CONTENTS

APS MEMBERSHIP STATUS

September 1969

Active Members	3259
Retired Members	186
Honorary Members	17
Associate Members	296
	3758

DECEASED MEMBERS

The following deaths were reported since the 1969 Spring Meeting.

Rafael Domingues - 11/21/67
Carl M. Herget - 4/24/69
Raul Hernandez-Peon - 4/16/68
Charles P. Huttrer - 5/30/69
Theophile K. Kruse - 3/26/69
Jacob Markowitz - 1/29/69
Elaine P. Ralli - 10/6/68
J. Walter Wilson - 5/10/69

NEWLY ELECTED MEMBERS

The following, nominated by the Council, were elected to membership in the American Physiological Society at the Fall Meeting, 1969.

FULL MEMBERS

ALEDORT, Louis M.: Asst. Prof. Med., Mt. Sinai Sch. Med., N.Y.
ARMSTRONG, Clay M.: Asst. Prof. Physiol., Duke Med. Ctr., Durham, N.C.
BAILEY, Richard E.: Assoc. Prof. Med., Univ. Oregon, Portland
BANERJEE, Mukul R.: Asst. Prof. Anat. & Physiol., Indiana Univ., Bloomington, Ind.
BEACHAM, William S.: Asst. Prof. Physiol. & Biophys., Washington Univ., St. Louis, Mo.
BELKIN, Daniel A.: Asst. Prof. Physiol., Univ. of Florida, Gainesville.
BENTLEY, David R.: Asst. Prof. Zool., Univ. of California, Berkeley
BEYER, Carlos: Head, Neuroendocrinol., Inst. Mexicano del Seguro Social
BLOUNT, Don H.: Head, Physiol., Melpar, Inc., Springfield, Va.
BOULPAEP, Emile L.: Asst. Prof. Physiol., Cornell Univ. Med. Coll.
BOWIE, Walter C.: Prof. Physiol. & Pharmacol., Tuskegee Inst., Ala.
BREITENBACH, Robert P.: Prof. Zool., Univ. of Missouri, Columbus
BRENNER, Barry M.: Sr. Invest., Kidney & Electrolyte Metabolism, NIH
BURGESS, John H.: Asst. Prof. Med., McGill Univ., Montreal, Canada
BURKE, Robert E.: Res. Assoc., Lab. Neural Control, NINDS, NIH
BUSH, Francis M.: Asst. Prof. Anat., Med. Coll. of Virginia, Richmond
BUTLER, Robert A.: Asst. Prof. Anesthesiol., Univ. Pennsylvania, Philadelphia
CANDIA, Oscar A.: Assoc. Prof. Ophthalmol., 100th St. & Flower Ave., New York
CIRKSENA, William J.: Chief, Exptl. Nephrol., Walter Reed Army Inst. Res., Washington, D.C.

COHEN, Peter J.: Assoc. Prof. Anesthesiol., Univ. of Pennsylvania Hospital, Philadelphia
COOPER, Gary P.: Asst. Prof. Physiol., Univ. of Cincinnati Med. Sch.
COSTANTIN, LeRoy L.: Asst. Prof. Physiol., Coll. P & S., New York
CRAWFORD, Eugene C.: Asst. Prof. Zool., Univ. Kentucky, Lexington
CSERR, Helen F.: Instr. Physiol., Children's Hosp., Boston
CURRY, Donald L.: Asst. Res. Physiologist, Univ. of California Med. Ctr., San Francisco
DARIAN-SMITH, Ian: Assoc. Prof. Physiol., Johns Hopkins Med. Sch., Baltimore
DAWSON, Arthur D.: Assoc. Cardiopul. Div., Scripps Cl. & Res. Fndn., La Jolla, Calif.
DESJARDINS, Claude: Asst. Prof. Physiol. & Pharmacol., Oklahoma State Univ.
DIGBY, Peter S. B.: Prof. Zool., McGill Univ., Montreal, Canada
DRABKIN, David L.: Em. Prof. Biochem., Univ. of Pennsylvania
DUARTE, Cristobal G.: Asst. Prof. Physiol., VA Hosp., New Orleans
EISNER, Gilbert M.: Asst. Prof. Med., Georgetown Univ. Hosp., Washington, D. C.
FEDDE, Marion R.: Assoc. Prof. Physiol., Kansas State Univ., Manhattan
FOX, Stephen S.: Assoc. Prof. Psychol., Univ. Iowa, Iowa City
FRANTZ, William L.: Assoc. Prof. Physiol., Michigan State Univ., East Lansing
FRIEDMAN, William F.: Asst. Prof. Cardiol., Univ. of California, La Jolla
GAAR, Kermit A.: Asst. Prof. Physiol. & Biophys., Univ. of Miss., Jackson
GANS, Carl: Prof. Biol., State Univ. of New York at Buffalo
GERSHON, Michael D.: Asst. Prof. Anat., Cornell Univ. Med. Coll.
GOLDBERG, Alfred L.: Instr. Physiol., Harvard Med. Sch., Boston
GOLDBERG, Stanley J.: Asst. Prof. Cardiol., UCLA
GOMES, Wayne R.: Asst. Prof. Dairy Science, Ohio State Univ.
GONZALEZ, Carlos F.: Asst. Prof. Biophys., Mt. Sinai Sch. Med.
GORDON, Malcolm S.: Prof. Zool., Univ. of California, Los Angeles
GORNALL, Allan G.: Prof. Pathol. Chem., Univ. of Toronto, Canada
GREEN, Keith: Asst. Prof. Ophthalmol., Johns Hopkins Sch. Med.
GREENE, James A.: Assoc. Prof. Int. Med., Univ. Hosp., Ann Arbor
GREENLEAF, John E.: Res. Physiologist, Ames Res. Ctr., Moffett Field, Calif.
GUTKNECHT, John W.: Res. Assoc. Physiol. & Pharmacol., Duke Univ., Durham
HAINSWORTH, Fenwick, R.: Asst. Prof. Zool., Syracuse Univ., Ithaca
HILL, Robert B.: Assoc. Prof. Zool., Univ. of Rhode Island, Kingston
HOCHWALD, Gerald M.: Asst. Prof. Neurol., New York Univ. Med. Ctr.
HOEBEL, Bartley G.: Assoc. Prof. Psychol., Princeton Univ., Princeton, N.J.
HOLLENBERG, Milton: Assoc. Prof. Med., Univ. of Calif. Med. Ctr., San Francisco
HONG, Suk Ki: Prof. Physiol., Univ. of Hawaii, Honolulu
HSIEH, Arnold C. L.: Assoc. Prof. Human Physiol., Univ. California, Davis
HULL, Chester D.: Assoc. Res. Anatomist, Sch. Med., UCLA

HUMPHREY, Donald R.: Res. Physiologist, Lab. Neural Control, NIH
HUTCHISON, Victor H.: Prof. Zool., Univ. of Rhode Island, Kingston
IANNONE, Anthony M.: Prof. Neurol., Med. Coll. Ohio, Toledo
ISAACSON, Robert L.: Prof. Psychol., Univ. of Florida, Gainesville
JACKLET, Jon W.: Asst. Prof. Biol. Sciences, State Univ. of New York at Albany
JACKSON, Michael J.: Asst. Prof. Physiol., Geo. Washington Univ., Washington, D. C.
JEFFERSON, Leonard S.: Asst. Prof. Physiol., Milton Hershey Med. Ctr., Hershey, Pa.
KARPATKIN, Simon: Asst. Prof. Med., New York Univ. Sch. Med.
KAWAMURA, Hiroshi: Chief, Neurophysiol. & Neuropharmacol., Lafayette Clinic, Detroit
KAYE, Michael P.: Asst. Prof. Physiol., Loyola Univ., Hines, Ill.
KERR, Frederick W. L.: Assoc. Prof. Neurol. Surg., Mayo Clinic
KRAGT, Clifford L.: Asst. Prof. Physiol., San Francisco Med. Ctr., San Francisco
KRASNEY, John A.: Instr. Physiol., Albany Med. Coll. of Union Univ., Albany
LASIEWSKI, Robert C.: Assoc. Prof. Zool., Univ. Calif., Los Angeles
LENNON, Edward J.: Prof. Med., Marquette Sch. Med., Milwaukee
LIEBERMAN, Edward M.: Asst. Prof. Physiol., Bowman Gray Sch. Med., Winston-Salem
LICKEY, Marvin E.: Asst. Prof. Psychol., Univ. of Oregon, Eugene
LIND, Alexander R.: Assoc. Prof. Med., Indiana Univ., Dayton, Ohio
LIU, Ching-Tong: Asst. Prof. Physiol., Baylor Univ., Houston, Texas
LONGO, Lawrence D.: Assoc. Prof. Physiol., Loma Linda Univ., Calif.
McCOOK, Robert D.: Asst. Prof. Physiol., Loyola Univ., Hines, Ill.
McHUGH, Paul R.: Assoc. Prof. Neurol., Cornell Med. Ctr., White Plains, N. Y.
MEDWAY, William: Prof. Clinical Studies, Vet. Med., Univ. of Pennsylvania
MELLINS, Robert B.: Asst. Prof. Pediat., Columbia Univ., New York
MELLON, DeForest, Jr.: Assoc. Prof. Biol., Univ. of Virginia, Charlottesville
MENDELL, Lorne M.: Asst. Prof. Physiol., Duke Univ. Med. Ctr., Durham
MERYMAN, Harold T.: Asst. Res. Director, Am. Red Cross Res. Lab., Bethesda, Md.
MILLER, Donald M.: Asst. Prof. Physiol., Southern Illinois Univ., Carbondale
MILLER, L. Keith: Asst. Prof. Physiol., Univ. of Alaska, College, Alaska
MILLER, Leonard D.: Assoc. Prof. Surg., Univ. Pennsylvania Hosp.
MILLS, Kenneth S.: Prof. Zool., Univ. of Oklahoma, Norman
MITTMAN, Charles: Dir., Resp. Dis. Dept., City of Hope Med. Ctr., Duarte, Calif.
MORRILL, Gene A.: Asst. Prof. Physiol., Albert Einstein Coll. Med.
MOSCHOS, Christos B.: Asst. Prof. Med., New Jersey Coll. Med. & Dent., Jersey City
MULVEY, Philip F., Jr.: Res. Physiologist, US Army Res. Inst., Natick
MURPHY, Richard A.: Asst. Prof. Physiol., Univ. of Virginia

NEELY, James R.: Asst. Prof. Physiol., Milton Hershey Med. Ctr., Hershey, Pa.
NICHOLLS, John G.: Assoc. Prof. Neurobiol., Harvard Med. Sch.
NIEMETZ, Julian: Asst. Prof. Med., VA Hosp., Bronx, N.Y.
NOLASCO, Jesus B.: Assoc. Prof. Physiol., New Jersey Coll. Med. & Dent., Jersey City
NYSTROM, Richard A.: Assoc. Prof. Biol. Sci., Univ. of Delaware
PARSONS, Rodney L.: Asst. Prof. Physiol., Univ. of Vermont, Burlington
PEKAS, Jerome C.: Res. Physiologist, Metab. & Radiation Res. Lab. Fargo, N.D.
PFEIFFER, Egbert W.: Prof. Zool., Univ. of Montana, Missoula
POULOS, Dennis A.: Asst. Prof. Physiol., Albany Med. Coll.
POWELL, William J., Jr.: Res. Fellow Cardiol., Mass. Gen. Hosp., Boston
POWER, Gordon G.: Res. Internist, Physiol. & Med., US Army Res. Inst., Natick
PRIOLA, Donald V.: Asst. Prof. Pharmacol., Univ. New Mexico, Albuquerque
PURI, Protpal: Asst. Prof. Med., Wayne State Univ., Detroit
RAY, Oakley S.: Assoc. Prof. Psychol. & Pharmacol., Univ. Pittsburgh
REINKE, David A.: Asst. Prof. Physiol. & Pharmacol., Michigan State Univ.
Rhodes, James B.: Asst. Prof. Med., Univ. of Kansas Med. Ctr., Kansas City
RIEDER, Ronald F.: Asst. Prof. Med., State Univ. of New York, Downstate Med. Ctr., Brooklyn
RIVLIN, Richard S.: Asst. Prof. Med., Columbia Univ., New York
ROBBINS, Norman: Vis. Sci., Lab. Neurophysiol., NIH, Bethesda
ROYCE, Paul C.: Asst. Prof. Med., Albert Einstein Coll. Med.
RUBINSTEIN, Eduardo H.: Asst. Prof. Physiol., UCLA
RUDOMIN, Pedro N.: Prof. Physiol., Ctr. Res. & Adv. Studies, Mexico, & NIH, Bethesda
SCHWARTZ, Arthur S.: Chief, Lab. Physiol. Psychol., Barrow Neurol. Inst., Phoenix
SCHILB, Theodore P.: Asst. Prof. Biophys. Chem., Mt. Sinai Sch. Med., N.Y.
SCOTT, Walter N.: Asst. Prof. Biophys. Chem., Mt. Sinai Grad. Sch.
SENFT, Joseph P.: Asst. Prof. Physiol., Nelson Biol. Labs., Rutgers Univ.
SHEPRO, David: Prof. Vascular Physiol., Boston Univ., Boston
SHOEMAKER, Richard L.: Asst. Prof. Physiol., Univ. Alabama Med. Ctr., Birmingham
SIMPSON, David P.: Asst. Prof. Med., Univ. of Washington, Seattle
SKIPSKI, Vladimir P.: Asst. Prof. Biochem., Cornell Univ., Sloan-Kettering Inst.
SLOTKOFF, Lawrence M.: Asst. Prof. Physiol., Georgetown Univ., Washington, D.C.
SMITH, Theodore C.: Asst. Prof. Anesthesia, Hosp. Univ. Pennsylvania
SNIPES, Charles A.: Asst. Prof. Physiol., Hahnemann Coll. Med., Philadelphia
SPECTOR, N. Herbert: Asst. Prof. Physiol., Medical Coll. of Virginia, Richmond

STEINER, George: Asst. Prof. Physiol., Univ. of Toronto, Canada
STRICKHOLM, Alfred: Assoc. Prof. Physiol., Indiana Univ., Bloomington
STREIDER, Denise J.: Asst. Med., Mass. Gen. Hosp., Boston
TARR, Charles M.: Asst. Prof. Physiol., Univ. of Kansas Med. Ctr.
THEILEN, Ernest O.: Prof. Int. Med., Univ. of Iowa, Iowa City
TORDA, Clara: Assoc. Cl. Prof., State Univ. of New York, Downstate Med. Ctr., New York
VORHERR, Helmuth W.: Assoc. Prof. Ob-Gyn. & Pharmacol., Univ. of New Mexico, Albuquerque
WATLINGTON, Charles O.: Asst. Prof. Med., Medical Coll. of Virginia, Richmond
WEINSTEIN, Stephen A.: Assoc. Prof. Environ. Med., Johns Hopkins Univ.
WEST, George C.: Prof. Zoophysiol., Univ. of Alaska, College, Alaska
WOODY, Charles D.: Res. Officer, Lab. Neural Control, NIH
WORTHINGTON, Ward C.: Prof. Anat., Med. Coll. of South Carolina, Charleston
WRIGHT, Fred S.: Instr. Physiol., Yale Sch. Med., New Haven, Conn.
ZAWOISKI, Eugene J.: Asst. Prof. Physiol., Jefferson Med. Coll., Philadelphia
ZELIS, Robert F.: Chief, Lab. Cl. Physiol., Univ. California, Davis

ASSOCIATE MEMBERS

BECKMAN, David L.: Assoc. Res. Physiologist, Univ. of Michigan
CHEY, William Y.: Assoc. Prof. Med., Temple Univ., Philadelphia
EDDY, Richard L.: Dept. Endocrinol. & Physiol., Scott & White Cl., Temple, Texas
ERASMUS, Beth DeWet: Instr. Physiol., State Univ. of New York at Buffalo
FARIDY, Edmund E.: Asst. Prof. Physiol., Univ. of Manitoba, Canada
FRANZ, Gunter N.: Asst. Prof. Physiol. & Biophys., West Virginia Univ., Morgantown
GOODRICH, Cecilie A.: Res. Fellow Anat., Harvard Medical School
HARDIN, Carolyn M.: Asst. Res. Physiol., George Washington Univ. Washington, D. C.
HERMSMEYER, Ralph K.: Postdoctoral Fellow Physiol., Univ. of Virginia, Charlottesville
HOGAN, Perry M.: Instr. Physiol., State Univ. of New York at Buffalo
HOLMES, Mary O.: Asst. Prof. Biol., Beaver Coll., Philadelphia
LEITCH, Gordon J.: Vis. Prof. Physiol., Rockefeller Fndn., Bangkok, Thailand
LILES, Samuel L.: Instr. Physiol., Louisiana State Univ., New Orleans
LIPMAN, Ralph I.: Postdoctoral Trainee Physiol., Geo. Washington Univ., Washington, D. C.
LOWENSOHN, Howard S.: Res. Physiologist, Walter Reed Army Inst. Res., Washington, D. C.
MAGNO, Michael G.: Instr. Physiol., Albany Med. Coll., Albany
MAJEAU, Deborah A.: Instr. Physiol., L.S.U. Med. Ctr., New Orleans
MILLER, David T.: NIH Predoct. Fellow Physiol., Univ. of Virginia Charlottesville
NELSON, Curtis N.: Grad. Student Physiol., Univ. of Rochester
PACE, John B.: Instr. Physiol., Loyola Univ., Hines, Ill.

PONESSA, Joseph T.: Postdoct. Fellow Physiol., Hahnemann Med. Coll., Philadelphia
ROBERTS, Jane C.: Grad. Student, Dept. Biol. Sci., Univ. California, Santa Barbara
ROLF, Lester L., Jr.: Grad. Asst. Physiol. & Pharmacol., Vet. Med., Texas A & M Univ.
RUH, Mary F.: Doct. Candidate Physiol., Marquette Univ., Milwaukee
RUH, Thomas S.: Doct. Candidate Physiol., Marquette Univ., Milwaukee
SAMMON, Patrick, J.: Postdoct. Trainee Physiol., Univ. of Louisville
SIEGMAN, Marion J.: Asst. Prof. Physiol., Jefferson Med. Coll., Philadelphia
SPEEG, Kermit V., Jr.: Res. Assoc. Biol., Rice Univ., Houston
STEINBERG, Roy H.: Head Neurophysiol. Br., Naval Aerospace Med. Ctr., Pensacola
VAN HORN, Diane L.: Instr. Physiol., Marquette Sch. Med., Milwaukee
VOGEL, Thomas T.: Hartford Fellow Surg., Ohio State Univ. Hosp., Columbus
VOIGHT, Roger W.: Grad. Student Biol., Univ. Alabama Med. Ctr.
WIEDMEIER, V. Thomas: Instr. Physiol., Marquette Sch. Med.
ZAJAC, Felis E. III: Staff Assoc., Lab. Neural Control, NIH
ZAUNER, Christian W.: Assoc. Prof. Phys. Ed., Univ. Florida, Gainesville
ZORNITZER, Abraham E.: Postdoct. Fellow Physiol & Biophys., Univ. of Louisville

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THE AMERICAN PHYSIOLOGICAL SOCIETY

Founded December 30, 1887; Incorporated June 2, 1923

OFFICERS 1969-1970

President - C. Ladd Prosser, University of Illinois, Urbana, Illinois
President-Elect - A. C. Barger, Harvard University Medical School, Boston, Massachusetts
Past-President - Loren D. Carlson, University of California Medical School, Davis, California
Council - C. L. Prosser (1971), A. C. Barger (1972), L. D. Carlson (1970), D. C. Tosteson (1973), E. Knobil (1972), H. D. Patton (1971), J. R. Brobeck (1970)
Executive Secretary-Treasurer - Ray G. Daggs, 9650 Rockville Pike, Bethesda, Maryland 20014

STANDING COMMITTEES

Publications - D. S. Fredrickson (1972), Chairman; P. F. Curran (1972), J. Mead (1971). Ex officio - J. R. Brobeck, Physiological Reviews; J. M. Brookhart, Journal of Neurophysiology; A. P. Fishman, Handbooks; R. G. Daggs, Executive Secretary-Treasurer; Sara F. Leslie, Publications Manager and Executive Editor; S. R. Geiger, Executive Editor for Handbooks
Finance - J. M. Brookhart (1970), Chairman; E. E. Selkurt (1972), R. M. Berne (1971). Ex officio - R. G. Daggs, Executive Secretary-Treasurer; W. A. Sonnenberg, Business Manager
Education - A. C. Guyton (1970), Chairman; A. R. Dawe (1971), L. E. McDonald (1971), W. C. Randall (1970), J. A. F. Stevenson (1970); Representatives from the Society of General Physiologists - I. J. Deyrup-Olsen (1970), J. W. Green (1970); Representatives from the Comparative Physiology Division of the American Society of Zoologists - G. C. Stephens (1972), I. J. Deyrup-Olsen (1971); R. G. Daggs, Executive Director of Education Programs
Membership Advisory - J. B. Preston (1971), Chairman; E. Knobil (1972), L. E. Farhi (1971), G. F. Cahill (1970), I. S. Edelman (1970), C. Eyzaguirre (1970)
Program Advisory - H. D. Lauson (1971), Chairman; F. F. Jobsis (1972), N. B. Schwartz (1970)
Public Affairs - R. E. Forster (1970), Chairman; R. K. Crane (1970), B. F. Hoffman (1970)
Senior Physiologists - D. B. Dill (1971), Chairman; H. Davis (1972), H. E. Essex (1972), E. M. Landis (1971)
Perkins Memorial Fund - J. R. Pappenheimer (1974), Chairman; H. Rahn (1974), J. R. Brobeck (1970), R. E. Forster (1970). Ex officio - R. G. Daggs, Executive Secretary-Treasurer
Porter Physiology Development Program - A. C. Barger (1971) and E. W. Hawthorne (1971), Co-chairmen; C. Russ (1972), D. F. Opdyke (1971), E. P. Radford, Jr. (1971), H. E. Morgan (1970), A. B. Otis (1970)

Legal Counsel - W. H. Pattison, Jr.

REPRESENTATIVES TO OTHER ORGANIZATIONS

Federation Board - A. C. Barger (1972), C. L. Prosser (1971), L. D. Carlson (1970)
Federation Executive Committee - L. D. Carlson (1970)
Federation Public Affairs Committee - R. E. Forster (1970)
Federation Public Information Committee - C. S. Tidball (1970)
Federation Long Range Planning Committee - D. C. Tosteson (1972)
Federation Proceedings Editorial Committee - E. M. Landis (1970)
U. S. National Committee for International Union of Physiological Sciences - J. M. Brookhart (1975), A. C. Barger (1975), L. D. Carlson (1973), R. E. Forster (1972)
U. S. National Committee for International Union of Biological Sciences - E. Knobil (1973)
U. S. National Committee for International Union of Pure and Applied Biophysics - A. P. Gagge (1973)
U. S. National Committee for Engineering in Medicine and Biology - M. L. Wolbarsht (1975)
National Research Council, Division of Biology and Agriculture - D. K. Detweiler (1970); Division of Medical Sciences - N. W. Shock (1970)
American Association for the Advancement of Science - W. G. Van der Kloot (1970), R. G. Daggs
National Society for Medical Research - B. J. Cohen (1970)
American Society for Information Science - Sara F. Leslie (1970)
Council on Medical Education and Hospitals of the AMA - D. C. Tosteson (1970)
Council of Academic Societies of the Association of American Medical Colleges - R. E. Forster (1973), A. B. Otis (1971)

PUBLICATIONS

Publications Committee - D. S. Fredrickson (1972) Chairman; P. F. Curran (1972), J. Mead (1971)
Publications Manager and Executive Editor - Sara F. Leslie
American Journal of Physiology and Journal of Applied Physiology Section Editors - D. F. Bohr, T. Cooper, W. C. Randall (Circulation); L. E. Farhi, S. Permutt (Respiration); W. B. Kinter, E. E. Windhager (Renal and Electrolyte); O. D. Ratnoff (Hematology); P. F. Curran (Gastrointestinal); B. R. Landau, F. E. Yates (Fndocrinology and Metabolism); J. D. Hardy (Environmental); C. L. Prosser (Comparative and General); D. P. Purpura (Neurophysiology)
Journal of Neurophysiology - J. M. Brookhart, Chief Editor
Physiological Reviews - J. R. Brobeck, Chairman Editorial Board; E. Neil, Chairman European Committee; R. G. Daggs, Associate Editor
Handbooks of Physiology - A. P. Fishman, Chairman Editorial Committee; S. R. Geiger, Executive Editor
The Physiologist - R. G. Daggs, Editor

PAST OFFICERS

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

Howell. 1911-1913 S. J. Meltzer. 1914-1916 W. B. Cannon. 1917-1918 F. S. Lee. 1919-1920 W. P. Lombard. 1921-1922 J. J. R. MacLeod. 1923-1925 A. J. Carlson. 1926-1929 Joseph Erlanger. 1930-1932 W. J. Meek. 1933-1934 A. B. Luckhardt. 1935 C. W. Greene. 1936-1937 F. C. Mann. 1938-1939 W. E. Garrey. 1938 W. T. Porter Honorary President. 1940-1941 A. C. Ivy. 1942-1945 Philip Bard. 1946-1947 W. O. Fenn. 1948 M. B. Visscher. 1949 C. J. Wiggers. 1950 H. C. Bazett (April to July); D. B. Dill. 1951 R. W. Gerard. 1952 E. M. Landis. 1953 E. F. Adolph. 1954 H. E. Essex. 1955 W. F. Hamilton. 1956 A. C. Burton. 1957 L. N. Katz. 1958 Hallowell Davis. 1959 R. F. Pitts. 1960 J. H. Comroe, Jr. 1961 H. W. Davenport. 1962 H. S. Mayerson. 1963 Hermann Rahn. 1964 J. R. Pappenheimer. 1965 J. M. Brookhart. 1966 R. E. Forster. 1967 R. W. Berliner. 1968 L. D. Carlson.

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

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

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

CONSTITUTION AND BYLAWS

CONSTITUTION

(Adopted at the 1953 Spring Meeting)

ARTICLE I. Name

The name of this organization is THE AMERICAN PHYSIOLOGICAL SOCIETY.

ARTICLE II. Purpose

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

BYLAWS

(Amended April 1966)

ARTICLE I. Principal Office

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

ARTICLE II. Corporate Seal

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

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

ARTICLE III. Membership

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

SECTION 2. Regular Members. Any person who as conducted and published meritorius original research in physiology, who is presently engaged in physiological work, and who is a resident of North America shall be eligible for proposal for regular membership in the Society.

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

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

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

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

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

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

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

ARTICLE IV. Officers

SECTION 1. Council. The management of the Society shall be vested in a Council consisting of the President, the President-Elect, the immediate Past-President, and four other regular members. The terms of the President and of President-Elect shall be one year. The terms of the four additional Councilors shall be four years each and they shall not be eligible for immediate reelection except those who have served for two years or less in filling interim vacancies.

A quorum for conducting official business of the Society shall be five of the seven elected members of Council.

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

SECTION 2. President. A person shall serve only one term as President, except that if the President-Elect becomes President after September 30 he shall continue as President for the year beginning the next July 1. The President shall chair all sessions of the Council and business meetings of the Society and shall be an ex officio member of all committees without vote.

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

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

SECTION 5. Executive Secretary-Treasurer. The Council shall be empowered to appoint and compensate an Executive Secretary-Treasurer who shall assist it in carrying on the functions of the Society including the receipt and disbursement of funds under the direction of the Council. He shall be responsible for management of the Central Office of the Society under general supervision of the Council.

ARTICLE V. Standing Committees

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

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

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

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

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

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

ARTICLE VI. Dues

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

SECTION 2. Non-payment of dues. A regular or associate member whose dues are two years in arrears shall cease to be a member of the Society, unless after payment of his dues in arrears and application to the Council, he shall be reinstated at the next meeting by vote of the Council. It shall be the duty of the President-Elect to notify the delin-

quent of his right to request reinstatement.

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

ARTICLE VII. Financial

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

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

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

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

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

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

ARTICLE VIII. Publications

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

ARTICLE IX. Meetings

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

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

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

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

SECTION 5. Parliamentary Authority. The rules contained in Roberts Rules of Order, Revised shall govern the conduct of the business meetings of the Society in all cases to which they are applicable and in which they are not inconsistent with the Bylaws or special rules of order of the Society.

ARTICLE X. Society Affiliations

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

ARTICLE XI. Regulations

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

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

publishing or distributing of statements) any campaign on behalf of any candidate for public office.

d. The Society shall not be organized or operated for profit.

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

ARTICLE XII. General

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

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

ARTICLE XIII. Amendments

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

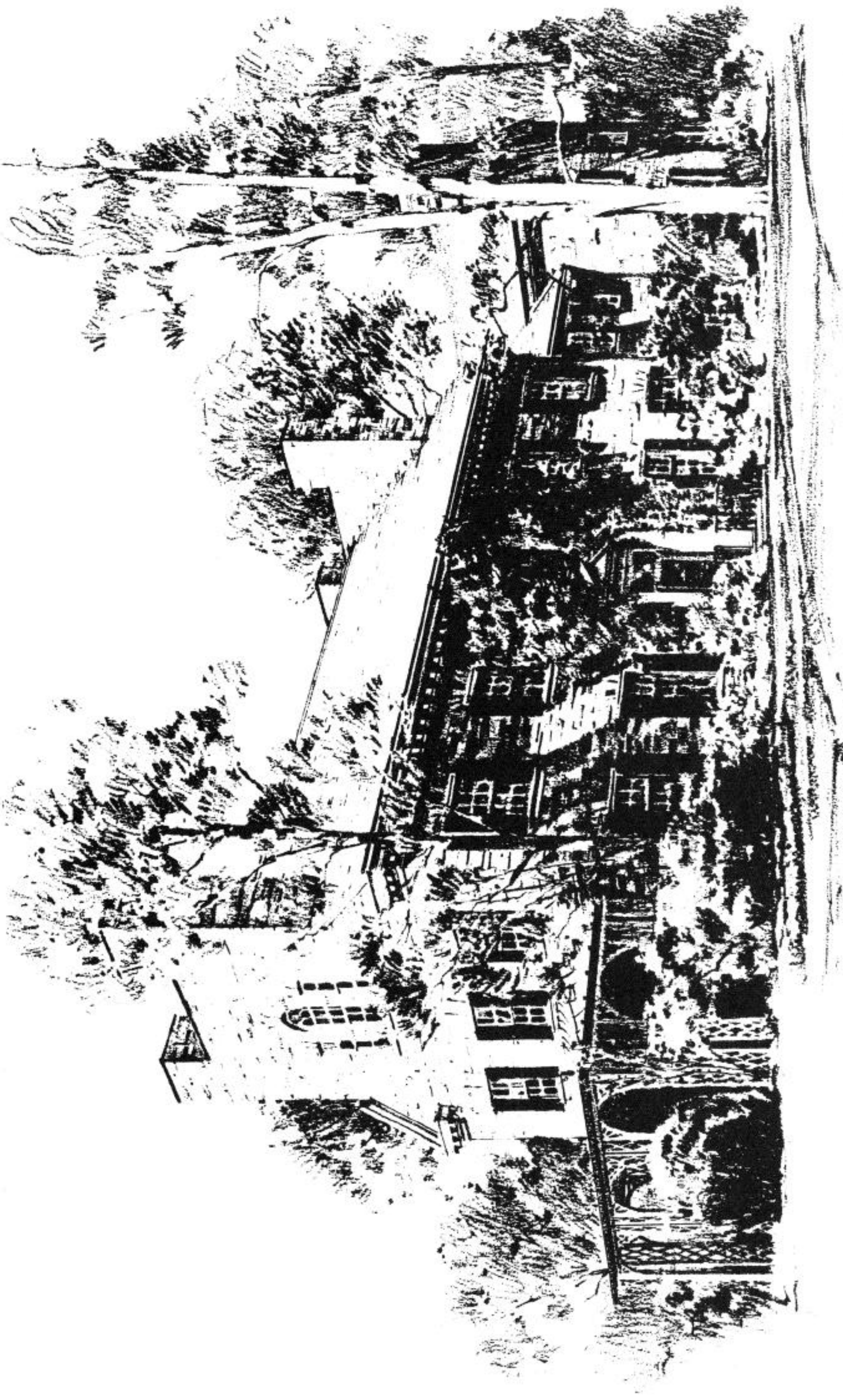
SECTION 2. Adoption. These Bylaws may be amended at any Spring business meeting of the Society by a two-thirds majority vote of the regular members present and voting.

BEAUMONT HOUSE

The picture on the opposite page is taken from an original sketch by the artist Mr. DeWitt Whistler Jayne of Fair Oaks, California. Prints of the original sketch, measuring 18 inches by 24-1/2 inches suitable for framing, are available from the APS office at $5.00 per copy. These are excellent reproductions. This print makes a fine addition to the composite pictures of Past-Presidents of APS for University Physiology Departments.

Beaumont House, a large private residence in Bethesda, Maryland, was originally purchased by the American Physiological Society and then turned over to the Federation as a home for all of the Federation societies. The APS had its offices in Beaumont House from 1955 to 1965 when, because of increased space requirements, the offices were moved to the new Lee Building on the same campus.

Beaumont House was named for William Beaumont, the army surgeon who in the early eighteen hundreds did experiments and made detailed observations on the gastric juice and the physiology of digestion, using the wounded French Canadian Alexis St. Martin as his subject. Sir William Osler in an address in 1902 said, "Beaumont is the pioneer physiologist of this country, the first to make an important and enduring contribution to this science."



BEAUMONT HOUSE
AMERICAN PHYSIOLOGICAL SOCIETY

AAAS - APS SYMPOSIUM
AAAS Meetings, Boston, Mass., Dec. 26-31, 1969

NEUROBIOLOGICAL SUBSTRATES OF BEHAVIOR
Arranged by R. G. GRENELL, Univ. of Maryland
and H. D. LERNER, Gordon and Breach, Wash., D. C.

MONDAY, Dec. 29 - War Memorial, Room 102

9:00 AM Chairman: D. W. BRONK

An Electrochemical Synaptic Switch in the Sensory Cortex. R. G. GRENELL and E. GUSTAVO, Univ. of Maryland Sch. of Med.

Synaptic Mechanisms in the Cerebral Cortex. D. PURPURA, Albert Einstein Coll. of Med.

Acetylcholine and the Cerebral Cortex. K. KRNJEVIC, McGill Univ.

CNS Integrative Mechanisms. M. A. B. BRAZIER, UCLA.

2:00 PM Chairman: R. G. GRENELL

Some Problems and Anatomical Aspects of Information Processing Beyond Primary Areas. W. NAUTA, M.I.T.

Psychophysical and Neurophysiological Correlations in Sensation. V. B. MOUNTCASTLE, Johns Hopkins Univ. Sch. of Med.

A Model of the Reticular Formation and its Relationship to Afferent Input. W. S. McCULLOCH, M.I.T.

Brain Research and Behavior. G. C. QUARTON, Univ. of Michigan.

Noteworthy advances have occurred recently in the theory and research on electrical, chemical, and other determinants of behavior advances that may have important implications for such fields as neurophysiology, molecular biology, biophysics, biochemistry, psychiatry, psychology, and pharmacology. In this symposium a number of developments will be summarized by key contributors to research on neurobiology and behavior. Data and models on sensory, cerebral, and integrative processes will be examined. The speakers will discuss interrelations among the various findings as well as significance for related disciplines and for public issues. APS members are encouraged to attend.

HANDBOOK OF PHYSIOLOGY: New Volumes

The success of the Handbook of Physiology, published by the American Physiological Society, is proven by the excellent reviews that have been received and by the continued sale* of the volumes (Fig. 1). Income from the sale of section 1 (Neurophysiology) has passed the cost of production and a profit is anticipated by sections 2 (Circulation) and 3 (Respitation) in 1969. Such profit can now be invested in the production of additional volumes.

Three new sections are in preparation: on renal physiology, endocrinology, and muscle. The renal physiology section will appear in one volume with Drs. R. W. Berliner and J. Orloff of the National Institutes of Health as section editors. The endocrinology section, in five volumes, is being guided by Dr. E. B. Astwood of the New England Medical Center Hospital in Boston and Dr. R. O. Greep of Harvard Medical School. The topics, editors, and co-editors of the endocrinology volumes are:

The Hypothalamo-Hypophyseal Complex	
The Adenohypophysis	E. Knobil (Univ. of Pittsburgh Sch. of Med.
The Neurohypophysis	W. Sawyer (Coll. Physicians & Surgeons, N.Y.)
The Thyroid and Parathyroid Glands	
Thyroid	M. Greer (Univ. of Oregon Med. Sch.) and D. H. Solomon (Harbor Gen. Hosp., Calif.)
Parathyroid	G. Aurbach (Natl. Insts. of Health)
The Adrenal Gland	
Adrenal Cortex	G. Sayers (Western Reserve Univ. Sch. of Med.)
Adrenal Medulla	H. Blaschko (Oxford) and A. D. Smith (Oxford)
The Reproductive System	
Female and Male Systems	R. O. Greep (Harvard Medical Sch.)
The Endocrine Pancreas	N. Freinkel (Northwestern Univ. Med. Sch.) and D. Steiner (Univ. of Chicago)

Drs. B. Abbott of the University of Southern California and A. Brady of the University of California, Los Angeles, will edit the section on muscle physiology.

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*Volumes of the Handbook may be purchased by members of the Society, from the Bethesda office of the Society at a 20% discount.

The Editorial Committee of the Handbook of Physiology, composed of Drs. A. P. Fishman (Chairman), J. M. Brookhart, G. F. Cahill, L. D. Carlson, and C. L. Prosser, has been responsible for inviting this distinguished group of section editors to participate in the continuation of the series.

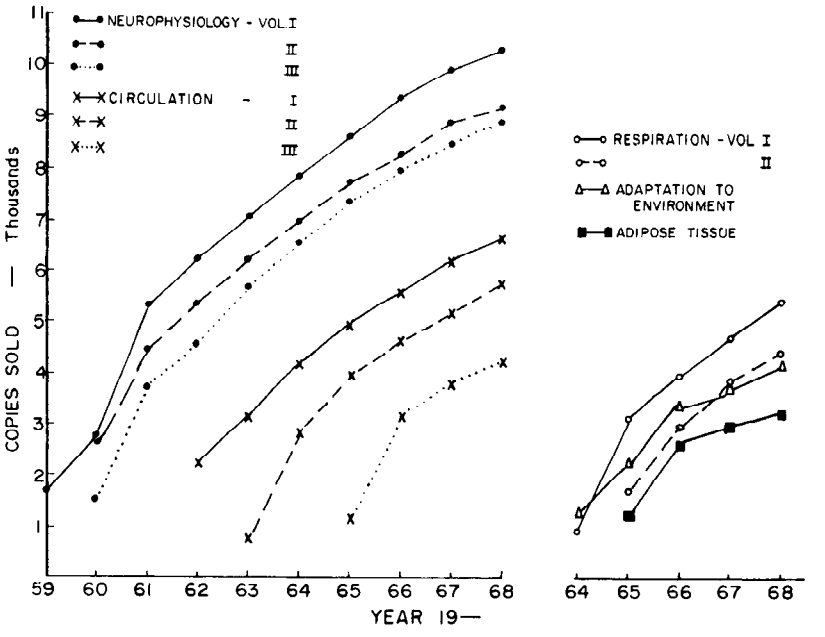


Fig.1. HANDBOOK OF PHYSIOLOGY: Cumulative Sales. Trends for section 6 (Alimentary Canal), published in 1967 and 1968, are not yet clear.

PAST-PRESIDENT'S ADDRESS
THE WAY OF AN INVESTIGATOR - REANALYZED

LOREN D. CARLSON

A year ago, at the International Physiological Congress, Cannon's The Way of an Investigator was the souvenir book, representing, in the IUPS-USNC view, the American Physiological way. The past year has given me cause to reassess certain aspects of the way.

For me to reanalyze Cannon's The Way of an Investigator is presumptuous because I have neither attained the status as an investigator which he enjoyed nor the time in life at which he reminisced and remarked on the subject. To establish my age, Cannon published his book the year I started teaching. However, I shall persist in this presumption since I believe that the image has changed and the milieu in which the investigator works is different. This is a matter of importance to physiologists.

Even though the Past President of the American Physiological Society was spared the opportunity of presenting his golden words of forecast or analysis last year due to the International Congress, a review of previous Presidential addresses demonstrates that these problems have been presented before and lends some force to the words with which the French philosopher Andre Gide once opened his lecture, "All this has been said before - but since nobody listened, it must be said again." I have no way of knowing if the audience listened to Gide.

Cannon's characterization of the "way" is illustrated in his table of contents. I want to "reanalyze" in the context of only a few of these chapters.

As a kind of syllogism (paraphrasing a recent article by Emilio Daedario) my theme can be stated:

1) Physiologists and their sphere are a miniscule part of an America that is faced today with new physical, biological, social and economic problems.

2) These problems will not be removed nor resolved without new methods and new approaches.

Editor's Note: The Past-President's address was accompanied by an ever changing series of background slides which served as an excellent backdrop for the points being made by the speaker. These slides, projected from a Kodak Carrousel Dissolve System, included both color photographs and cartoons. Dr. Carlson informed me that he is indebted to Dr. Barry Wilson for the slides of student and campus activities, to Mr. Hal Pullum for the cartoons and to Mr. Will Renner for his technical advice. The printed address loses much of its charm without the whole series of slides, which could not be reproduced here. Only a few have been included to illustrate the types of slides used.

3) Since we do not have either the methods or approaches, we must develop them through research - and physiologists and their sphere become a more important contributor (certainly less miniscule) in the solution phase.

4) This development and this research must be undertaken with a community of support, for the public funding requires public understanding or confidence. The public has always thought of science as a means of achievement and is still of that mind, but some want to say what will be achieved and to see it achieved.

There is an implicit assumption of relevance of research in the syllogism - an ability to determine the problem and resolve it. Cannon was characterized in a somewhat different way by his colleague Ralph Burton Perry who said of him, "he was a good prospector - he knew how to locate the veins of rich scientific ore - but he also knew how to refine the gold." The freedom to prospect for scientific ore is a privilege that requires vigorous and lucid defense in an era of applied research.

Alexis de Toqueville observed more than 100 years ago, "In aristocratic ages science is more particularly called upon to furnish gratification to the mind, in democracies to the body. Democratic nations, therefore, will habitually prefer the useful to the beautiful and they will require that the beautiful be useful." Is the world of Pappenheimer's "Bicycle in the Age of Jets" the fading of the vestiges of aristocratic science into democratic science?

Some time ago, Project Hindsight analyzed significant developments in regard to the events that produced them. The project determined that undirected research paid off in applications on a 30 to 60 year or more time scale. In the study, only 2 out of 92 events identified as science (in distinction to 638 events classified as technology) were found to come from basic academic research. While not widely publicized, I believe Project Hindsight had a subtle, if subliminal, effect on thinking in government. It established a requirement for the faster payoff, a direct problem-solution link.

Many years ago in London, a severe outbreak of cholera devastated the population. An English physician named John Snow had a hunch. He looked up the addresses of all the cholera victims and found that every one of them drew their drinking water from the same pump on Broad Street. Dr. Snow knew little of the nature of the cholera organism or how it transmitted the disease in the water. But he removed the handle of the Broad Street pump. And he stopped the epidemic.

-The problem was solved but not understood - an action relevant and applied enough to make politicians and the public content - but no explanation of mechanism.

Cannon correctly labeled his personal involvement in World War I as a parenthesis of war. Some of us entered and left World War II with the same hope of the containment of a parenthesis - that the recurrence of strife was a temporary insertion in our career but the final bracket of the parenthesis was not very stable; it tilted for the Korean War and was frozen off by the cold wars.

Being a citizen today still involves the perennial jousting with anti-vivisectionists that Cannon narrated but it is now more a matter of legislation and legislators. The question of being a citizen extends to participation in university affairs to help solve the current student revolt and to enter into the game of influencing government to support research. Our younger members represent a generation that is watching the end of the Industrial Era and the beginning of what Daniel Bell characterizes as the Post Industrial Society. Bell sees this as an academically oriented society but that vision seems somewhat clouded today by the ominous shadows of "minority" and "anarchy" and the strategy of confrontation.

According to Bell, the term Industrialism was coined by Claude-Henri de Rouvroy le Comte de Saint Simon to characterize the era when wealth was created by production and machinery rather than seized through plunder and war. The real noblemen of this era were the industrialists and the real priests were the scientists - a new elite, the word scientist first appeared about 1840.

In contrast, the post industrial society is a service economy. The social change that used to be crescive is now considered an object for planned change. A national society has arisen in which more and more endeavors must be undertaken through group or community projects. Decisions are made through planning and we are in an era of innumerable committees, councils or soviets of scientists and technicians. The recent "freeze" on NIH study sections and councils affected over 50 committees and 600 people. Science is in politics, as DuBridge has said, and Science and Technology become inseparable from social and political problems.

In addition to making science relevant, we are faced with the requirement to make it acceptable to our peers and understandable to the public. Cannon quotes a member of the House of Commons as saying that, "Physiology, besides being costly and useless, is immodest." Cannon himself might have been somewhat influenced by the sensitive Cambridge lady who hoped that he would give up his disgusting researches on the stomach when he turned his attention to the study of the influence of emotions on the body.

Now being a citizen means facing the social problems of today which were recently succintly characterized by Walter Reuther in a press interview: "There is 'a large gap of hypocrisy' in our present 'mass culture' that has left youth 'alienated from a sense of human community.'

"Society has been unable to translate its rapidly expanding technology into human terms and make it serve human needs.

" ' Things are in the saddle and things are getting bigger. Meanwhile, man is getting smaller and smaller.' "

Another statement seemingly about our times has a surprising date and author.

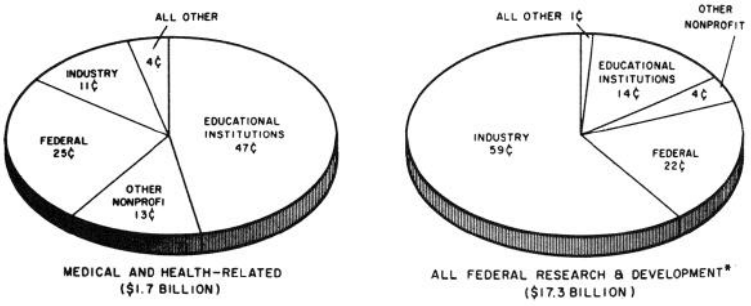
"The streets of our country are in turmoil. The universities are filled with students rebelling and rioting. Communists are seeking to destroy our country. Russia is threatening us with her might. And the republic is in danger. Yes, danger from within and without. We need law and order ... without law and order our nation cannot survive..."

These words are reported to have been spoken in 1932 by Adolf Hitler.

To bring this closer to our problems, budgets for scientists are being reduced at the national and state levels due to the pressures of other national affairs. Dr. Handler, new President of the National Academy of Sciences and prestigious in many other committees, is widely quoted

as saying that the universities must put their house in order before Congress can respond to their increased needs. To my knowledge, he hasn't identified what is out of order nor given us the mechanics of the ordering process. In Cannon's time, the faculty of university and colleges were just emerging and becoming involved in academic affairs. Today, in some places, faculty involvement has created a parallel administrative structure that has occasioned the editorial charge of academic feather-bedding by a San Francisco newspaper. Now, the students wish (demand) this involvement - these lines of communication.

FEDERAL R & D DOLLAR DISTRIBUTED BY PERFORMER, 1969 EST.



*THE RESEARCH CENTERS ADMINISTERED BY INDUSTRIAL FIRMS, UNIVERSITIES, AND OTHER NONPROFIT INSTITUTIONS ARE ATTACHED TO THE APPROPRIATE SECTOR.

We are a part of that group who must translate technology or science into human terms and make it serve human needs - who else will do it? We are members of that group of scientists who are blamed for making the "things" that are in the saddle. There are 4,000 or 5,000 physiologists, 25,000 to 30,000 biologists, in a population of 200 million. We

have a budget support of perhaps 500 million dollars; that is less than .06 of 1% (.0006) of the gross national product.

The point is that a few of us must make the cause of science clear to those who fund it. There are many compelling reasons why the support of scientific endeavor and training is a national problem and must be supported by government agencies whose organization Dean Harvry Brooks of Harvard characterizes as tending to be optimized for dealing with obsolete problems. We don't want a medicare program for old labs as Craig Hosmer (Rep. CA) calls it - but is it clear what we want? I think it is quite defensible to call for national support for the training of scientists because state boundaries are permeable to scientists - they move freely across those membranes depending on the prestige, reward or opportunity offered. The results of their activities in teaching with research is even more miscible nationally.

We are part of that group who must find a way for the university to react to student opinion and involve them in decisions and, at the same time, maintain the academic excellence of institutions we represent. This cannot be done by refusing to change, but by changing in such a manner as to hold to that which has been proven good in a new context.

It is rather remarkable that our undergraduate curriculum, the medical curriculum and research are being "overhauled" or revised to concentrate on the relevant, yet little has been done to change graduate programs except to debate the virtues of structured and unstructured programs, reducing or eliminating the language requirement, despairing over the fragmentation of physiology into subdisciplines, and concern over the appeal of the classical part of our discipline in teaching and research to clinical medicine. Fitness for the enterprise now calls for new experience with new resources. The spirit of adventure is not completely compatible with relevance. Students and public are questioning the interest and involvement of university faculties in teaching. The link between research and teaching needs to be more visible.

What happens to departmental chairmen in this new atmosphere of involvement - where and how does leadership emerge and how is it rewarded - certainly not by daily questioning or monthly reviews. Recently, President Hitch of the University of California predicted that we might have to recruit students as some schools recruit athletes. Hiring a department chairman may take the same aspect as hiring the coach. A "contract" might have some merit. Certainly many of the prerogatives of the department chairman are gone but in their place is the challenge of bringing an ordered change into the new system with its new requirements.

Before I summarize, I can add a happy and optimistic note in this discussion. It is the role of friends at home and abroad. Being a biologist has brought to me the benefits and pleasures of friendships in the United States and in many countries. At home, here in Davis, this has been particularly true for me. As a physiologist and as your President, I am grateful to those of you whom I know for your friendship and, to those of you who attend the business meetings, for your confidence in electing me your President. I accept with some sadness the edict that nothing gets paster faster than a past president.

Cannon's reader was left to distill the way of an investigator from the text - there is no summary, no statement of relevance to your problems. I wish my conscience would allow me the same route. However, let me summarize.

The way of an investigator has changed.

We have passed through an era of "blessedness" when support of research was unquestioned as providing a source of betterment and progress.

We are faced with fragmentation of disciplines to subdisciplines.

We are increasingly aware that we can no longer live in an ivory tower and insulate ourselves from political, economic and social pressures.

We must accept the inevitability of change in university structure from an aristocratic one to a democratic form involving the student and faculty community in its decisions.

Somehow, we must change the connotation of the conjunction between teaching and research to teaching with research so that the public and government recognize their inseparable nature in the university.

In the preparation of this report I relied in part on these references: The Way of an Investigator, Walter B. Cannon. 1945, Hafner Press, New York.

The Post Industrial Society: A Speculative View, Daniel Bell in Scientific Progress and Human Values, ed. Edward and Elizabeth Hutchings. 1967, Elsevier, New York.

A Matter of Opinion, Emilio Daedario. Scientific Research, June 24, 1968, McGraw-Hill, New York.

Past President's addresses which are found in the November issue of each volume of The Physiologist.

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ABSTRACTS FOR 1970 SPRING MEETING

At the business meeting of April 15, 1969, the Society voted to continue the lottery system of eliminating every n^{th} paper from oral presentation for the 1970 Spring Meeting.

> The number of papers to be presented orally will be approximately 850. Each abstract will be given a number as it is received in the Central Office. To reduce the number to be presented orally to 850, every n^{th} paper will be excluded. No sponsored abstracts will be accepted. A person's name can appear on only one abstract. An APS regular, retired or honorary member must be one of the authors. Associate members, since they are not members of the Federation, are treated as non-members for the Spring Meeting. Abstracts that are excluded by the above mentioned method may be printed in Federation Proceedings if the authors so desire but will not appear on the program for oral presentation.

LALOR FOUNDATION RESEARCH AWARDS

The Lalor Foundation announces its 1970 program of postdoctoral awards offered for research in certain aspects of mammalian reproductive physiology. The awards are open to all nationalities and the work may be carried on at the applicant's own institution or elsewhere. The awards may be for a few months or up to one year in length and may range up to $9,000 depending upon the scope and duration of the projects approved. Requests for information should be sent to the Lalor Foundation, 4400 Lancaster Pike, Wilmington, Delaware 19805. Final date for receipt of completed applications is January 15, 1970.

PRESIDENT'S LETTER TO MEMBERSHIP with REQUEST FOR REPLIES

C. LADD PROSSER

Many signs indicate that all is not well with our science. Physiology is being deemphasized in some medical schools, virtually excluded in a few and is being taught increasingly by departments of medicine. Physiology in many undergraduate schools needs to be made more rigorous and quantitative. Training programs in physiology have been severely criticized in general evaluations resulting from meetings called under the auspices of the Institute of General Medical Sciences, National Institutes of Health. New societies, some of them including many physiologists, are drawing strength away from the American Physiological Society. The growth of the Biophysical Society and the American Society for Cell Biology has been phenomenal. The number of applications for membership in APS and the numbers of papers submitted for publication and for delivery at meetings have not declined, but there is an impression of decline in quality and of support by first-rate physiologists.

Your Council does not wish to sit back and watch the decline of physiology without making some effort to reverse this trend. The following are some areas in which efforts by the Society may yield useful results.

1. Programs. Symposia at our national meetings and the introductory talks at the Spring Meeting are scheduled rather on an "ad hoc" basis. The Program Committee makes suggestions which are often considerably modified by Council. It is proposed to enlarge the Program Committee, to charge it with long-range scheduling of symposia and with other duties. Members have suggested that the Society should sponsor symposia at other times than at the national meetings. Others have suggested that the Society should encourage regional meetings. Some have suggested that Society funds should be used to bring foreign speakers to our symposia. Council would welcome a response from members to these suggestions.

2. Public Information. Understanding of our science by the public is limited and frequently distorted. Public ignorance is reflected in congressional appropriations. Our Public Information Committee has been restricted to screening Spring Meeting abstracts for newsworthy items. It has been suggested that this committee be much expanded, that it undertake regional publicity. Another suggestion is that the Society sponsor television and other public programs. What public information activities should we sponsor in addition to those of the Federation? Should Society funds be used to develop television programs?

3. Organization of Physiological Societies. Ever since the formation of the Society of Biological Chemists, the APS has been subject to fragmentation into new societies. Fifteen years ago when the Biophysical Society and Society of General Physiologists were being formed, it was proposed that the APS go to a divisional organization, but this was rejected. A divisional form of organization has kept the American Society of Zoologists and the American Psychological Association from becoming

fragmented. Most recently, the Biomedical Engineering Society has formed, and the formation of a new organization in Neurosciences is now proposed. We already have dinner groups, some with funds administered by the APS. There is in each subdiscipline a need for identity. Some of the predictions made in 1955 by APS officers about Biophysics have proven to be wrong. We cannot reverse what has occurred, but we could provide the mechanism by which further fragmentation might be prevented and we could encourage a Union of Physiological Societies. Two meetings have been held with officers of some six animal physiological societies. The advantages of some sort of Union for new meeting alignments, for educational activities and for strengthening the image of physiology are evident. The chief disadvantage lies in concern about dominance by the APS and about loss of autonomy. Meanwhile, plans for a restructuring of the Federation are being developed by a committee headed by our Past-President. Possibly some new physiological societies might join the Federation. One specific proposal from the meeting at Davis is that we start planning a scientific meeting on a broad theme, separate from Society meetings, to be held in 1971 or 1972, to be organized by a committee with representatives from APS, Society of General Physiologists, Biophysical Society, Division of Comparative Physiologists and Society of Biomedical Engineers.

A second proposal, on which Council is divided, is that we ask approval of a bylaw which would permit large subgroups to form semi-autonomous divisions within the Society. This might forestall the splitting off of new specialty societies. I should like membership reaction to these proposals.

4. Education. It is in the area of education that there is most agreement on Council that APS should provide leadership for physiological science. Our Education Committee has promoted various action programs which have varied with interests of committee members. Several new programs are now contemplated. With the change in teaching functions of physiology departments and with the advent of computer and television teaching, there is need for more than action programs, namely research. It is proposed that the Society establish an Office of Education Research and employ a new staff member to direct it. Organizations such as the American Chemical Society have large and effective Offices of Education. Some of the proposed functions of the APS Office of Education Research are the following:

1. Work with the Education Committee in projects of that Committee.
2. Establish working relations with other organizations concerned with biological and medical education.
3. Initiate projects to aid teachers in colleges and in developing medical schools.
4. Initiate projects to develop teaching equipment and test commercially available equipment.
5. Acquire and distribute teaching films and TV tapes.
6. Provide an information exchange; write items for The Physiologist.
7. Develop a physiological dictionary for computer programs.
8. Assist in programming physiological topics for computer-assisted education.

9. Acquire materials for public information.
10. Cooperate with Public Information Committee and the Public Affairs Committee of FASEB on identifying useful material.
11. Serve as Assistant to the Executive Secretary.
12. Develop grant proposals in education.

In addition, the Education Research Officer might assume some of the duties now carried by the Executive Secretary. To finance such an office, some of the Society earnings could be used initially. It is hoped that some grant funds may be obtained and, if this is a cooperative effort, some contributions might be made from other physiological societies. Already the Education Committee has members from SGP and Division of Comparative Physiologists. If members recognize the value of education research in strengthening their profession, they might favor a small increase in dues for this purpose.

Council strongly recommends the employment of an Education Research Officer this year, if an appropriate person can be found. A person is needed who has the following qualifications.

1. A doctorate in physiology or a related field.
2. At least five years of experience in teaching and research.
3. Acquaintance with broad aspects of physiology.
4. Interest in promoting the teaching of physiology at all educational levels.

Nominations for this position are invited from membership.

Also opinions concerning the proposed Education Research Office are requested. Do you favor such an activity for APS? Can you suggest directions of research other than those mentioned above? Would you contribute in dues toward maintenance of an Education Research Office?

5. Publications. This is an area where Council has no recommendations. Last year, Mr. Stephen Geiger, trained at the Rockefeller University scientific publications program, was added to the staff, initially to edit the handbooks. Our journals are doing well both in quality and in page production. Handbooks are flourishing. We are grateful to the Publications Committee and to the excellent staff.

This letter reflects long-range policy deliberations in Council. It is most important that all members give serious thought to the questions raised. I shall be pleased to receive reactions and suggestions prior to the February 1970 meeting of Council. Address replies to C. Ladd Prosser, Dept. of Physiology and Biophysics, University of Illinois, Urbana, Ill. 61801.

PHYSIOLOGY FOR FUTURE DOCTORS

The human body functions.
If successfully . . . life.
If not . . . . death.
Health is never achieved
But only approached.
Suffering is universal,
But why so common?
The student doctor learns
To help men toward health.

What must be learned?
What our predecessors discovered
About human function?
Inviolable principles
Of essential life processes?
Numerical values that distinguish
Between sickness and health?
Yet beyond learning is wisdom --
Using knowledge
To solve human problems.

Disease is altered physiology;
Diagnosis is detective work.
Where in the unfathomable complexity
Of a human being
Has the criminal done his work
And created all these clues
That can lead us to his lair?

Learning and finding wisdom never cease.
We are students of man's suffering
All our lives.
Core physiology is only a beginning.

Roger Thies

THE ROLE OF SODIUM IN NON-ELECTROLYTE TRANSPORT ACROSS ANIMAL CELL MEMBRANES*

STANLEY G. SCHULTZ** and PETER F. CURRAN***

Evidence for an interaction between sodium transport and the transport of non-electrolytes across animal cell membranes first emerged explicitly from studies on intestinal transport of sugars and amino acids. Work carried out in the past decade has repeatedly demonstrated that the ability of intestinal epithelium and renal tubular cells to transport many sugars and amino acids against concentration differences is dependent upon the presence of sodium in the mucosal or lumenal fluid. During the same period of time, it has become clear that the accumulation of many amino acids by a wide variety of non-epithelial cells and subcellular organelles is dependent upon the presence of sodium in the external medium. Thus, the interaction between sodium and the transport of other solutes across cell membranes appears to be a wide-spread phenomenon that is intimately related to the ability of animal cells to transport these solutes against electrochemical potential differences. Indeed, one common feature of all sodium-dependent transport processes described to-date is that they appear capable of uphill or active transport. In no instance has compelling evidence been presented for a role of sodium in transport processes that are exclusively involved in carrier-mediated equilibration or facilitated transfer.

We should like to review briefly three major aspects of this problem; namely, what are the characteristics of the interaction between sodium and the transport of other solutes across cell membranes;in what way may this interaction serve to bring about uphill transport of the involved solute; and, what are the implications of this interaction with respect to the molecular mechanism of sodium-dependent transport processes? We will draw primarily upon information derived from our studies on the sodium-dependent transport of amino acids and sugars across rabbit small intestine. However, qualitatively similar findings have been reported for several other cell systems so that our more general interpretations and conclusions need not be restricted to the case of small intestine.

The effect of sodium on the uptake of alanine by mucosal strips of rabbit ileum is illustrated in Figure 1. In this preparation, the intestinal

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*Taken from the introductory remarks given at the session on Intestinal Absorption at the 1969 Federation Meetings. This work was supported in part by grants from the USPHS (AM-06540 and AM-11449) and the American Heart Association (66-685 and 67-620).

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***Department of Physiology, Yale University School of Medicine, New Haven, Conn.

mucosa is separated from the underlying submucosal and muscular layers and the sheet of epithelial cells is simply incubated in a flask containing the desired extracellular medium. Thus, the polar orientation of the absorptive cells cannot be discerned experimentally and the system resembles a suspension of non-polar cells such as nucleated erythrocytes or Ehrlich ascites tumor cells. The results shown are qualitatively typical of virtually all of the sodium-dependent transport processes that have been described. When the extracellular medium contains 5mM alanine and 140 mM sodium, alanine is rapidly accumulated within the mucosal strip in a chemically unaltered, osmotically active form and the final steady-state intracellular alanine concentration is 8 to 10 times that in the surrounding medium. When the extracellular medium is rendered Na-free by replacement with choline, Tris potassium, lithium or mannitol two effects are observed. First, the rate of net uptake of alanine is markedly reduced. Second, the final steady-state concentration never significantly exceeds that in the surrounding medium; that is, the ability of the cells to transport alanine against a concentration difference is abolished. A similar effect is observed if the tissue is treated with ouabain in the presence of externa sodium. The effects of sodium removal and ouabain on 3-0-methylglucose accumulation resemble those observed for alanine (20).

In a polar tissue such as small intestine, the interaction between sodium and the transport of amino acids and sugars is manifested in

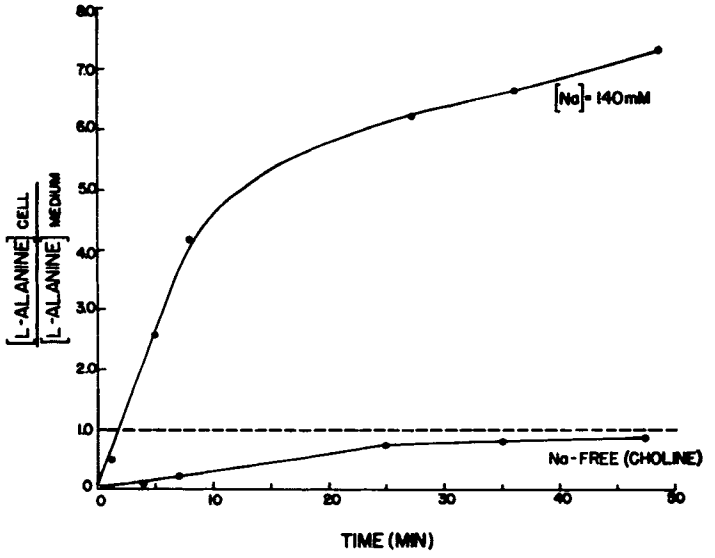

Fig.1. Time course of L-alanine accumulation by mucosal strips of rabbit ileum in the presence and absence of sodium. The alanine concentration in the external medium was 5 mM.

two additional ways. First, removal of sodium from the mucosal solution abolishes transmural transport of sugars and amino acids against, or in the absence of, an electrochemical potential difference (7, 12, 13). Second, the addition of actively transported sugars or amino acids to the mucosal solution brings about a prompt increase in the rate of active sodium transport from mucosa to serosa (21, 22). These phenomena are obviously restricted to certain epithelial tissues and one may ask whether they reflect a fundamental difference between epithelial and non-epithelial cells with respect to the interaction between sodium and the transport of other solutes. At present there is no reason to believe that this is the case. Indeed, there is good evidence that the effect of sodium on transmural transport of sugars and amino acids and the effect of these solutes on transmural sodium transport are simply consequences of an interaction that takes place at the brush or mucosal border of the epithelium. It is this interaction at this single face of the epithelial cell that resembles the phenomena observed in a wide variety of non-epithelial cells. The exit of sugars and amino acids from the absorptive cells across the serosal border appears to take place down a concentration gradient and, though this process may be carrier-mediated, there is no evidence that it is influenced by sodium.

Let us focus then on the interaction between sodium and the transport of amino acids and sugars across the brush border of rabbit ileum and, in particular, on the unidirectional movements of solutes from the mucosal solution across the brush border into the epithelium. This movement is essentially the initial or zero time rate of uptake of solutes by the epithelium across the brush border alone and is referred to as the influx. The method employed for the determination of unidirectional influx has been described in detail (19) and is summarized in Figure 2.

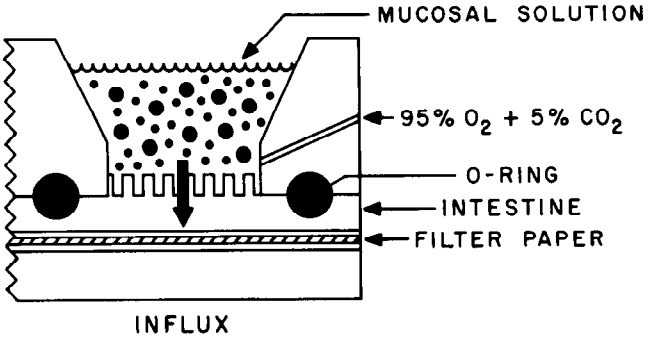

Fig.2. Method for determination of unidirectional influx across the brush border of small intestine. The tissue is mounted mucosal surface up with the serosal surface resting on a piece of moistened filter paper. A defined area of the mucosal surface is exposed for a brief period (less than one minute) to a mucosal solution containing H^3-inulin, C^{14}-amino acid and Na^{22}. The tissue is then extracted and influxes of amino acid and sodium are calculated from the tissue C^{14} and Na^{22} contents after correction for the adherent inulin space.

The unidirectional influx of alanine across the brush border of rabbit ileum as a function of the alanine concentration in the mucosal solution is shown in Figure 3. The data are plotted according to the method of Lineweaver and Burk. Clearly, alanine influx is a saturable process that conforms to Michaelis-Menten kinetics in the presence and absence of sodium. Thus, alanine influx, J^i_A, can be described by the expression

$$J^i_A = \frac{J_A{}^{imax}[A]_m}{K_t + [A]_m}$$

in which $[A]_m$ is alanine concentration in the mucosal solution, J_A^{imax} is the maximal influx and K_t is the "apparent Michaelis constant" (the value of $[A]_m$ for which J^i_A equals one-half J_A^{imax}). The two lines in Figure 3 have a common intercept on the ordinate corresponding to a common maximal alanine influx; however, their slopes differ markedly indicating that the concentration of alanine needed to elicit a half-maximal influx (K_t) is much greater in the absence of sodium than in its presence. The kinetics of alanine influx have been examined at several sodium concentrations between 0 and 140 mM and the results indicate that the maximal influx is not affected by the external sodium concentration but that the concentration of alanine required to elicit a half-maximal influx gradually increases as the sodium concentration in the mucosal solution is lowered. Qualitatively similar results have been obtained using leucine, valine (8) and lysine (17).

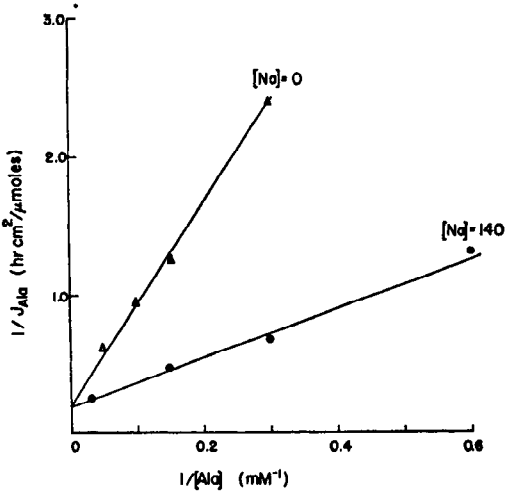

Fig.3. Lineweaver-Burk plots of alanine influx as a function of alanine concentration in the mucosal solution. (Reproduced from Curran et al. (8) by permission of the Rockefeller Institute Press.)

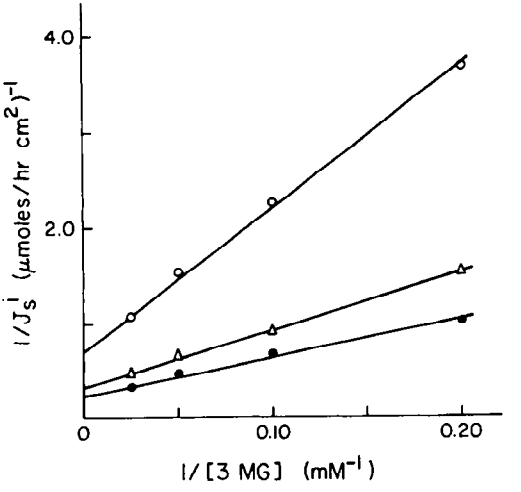

Fig.4. Lineweaver-Burk plots of 3-0-methyl-glucose influx as functions of sugar concentration in the mucosal solution in the presence of 21 mM (•), 65 mM (Δ) and 130 mM (•) sodium.

Studies on the influx of the actively transported, non-metabolized sugar 3-0-methyl-glucose across the brush border of rabbit ileum have revealed a somewhat different pattern of sodium dependence (13). As shown in Figure 4, plots of the reciprocal of sugar influx versus the reciprocal of sugar concentration have different intercepts on the ordinate indicating a decrease in maximal sugar influx with a decrease in sodium concentration. Conversely, the apparent Michaelis constant changes very little with changes in sodium concentration. Further, we have been unable to demonstrate any mediated influx of methyl-glucose across rabbit ileum in the complete absence of sodium. Under these conditions, methyl-glucose influx is a linear function of concentration and is not inhibited by phlorizin which is an effective inhibitor of the mediated sugar influx observed in the presence of sodium.

The next point that must be clarified is the question of whether or not sodium is actually a co-substrate of the transport processes. That is, are the movements of sodium and organic solutes coupled, or is the effect of sodium on these transport processes indirect? The relation between alanine influx and Na influx, determined simultaneously in the presence of 70 mM sodium, is illustrated in Figure 5. The data shown are the results of three experiments; in each experiment, eight determinations of simultaneous alanine and sodium influxes were carried out on tissue from the same animal. There is a direct and linear relation between alanine influx and sodium influx and this relation was found

to hold at all sodium concentrations examined. Thus, at any fixed sodium concentration an increase in alanine influx is associated with a proportional increase in sodium influx and the proportionality constant was found to depend upon the sodium concentration alone. This relation between alanine influx and the increment in sodium influx is given as a function of sodium concen ration in Figure 6.

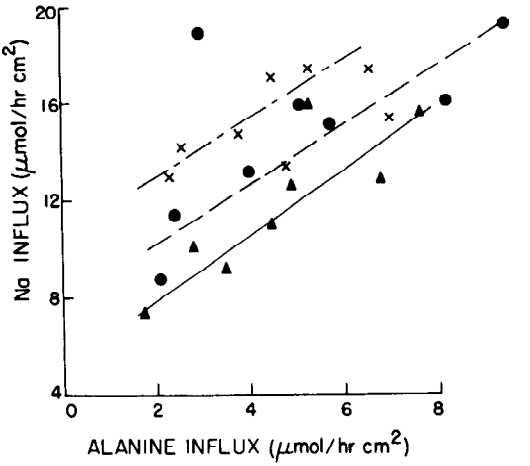

Fig.5. Relation between sodium influx and alanine influx. The different symbols and lines denote the results of three experiments in which eight simultaneous determinations of alanine and sodium influxes were obtained on tissue from the same animal. (Reproduced from Biological Membranes (R. Dowben, editor), by permission of Little, Brown and Company.)

Again, a different quantitative pattern of behavior was found for 3-0-methyl-glucose. Sodium influx was also found to increase linearly with methyl-glucose influx at constant sodium concentration. However, the proportionality constant relating the increase in sodium influx to methyl-glucose influx was found to be independent of the sodium concentration and was approximately unity at all sodium concentrations tested (13).

A kinetic model that describes the interaction between sodium and alanine influx is shown in Figure 7 (8). According to this model, alanine combines with a membrane component to form a binary complex, XA. This binary complex can either cross the membrane or it can combine with sodium to form a ternary complex that then crosses the membrane. Estimates based on our experimental observations indicate that the dissociation constant of the binary complex is much greater than that of the ternary complex. Thus, in the absence of sodium a very weak amino acid-carrier complex is formed and high alanine concentrations are needed to elicit a significant influx. The presence of sodium

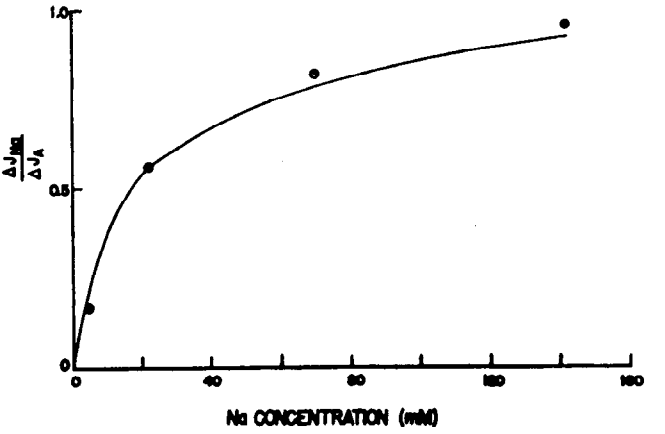

Fig.6. Relations between the increment in sodium influx and the increment in alanine influx as a function of the sodium concentration in the mucosal medium. The points represent the experimentally determined coupling coefficients and the solid curve represents the relation predicted by the model illustrated in Figure 7. (Reproduced from Curran et al. (8) by permission of the Rockefeller Institute Press.)

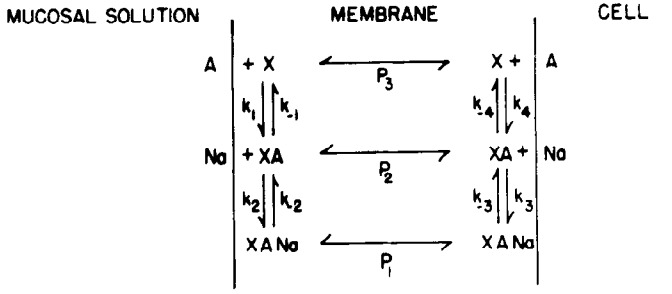

Fig.7. Kinetic model of the interaction between sodium and alanine transport across the brush border of rabbit ileum. (Reproduced from Curran et al. (8) by permission of the Rockefeller Institute Press.)

permits the formation of a much more stable complex and thus draws the reaction in the direction of the ternary complex. Clearly, at infinite alanine concentration one obtains a maximal influx that is independent of the presence or absence of sodium. Further, at any particular

set of alanine and sodium concentrations, a certain fraction of alanine influx will be mediated by the binary complex and the remainder by the ternary complex. The distribution between these two influx routes determines the coupling coefficient between alanine and sodium influxes. Clearly, as the sodium concentration increases more and more of the alanine influx will be mediated by the ternary complex and, as illustrated in Figure 6, a maximal coupling coefficient of unity is approached at high sodium concentrations.

Thus, according to this model, sodium stimulates alanine influx because it promotes the formation of a ternary complex that is more stable than the binary complex; the greater the stability of the ternary complex relative to that of the binary complex, the greater will be the stimulatory effect of sodium at any given alanine concentration.

One possible mechanism by which sodium could promote the formation of a stable ternary complex is through its participation in an exergonic chemical reaction leading to a chemical modification of the carrier. For example, sodium could be required for the coupling of ATP hydrolysis to the amino acid transport mechanism via the sodium-potassium-dependent, ouabain sensitive ATPase that has been identified in brush border preparations (5, 23). However, studies on the effects of metabolic inhibitors and ouabain on the ability of sodium to stimulate alanine influx across the brush border essentially exclude this possibility (2). The results of these studies are shown in Figure 8. Cyanide and ouabain, which completely abolish active transmural alanine transport and completely inhibit alanine accumulation by mucosal strips of intestine (12, 20) have no effect on alanine influx or on the ability of sodium to stimulate the influx process. These results, together with data obtained using other cell systems (9, 24) suggest that the stimulatory effect of sodium is the result of a conformational change brought about by the binding of sodium to the membrane component; no evidence for the coupling of a metabolic reaction to the influx mechanism has been presented for any sodium-dependent transport process.

Since the results obtained for the kinetics of methyl-glucose influx differ in several particulars from those obtained for alanine, the model shown in Figure 7 does not provide an adequate description for the influx of this non-metabolized sugar, and the more complex model shown in Figure 9 appears to be necessary (13). We again assume the existence of a transport site, X, in the membrane that can combine with both sugar and sodium. However, there is no specified order of combination to form the ternary complex XS Na; X may combine first with sodium to form X Na or with S to form XS. We must further assume that XS and X Na cannot translocate across the membrane at appreciable rates. Thus, according to this model, the role of Na is to form the complex XS Na that is required for translocation; the coupling coefficient is always unity and carrier-mediated influx is abolished by removal of Na. Evaluation of the dissociation constants for the model illustrated in Figure 9 (13) indicates that sodium does not play a stabilizing role in this system as it does in the amino acid system.

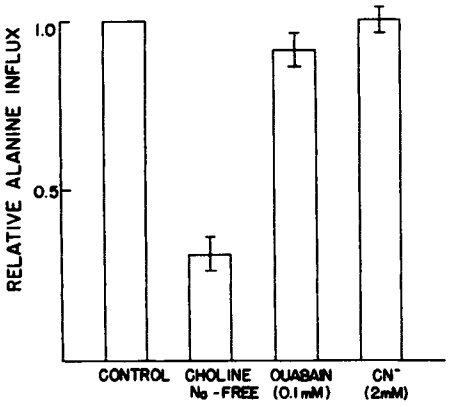

Fig.8. Effects of sodium removal, ouabain and cyanide on alanine influxes across the brush border of rabbit ileum. The results are expressed relative to the control influxes obtained in the presence of 140 mM sodium on tissue from the same animal.

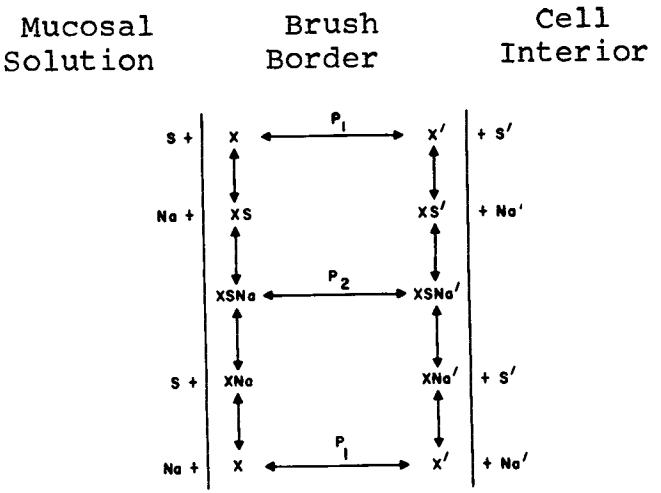

Fig.9. Kinetic model of the interaction between sodium and sugar transport across the brush border of rabbit ileum (13).

The role of sodium in sugar influx could involve promotion of a chemical reaction necessary for translocation of the ternary complex across the membrane. Thus, translocation could be dependent upon ATP hydrolysis by a sodium-dependent, ouabain-sensitive ATPase. However, we have obtained preliminary evidence suggesting that such a phenomenon is unlikely. Cyanide and ouabain, which completely inhibit active transmural transport of methyl-glucose, have minimal effects on influx across the brush border. In particular, the effects of these inhibitors are far less than the effect of sodium removal. If translocation involved a sodium-dependent, ouabain-sensitive ATPase, the effects of all three treatments (cyanide, ouabain and Na removal) should be equivalent.

The Sodium-Gradient Hypothesis

The finding that metabolic inhibitors and ouabain do not affect influx but completely abolish active transport and accumulation is strong evidence for the so-called sodium-gradient hypothesis (4). This hypothesis maintains that the energy required for the transport of amino acids and sugars from a region of lower concentration to a region of higher concentration is not the result of a direct coupling between metabolic energy and the sugar or amino acid transport mechanism, but is derived from the ionic asymmetries across cell membranes, in particular from the asymmetric distribution of sodium. The modus operandi of the sodium-gradient hypothesis for non-electrolyte transport by small intestine is illustrated in Figure 10. The fundamental assumption, one that has yet to be unequivocally verified, is that efflux out of the cell across the brush border is influenced by the local intracellular sodium concentration in much the same way as the influx is influenced by the sodium concentration in the mucosal medium. If this is true, the effects of sodium depletion, ouabain and metabolic inhibitors on amino acid and sugar transport can be explained quite readily in terms of their effects on the intracellular sodium concentration and the sodium-gradient across the mucosal membrane. Under normal conditions, the intracellular sodium concentration is lower than that in the mucosal medium due to the operation of an energy-dependent, ouabain-sensitive active sodium transport mechanism that is believed to be located on or near the serosal or lateral membranes of the absorptive cell (20, 21); this process is primarily responsible for active sodium absorption by the small intestine. As a result of the asymmetric distribution of sodium between the cell interior and the mucosal solution, influx of amino acid or sugar into the cell across the brush border will exceed efflux out of the cell across this boundary leading to an accumulation of these solutes within the cell and, in turn, to net transmural transport. The sodium that accompanies the amino acid or sugar into the cell is pumped out of the cell by means of the serosal transport process and can quantitatively account for the stimulation of net sodium transport by sugars and amino acids (8, 13). Clearly, the driving force for the active transport of sugars and amino acids is derived from the electrochemical potential difference for sodium across the mucosal membrane and, thus, is dependent upon the integrity of the serosal sodium pump. In a sense, the serosal sodium pump utilizes metabolic energy to establish an electrochemical battery that can, in turn, supply energy to any solute whose transport across the brush border is

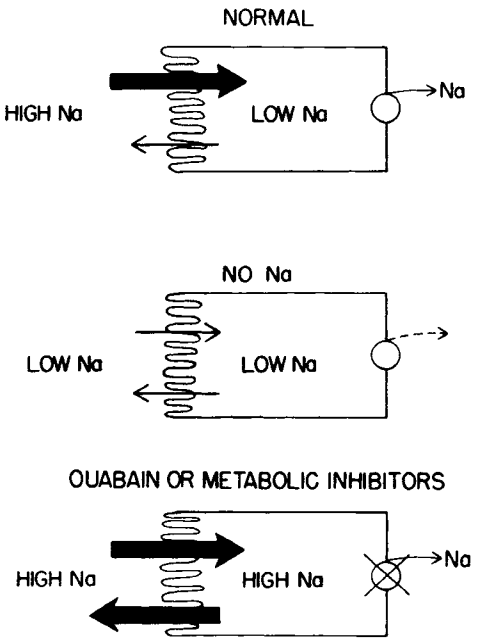

Fig.10. The influence of the Na-gradient on net solute transport across the brush border of small intestine. The circle denotes the energy-dependent, ouabain-sensitive active sodium extrusion mechanism at the serosal (and/or lateral) border. The magnitudes of the two unidirectional solute fluxes across the brush border are reflected by the thickness of the arrows. The sodium-gradient is abolished in the absence of sodium or by the presence of ouabain or metabolic inhibitors.

coupled to the flow of sodium. If the sodium pump is inhibited by ouabain or metabolic inhibitors, the sodium-gradient will run down and ultimately vanish (20) and net uphill transport of sugars and amino acids will no longer be possible. According to this hypothesis, the inhibition of sugar and amino acid transport by metabolic inhibitors and ouabain is not due to an inhibition of influx but rather to an acceleration of efflux across the brush border that results from the increased intracellular sodium concentration. The sodium-gradient across the mucosal membrane can also be abolished by simply removing sodium from the surrounding medium and the consequences in terms of net solute transport are the same as those observed using metabolic inhibitors or ouabain (20). It should be noted that the sodium-gradient across the mucosal membrane can contribute to the energy required for the uphill transport of both sugars and amino acids even though the kinetics of the interaction between

Na and the influxes of these solutes differ markedly. The only requirement of the sodium-gradient hypothesis is that the unidirectional fluxes of a solute across the mucosal membrane be influenced by the local sodium concentration. This influence could be the result of an indirect effect of sodium (for example, sodium could simply increase the accessibility of the carrier site to the solute) or a direct coupling between the flows of sodium and the solute. The kinetics of the interaction, direct or indirect, determines the efficiency with which the energy "stored" in the sodium-gradient can be utilized for the uphill transport of another solute.

Thus, there is considerable evidence consistent with the notion that the sodium-dependent active transport of sugars and amino acids is not directly coupled to energy-yielding metabolic reactions but is dependent upon the asymmetric distribution of sodium across the membrane. This evidence is, however, largely indirect, and the question is: is there direct evidence that the intracellular sodium concentration influences efflux out of the cell? It is extremely difficult to provide unequivocal evidence on this point largely because of uncertainties regarding the distribution and activities of intracellular solutes. This is particularly true for the case of sodium, where there is a growing body of evidence derived from histochemical (c.f. 26), nuclear magnetic resonance (c.f. 3) and microelectrode (16) studies that intracellular sodium is compartmentalized, and that it behaves as if it were, to a large extent, bound. Perhaps the most compelling evidence in favor of the sodium gradient hypothesis comes from the studies of Vidaver on glycine uptake by reconstituted pigeon erythrocytes (24) and from the more recent studies of Eddy on glycine uptake by poisoned Ehrlich ascites tumor cells (9). Both of these investigators succeeded in adjusting the intracellular sodium concentrations in their cells, and were able to evaluate the effect of varying size and direction of the sodium-gradient on glycine accumulation. Some of Eddy's data are shown in Figure 11. It is seen that there is an inverse, linear relation between the logarithm of the sodium distribution ratio and the logarithm of the glycine distribution ratio such that the direction of the sodium-gradient determines the direction of net glycine transport. When the extracellular sodium concentration is greater than the intracellular sodium concentration, the intracellular glycine concentration exceeds that in the surrounding medium. On the other hand, when the normal sodium-gradient is reversed, that is when the intracellular sodium concentration exceeds the extracellular sodium concentration, the intracellular glycine concentration is less than that in the surrounding medium; under these conditions glycine is actually excluded from the cell. When the sodium distribution ratio is unity, the intracellular glycine concentration closely approximates that in the surrounding medium.

What then is the present status of the sodium-gradient hypothesis? There is certainly considerable evidence, both direct and indirect, that suggests that the sodium-gradient can and does contribute to the energy requirement for active transport of sugars and amino acids. It is by no means certain that the sodium-gradient alone can account entirely for these active transport processes and the possibility of a direct involvement of other asymmetries, or even chemical reactions, as contributory

sources of energy has not been excluded. For example, the roles of the asymmetric distribution of potassium, and the electrical potential difference across the membrane have yet to be clarified.

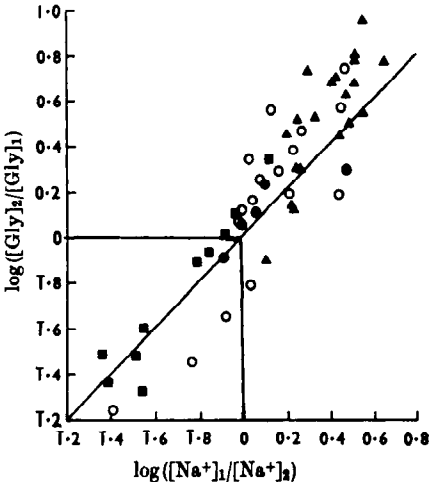

Fig.11. The relation between the logarithm of the sodium distribution ratio and the logarithm of the glycine distribution ratio in cyanide-poisoned Ehrlich ascites tumor cells. The subscript 1 denotes the extracellular concentrations and the subscript 2 denotes the intracellular concentrations. From Eddy (9), (The lines were drawn by the authors).

Let us now consider - all too briefly - the molecular implications of the interactions between sodium and the carrier mechanisms for sugars and amino acids. Needless to say we have no direct knowledge of the workings of any of these mechanisms at the molecular level so that our present concepts are essentially deduced from kinetic descriptions. In essence, our interpretations are tied to classical models for carrier-mediated transport and whether these interpretations are correct or not hinges largely on the validity of these models. The kinetic descriptions of a variety of sodium-dependent transport processes disclose two common features and a number of significant differences. One common feature is that the sodium requirement of these processes appears to be highly specific. A large number of inorganic and organic cations have been examined as to their abilities to replace sodium in these transport processes. In only one instance has another cation, namely lithium, been found to partially simulate the effect of sodium (1). The other common feature is that in every instance that has been examined, coupled transport of sodium and the involved solute has been observed. Some of the differences are as follows: First, in some instances, for example glycine uptake by Ehrlich ascites cells (11) and

methyl-glucose influx into rabbit ileum (13), the requirement for sodium appears to be almost absolute; that is, carrier-mediated influx is negligible in the absence of sodium. On the other hand, for the case of amino acid influx into rabbit small intestine we have seen that sodium stimulates carrier-mediated influx but is not an obligatory co-substrate for the transport mechanism. Second, the effect of sodium on the kinetics of sugar and amino acid influxes also differ in different systems. In some instances, for example amino acid influx into rabbit ileum (8) and sugar uptake by hamster small intestine (6), sodium appears to affect the half-saturation concentration or K_t of the process with no effect on the maximal influx. In other instances, such as sugar uptake by rabbit ileum (13) and rabbit kidney cortex slices (14), sodium affects the maximal uptake rate but has no effect on the K_t. In yet other cases, for example the uptake of several amino acids by Ehrlich cells and nucleated erythrocytes (25), sodium influences both the maximal rate of uptake and the half-saturation concentration. Third, the coupling coefficients between amino acid influx and sodium influx (that is, the stoichiometry of the co-transport process) appear to span a wide range. For the case of alanine influx in rabbit ileum we have seen that this coupling coefficient is dependent upon the sodium concentration and may have a value between zero and unity. For glycine (10), and AIB (18) uptake by Ehrlich ascites cells and methyl-glucose influx in rabbit ileum (13), the coupling coefficient appears to be unity over a wide range of non-electrolyte and sodium concentrations. And, coupling coefficients as high as 4.5 have been reported for amino acid uptake by pigeon erythrocytes (15); that is between 4 and 5 sodium ions may accompany one amino acid molecule into the cell.

Although these experimental observations indicate the presence of a very considerable diversity in the kinetic behavior of sodium-dependent transport process, it does not, at present, appear necessary to postulate fundamentally different transport models for each of the examples cited above. In fact, preliminary calculations on variants of the general model shown in Figure 12 indicate that such a system could accomodate most of the experimental observations now available on sodium-dependent transport systems for sugars and amino acids. In this respect, we should note that the models shown in Figures 7 and 9 are actually simple variants of the more general one in Figure 12. We need only require that the dissociation constant for the reaction $X + Na \rightleftharpoons XNa$ be large and that for the reaction $XA\ Na \rightleftharpoons XNa + A$ be small in order to obtain the system in Figure 7 from the one in Figure 12. In general, a wide variety of kinetic patterns and coupling coefficients can be generated from the model illustrated in Figure 12 by varying the dissociation constants, and thereby the preferred pathways for the formation of the ternary complex, and by varying the rates at which the various carrier forms can translocate across the membrane. Clearly, the role of Na postulated by these systems is that of an allosteric modifier that influences the ability of the membrane component to bind sugars or amino acids and/or the ability of the transport site to translocate across the membrane. Hopefully, further exploration of these Na-dependent transport processes will illuminate many of the physical and chemical properties of the transport systems that are responsible for these phenomena.

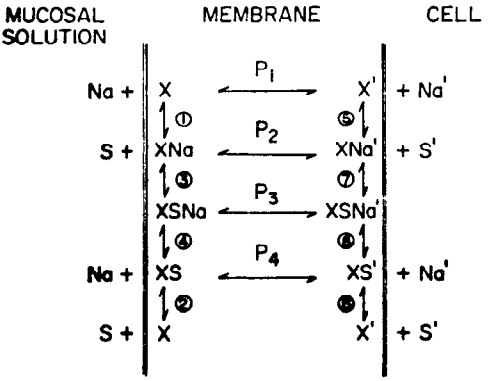

Fig.12. A general model for the formation of a ternary complex comprising a membrane site (X), a solute (S) and sodium. The sequence of formation of the ternary complex is not specified and all forms of X are permitted to translocate across the membrane.

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REGIONAL CONGRESS OF THE INTERNATIONAL UNION OF PHYSIOLOGICAL SCIENCES

The Regional Congress of the IUPS organized by the Academy of the Socialist Republic Romania and the Romanian Society of Physiology will be held in Brasov (a resort in the Carpathian Mountains) August 10-16, 1970. The topics of the Congress are centered on modern physiological problems in the light of the latest discoveries in biochemistry and biophysics. For further information write The Romanian National Organizing Committee, Institute of Physiology, Bd. 1, Mai No. 11, Bucharest VIII, Romania.

PAN AMERICAN CONGRESS OF NEUROLOGY

The Third Pan American Congress of Neurology will be held in Sao Paulo, S. P., Brazil in 1971 under the auspices of the World Federation of Neurology and the Brazilian Academy of Neurology. Inquiries should be sent to J. Armbrust-Figueiredo, Secretary, Caixa, Postal 5496, Sao Paulo, S. P., Brazil.

INTERNATIONAL CANCER CONGRESS

The Tenth International Cancer Congress will be held in Houston, Texas, May 22-29, 1970 under the auspices of the International Union Against Cancer. Inquiries should be sent to Office of the Secretariat, Tenth International Cancer Congress, P.O. Box 20465, Astrodome Station, Houston, Texas 77025.

INTERNATIONAL CONGRESS ON HORMONAL STEROIDS

The Third International Congress on Hormonal Steroids will be held in Hamburg, Germany, September 7-12, 1970. For further information write to II Medizinische Universitats - Klinik und Poliklinik, Universitats Krankenhaus Eppendorf, 2 Hamburg 20, Germany.

INTERNATIONAL CONGRESS OF MICROBIOLOGY

The Tenth International Congress of Microbiology will be held in Mexico City, August 9-15, 1970. For further information write Dr. Luis F. Bojalil, Tenth International Congress of Microbiology, Apartado Postal (P.O. Box) 60-603, Mexico 18, D.F., Mexico.

ERRATA

The May 1969 issue of The Physiologist carried the Bowditch Lecture by Eugene Braunwald. A footnote should have read - by Eugene Braunwald, M.D., Professor and Chairman, Department of Medicine, University of California, San Diego, School of Medicine.

There was also an omission of the following table from the text.

TABLE 1

DETERMINANTS OF MYOCARDIAL O_2 CONSUMPTION

1) Tension Development
2) Contractile State
3) Basal
4) Depolarization
5) Activation
6) Maintenance of active state
7) Shortening against a load - Fenn effect
8) Direct Metabolic Effect of Catecholamines

The paper "Medical Physiology Student Laboratory" which appeared in the May 1969 issue of The Physiologist (Vol. 12, pp. 94-97) should have been co-authored by Dr. R. L. Van Citters and Dr. A. M. Scher.

On page 94 the paper should have cited the article "Square-wave electromagnetic flowmeter employing commercially available recorder, Scher, A.M., Zepeda, J., and Brown, O.F. Journal of Applied Physiology 18: 1265-1267, 1963," which describes the flowmeter used in this laboratory.

Grant HE 07746 supported the research on which the flowmeter was developed and should have been cited.