraduate or graduate student.

Amount: No student may be loaned over \$1,000 in any year or over \$5,000 in the aggregate.

Interest: Three percent per year on the unpaid balance beginning with the date on which repayment of the loan is to begin.

Repayment: Begins 1 year after a borrower ceases to pursue a full-time course of study at an institution of higher education, and ends 11 years thereafter. The borrower may, however, accelerate his repayments.

Nature of student contract: The loan must be evidenced by note or other writing, but no security or endorsement may be required unless the borrower is a minor not legally able to create a binding obligation, in which case either security or endorsement may be required.

## National Defense Fellowships (Title IV)

Purpose: To increase the number of students in graduate programs, particularly students interested in teaching in institutions of higher education.

Number of fellowships authorized: One thousand fellowships may be awarded during the fiscal year 1959 and 1,500 during each of the 3 succeeding years.

Terms of fellowships: Individuals receiving fellowships must be accepted for study in graduate programs of institutions of higher education, which programs are approved by the Commissioner of Education. To have a graduate program approved, the institution must apply to the Commissioner and he must find that the program is a new program or an existing program which has been expanded; that the program or the expansion will increase the facilities available for graduate training of college or university teachers and will promote a wider geographical distribution of such facilities; and that in accepting persons for graduate study in these programs, preference will be given to persons interested in teaching in institutions of higher education.

Fellowship stipends: Each holder of a fellowship will receive \$2,000 for the first year of graduate study, \$2,200 for the second year, and \$2,400 for the third year, plus \$400 each year for each dependent.

Duration of fellowships: Fellowships are for periods of study, not in excess of 3 academic years, during which the holder maintains satisfactory proficiency in, and devotes full time to, study or research in the field in which the fellowship was awarded, in an institution of higher education, and does not engage in gainful employment (other than part-time employment by the institution in teaching, research, or similar activities, approved by the Commissioner of Education).

Cost-of-education payments to institutions: The institution of higher education which a fellowship holder attends will be paid that portion of the cost of the new graduate program, or of the expansion of the existing program, in which the fellow is pursuing his course of study, which is reasonably attributable to him -- but not more than \$2,500 per year per fellow.

#### WOODROW WILSON NATIONAL FELLOWSHIPS

Going directly to the heart of education's most urgent problem -- the critical shortage of qualified teachers -- the Woodrow Wilson National Fellowship program recruits and supports promising scholars for their first year of graduate study. The project is backed by a \$25 million grant from the Ford Foundation and administered by the Woodrow Wilson National Fellowship Foundation at Princeton, New Jersey.

It has been predicted that between 30 and 40,000 new full-time college teachers each year will be needed to train the wave of students seeking college educations in the sixties. The current annual output of Ph.D.'s averages 9,000, of which only half go into college teaching.

This year's 1,200 Wilson Fellows were chosen from 7,000 candidates, all nominated and all rigorously screened by committees

of faculty members. These candidates came from over 700 undergraduate colleges. The elected Wilson Fellows begin graduate work next fall at 80 different universities. Each Fellow receives a living allowance of \$1,500, plus the full cost of tuition and fees. Married students receive additional stipends. In this year's group of winners, there are 875 men and 325 women. Of these, 38% are planning to take courses in the humanities; 34% in the social sciences and 28% in the natural sciences and mathematics.

## PRESIDENT-ELECT TOUR

R. F. PITTS

The President-Elect Tour has become an established tradition of the American Physiological Society. Sometime during the year following his election in April, the neophyte President-to-be embarks on a series of visits to universities and research institutes selected by the august President from a list of institutions not previously so favored. The avowed purpose of the tour is to acquaint the President-Elect with grass-roots sentiments, in part to improve his mind, but perhaps of more significance to protect Society members when he picks up the reins of office. While a tradition for the Society, the tour is a unique experience for the President-Elect.

For a couple of weeks prior to December 1, 1958, when I departed on the first stage of my trip, I became increasingly embarrassed by the prospect of inflicting myself on my busy colleagues, the more so for choosing the pre-Christmas season when both professional and family pressures are at their peak. The feeling persisted till I stepped off the train in Albany; it never returned. I rapidly relearned such half-forgotten truths as these: physiologists have a real interest and pride in the activities of their Society; they have ideas as to what the Society should do and how it should do it; they have no adequate means of expression of those ideas and welcome a visit by a Society officer for the opportunity it presents to unburden their souls.

Two concrete suggestions were made as to how to improve this latter situation. First, THE PHYSIOLOGIST should welcome and initially solicit expressions of views on Society affairs by members for a "Letters to the Editor" column. Second, a more effective method of bringing member views to the attention of Society officers would be to replace the annual President-Elect Tour with multiple Council member tours. Members of Council are geographically well distributed over the country; hence local tours by each could provide a wider sampling of sentiments than could a single President-Elect Tour. Furthermore, policy of the Society is as much in the hands of the members of Council as in those of the President. If education is good for the President, it is obviously equally good for members of Council.

In addition to listening receptively to such spontaneous expressions as those outlined in the paragraph above, I asked specific questions on matters of publications, membership and meetings. Unanimity of opinion is not characteristic of a group of physiologists nor were stereotyped answers given in response to these questions. A few of the reactions are noted below.

In regard to publications, most felt that THE PHYSIOLOGIST serves a useful function as a house organ of the Society and might be increasingly useful, if it could become more of a forum for member discussion of Society problems. Few objected to compulsory journal subscription, though a minority were against it as representing a form of regimentation. A number said they would like an itemized bill for annual dues, including journal subscriptions, which would indicate where their dollars went. Opposition to rapid publication of short unedited notes was nearly unanimous, whereas opinion as to the advisability of sectionalizing the American Journal of Physiology was more or less evenly divided.

Those who are most concerned with the training of graduate students or post-doctoral research fellows felt that Associate Membership fills a real need of the junior scientist for a professional society affiliation at a time when he is unable to meet the requirements of full membership. In addition many felt that Associate Membership fulfills an obligation of the Society to the college teacher of biology, long without a professional physiological home. The prospect of a brochure written for college students which describes what physiology is, the kind of training a physiologist needs, and the nature of career opportunities available to trained physiologists was welcomed for the value it will have in directing more and better students into graduate programs in physiology.

A finding which disturbed me personally was the number of full-time professional physiologists of stature who are not members of our Society. Often these men have been proposed in the past, not accepted, and with justifiable pride have refused proposal a second time. Wherever I met such individuals, I urged reapplication. Perhaps the Society is remiss in not following up applications, disapproved when first submitted. Certainly the Society loses in failing to have these able men in its ranks.

Questions relating to meetings, especially to the Federation meetings, called forth the most widely divergent opinions, varying from the immediate dissolution of the Federation to its preservation at any cost. Members are well apprised of the problems created by large attendance, numerous papers, and multiple concurrent sessions. While some advocated a selected program, the majority were opposed and valued highly the right of presentation of the customary 10-minute paper. Longer meetings, overlapping meetings, and regional meetings have their obvious drawbacks appreciated by and pointed out by Society members. No easy and universally acceptable solution evolved from the discussions.

Most who attended the sessions last April which were introduced by a 30-minute summary of the present status of a field felt them to be of considerable value, especially as a quick review for the teacher, and hoped that they would be continued. There was less general agreement as to the virtues of the Inter-Society Sessions and considerable opposition to a truly Federated program where Society identification would be largely lost.

This brief description cannot do justice to the many topics discussed, nor to the various shades of opinion expressed. The opportunity to talk over Society affairs with interested groups was for me a valuable educational experience. It was also a most enjoyable one, for wherever I went I was most cordially received. Below are listed the institutions visited and the hosts who arranged my program. To them and to their colleagues, I am indebted.

- Dec. 1 -- Sterling-Winthrop Research Laboratories, Rensselaer, New York -- Dr. Maurice Tainter, Dr. Oliver Buchanan.
- Dec. 2 -- Albany Medical College of Union University, Albany, New York -- Dr. Robert Alexander
- Dec. 3 -- McGill University, Montreal, Quebec, Canada -- Dr. F. C. MacIntosh
- Dec. 4 -- University of Montreal, Montreal, Quebec, Canada -- Dr. Eugene Robillard
- Dec. 5 -- University of Toronto, Toronto, Ontario, Canada -- Dr. Charles Best, Dr. J. Campbell, Dr. Frank Monkhouse
- Dec. 9-10 -- Wayne State University, Detroit, Michigan -- Dr. Walter Seegers, Dr. J. F. Johnson
- Dec. 11 -- Indiana University, Bloomington, Indiana -- Dr. Sid Robinson
- Dec. 12 -- Indiana University Medical College, Indianapolis, Indiana -- Dr. Ewald Selkurt
- Dec. 15 -- University of Pittsburgh College of Medicine, Pittsburgh, Pennsylvania -- Dr. Paul L. McLain

# EUGENE F. DUBOIS, A MAN OF FORTITUDE

D. B. DILL

Chairman, Committee on Senior Physiologists

About a year ago our Committee on Senior Physiologists addressed a letter of inquiry to all Society members born before 1895. A copy is appended. One of the most thoughtful and challenging replies came from Eugene F. DuBois who died 10 months later, February 12, 1959, at age 76. His letter includes highlights of his career and lists the three publications which he considered most significant. I have submitted Eugene's letter to THE PHYSIOLOGIST believing it should be preserved in the annals of the Society. Those of his friends who read his letter will take courage from this evidence that he remained in good spirits and active, undeterred by a crippling illness.

Letter to Senior Physiologists - March 19, 1958

Dear Dr. \_\_\_\_\_:

You may have read the report of our session on "Roles for Senior Physiologists" at the Iowa City meeting. This report appeared in the January 3rd issue of Science and was reprinted in February issue of THE PHYSIOLOGIST.

From time to time our committee hears of openings for Senior Physiologists. We furnish names of physiologists but are handicapped because of lack of information on interest and availability. Accordingly this letter, drafted by Fenn, Hamilton, Landis and myself, is being mailed to members of the Society who have retired and to others who were born before 1895 but who are still active members. If I receive no reply within 30 days I shall assume you do not wish to be included in a list of available (or soon to be available) Senior Physiologists.

The information desired is as follows:

1. Do you desire a full-time position:
  - (a) As a teacher?
  - (b) In research?
  - (c) In administration?
  - (d) As an editor?
  - (e) As a translator and abstractor (if so, what languages)?
2. Do you prefer part-time activities along any of the above lines?
3. In what parts of the United States or its possessions are you willing to work other than your home community?

4. Are you willing to go abroad for a minimum of:
  - (a) One year?
  - (b) Two years?
  - (c) Three years?
5. Are you willing to accept a Civil Service appointment for:
  - (a) Unclassified work?
  - (b) Classified work?
6. If you are not available now when do you anticipate being available?

It would be helpful if you send four copies of your reply so that one can be furnished each member of the Committee.

Also it would be helpful to have a brief curriculum vitae (also four copies) including references to three or four of your most significant publications.

Sincerely,

D. B. Dill

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Dr. D. B. Dill  
R.F.D. 1, Box 190  
Joppa, Maryland

Dear Bruce:

I have your letter of March 19, 1958, and I shall try to answer it as fully as possible at the present time. I have also received a somewhat similar letter from Bellevue and New York hospitals, asking if I am able to return to work. I wrote to them saying that I would be glad to work if I could be useful to either hospital, but that I did not want to take any job that would interfere with the training or advancement of younger men. I told them that I thought I might be useful at a desk job or library and that I might possibly be able to work in a dispensary.

If I do start work along these lines I would like to do it in New York where I have my apartment with good medical care and nursing. Travel would be very difficult, as I have to spend most of my time in a wheel chair. Going abroad would be out of the question.

I am still enrolled in the U.S. Naval Reserve Medical Corps, although I am retired. In case of a national emergency I would have to offer my services first to the Navy, but I doubt if they would accept me. In a few days I hope to have a visit from the District Medical Officer, Admiral Van Peenen, and can talk the matter over with him.

In the questions of the letter of March 19, item #6, I am not available for a position now, and cannot estimate the time when I



will be available, but I am improving and hope to recover from my stroke.

I am writing a very brief curriculum vitae. I was born June 4, 1882, in New York, graduated from Harvard, A.B. 1903, and from Columbia College of Physicians and Surgeons, M.D. 1906. I have served as Medical Director of the Russell Sage Institute of Pathology, and as Director of the Second Medical Division of Bellevue Hospital, as Professor of Medicine and Physician-in-Chief at the New York Hospital from 1932. Later I was Professor of Physiology at Cornell University Medical College, and I have been Captain in the Medical Corps, U.S. Navy, and am now in the U.S.N.R. on the retired status. I do not have available the exact dates, but they can be found in Who's Who or American Men of Science.

My most significant publications are:

Basal Metabolism in Health and Disease, Lea and Febiger, Philadelphia, 1924 (now out of print and missing in most libraries).

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I am glad to see that you are trying to get work for the older physiologists, and wish you every success.

Sincerely yours,

Eugene

EFDB:BG

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\*These monographs are used at the Summer Teaching Workshop for College teachers. The monographs are the property of the APS Education Committee and are under the supervision of Dr. H. W. Schoenborn, Univ. of Maryland.

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## NEW INSTRUMENTS FOR PHYSIOLOGISTS

Almost all new ideas for instrumentation originate in the laboratory rather than in the design rooms of producing companies, a fact which manufacturers gladly admit. This is the way it should be. The invention of a new gadget or a novel technique involving the development of complex apparatus signifies that it was devised because it was needed and a certain good market is almost assured because other investigators are working in similar areas of research. However, there is hardly a scientist who has labored to develop a new instrument who has not experienced the same fate for his brain child when it became commercially available: what he put together for a trivial sum, with paper and string, so to speak, now has a frightening price tag attached to it. Moreover, the same apparatus which responded perfectly to his every touch, when produced by well-equipped machine shops and electronic assembly lines, develops obstinate "bugs" and the first units simply refuse to perform properly. These consequences, too, are inevitable. The price problem is a complex one but compared to the matter of performance is secondary. Sufficient to say, most manufacturers are realistic and intelligent in their pricing policies, for obvious reasons of competition, if for no other. The inventor, who usually equates his own labor with zero, often fails to appreciate the expense of systematic production





and marketing. What is more important, the bugs which appear when the instrument moves from laboratory to factory underscore the technical mishaps which must appear in the transfer. The kinship with the instrument, developed in the lab with a single unit whose every bolt and mood is familiar to the inventor, must now be transferred to many engineers and technicians producing whole batches of the apparatus. This process takes time and in the meantime the purchasing scientist must weigh his needs with his courage. The instruments described below are in just such a twilight stage. Some, such as the Fetal Heart-Beat Monitor, are not yet in production, but should be pursued by inquiries to both experimental users and the prospective manufacturer. Others, like the Systolic Monitor, are quite proven out in several institutions and are probably past the guinea pig period. Some were on exhibit for the first time at the recent Federation meeting.

Continuous Systolic Monitor. An ingenious and inexpensive instrument which should be highly useful in pediatrics research and in operating and recovery rooms, as well as in pharmacology and in animal studies, this completely automatic system accurately measures the systolic blood pressure by the indirect method. The operation of the Systolic Monitor requires only the application of a digit cuff and a highly sensitive pickup to the subject's finger. Pressure in the cuff is then maintained at the systolic level by means of a servo-mechanism. This pressure is continuously indicated on the manometer and can be recorded when a permanent record is desired. Because the digit cuff is not completely around the finger, a pathway is maintained open for blood to flow back to the heart. Thus digital systolic pressures may be measured for periods of one hour or longer without releasing the cuff pressure. A rare and well-designed accessory for the Monitor, which the writer had occasion to examine in the manufacturer's laboratory, is a pneumatic recorder, with a 5-inch paper width and rectilinear coordinates.

Fetal Heart-Beat Monitor. The isolation of the fetal heart beat from the surrounding electronic noise caused by interference with maternal organs has long posed a challenge to design-minded physiologists and anesthesiologists. Tachometer gadgets were found to be unnecessarily complex and unreliable. What may prove to be the first consistently successful instrument has now been developed along lines of fetal electrocardiography. At the Winnipeg General Hospital, Winnipeg, Canada, a special EEG channel was employed with a short time constant for recording the fetal electrocardiogram. It is reported that with this single modification satisfactory results were obtained with no difficulty in approximately 75 per cent of deliveries. According to the originator of the unit, a nurse can be instructed to operate the apparatus in about two hours.

Apparatus for Blood O<sub>2</sub> and CO<sub>2</sub> Determination. Many investigators are familiar with the brilliant and original work done by John W. Severinghaus in this field during his stay at the National Institutes

of Health. In several labs individual workers have successfully reproduced the units described in great detail in a paper written by Severinghaus and Bradley. In each instance, however, the project was fraught with many uncertainties. The instrument consists of a miniature thermostatted water bath, in which are immersed the oxygen and carbon dioxide electrodes, a tonometer, and a gas humidifier. A null-balance meter and a highly sensitive pH meter or vibrating reed electrometer measures the response of the electrodes. Severinghaus, now in California, is working on an improved  $O_2$  electrode, a more stable amplifier, and an electrometer capable of reproducing measurements of 0.00325 pH units.

The apparatus is actually two instruments in one and it does not need a prophet to foresee that by use of the polarographic method common to the two systems the standard techniques of Warburg, Haldane, Scholander and Van Slyke will take second place for speed and accuracy in a great many applications. At the present time one manufacturer has already placed the instrument on the market and another is about to do so.

U.V. Absorption Meter for Proteins. Although the demand for monitoring equipment has in the past been for the 2537 Angstrom range for nucleotides, an increasing need has been expressed for making measurements of protein absorption in the 2800 to 3100 band. The easy availability of germicidal lamps as light sources and a simple nickel sulfate filtering system account for the early appearance of highly efficient commercially produced U.V. recording meters for studying the absorption of nucleotides. Until now anyone interested in the U.V. absorption of proteins had the choice of giving up his interest or of making his own rig, consisting of an expensive monochromator, amplifier and a narrow band filter arrangement. Thanks to some diligent experimentation on the part of Robert Woodworth of the National Institutes of Health, a simple and effective instrument will now accomplish the same results. The manufacturer's special contribution to Dr. Woodworth's design is an interchangeable light source and filter for doing absorption work with either proteins or nucleotides.

Multi-Membrane Analyzer. An entire category of analytical instruments could be set aside for the separation of macromolecules, few of them simple and none inexpensive. A good instrument combining both virtues would have to be designed by an outstanding physical chemist who carried on research in a medical school located in a state not known for its great wealth. That exactly describes the scientist who elaborated a device which utilizes lucite rings and easily obtained pore-size filters to separate peptides, proteins, polysaccharides and other large-weight molecules. The separation effect, due to differences in the retention factor for two substances, is enhanced with each additional membrane. An air bubble, which is unavoidably left in filling each compartment between two membranes, acts as a stirrer when the assembled unit is rotated at an angle.

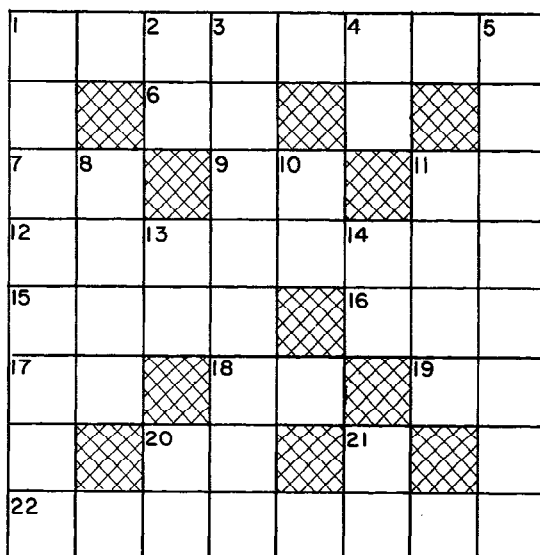
The commercially manufactured apparatus will separate substances from a fraction of a milliliter to 10 ml.

**Dialystat.** Dialysis is perhaps the crudest and most widely used procedure in almost every chemistry and physiology laboratory. Practically all dialyzing is carried out merely by pouring the sample into a length of Visking sausage casing, tying both ends, and throwing the inflated casing into a jar of water or other buffer. However, if one dialyzes a sample with a view to analytical findings, as for example to know well in advance exactly when the Donnan equilibrium point will be reached or how to avoid diluting the sample by a back-flow of excess hydroxyl ions, one must do better. The scientist mentioned above has also designed a straightforward mechanism which by shearing action of the sample at the buffer level creates the ideal conditions for complete dialysis. Several analytical cells, or as many as 20 cells for routine dialysis against individual buffers, can be accommodated in the same apparatus. If the pilot model is a basis for estimating the price, the instrument will be not only the best but the most economical dialyzing unit for research and routine work.

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Address a post card to New Instruments for Physiologists,  
American Physiological Society, 9650 Wisconsin Avenue,  
Washington 14, D.C., for further information about any item  
described above.

## CROSSWORD PUZZLE



## ACROSS

1. Second President of APS
6. Prefix meaning not
7. Preposition
9. Officer of the day
11. Node or bundle
12. Embryonic stage
15. Public disturbance
16. Large barrel
17. Indefinite article
18. Type of injection
19. Therefore
20. Half a printer's measure
22. A malignant disease

## DOWN

1. Muscle recorder
2. Musical note
3. A time changed by heparin
4. Printer's measure
5. Lifting muscles
8. Well-pleased
10. Title of 1 across
11. Expression of sorrow
13. Therefore
14. Type of rays
20. A redactor
21. Dr. Gregory to speak before this Section