CONTENTS

APS MEMBERSHIP STATUS

September 1973

Regular Members	3638
Retired Members	254
Honorary Members	15
Associate Members	434
Retired Associate	1
	4342

DEATHS SINCE SPRING MEETING 1973

Eors Bajusz - 2/24/73- Visiting Professor, Univ. of Montreal
J. Percy Baumberger - 6/21/73 - Sr. Res. Assoc., Palo Alto Med. Res. Fndn.
Herbert J. Bartelstone - 5/11/73 - Professor, Columbia University
Harwood S. Belding - 8/6/73 - Professor, University of Pittsburgh
George R. Cowgill - 4/12/73 - Emeritus Professor, University of Southern California
Ernst Gellhorn - 4/20/73 - Emeritus Professor, Univ. of Minnesota
A. J. Kosman - 11/27/71 - Professor, Northwestern University
Ramon L. Lange - 8/20/72 - Professor, Marquette Sch. of Med.
Donald M. Maynard, Jr. - 1/29/73 - Res. Assoc., Univ. of Oregon
Marian I. Osterhout - 5/10/73 - New York
Charles B. Puestow - 2/10/73 - Clinical Professor Surgery Emeritus, University of Illinois
Jurgen Steinke - 5/21/73 - Rancho Los Amigos Hospital
N. B. Taylor - 5/6/72 - Toronto, Canada
James R. Templeton - 5/18/73 - Professor, University of Montana
Howard M. Yanof - 5/1/73 - Assoc. Professor, Med. Coll. of Ohio

The following members were granted retired status at the 1973 Fall Meeting:

D. I. Abramson
D. E. Bass
C. H. Best
I. H. Blank
H. L. Blumgart
W. R. Bryan
C. A. Bunde
H. R. Catchpole
J. M. Crismon
J. E. Davis
Samuel Gelfan
J. F. Hall, Jr.
A. S. Harris
H. E. Himwich
D. J. Ingle
W. R. Ingram
J. B. Loefer
H. S. Louckes-Davis
H. W. Magoun
R. A. McFarland
J. A. Miller, Jr.
F. J. Mullin
E. A. Pinson
A. F. Rieck
Hans Selye

NEWLY ELECTED MEMBERS

The following, nominated by the Council, were elected to membership in the American Physiological Society at the Fall Meeting, 1973.

FULL MEMBERS

ALLEN, Gary I.: Res. Asst. Prof. Physiol., State Univ. N.Y., Buffalo
ANDERSON, John J. B.: Asst. Prof. Surg., Univ. North Carolina, Chapel Hill

ANNAU, Zoltan: Assoc. Prof. Environ. Med., Johns Hopkins Univ.
ARIEFF, Allen I.: Asst. Prof. Med., Univ. of California, Los Angeles
ATENCIO, Alonzo C.: Asst. Prof. Biochem., Univ. of New Mexico
BACHE, Robert J.: Asst. Prof. Med., Duke Univ., Durham
BARKER, Kenneth L.: Assoc. Prof. Biochem., Univ. of Nebraska
BECKETT, Sidney D.: Assoc. Prof. Vet. Physiol., Auburn Univ.
BECKMAN, David L.: Asst. Prof. Anesthesiol. & Physiol., Wayne State Univ., Detroit
BERK, Paul D.: Sr. Invest., Natl. Cancer Inst., NIH, Bethesda, Md.
BISGARD, Gerald E.: Asst. Prof. Vet. Sci., Univ. of Wisconsin
BLAKE, Charles A.: Asst. Prof. Anat., Duke Univ., Durham
BOND, Gary C.: Res. Physiologist, St. Luke's Hosp., Kansas City
CANONICO, Peter G.: Chief Researcher, US Army Med. Res. Inst. Infect. Dis., Fredrick, Md.
CAPRANICA, Robert R.: Assoc. Prof. Neurobiol. & Behavior, Cornell Univ., Ithaca
CASSIDY, Marie M.: Assoc. Prof. Physiol., Geo. Washington Univ.
CHAPLER, Christopher K: Asst. Prof. Physiol., Queen's Univ., Kingston, Ont., Canada
CLARK, Francis J.: Assoc. Prof. Physiol. & Biophys., Univ. of Nebraska Med. Ctr.
CUERVO, Leon A.: Asst. Prof. Physiol. & Biophys., Univ. of Miami
D'AOUST, Brian G.: Investigator, Hyperbaric Physiol., Virginia Mason Res. Ctr., Seattle
DAVIES, Donald G.: Asst. Prof. Physiol., Albany Med. Coll.
DELAHAYES, Jean F.: Asst. Prof. Physiol., Ohio State Univ.
Di GIROLAMO, Mario: Assoc. Prof. Med., Emory Univ., Atlanta
ELKINS, Ronald C.: Asst. Prof. Surg., Univ. of Oklahoma Health Sci. Ctr., Oklahoma City
ENGEN, Richard L.: Assoc. Prof. Vet. Physiol., Iowa State Univ.
ERICKSON, Howard H.: Vet Scientist, USAF Aerosp. Med. Brooks AFB
FAIN, John N.: Prof. Med. Sci., Brown Univ., Providence, RI
FARNSWORTH, Patricia N.: Asst. Prof. Physiol. & Med., Coll. of Medicine & Dentistry, Englewood, NJ
FEINBLATT, Joel D.: Asst. Prof. Physiol. & Biochem., Univ. of Massachusetts, Worcester
FELLOWS, Robert E.: Assoc. Prof. Physiol. & Pharmacol., Duke Univ.
FISCHBARG, Jorge: Asst. Prof. Ophthalmol., Columbia Univ., N.Y.
FISHMAN, Irving Y.: Prof. of Biol. in Physiol., Grinnell College, Iowa
FOLTS, John D.: Asst. Prof. Med., CV Res. Lab., Univ. Wisconsin
FORSTER, Hubert V.: Asst. Prof. Physiol. & Environ. Med., Med. Coll. of Wisconsin, Milwaukee
FOSTER, Giraud V.: Assoc. Prof. Physiol., Johns Hopkins Univ.
FREDERICKS, Christopher M.: Asst. Prof. Physiol., Wayne State Univ.
FREE, Michael J.: Sr. Res. Sci., Pacific Northwest Labs, Richland, WA
FRIEDLER, Robert M.: Asst. Prof. Med., Univ. of California, L.A.
GALLO, Robert V.: Asst. Prof. Physiol., Univ. California, S.F.
GELBAND, Henry: Asst. Prof. Pediat., Univ. of Miami
GRIGG, Peter: Asst. Prof. Physiol., Univ. of Massachusetts, Worcester
GRONWALL, Ronald R.: Assoc. Prof. Physiol., Kent State Univ., Manhattan, KS
HAIT, Gershon: Assoc. Prof. Pediat., Albert Einstein Coll., Bronx, NY
HAMOSH, Paul: Asst. Prof. Physiol. & Biophys., Georgetown Univ.

HAVLICEK, Viktor: Assoc. Prof. Physiol., Univ. of Manitoba
HERREID, Clyde F. II: Assoc. Prof. Biol., State Univ. N.Y., Buffalo
HESS, Michael L.: Asst. Prof. Physiol., Med. Coll. Virginia, Richmond
HIFT, Helen: Asst. Cl. Prof. Physiol., Univ. of Wisconsin
HIGHSTEIN, Stephen M.: Asst. Prof. Neurol., Mt. Sinai Sch. Med., N.Y.
HLASTALA, Michael P.: Acting Instr., Div. Resp. Dis., University Hosp., Seattle
HOGAN, Perry M.: Asst. Prof. Physiol., State Univ. N.Y., Buffalo
HORVATH, Fred E.: Assoc. Prof. Physiol., New York Med. Coll.
HUTCHINS, Phillip M.: Asst. Prof. Physiol., Bowman Gray Sch. Med.
JURF, Amin N.: Asst. Prof. Physiol., Univ. of Maryland, Baltimore
KAAS, Jon H.: Asst. Prof., Lab. of Neurophysiol., Univ. of Wisconsin
KAMON, Eliezer: Assoc. Res. Prof., Occupational Health, Univ. of Pittsburgh
KATZ, Sidney: Assoc. Prof. Physiol., Med. Univ. of South Carolina
KITA, Hiroshi: Res. Assoc. Physiol. & Biophys., State Univ. of N.Y. Stony Brook
KLISSOURAS, Vassilis: Asst. Prof. Physiol., McGill Univ., Montreal
KLUGER, Matthew J.: Asst. Prof. Physiol., Univ. of Michigan
KOLDOVSKY, Otakar: Asst. Prof. Pediat., Children's Hospital of Philadelphia
KOMISARUK, Barry R.: Assoc. Prof. Zool., Inst. Animal Behavior, Rutgers, Newark, NJ
KREGENOW, Floyd M.: Lav. Kidney & Electrolyte Metab., NIH
KUTCHAI, Howard C.: Asst. Prof. Physiol., Univ. of Virginia
LEMANN, Jacob, Jr.: Prof. Med., Med. Coll. of Wisconsin, Milwaukee
LEVITT, David G.: Asst. Prof. Physiol., Univ. of Minnesota
LIPTON, James M.: Asst. Prof. Physiol., Univ. Texas Health Sciences Ctr., Dallas
McCAA, Robert E.: Asst. Prof. Physiol. & Biophys., Univ. of Mississippi, Jackson
McGUIRE, William L.: Assoc. Prof. Med., Univ. of Texas Med. Sch., San Antonio
MAHER, John T.: Res. Physiologist, US Army Res. Inst. of Environ. Med., Natick, Mass.
MANTHEY, Arthur A.: Asst. Prof. Physiol. & Biophysics, Univ. of Tennessee, Memphis
MASSARO, Gloria D.: Asst. Prof. Med., Geo. Washington Univ.
MAYER, George P.: Prof. Physiol., Coll. Vet. Med., Oklahoma State Univ., Stillwater
MENNINGER, Richard P.: Asst. Prof. Physiol., Univ. of South Florida
MEYER, Ralph A., Jr.: Asst. Prof. Physiol. & Pharmacol., New York Univ. Coll. Dentistry
MICHAEL, Joel A.: Assoc. Prof. Physiol., Rush Medical Coll., Chicago
MOUW, David: Asst. Prof. Physiol., Univ. of Michigan, Ann Arbor
NEJAD, Nasser S.: Assoc. Prof. Physiol. & Med., Univ. of Oklahoma Health Ctr., Muskogee
NICOLOSI, Gregory R.: Asst. Prof. Physiol., Univ. of South Florida
NUTTING, David F.: Asst. Prof. Physiol. & Biophys., Univ. of Tennessee, Memphis
ODELL, William D.: Chrmn., Dept. Med., Harbor Gen. Hosp., Torrance, Calif.

PENGELLY, Lionel D.: Assoc. Prof. Med., McMaster Univ. Med. Ctr., Hamilton Ont., Canada
PHILLIS, John W.: Prof. Physiol., Univ. of Saskatchewan Med. Coll.
PINSKER, Harold M.: Asst. Prof. Physiol., Univ. of Texas Med. Br. Galveston
PRICE, Steven: Assoc. Prof. Physiol., Med. Coll. of Virginia
PUSCHETT, Jules B.: Asst. Prof. Med., Univ. of Pennsylvania
RAVEN, Peter B.: Asst. Res. Physiologist, Univ. of California, Santa Barbara
REYNOLDS, David G.: Chief, Div. Surg., Walter Reed Army Inst. Res., Washington, D.C.
RICHARDSON, Daniel R.: Asst. Prof. Physiol. & Biophys., Univ. of Kentucky, Lexington
RIDLEY, Peter T.: Dir. Pharmacol., Smith Kline & French Labs.
ROGERS, Robert M.: Assoc. Prof. Physiol., Univ. of Oklahoma
ROMERO, Juan C.: Res. Assoc., Nephrol., Mayo Grad. Sch. Med.
ROSE, Birgit: Res. Sci., Physiol. & Biophys., Univ. of Miami
ROSENTHAL, Myron: Asst. Prof. Physiol., Duke Univ. Med. Ctr.
ROTH, Gerald I.: Assoc. Prof. Oral Biol., Univ. of Kentucky
ROY, Arun K.: Asst. Prof. Biol. Sci., Oakland Univ., Rochester, Minn.
RUDERMAN, Neil: Asst. Prof. Med., Cornell Med. Sch., New York
SCHWINGHAMER, James M.: Assoc. Prof. Physiol., Michigan State Univ., East Lansing
SHANK, Brenda M.B.: Asst. Prof. Physiol., CMDNJ, Rutgers Med. Sch.
SHERMAN, Robert G.: Asst. Prof. Physiol., Clark Univ., Worcester
SMITH, Ora L.K.: Res. Assoc. Epidemiol., Yale Univ., New Haven
STEVENSON, Nancy R.: Asst. Prof. Physiol., CMDNJ, Rutgers Med. Sch.
STINSON, Joseph M.: Assoc. Prof. Physiol., Meharry Med. Coll.
STITH, Rex D.: Asst. Prof. Physiol. & Biophys., Univ. of Oklahoma
STRAUSS, Harold C.: Asst. Prof. Med., Duke Univ. Med. Ctr.
SZURSZEWSKI, Joseph H.: Asst. Prof., Mayo Fndn. & Clinic
TEMPLETON, Gordon H.: Asst. Prof. Physiol., Univ. Texas SW
THARP, Garald D.: Assoc. Prof. Zool., Univ. of Nebraska, Lincoln
THIND, Gurdarshan S.: Asst. Prof. Med., Washington Univ., St. Louis
TRUONG, Xuan T.: Dir. Res. & Education, Inst. Phys. Med. & Rehab., Peoria, Ill.
TURINSKY, Jiri: Assoc. Prof. Physiol., Albany Med. Coll., Albany, NY
UPTON, G. Virginia: Sr. Res. Assoc., VA Hosp., West Haven, CT
VALERI, C. Robert: US Naval Reserve, Naval Blood Res. Lab., Chelsea
WALDO, Albert L.: Assoc. Prof. Med., Univ. of Alabama, Birmingham
WALKER, John L.: Assoc. Prof. Physiol., Univ. of Utah Coll. Med.
WEATHERS, Wesley W.: Asst. Prof. Environ. Physiol., Rutgers Univ.
WEGLICKI, William B.: Asst. Prof. Med., Harvard Med. Sch.
WEINER, Richard: Assoc. Prof. Physiol., New York Med. Coll.
WEISKOPF, Richard B.: Res. Sci., US Army Res. Inst. Environ. Med., Natick, Mass.
WEISS, Harvey R.: Asst. Prof. Physiol., Rutgers Med. Sch.
WELBOURNE, Tomas C.: Asst. Prof. Med., Montreal Univ.
WHEELER, Darrell D.: Asst. Prof. Physiol., Univ. of South Carolina
WIESENDANGER, Mario: Assoc. Prof. Physiol., Univ. of Western Ontario
WILLIAMS, John A.: Asst. Prof. Physiol., Univ. of California, S.F.
WILSON, David L.: Asst. Prof. Physiol. & Biophys., Univ. of Miami
WOHL, Mary E.: Asst. Prof. Pediat., Children's Hosp., Boston
YATES, Robert D.: Chrmn, Dept. Anat., Tulane Univ. Sch. Med.

ASSOCIATE MEMBERS

ABBOTT, William M.: Instructor, Dept. Surgery, Harvard Med. Sch.
AHMED, Shaikh S.: Asst. Prof. Med. Cardiol., New Jersey Med. Sch.
ALTER, William A. III: Doct. Cand., Physiol., Univ. of New Mexico
BASON, Robert: Asst. Prof., Preventive Med., Ohio State Univ.
BELLONI, Francis L.: Grad. Stu., Dept. Physiol., Univ. of Michigan
CANGIANO, Jose L.: Staff Nephrologist, VA Hosp., San Juan, P. R.
CANT, James R.: Teaching Fellow Physiol., Univ. of Michigan
COESTER, Waneta K.: Res. Assoc., Physiol., Lovelace Fndn.
CORNELL, Robert P.: Res. Assoc., Physiol., Loyola Univ.
De HART, William D.: Educational Administrator, APS Headquarters, Education Office
DOWNEY, James M.: Asst. Prof. Physiol., Univ. of South Florida
GEOKAS, Michael C.: Chief of Med., VA Hosp., Sepulveda, Calif.
GREGG, Christine A.: Predoct. Fellow, Physiol., Univ. of Michigan
HENNINGER, Ann Louise: Teaching Fellow, Physiol., Univ. of Michigan
HOLLOWAY, Lewis S.: Asst. Prof. Physiol., Texas Tech. University
IANUZZO, C. David: Asst. Prof. Biol., Boston University
KATTLOVE, Herman E.: Asst. Prof. Med., Univ. California, L. A.
KOPETZKY, Michael T.: Chief Pulmonary Function Lab., Natl. Jewish Hospital, Denver
LAPP, N. LeRoy: Assoc. Prof. Med., West Virginia University
LEGAN, Sandra J.: Grad. Stu., Pathology, Univ. of Michigan
LICHTENBERGER, Lenard M.: Postdoct. Fellow Physiol., UCLA
LUCCI, Majory S.: Predoct. Trainee Physiol., Univ. of New Mexico
LYONS, H. Jay: Predoct. Trainee Physiol., Univ. of New Mexico
MARTIN, David E.: Prof. Physiol., Georgia State University
MILLS, Steven H.: Postdoct. Fellow, Space Sci. Res. Ctr., Univ. of Missouri
MORIN, Richard A.: Dir. of Facilities, Dept. Physiol., State Univ. of New York, Buffalo
PEARSON, Terry W.: Grad. Student, Dept. Human Physiol., Univ. of California, Davis
REMLER, Michael P.: Asst. Prof. Med. & Anat., Univ. North Carolina
RIKEL, James E.: Teaching Asst. Physiol., Univ. of Southern California
SHIAU, Yih-Fu: Jr. Asst. Resident, Dept. Med., Philadelphia Gen. Hosp.
SINGH, Sant P.: Prof. Med., State Univ. of New York, Downstate Med. Ctr., Brooklyn
THORNBURG, Kent L.: Postdoct. Fellow, Dept. Physiol., Univ. of Oregon
WAGNER, Wiltz W.: Res. Assoc., CV Lab., Univ. of Colorado Med. Ctr.
ZUCKER, Irving H.: Postdoct. Fellow, Dept. Physiol., Univ. of Nebraska Med. Ctr.

THE AMERICAN PHYSIOLOGICAL SOCIETY

Founded December 30, 1887; Incorporated June 2, 1923

OFFICERS 1973-74

President - D. C. Tosteson, Duke University, Durham, North Carolina
President-Elect - A. C. Guyton, University of Mississippi, Jackson
Past-President - R. M. Berne, University of Virginia School of Medicine, Charlottesville
Council - D. C. Tosteson (1974), A. C. Guyton (1975), R. M. Berne (1974), J. Mead (1977), D. F. Bohr (1976), B. Schmidt-Nielsen (1975), E. E. Selkurt (1974).
Executive Secretary-Treasurer - O. E. Reynolds, 9650 Rockville Pike, Bethesda, Maryland 20014

STANDING COMMITTEES

Publications - P. F. Curran (1975), Chairman; Paul Horowicz (1974), A. P. Fishman (1975). Ex officio - H. E. Morgan, Physiological Reviews; J. M. Brookhart, Journal of Neurophysiology; J. R. Pappenheimer, Handbooks; O. E. Reynolds, Executive Secretary-Treasurer, Editor of The Physiologist and Physiology Teacher; Sara F. Leslie, Publications Manager and Executive Editor; S. R. Geiger, Executive Editor for Handbooks.
Finance - E. B. Brown, Jr. (1974), Chairman; C. F. Code (1976), J. R. Brobeck (1975). Ex officio - O. E. Reynolds, Executive Secretary-Treasurer; W. A. Sonnenberg, Business Manager; P. F. Curran, Chairman of Publications Committee.
Education - J. L. Kostyo (1976), Chairman; Leonard Share (1976), L. S. Jefferson (1975), Adelbert Ames III (1974), P. B. Dunham (1975); Representatives from Society of General Physiologists - B. A. Curtis (1975), B. Kaminer (1976); Representatives from Comparative Physiology Division of the American Society of Zoologists - I. J. Deyrup-Olsen (1974), Patricia N. Farnsworth (1975). Ex officio - O. E. Reynolds, Education Officer.
Membership Advisory - Sidney Solomon (1974), Chairman; E. R. Ranney (1976), N. C. Staub (1976), B. D. Lindley (1976), C. M. Armstrong (1975), B. R. Duling (1975).
Program Advisory - F. F. Jobsis (1975), Chairman; Claude Lenfant (1976), G. G. Somjen (1976), F. G. Knox (1976), S. D. Gray (1975), H. M. Goodman (1975), S. Y. Botelho (1974).
Public Affairs - R. K. Crane (1976), Chairman; L. D. Longo (1976), H. D. Patton (1974), J. B. Preston (1974), Theodore Cooper (1974).
Senior Physiologists - D. B. Dill (1974), Chairman; H. S. Mayerson (1974), Hallowell Davis (1975), M. B. Visscher (1975).
Perkins Memorial Fund - J. R. Pappenheimer (1974), Chairman; H. Rahn (1974), E. E. Selkurt (1974), B. Schmidt-Nielsen (1974). Ex-officio - Mrs. J. F. Perkins, Jr., O. E. Reynolds.
Porter Physiology Development Program - A. C. Barger (1974) and E. W. Hawthorne (1974), Co-Chairmen; E. P. Radford (1974), W. C. Foster (1974), R. D. Berlin (1976), H. Sparks, Jr. (1975), C. Russ (1975).
Animal Care and Experimentation - H. R. Parker (1974), Chairman; E. T. Angelakos (1974), L. S. Lilienfield (1974), W. J. Tietz, Jr. (1974).
Legal Counsel - W. H. Pattison, Jr.

REPRESENTATIVES TO OTHER ORGANIZATIONS

Federation Board - A. C. Guyton (1976), D. C. Tosteson (1975), R. M. Berne (1974).
Federation Executive Committee - A. C. Guyton (1976)
Federation Publications Committee - C. S. Tidball (1976)
Federation Meetings Committee - F. E. Yates (1974)
Federation Program Committee - O. E. Reynolds
Federation Public Affairs Committee - L. D. Longo (1976)
Federation Public Information Committee - R. K. Crane (1976)
Executive Officers Advisory Committee of the Federation -O.E. Reynolds
U.S. National Committee for International Union of Physiological Sciences - J. M. Brookhart (1975), J. R. Brobeck (1976), A. C. Barger (1975), A. C. Guyton (1979).
National Research Council - Div. of Biology and Agriculture - H. Gainer (1974); Div. of Medical Sciences - M. B. Burg (1974).
American Association for the Advancement of Science - W. G. Van der Kloot (1973), E. J. Masoro (1973).
National Society for Medical Research - H. R. Parker (1976).
American Society for Information Science - S. R. Geiger (1976)
Council of Academic Society of the Association of American Medical Colleges - A. B. Otis (1974), R. E. Forster (1974).

PUBLICATIONS

Publications Committee - P. F. Curran (1975), Chairman; A. P. Fishman (1975), P. Horowicz (1974).
Publications Manager and Executive Editor - Sara F. Leslie
American Journal of Physiology and Journal of Applied Physiology - Section Editors - D. F. Bohr, F. J. Klocke, W. C. Randall (Circulation); L. E. Farhi, T. C. Lloyd, Jr. (Respiration); J. H. Dirks, E. E. Windhager (Renal and Electrolyte); S. G. Schultz (Gastrointestinal); N. S. Halmi, F. E. Yates (Endocrinology and Metabolism); E. R. Buskirk, A. P. Gagge (Environmental); L. B. Kirschner (Comparative and General); O. A. Smith (Neurobiology); H. M. Ranney (Hematology); F. N. Briggs (Muscle).
Journal of Neurophysiology - J. M. Brookhart, Chief Editor
Physiological Reviews - H. E. Morgan, Chairman, Editorial Board; D. R. Wilkie, Chairman, European Committee; R. C. Rose, Associate Editor.
Handbooks of Physiology - J. R. Pappenheimer, Chairman Editorial Committee; S. R. Geiger, Executive Editor.
The Physiologist - O. E. Reynolds, Editor
The Physiology Teacher - O. E. Reynolds, Editor, W. D. DeHart, Executive Editor.
Physiology in Medicine (in the New England Journal of Medicine) - A. P. Fishman, Editor.

PAST OFFICERS

Presidents - 1888 H. P. Bowditch. 1889-1890 S. W. Mitchell. 1891-1895 H. P. Bowditch. 1896-1904 R. H. Chittenden. 1905-1910 W. H. Howell. 1911-1913 S. J. Meltzer. 1914-1916 W. B. Cannon. 1917-1918 F. S. Lee. 1919-1920 W. P. Lombard. 1921-1922 J. J. R. MacLeod. 1923-1925 A. J. Carlson. 1926-1929 Joseph Erlanger. 1930-1932 W. J. Meek. 1933-1934 A. B. Luckhardt. 1935 C. W. Greene. 1936-1937 F. C. Mann. 1938-1939 W. E. Garrey. 1938 W. T. Porter Honorary President. 1940-1941 A. C. Ivy. 1942-1945 P. 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 H. Davis. 1959 R. F. Pitts. 1960 J. H. Comroe, Jr. 1961 H. W. Davenport. 1962 H. S. Mayerson. 1963 H. Rahn. 1964 J. R. Pappenheimer. 1965 J. M. Brookhart. 1966 R. E. Forster. 1967 R. W. Berliner. 1968 L. D. Carlson. 1969 C. L. Prosser. 1970 A. C. Barger. 1971 J. R. Brobeck. 1972 R. M. Berne.

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. 1956-1972 R. G. Daggs. 1973 - O. E. Reynolds.

CONSTITUTION AND BYLAWS

CONSTITUTION
(Adopted at the 1953 Spring Meeting)

ARTICLE I. Name

The name of this organization is THE AMERICAN PHYSIOLOGICAL SOCIETY.

ARTICLE II. Purpose

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

BYLAWS
(Amended April 1966)

ARTICLE I. Principal Office

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

ARTICLE II. Corporate Seal

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

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

ARTICLE III. Membership

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

SECTION 2. Regular Members. Any person who as conducted and published 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 twc 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 delinquent of his right to request reinstatement.

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

ARTICLE VII. Financial

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

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

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

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

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

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

ARTICLE VIII. Publications

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

ARTICLE IX. Meetings

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

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

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

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

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

ARTICLE X. Society Affiliations

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

ARTICLE XI. Regulations

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

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

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

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

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

ARTICLE XII. General

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

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

ARTICLE XIII. Amendments

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

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

PAST-PRESIDENT'S ADDRESS

The American Physiological Society - A Piece of the Continent, A Part of the Main

ROBERT M. BERNE

I would like to say at the outset that I owe the membership an apology. When I was elected President-Elect, I felt inadequately prepared for the office: I was concerned about how I would handle the job and meet the many other commitments that I had made. Consequently, when President Barger called on me for a brief report following the final ballot, I made some inappropriate remark that showed a lack of appreciation. I realized later that I probably had offended my friends and colleagues who had voted for me. Since offense certainly was not my intent, I now offer my sincere apology. In retrospect, this year as President of the American Physiological Society has been a most interesting, exciting and rewarding experience, and I am very grateful to the membership that elected me. Concerning presidential elections (all of them) I shall always identify more with the electors than the elected, although even there I have been humbled by Ogden Nash's limerick.

> "They have such refined and delicate palates
> That they can discover no one worthy of their ballots.
> And when someone terrible gets elected,
> They say, There, that's just what I expected!"

This limerick does not reflect on other past or future presidents, but the names of the last three presidents, Barger, Brobeck and Berne, reminded me of the chant that Franklin Roosevelt popularized in one of his speeches in which he retaliated for the attacks of certain members of Congress. I am referring to "Martin, Barton and Fish." This chant stimulated me, with the able help of my wife, to compose a limerick of my own.

> "Barger, Brobeck and Berne
> As the President they each had a term.
> Barger and Brobeck
> Came close to perfect,
> But Berne was slower to learn.
>
> Cliff B., John B. and me
> Are but pages in history.
> We can't hold a candle
> To the Watergate scandal,
> Council's tapes are no mystery.
>
> Barger, Brobeck and Berne
> Can never ever return.
> The rules on election
> Make no exception,
> So now it's Tosteson's turn."

It has become traditional for the past-president to address the membership at the Fall Meeting, but this was not always the case. On a number of occasions during the earlier years of the Society, the membership was asked to express its opinion about whether the president should give a "Presidential Address" at the annual meeting. Repeatedly, the membership voted against such an address. In 1896 the Council voted that "it is inexpedient to have an annual presidential address," and in 1913 the Society voted that "it is the sense of the Physiological Society that a formal presidential address is not desirable." It was said that "in the opinion of the members as a whole, the main purpose of the meetings has been to give an opportunity for the presentation of scientific papers and demonstrations. Everything else, including business session and election has been of subsidiary importance. One may be allowed to express the hope that this wholesome tradition will always prevail."

Obviously, this "wholesome tradition" did not prevail, and in 1948 Maurice Visscher broke the old tradition and started a new one. After an invited speaker belatedly declined to talk to the Society, Visscher called on Past-President Wallace Fenn to give an after-dinner address. It took quite a bit of persuasion, a $9.50 telephone call - but the result was well worth the effort. Fenn's address set a high standard that has been difficult to equal or even approach, and people are still citing his witty stories. Thus, it has since been the task of the Past-President to speak to the Society after the Fall Meeting banquet on a subject of his choice. Many Past-Presidents were gifted after-dinner speakers, but others like myself, dreaded this moment from the day they were voted President-Elect.

During my year in office, in addition to reading the talks of Past-Presidents, I have read a great deal about the history of the Society. I was concerned about the role of the Physiological Society today and thought that perhaps I could find some answers in the goals and the purposes of the founders of the Society. My concern was essentially two-fold. Looking internally at the present membership, I wondered if the APS was meeting the needs of all of its members, or, at least the majority of its members. I wondered if Society elections represented a true expression of the membership's views. I was also especially concerned about the new fields of interest such as biophysics and bioengineering that have been spawned by the many new developments in physiology, and I wondered whether the Society truly represented them or provided them equally with the opportunities they need and want to present and discuss their scientific observations. I wondered about the effect on the Society of the increasing number of smaller societies that have in large part taken origin from the APS. I wondered about the social minorities in the Society that reflected the same situation outside the Society, such as the number and status of women and black members, and I wondered if the Society was keeping pace in achieving true social equality.

Looking externally, I wondered about the relationship of the Society to the Federation and beyond that to the total pursuit of basic scientific knowledge in the world today. There is no question that in the last year we have witnessed greater political threats to the funding of basic scientific research, and I wondered whether the Society was meeting its responsibility, not as a political organization, but as a torch bearer for the right to freely pursue basic research. We have seen the movement towards disease-oriented research in heart and cancer programs, we have watched the growth of special institutes, and, as individuals, many of us have voiced our views. Now it is time for the Society to look at the whole direction of scientific research and attempt to take a stand with other societies on that which concerns all citizens but is the special province of scientists. I wondered how we, as a society, had started and if we, as a society, were keeping pace with the tremendous growth in scientific knowledge that has taken place since our founding.

The APS was founded in 1887 by 28 physiologists, 17 of whom attended the first meeting on December 30th at the College of Physicians and Surgeons. The stated purpose of the Society was "to promote the advancement of physiology and to facilitate personal intercourse among physiologists" (that was of course before the recent Supreme Court decision on pornography). A constitution was drawn up and adopted, and through the years there have been several changes in the structure of the Society as it has progressively increased in size. At the first election, Bowditch, Curtis, Martin, Mitchell and Wood were elected to the Council, but Weir Mitchell declined and Sewall was elected to replace him. The Council then elected Bowditch as President and Martin as Secretary-Treasurer. Had he been willing to serve, Mitchell probably would have been elected President because of his prominence and seniority. Bowditch served six nonconsecutive terms as President (Mitchell was President for two terms) followed by Chittenden who served for nine terms. From year to year there was little change in the Council, and the Council tended to reelect its oldest, most distinguished member as President. This procedure worked well and was acceptable to the Society for many years, since it provided permanence and continuity. However, some unrest developed in 1904 because the growing society was being run by a small "in group" (a feeling that has recently been expressed by some of the present younger members of the Society.) Therefore an amendment was adopted stating that "the management of the Society shall be vested in a Council consisting of the President, Secretary, Treasurer and two other members to be (all) chosen from the ordinary members by ballot at each annual meeting, and to serve until the close of the meeting at which their successors are elected." Elections have remained in the hands of the Society ever since, although there have been changes in the number, the designation and the length of term of the Society officers. Furthermore, elections by ballot at the annual meetings have continued since 1904. However, in a poll conducted during the past year the membership indicated a 5 to 1 preference for some form of mail ballot to permit wider membership representation, uninterrupted discussion of substantive issues, and limitation of Society business matters to one meeting. An ad hoc committee is currently studying procedures for a mail ballot and will present their recommendations for a vote at the next Spring Meeting.

With the skillful guidance of its officers, the Society grew and flourished. As you know, physiology was originally a part of medicine, then for some time it was combined with anatomy. After physiology was established as an independent discipline, physiological societies were formed in several countries including the United States, and initially the APS consisted of a small congenial group of scientists who worked on a variety of research problems at a level that was understandable to colleagues working in different areas. Furthermore, the small size of the Society permitted spontaneous informal social gatherings where science, politics and other subjects were discussed, sometimes late into the night over a number of beers. As the Society grew and the physiologists became more specialized in their research interests, so did their informal gatherings. Also, because of the increasing difficulty for physiologists in one area to comprehend material presented by their colleagues in other areas, it became necessary at first to group similar papers and later to provide separate sessions for each subject, as we do now. The different groups became less and less tolerant of each other, and finally in 1906 a group of physiologists who were interested primarily in physiological chemistry started the American Society of Biological Chemists and two years later the Pharmacologists formed their own Society. These actions caused some concern among the remaining physiologists, and President Chittenden expressed the hope that the societies' relationships would remain cordial and that no conflict of interests would develop. Since some of the "separationists" were influential members of the APS, it was deeply regretted that this division took place. It was felt that there was "no doubt that specialization of this kind may be carried so far that what is gained in the way of stimulus and inspiration may be more than offset by what is lost in general culture and information." As the years passed and the membership of the Society continued to enlarge, certain problems arose (even as far back as 1911); we still face some of these problems today. Originally there was no time limit either for the presentation of papers or for their discussion, but later they were limited to 20 minutes, then to 15 and finally to 10. The "congested nature of the programs" around 1911 prompted a number of remedial suggestions such as having meetings in sections, holding longer meetings (4 days or more), changing the time of the meetings from December to June, making abstracts mandatory, dispensing with reading of papers and proceeding with discussion on the basis of printed abstracts (a worthwhile suggestion that was never carried out), establishing closer affiliation with the Biochemical and Pharmacological Societies and limiting the number of papers. These recommendations were referred to the Council, but apparently no action was taken; the whole problem was dumped into the lap of the Federation when it was formed in 1913.

Although the American Physiological Society spawned the Biochemical and Pharmacological Societies, the fourth original member of the Federation, the Experimental Pathologists, had an independent origin with only some of its members holding membership in the APS. Later the Nutritionists and Immunologists joined the Federation, and Society membership in FASEB has remained unchanged for a number of years. Prior to the formation of the Federation, the APS had started the publication of the American Journal of Physiology and subsequently started Physiological Reviews and the Journal of Applied Physiology, purchased the Journal of Neurophysiology and in recent years initiated The Physiologist, Physiology Handbooks, Physiology for Physicians, The Physiology Teacher and brochures on Careers in Physiology. Special committees such as the Finance Committee, the Program Committee, the Membership Committee, the Education Committee, the Public Affairs and Public Information Committee, the Committee on Animal Care and Experimentation, the Porter Fellowship Committee and others were formed to aid in carrying out the numerous functions of the Society. The APS set high standards for membership and for the development of scientific research in this country. In the words of President Howell, the APS has "in many ways and on many occasions brought about cooperation and mutual stimulation among its members, and it has been a constantly acting mechanism for promoting that personal acquaintance and understanding among workers which counts for so much in the progress of every science."

Despite certain unifying trends such as the expanded activities of the Education Committee and an increasing need for the American Physiological Society to establish standards for Physiology Departments throughout the country, the bonds between the various subgroups within the Society became more and more strained. With growth of the Society and greater specialization in research, there emerged sizable fractions of members with mutual research interests who felt the need for an independent society that would also attract scientists from other disciplines with a similar focal point in research. The development of these smaller societies is a natural, desirable phenomenon, since they can provide small workable meetings on subjects of interest to all participants without competing or interspersed papers on unrelated subjects. Within the past few years we have seen the birth of the Society of General Physiologists, the Biophysics Society, the Biomedical Engineering Society, the Society for Neurosciences and the Microcirculatory Society, and it is quite conceivable that within the next several years existing and/or new groups within the APS will also seek independent status if they feel restricted by the structure of this Society.

This trend is the reverse of climbing on the bandwagon but not quite comparable to jumping off a sinking ship. It reminds me of the story about the passenger who boarded the night train in New York for Charlottesville and points south. Before retiring he went up to the porter and said "Look, I want to get off at Charlottesville, Virginia but once I'm asleep it's very difficult for me to wake up. Sometimes I'm nasty and don't know what I'm saying. Here's ten dollars. Please, no matter what I say or do, wake me up and get me off the train in Charlottesville." Next morning the man woke up in Durham, North Carolina and he was furious. He found the porter, screamed and yelled and even took a swing at him. Then he got off the train. The conductor saw what went on and went up to the porter and said "What happened? I've never seen anyone get that mad." The porter replied "That's nothing. You should have seen the guy I put off the train in Charlottesville."

Unlike the angry passenger who got off the train at the wrong station, the members of these newly formed societies are attracted by the opportunities to arrange their own meetings and symposia within limited research areas in a variety of attractive localities; these advantages far outweigh the advantages of the larger meetings that cover a host of subjects outside their realm of interest. Furthermore, the smaller societies cut across existing disciplinary boundaries (e.g. anatomy, chemistry, engineering, etc.) so as to include scientists of different backgrounds and training but with mutual research interests.

How does this fractionation of physiologists affect the APS and the meetings held by the Society? To a large measure this depends on whose opinion one seeks. In the eyes of a substantial number of active members, the APS has outgrown its usefulness and in the words of some "the good stuff is all presented at the smaller society meetings" thereby greatly weakening the APS programs. In fact, a significant number of physiologists who formerly attended the Federation and Fall meetings with regularity now attend the smaller, more specialized meetings instead. However, there are still many members who are quite satisfied with the present APS meetings and who enjoy the opportunity the meetings afford to get together with old colleagues and acquaintances and to meet new fellow scientists. Nevertheless, the question crops up again and again in the minds of the membership. If this trend of specialization and splintering continues, what will become of the APS? Will it become a "hollow shell" with a progressive decline in the quality of material presented and will this material consist only of bits and pieces that do not fall within the province of one of the many special groups?

To reply to these questions and to consider the problem of fractionation of physiology, one must define the role of the APS. In addition to fostering physiology in its broadest sense and encouraging the exchange of scientific ideas at scheduled meetings, the society has now assumed a number of functions which subserve its primary purposes. It publishes scientific journals and handbooks covering all aspects of physiology, it has greatly enlarged the scope of its educational program so as to provide refresher courses, educational materials and brochures to attract young people to a career in physiology, and recently it has arranged meetings, symposia and conferences that have involved participants from other societies. Further development of this latter function, to my mind, is the most important role the Society can serve if it is to train teachers of physiology and maintain its vitality and usefulness to the scientific community and to the public. The Society must have the flexibility to sustain the interests of nonmedical school as well as medical school-based physiologists, for without physiologists in medical schools where will the impetus and the training for research in the basic aspects of disease (abnormal physiology) arise and without nonmedical school physiologists how will the medical school physiologists keep abreast of the important advances in other aspects of physiology? Greater effort must be expended in developing meetings and programs that involve members of other related societies, and the membership of these smaller groups should be encouraged to maintain an affiliation with the APS. No attempt should be made to absorb the smaller societies. On the contrary, they should be encouraged to emerge and develop as their scientific interests dictate. However, the APS could serve a most useful function by maintaining closer liason with its offspring and provide the means whereby the siblings can relate to each other in the most effective and productive scientific environment by organizing and arranging subject-oriented meetings that will attract those smaller societies or large fractions of their membership. This has, of course, already been done to some extent, and I might add most successfully, particularly when the APS poses no threat of dominating the independent groups. Further efforts in this direction are planned for alternate Fall meetings starting in 1975 when the Society will meet in San Francisco in October. After all, physiology in all its parts constitutes the basis of medicine, and we must still train broad-based physiologists to teach in medical, graduate and undergraduate schools. Only a broad-based organization like the APS can lead the way in education in all of physiology and still provide the links between investigation in the numerous subdivisions of this continuously growing field.

Concerning the question of minority groups within the Society, Dr. Barger has extensively discussed some of the problems of black physiologists in his address two years ago and I will not deal with this subject now. With respect to women members of the APS, the history is in keeping with the position of women in society in general. In the very early days of the Society there were no women members; in fact there were no known women physiologists in this country. However, in 1895 a woman was proposed for membership in the Society but was rejected by the Council not because of her sex but because the publications she submitted lacked sufficient originality to meet the standards for membership demanded by the Society. This application for membership brought up the question of admission of women to the Society, but the Council declined to take a position on the issue. The next time the question of women membership arose was in 1902 when Ida H. Hyde from the University of Kansas was nominated. Her nomination was approved by the Council, and when it was presented to the membership they were also asked to consider the question of admission of women to the Society. At the business meeting there was apparently full discussion of this question but the minutes state only that Ida Hyde was admitted to the Society; there was no mention of any policy about women membership. It was not until 1913 that a second woman was admitted to membership in the APS. However, records show that the American Physiological Society was far less chauvinistic than its older British counterpart which reluctantly admitted its first woman in 1915.

As the size of the APS grew so did its female membership, but the percentage of women members has remained small as has the percentage of women physiologists. These observations plus the facts that there are a significant number of women physiologists who are either unemployed or inappropriately employed and that women members of the Society have played a relatively minor role in the administration of the Society, prompted a small group of women members to bring to my attention and to that of the Council the need for study of the situation. Consequently, a task force under the Chairmanship of Elizabeth Tidball has been appointed whose principal objectives are 1) to explore ways of encouraging, at all levels, the study of physiology by women, 2) to determine the demographic characteristics of women physiologists, 3) to assist in bringing names of qualified women to the attention of the Council, 4) to serve as a resource for information regarding women physiologists and as a liason with other APS committees and scientific groups, and 5) to define special problems as appropriate. The accomplishment of these worthy objectives should result in more women physiologists (consequently more women members of APS) and in a more important and influential role for women in the activities of the Society.

These are some of the problems facing the membership within the Society, but perhaps of greater importance is the role of the Society in the Federation and in the scientific community at large. Of even greater importance is our own responsibility as individuals in a free democratic society to preserve the right of all people to pursue scientific truth.

At the present time the Federation provides many useful services for its member societies, of which the principal one is the organization and running of the Spring Meeting. However, FASEB has come under some criticism from APS members because of the size of the meetings, the restriction to Atlantic City (and occasionally Chicago) and the exclusion of smaller biological societies. During the past year a task force under the Chairmanship of Eugene Yates and consisting of members of APS who also hold membership in related smaller societies carefully reviewed the present relationship of APS to the Federation with the view of defining what role FASEB could most profitably play in the future of the Society. They considered many aspects of the problem, and a report of their observations and conclusions was presented at the second business meeting of the Society in April of this year. Six proposals for change were suggested, but only one received the enthusiastic support of the committee members. The principle recommendation of the task force was that FASEB be reconstituted so that other smaller societies can be readily admitted. This goal would require modification of the financial rules under which FASEB now operates so that small and large societies could coexist on an equal basis within FASEB. With respect to meeting the scientific needs of a broader membership, the permanent staff of FASEB with their expertise in running meetings could work closely with the program committees of the member societies to provide two or more meetings per year, and these meetings could be society-focused and/or problem-oriented. Flexible, imaginative programs could be implemented which could promote greater interchange of ideas between scientists of different societies, and the size of the meetings could be small enough to permit a sharper focus and an increase in depth in selected areas and also a greater freedom in the choice of meeting places. Furthermore, the onerous task of organizing and running meetings with all the financial and other problems that each individual society meeting alone must now endure would be taken over by the professional staff at the Federation.

The decision of the biochemists not to meet with the Federation every third year has to some degree weakened the Federation, and should the Biochemists elect to meet less frequently, or not at all, with the Federation it would endanger its survival. Furthermore, were the APS to arbitrarily decide to meet separately from the Federation at regular intervals, it is also doubtful that the Federation could continue as an effective organization, particularly if both the Biochemical and Physiological Societies did not meet with the Federation in any given year. Hopefully, the Biochemists will not secede from the Federation and perhaps can meet their needs for a separate meeting by having a second meeting, similar to those of the Physiologists and Pharmacologists. Collapse of the Federation would deprive the member societies of many useful services as well as the intersociety symposia and the exhibits of scientific materials which also defray a large part of the cost of the meetings. Finally, there is great need for unity, and dismemberment of the Federation can only lead to weakening of the position of biological scientists at a time when greater strength and influence are essential.

The Federation also serves as a mouthpiece for its member societies on government and public issues. Each of the member societies also performs this function to different degrees. Hence, there is considerable duplication of effort, and often the efforts to impress governmental bodies with the scientists' views on important issues are carried out in a haphazard, uncoordinated fashion. This problem probably stems from the fact that in general scientists are as individualistic in their relation to society as they are with their research. However, it is obviously highly desirable to present a solid front on key issues to have any impact on the government or the public.

With the cutback in research funds, the elimination of training grants and fellowships and the frightening increase in support of contract research and specific disease-oriented research at the expense of independent research, there is an obvious need to inform the public what biological science has done, what it can do and what steps are necessary to provide optimal conditions for further rapid scientific development that ultimately leads to a healthier population. Accomplishment of this goal requires more than just the Federation. It requires the united efforts of many, if not all, of the scientific societies of this country. It is true that we have such organizations as the AAMC and the AAAS that do a fine job, but I think that closer, stronger bonds could be developed among the numerous scientific organizations in this country and that a single union of scientists would be much more forceful in dealing with governmental agencies and in keeping the public abreast of scientific advancements. Organization of such a union could also help furnish the moral leadership now so sorely needed in this country and point the way in the search for truth. In the words of Thomas Jefferson at the time of the founding of the University of Virginia "This institution (or union of scientists) will be based on the illimitable freedom of the human mind. For here we are not afraid to follow truth wherever it may lead, nor to tolerate any error so long as reason is left free to combat it."

The APS today faces many problems, but they are not problems that are unique to our Society or even our own times. Every society of scholars must be concerned with serving its own members as well as with serving the larger goal of all free men which is purely and simply the unfettered pursuit of truth. Our concerns as a society are not isolated in time or place and we are not "an island entire of itself." What John Donne once said of all men, applies more than ever today to societies such as ours, that we are in truth "a piece of the continent, a part of the main." We are "involved in mankind."

USA NATIONAL COMMITTEE FOR THE INTERNATIONAL UNION OF PHYSIOLOGICAL SCIENCES

ANNOUNCEMENT OF TRAVEL AWARDS

As previously announced in the February 1973 issue of The Physiologist, the USA National Committee for the International Union of Physiological Sciences (IUPS) is sponsoring a travel grant program to benefit American scientists who could not attend the XXVI International Congress of Physiological Sciences in New Delhi, India, 20-26 October 1974, without such assistance. A limited number of grants will be available. Those eligible for awards are qualified scientists who are citizens or permanent residents of the United States. Each applicant will be judged on the merit of his contribution to the Congress in New Delhi, considering his training, experience, and potential, as well as a reasonable representation of age groups. Grants will ordinarily be limited to the lowest group fare available plus domestic fare.

Requests for application forms should be addressed to:

USA National Committee for IUPS
Room 342
Division of Medical Sciences
National Research Council
2101 Constitution Avenue, N.W.
Washington, D.C. 20418

Deadline for receipt of applications is now 1 February 1974 rather than 1 December as previously announced.
Deadline for Congress registration and submission of abstracts is 15 April 1974

Additional information, prepared by Chevy Chase Travel, official agent for this Congress, can be found in a 16 page brochure "Travel Plans to the XXVI International Congress of Physiological Sciences, New Delhi, October 20-26, 1974 and Satellite Meetings Around the World " inserted with this issue of The Physiologist.

Final mailing of information, registration and housing forms from the Organizing Committee in India can be obtained by a request to Chevy Chase Travel, 4715 Cordell Avenue, Bethesda, Maryland 20014. Phone - (301) 657-3700.

REPORT OF COUNCIL ACTIVITIES - 1972-73

As is its custom the APS Council met just prior to the 1972 Fall and 1973 Spring meetings and in February of 1973. At the February meeting it was decided that in order to keep the membership aware of what transpired at Council meetings, an annual review of Council's deliberations and actions would be prepared by the President at the end of his term for publication in The Physiologist. It was also decided by Council to publish the reports of the various APS committees in The Physiologist rather than have them consume precious time at the business meetings that could be used for discussion of substantive issues of interest and importance to the membership. The report that follows summarizes many of Council's activities during the past year.

A major portion of Council's time is devoted to listening to reports from the Chairmen of the major APS committees, discussing the reports and recommendations of these committees and then voting on issues that require action. Since each of these committee chairmen will submit his own report, this one will deal with important actions taken by Council on committee recommendations.

1) Election of APS Officers: Since such a small percent is present at the business meetings to vote for President-Elect and Council member(s) and since the election consumes time and interrupts discussion at business meetings, the question of election by mail ballot was proposed and discussed by Council. It was decided that the membership be polled. The results of the poll indicated that 547 voted for a mail ballot and 118 voted to retain the present electoral system. A mail nominating ballot for officers was distributed to members and with it a notice that an agenda for the business meetings would be available at APS Headquarters and in future years would be mailed out to the membership prior to the Spring meeting. A vote on an amendment to the bylaws changing the electoral system was planned for the first business meeting in April but as those present well know, a substitute motion was proposed with inadequate preparation and to terminate the confusion in the minds of the members, the issue of amendment of the bylaws was tabled. It will be carefully worked through by an ad hoc committee and be brought up for discussion and vote at the Spring meeting in 1974.

2) Future Meetings: The Spring Meetings will be held in Atlantic City in 1974, 1975, 1977, 1978 and in Anaheim in 1976, whereas the Fall Meetings will be held at Albany Medical College of Union University, Albany, N.Y. in August 1974, San Francisco, October 5-10, 1975, University of Pennsylvania, Philadelphia in August 1976, Miami in October 1977, Michigan State University, East Lansing, in August 1978.

With respect to the Fall Meetings there was considerable discussion in Council about holding them in the Fall and in attractive cities as opposed to following the tradition of having them on University campuses in August, the only time that University housing facilities are available. A questionnaire was distributed to the members of APS and the vote was 352 for meetings in the Fall and 305 for meetings on University campuses in August. As a result of the almost equally divided opinion, Council decided to alternate August campus meetings and city Hotel Fall meetings. The first true Fall meeting is now scheduled for San Francisco in 1975. It is anticipated that arrangements will be made with other societies to participate in the planning and programming of the meeting and that an ad hoc committee representing related and interested societies will work with the APS Program Committee in arranging details of the meeting. There will be invited lectures, symposia, invited and submitted papers, but instead of a refresher course there may be one or more lectures organized by the Education Committee. There will also be some attention paid to problems in clinical physiology, a subject that some of the membership feel has been neglected by the Society.

Concerning the Spring meetings, the Council held lengthy discussion about their structure and composition. The Meetings Committee of FASEB had recommended that an ad hoc committee with representatives of the six member societies design a subject-oriented meeting for 1974. This proposal was rejected by the FASEB Executive Committee and only a one-day meeting of this type was authorized.

This compromise was not accepted by the Meetings Committee, so the subject is still to be discussed and resolved. Another innovation by the FASEB Meetings Committee was the FASEB "conference." The third such conference will be held in 1974 on "The Biology of Development and Aging" and Dr. Timiras is the APS representative to the planning committee. In addition the APS Council approved going ahead with sponsorship of a three-day intersociety colloquium at the 1974 Spring meeting on "Membranes, Ions and Impulses" in conjunction with appropriate representatives from the Biophysical Society, the Society of General Physiologists, and the Neuroscience Society. The Council would like to get an expression of the members feelings about conferences of this type and it is anticipated that a questionnaire will be sent out regarding this issue in the Fall of this year.

3) Relationship of APS to FASEB: Since the Biochemists have decided to meet separately in the Spring every third (and possibly every second) year, there has been considerable concern about the effect of this policy on FASEB. If the APS decides to do likewise in the same years the Federation would suffer serious consequences. Furthermore there has been increasing concern about the formation of new societies, in large part as splinters from APS, and the resultant weakening of the APS scientific programs. Finally, there has been great dissatisfaction with the size of the Federation meetings and with the fact that this forces us to meet in Atlantic City. A task force consisting of members of APS with joint membership in smaller related societies and chaired by Eugene Yates studied these problems. The report of this task force was given orally at the APS Spring meeting. A number of suggestions were considered but the consensus was that FASEB, whose many services are greatly appreciated, be restructured so that smaller societies could become members on an equal basis without incurring a serious financial burden. This recommendation of the task force was endorsed by Council and will be discussed with FASEB.

4) New Financial Arrangements with FASEB: An increase in telephone charges and particularly an increase in rent charged the APS for space on the Beaumont campus by FASEB posed a real threat to the Society. Council felt that APS could not afford these increased costs without some increase in revenue return by FASEB and began to explore less expensive facilities. However, a formula for distribution of FASEB meeting income was developed by the FASEB Finance Committee that in large part compensated for the higher rent by raising the monetary return to the APS.

According to this proposal each Society of FASEB pays $12.00 (instead of $6.00) per member for Federation services, (Federation Proceedings, Directory, Office of Public Affairs, Placement Service) and this increased assessment would be offset from funds from sources such as dues and proceeds from annual meetings. Monies returned to the member societies of FASEB would be as follows: a) $4.00 of the registration fee for each society for each member or non-member who identified himself with that society attending the FASEB meeting. b) $3.00 for each registrant would be put into a pool and the pool divided equally among the member societies. c) $8.50 from each registrant be put into another pool and this sum be divided among the societies in proportion to their total membership. APS, having the largest membership would get a greater return. However, this would be offset by the higher rent APS must pay for its space. When a Society does not meet with FASEB they will still be charged at $12.00 per member but will not share in the distribution of income generated by the Spring meeting. Hence, a Society meeting separately from the Federation must be able to generate at least $12.00 per member to break even. This general plan appeared to be the more equitable one proposed and was approved by the APS Council. Subsequently it was passed by the FASEB Board and is now in effect. Dr. John Brobeck, as Past President of the Society, and therefore a member of Council and APS member of the FASEB Finance Committee had a large part in development of this more equitable plan, which increases the flexibility of society relations with FASEB.

5) Women Physiologists: A small group of women members of APS felt that there was a need for a committee in APS to study the role of women in physiology and in the APS. Council agreed that there was a need for role models for women in physiology and a need to encourage women to select physiology as a career. After some discussion it was decided to appoint a task force under the chairmanship of Elizabeth Tidball to study this problem and report its observations and conclusions to Council.

6) The AAMC and the APS: Our Society, along with many other biological societies is a member of the Council of Academic Societies of the AAMC. The latter has done a fine job in presenting the scientific points of view on many issues to congressional committees, etc. However, they were operating on a very limited budget and it was necessary to increase the dues of member organizations. For societies larger than 2000 members the dues proposal was $2000 per year. After careful consideration of the pros and cons of continuing our relationship with the AAMC, Council agreed to the dues increase.

7) Travel Funds to International Meetings: The Society assists the U.S. National Committee for IUPS in its attempts to generate funds to aid younger members with travel funds to the IUPS meetings. Funds are solicited from many sources (private and government). To date the results have been very disappointing and it appears that only limited amounts of money will be available to aid young members of APS to attend the next Congress meeting in New Delhi.

8) Committees of APS:

a) Finance Committee: Council approved a recommendation of the Finance Committee that the Publication Contingency Reserve Fund be kept as segregated securities by Wood, Struthers and Winthrop with the proviso that authorized members of APS routinely check the status of the securities.

b) Program Committee: Council approved two meetings of this committee per year for the purposes of planning and arranging the program for the Spring meeting. The Program Committee will also have a representative on the local program committee for the August meetings to be held on University campuses and will be responsible for the program of the City Hotel Fall meetings.

c) Council approved the contract obtained by the Education Committee from the National Library of Medicine to evaluate current methods and materials for teaching physiology in medical curricula and to produce needed audiovisual materials for teaching purposes.

d) Publications Committee: Council approved the recommendation of the Publications and Finance Committees to have the chairman of the Publications Committee serve as ex-officio member of the Finance Committee since a major aspect of APS finances deals with the activities of the Publications Committee. Since publication of some of the Society journals has been operating at a loss it was proposed by the Publications Committee and approved by Council that subscription rates of AJP increase from $60 to $75 per year for non-members and for JAP from $45 to $55 per year. There will be no change in subscription rates for APS members. It was also approved by Council that Stephen Geiger be appointed on a yearly basis as Publications Manager and Executive Editor at the time of Sara Leslie's retirement January 1, 1975. He will continue as Executive Editor of the Handbooks and will be supplied with an assistant to aid in the management of the APS publications. The sectionalization of the APS journals was also discussed. A concrete recommendation from the Publications Committee will be presented to Council before any action is taken. It is proposed to poll the membership of APS on this question before reaching a final decision.

e) Reports of other committees with a much more detailed report of the above committees will appear in The Physiologist.

9) Committee Appointments: Council spent much time on appointments to standing committees and representatives to other organizations. These appointments and the Constitution of the Society appear on pages 502-510 of this issue.

Robert M. Berne
Past-President
July 1973

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AMERICAN PHYSIOLOGICAL SOCIETY
COLLOQUIUM ON MEMBRANES, IONS, AND IMPULSES
APRIL 9-11, 1974, ATLANTIC CITY

Honorary Chairman: K. S. Cole Organizing Chairman: J. W. Moore

This colloquium will be a component of the 1974 FASEB Annual Meeting.

The program was jointly planned by a committee representing the following societies: American Physiological Society, J. W. Moore, Chairman; Biophysical Society, C. M. Armstrong; Society for Neuroscience, W. Rall; Society of General Physiologists, R. J. Podolsky; American Society for Pharmacology and Experimental Therapeutics, A. Schwartz.

It is planned to have additional short contributed papers which complement or supplement the invited lectures. These will be selected by the session chairman. Anyone desiring to present a short contribution should write directly to the chairman of the appropriate session who are listed in the FASEB informational package.

INSTITUTE OF MEDICINE

Dr. John R. Hogness, President of the Institute of Medicine announced in July 1973 that 60 new members had been elected to the Institute. Four APS members are among the 60 who received this honor. They are: Drs. Carl W. Gottschalk, Univ. of North Carolina, Seymour S. Kety, Massachusetts General Hospital, Helen M. Ranney, University of California, San Diego, and Louis G. Welt, Yale University.

Candidates are chosen for their significant contributions to health and medicine, or to such related fields as the social and behavioral sciences, law, administration and engineering. Once appointed, members are committed to devote a significant portion of their time to work on Institute panels and committees engaged in a broad range of health policy studies. Active members, all under the age of 65, are limited to two five-year terms. Upon reaching age 65, a member is transferred to senior status.

Current activities of the Institute include an 18-month study for Congress on the costs of educating health professionals; a nearly-completed analysis of a method for measuring the quality of health care in different medical settings; and a series of policy statements on the nation's supply of hospital beds, the economic outlook for Health Maintenance Organizations(HMO), and the implications of approaching national health insurance by way of categorical diseases. Activities recently completed include a review of the National Cancer Plan and a staff analysis of the proposed federal health budget.

Other members of APS who have been elected to the Institute in previous years are: Drs. Robert W. Berliner, Julius Comroe, Jr., Vincent P. Dole, Donald S. Fredrickson, Edward W. Hawthorne, Donald Kennedy, Hermann Rahn, William B. Schwartz, Nevin S. Scrimshaw, William A. Spencer, Eugene A. Stead, Jr., Daniel Tosteson, James V. Warren. Senior Members: Irvine H. Page and James A. Shannon.

NATIONAL ACADEMY OF SCIENCES HONORS 12

For contributions to science and mankind, the National Academy of Sciences honored 12 persons at its 110th Annual Meeting.

One of the 12 so honored was APS member, Dr. Seymour S. Kety, Massachusetts General Hospital, who received the Jessie Stevenson Kovalenko Medal, "for exceptional contributions to medical science."

REPORT OF THE PRESIDENT - 1973-74

To the Members of the American Physiological Society

Dear Colleagues:

In keeping with requests from many of you for increased information about the activities of your Council, I will report to you in this and succeeding issues of The Physiologist during academic year 1973-74. I will not attempt to be comprehensive but rather to emphasize those matters which seem to me of greatest importance for the future of the APS. In this report I will concentrate on the meeting of Council and on the Business Meeting of the Society which took place in Rochester on August 19 and August 22, 1973 respectively.

Council received a report from the ad hoc Committee on Election Procedures chaired by Dr. Robert Berne. The Committee recommended the adoption of a procedure which would permit the nomination and election of President-Elect and Councilmen by mail ballot. The procedure allows for a sequential process of elimination and final selection by majority vote analagous to the procedure which has traditionally occurred at the Spring Meeting. This procedure will be drafted in the form of an amendment to the Bylaws and circulated to you well before the Business Meeting in April at which time the matter will be introduced for final resolution.

Council also voted unanimously to establish an ad hoc Task Force on the Neurosciences. In the continuing healthy growth and differentiation of the physiological sciences, it seems appropriate, from time to time to assess the quality of the services which the Society renders to members working in different aspects of the field. Researches in the physiology of nervous system have increased rapidly in number, range and complexity during recent years. Associated with this increased interest and effort, the Society for Neurosciences has emerged. Many members of APS are also members, in some cases founding members, of the new Society. In the judgement of Council, these developments make the time ripe to review the role of the APS in serving those of its members who are interested in the physiology of the nervous system. An ad hoc Task Force will be appointed to study this matter and report its findings and recommendations to Council and to members attending the Spring Meeting.

Dr. Sid Solomon, Chairman of the Membership Committee, recommended to Council the addition of 63 new regular members and 40 new associate members whose names will be brought to you for approval at the Spring Meeting. He also indicated the concern of the Membership Committee about the criteria for acceptance of candidates for membership. The problem involves the tension between those who feel that the APS should admit all professionally qualified, practicing physiologists and those who believe that some higher standard of professional achievement should be a requirement for membership. The Committee is drafting a new set of guide-lines for this process. If you have any suggestions or comments, please send them to Dr. Sid Solomon.

Council received a number of reports from standing committees. I list below a few of the highlights. E. B. Brown, Chairman of the Finance Committee, made a preliminary proposal of a balanced budget involving expenditures of about $1.5 million for 1974. Dr. Peter Curran, Chairman of the Publications Committee, reported that five new handbooks will be published during 1974. Dr. F. Jöbsis, Chairman of the Program Committee, reported that the program for the Spring Meeting includes, in addition to five symposia and fifteen introductory lectures, a three-day Colloquium on "Membranes, Ions and Impulses." The program for this Colloquium was organized by an ad hoc Committee, chaired by J. W. Moore, and consisting of representatives from the APS, the Biophysical Society, the Society of General Physiologists, the Society for Neurosciences and ASPET. Details about the rules for submission of abstracts for the Spring Meeting are being sent to you under separate cover. Council also received a written report from Dr. Jack Kostyo, Chairman of the Education Committee, which included a description of a new contract of APS with the National Library of Medicine to produce slide-tapes for use in teaching physiology.

Council also heard reports on relations between the several larger organizations with which APS is affiliated, e.g. the Federation of American Societies for Experimental Biology (FASEB), the International Union of Physiological Sciences (IUPS), and the Council of Academic Societies (CAS)of Association of American Medical Colleges (AAMC). Special attention was paid to the new rules for financial relations between FASEB and the constituent societies which make it much more feasible for non-member societies to participate in FASEB sponsored meetings. For example, the Microcirculatory Society and the Biomedical Engineering Society under the sponsorship of APS will participate in the FASEB Spring Meeting.

In case you missed the announcement which was sent out earlier, on page 520 of this issue you may find instructions for how to apply for support for travel to the IUPS Congress in New Delhi in October 1974.

It was also reported that the AAMC is bringing suit against the Executive Branch of the U.S. Government for failing to spend monies appropriated by Congress for the support of biomedical research and research training. The case will be heard in the Federal Court in the District of Columbia in mid-October.

Council considered the plan for future meetings and gave tentative approval to Miami as the site for a hotel-based meeting in October 1977.

I hope that this brief description of Council activities which summarizes a more complete verbal report made at the Business Meeting in Rochester will be useful to you. If you have questions about any of these matters or suggestions about subjects about which you would like to read in future reports, please contact me or Dr. Orr Reynolds, Executive Secretary of the Society.

Sincerely,

Daniel C. Tosteson

FINANCE COMMITTEE REPORT

Activities in 1972-73

During this period, the Finance Committee comprised John M. Brookhart, Chairman, Charles F. Code, Ernest B. Brown, Robert M. Berne (Ex-officio President-Elect until July 1, 1972), Daniel C. Tosteson (Ex-officio President-Elect after July 1, 1972). The Executive Secretary-Treasurer and the Business Manager met routinely with the Committee. By recent action of Council, the Committee meetings are also attended by the Chairman of the Publications Committee. The Committee met on the following dates: March 2, April 6, August 29, December 4, 1972 and February 22, 1973.

The Committee's work falls into a cyclic pattern. At its first meeting in each fiscal year (usually late February or early March) it devotes a major portion of its time to an examination of the annual auditor's report and compares actual operations in the categories of the Society's main subdivisions, the Society Operating Fund, the Publications General Fund, the Publications Special Projects Fund, and the investment funds held by the Society. It is the responsibility of the Committee to examine each of these funds in detail, noting discrepancies from predictions and forming recommendations where needed for Council action. The Committee also recommends to Council the disposition of dividend and interest income from the investment funds.

Meetings of the Committee during the latter part of the year are generally devoted to the development of plans for the succeeding year. Preliminary information about operations is reviewed and a tentative predictive budget is formed by the managerial staff. This budget takes into account predicted changes in operations, Federal and Federation changes in wage and salary scales, and alterations in personnel. On the basis of the information available, the Committee recommends to Council the adoption of the presented or amended budget.

During the course of the year, the long-term trends in the Society Operating Fund were significantly perturbed by some important changes. This is the fund which covers the Society's general services to its members in the conduct of Society Business, meetings, and educational activities. One of these events was the establishment of an Education Office headed by Dr. Orr Reynolds. The activities of this office are now largely supported by a grant from the National Medical Audiovisual Center. Dr. Reynolds continues as the Education Officer and has also replaced Dr. Ray Daggs as Executive Secretary-Treasurer of the Society. In the annual financial reports which appear in The Physiologist*, members may expect to see an increase in the total expenditures in this fund which result from the activities of the Education Office.

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*1972 Fiscal Report appears on pages 120 and 121 of the May issue. (Fiscal Report is published annually in the May Issue).

The Publications Operating Fund reflects the business which the Society conducts as a publisher of scientific journals. The trends in dollar turn-over in this fund continue upward, influenced primarily by escalations in the costs of printing. The year's operation was in the black on an overall basis, even though a worrisome deficit was incurred by the American Journal of Physiology's operations.

The ambitious undertaking represented by the production of a major set of new handbooks on Endocrinology did not seriously affect the Publications Special Projects Fund in 1972. Major outlays are anticipated for 1973. Before the publications costs for these new handbooks are offset by sales income, the Committee expects this account to remain in a deficit condition of some magnitude. Since the handbook series was first initiated in 1956, there have only been two or three years in which this has not been the case, hence this is not a new situation justifying alarm.

The Publications Contingency and Reserve Fund is an investment fund consisting of an ever changing portfolio of stocks and bonds. This fund is managed for the Society by Wood, Struthers, and Winthrop, Inc. according to goals and objectives defined by the Society. During 1972 the fund showed very satisfactory gains in both book and market values. The investment income has been used to aid in the establishment of the Education Office and to assist in the transition of managerial leadership. If the investment councillors continue to perform in their now traditional manner, they will be able to prevent this account from exhibiting as serious a drop as has characterized the general securities market in 1973.

During 1972, the Committee devoted a great deal of attention to an examination of its relationships with the investment company which supervises the investment portfolio for the Publications Contingency and Reserve Fund and for two funds for which the Society acts as custodian, - the John F. Perkins Memorial Fund and the International Union of Physiological Sciences Fund. The issue under debate was the matter of providing satisfactory protection for these funds against brokerage failure. After consultation with officers of the Wood, Struthers and Winthrop Co., Investment Councillors, with Morgan Guaranty Trust Co., with the Vice President and Trust Officer of a Silver Springs Bank, and after communications with Manufacturer's Hanover Trust Co., the Committee concluded that these investment funds should be left with Wood, Struthers and Winthrop in segregated account form, and that steps be taken to obtain routine assurance that this company's operating policies remain unchanged. It was also concluded that the additional expenses involved in the utilization of a bank as custodian for these funds would not provide the additional protection which would justify these expenses.

At the request of Council, the Committee also explored, with professional advice, the overall structure of its investment program. The Committee concluded that transferral of invested funds to income producing real estate would not be in keeping with the purposes of the Publications Contingency and Reserve Fund, i.e., to provide readily accessible capital to underwrite new publications ventures.

June 30, 1973 marked the end of my term as Chairman of the Finance Committee. Dr. E. B. Brown has agreed to lead the Committee in the years to come. I would be remiss if I did not express my sincere thanks to the past and present members of the Committee for their many hours of devotion to the Society's problems and their most faithful attendance at meetings.

John M. Brookhart
Ex-Chairman, Finance Committee
July 16, 1973

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MEMBER DISCOUNT FOR NEW HANDBOOKS

Copies of the Handbook of Physiology are available to members of the Society, when the books are ordered directly from the APS Business Office, 9650 Rockville Pike, Bethesda, Maryland 20014. Two volumes have recently been completed:

1. Female Reproductive System. Volume II of the Section Endocrinology. edited by Roy O. Greep. In 2 parts:

   Part 1, 666 pages, 334 figures (2 in color), index.
   $35.50 member price ($44.50 for non-members).

   Part 2, 381 pages, 240 figures, index.
   $20.00 member price ($25.00 for non-members).

2. Renal Physiology. Section 8 edited by Jack Orloff and Robert W. Berliner. Complete in 1 volume, 1090 pages, 545 figures, index.
   Member price $58.00 ($72.50 for non-members).

NOBEL PRIZE IN MEDICINE AND PHYSIOLOGY

The $120,000 Nobel Prize in Medicine and Physiology for 1973 will be shared by the three major founders of the relatively new science of ethology - Konrad Lorenz, Karl von Frisch (Honorary Member of APS) and Nikolaas Tinbergen.

Ethology is the scientific study of comparative behavior.

Von Frisch, 86, a Vienna-born zoologist, carried out his most important research on bees while at the University of Munich. He showed that bees communicate by elaborate dancing movements of their bodies.

The importance of both instinctive and learned behavior to survival was demonstrated by Tinbergen, 66, a Dutch-born zoologist who has spent most of his career at Oxford.

The Vienna-born Lorenz is best known for his research on instinctive behavior among birds conducted at the Max Planck Institute for Behavioral Physiology in Seewiesen, West Germany.

REPORT OF THE PUBLICATIONS COMMITTEE

This report covers the period from January 1, 1972 to June 30, 1973 with major emphasis on the calendar year 1972. The publications operation of the Society completed the year 1972 in relatively good health with considerable improvement in financial status compared to the previous year. Table I summarizes the publications record of the four journals for the years 1971 and 1972 in terms of number of articles and number of pages published. Table II presents a summary of the financial aspects of these two years. The modest loss on operations in 1972 was offset by interest and miscellaneous income of approximately $30,000 so that the final position of the journals for 1972 showed a profit of $23,000.

TABLE I

	Number of Articles		Number of Pages	
	1971	1972	1971	1972
American Journal of Physiology	625	503	4025	3236
Journal of Applied Physiology	359	335	1980	1807
Journal of Neuro-physiology	83	71	1117	1035
Physiological Reviews	20	18	827	962

TABLE II

	1971			1972		
	Income	Costs	Net	Income	Costs	Net
American Journal of Physiology	454,371	483,356	-28,985	414,738	454,356	-39,618
Journal of Applied Physiology	275,417	258,027	+17,390	269,033	258,987	+10,046
Journal of Neuro-physiology	92,321	106,884	-14,563	101,126	99,017	+2,109
Physiological Reviews	93,479	89,502	+ 3,977	121,253	100,942	+20,311

For the three primary Journals, subscriptions account for approximately 67%, sales of reprints for 12%, and page charges for 15% of income. Subscription prices for JN and PRV were increased in January 1972.

There are, however, certain disturbing features regarding financial aspects of the journals that we have had to consider carefully. First the total number of subscriptions to these four journals has shown a small decline during the past two years as opposed to a slow but consistent increase in prior years. The decline was small, 0.6% in 1971 and approximately 1% in 1972 but the trend is disturbing. Second, costs of publication continue to escalate at a rate of 6-10 percent per year.

Third, in spite of the fact that fewer pages were published in the American Journal of Physiology in 1972 than in 1971 the deficit for that journal increased. Similarly, the profit margin for the Journal of Applied Physiology decreased in spite of fewer pages published in 1972. Thus the financial balance cannot be easily controlled by limiting the number of pages published. Clearly, printing fewer pages decreased costs but income from page charges and sales of reprints also fell, and production costs other than printing remained essentially constant. These and other factors led the Publications Committee to recommend increases in subscription prices beginning in January 1974 to \$75 for the American Journal of Physiology and to \$55 for the Journal of Applied Physiology. The Committee recommended however that subscription prices for Society members be kept at the current levels of \$30 for the American Journal of Physiology and \$22.50 for the Journal of Applied Physiology. The Council has approved these recommendations. The prices for Physiological Reviews and the Journal of Neurophysiology, which were increased in 1972, will remain at their present levels in 1974. The other two periodicals under the jurisdiction of the Publications Committee, The Physiologist and The Physiology Teacher, do not represent a financial drain on the publications fund. The deficit for The Physiologist is offset by transfer of funds from the Society Operating Fund and The Physiology Teacher, a responsibility of the Education Committee, is paying its way through subscriptions and advertising.

The Committee must obviously continue to keep a very close eye on the financial aspects of the journals and continue to attempt economies where these will not detract from quality. One step in this direction has been an instruction to Section Editors to discourage the use of lengthy detailed tables and to encourage the use of figures instead of tables whenever possible, because production of tables is much more expensive than figures. Financial aspects of the Society's operation have been greatly aided in the past year by the decision to have the Chairman of the Publications Committee sit as a non-voting member of the Finance Committee. The resulting increased communication has greatly aided both committees in their deliberations and has prevented misunderstandings and misinterpretations.

As a result of an unfortunate incident of duplicate publication in 1972, the Committee has decided to require written assurance that manuscripts submitted to the American Journal of Physiology and the Journal of Applied Physiology have not been published, are not under consideration elsewhere, and will not be submitted elsewhere until there is a decision on acceptability. (Such assurance is already required by the Journal of Neurophysiology.) This policy will become effective as soon as revised instructions for authors are printed in the journals.

As you may have noted, we have begun a "Letters-to-the-Editor" column in these two journals. These columns are intended to provide for commentary on articles recently published in the journals. Letters may be submitted to the Editorial Office. They are subject to the usual review process and are expected to provide reasonable, scientific comment. Authors of the paper about which a letter is written are provided an opportunity to submit for consideration a rebuttal if they wish to do so.

The Committee is engaged in discussion of two areas that may ultimately lead to alteration in our journal publications. First, we have approached the Society for Neuroscience to explore the possibility that they join us in sponsorship of the Journal of Neurophysiology. This was done with the idea of broadening the scope of the journal and improving our service to the scientific community. The Society for Neuroscience has expressed interest and we are currently attempting to work out specific proposals for consideration by the Councils of the two societies. Second, we have over the past year discussed seriously the possibility of sectionalizing the journals. The fundamental idea is that the American Journal of Physiology and the Journal of Applied Physiology would be combined into a single journal that is published in several sections that would appear monthly or bimonthly somewhat in the manner of Biochimica et Biophysica Acta. The Committee is not convinced that such a move is desirable or financially feasible but feels it deserves serious consideration. We are in the process of preparing a specific proposal along these lines that will be published in The Physiologist for consideration and commentary by the membership of the Society.

The second major publication effort of the Society, the Handbook series, is proceeding well. The Section on Endocrinology is in full production; Volume I appeared in 1972 and Volume II will be published this year. The Section on Renal Physiology should also appear late this year. In addition, an extension of the volume on the Environment is in progress, as is revision of the Section on Neurophysiology. A section on Muscle is in the planning stage and we are beginning to consider revision of the volumes on Circulation. The overall financial aspects of the Handbooks are quite good. About a year ago, the total Handbook account passed into the black for the first time since the operation began. At present the account shows a deficit due to outlays for the volumes now in production but the prospects of continued success are excellent. In this regard, it is of interest to note that sales of the Neurophysiology volumes, the first volumes of the series, published in 1959-60, continued at quite a respectable rate last year. All in all, the Committee is most pleased with the Handbooks and feels that it has been a highly successful undertaking.

There have been a number of major changes in committee and editorial positions since July 1972. At that time, Alfred Fishman joined the Publications Committee replacing Donald Fredrickson, and John Pappenheimer replaced Fishman as Chairman of the Handbook Editorial Committee. Another major change during this period was in the editorship of Physiological Reviews. John Brobeck's term expired in December and he was succeeded by Howard Morgan as Editor. Richard Rose succeeded Ray Daggs as Associate Editor. The following were appointed Section Editors of the American Journal of Physiology and the Journal of Applied Physiology in 1972; T. C. Lloyd, Jr. (Respiration), H. S. Belding and A. P. Gagge (Environmental Physiology), O. A. Smith (Neurobiology), J. Dirks (Renal and Electrolyte Physiology), H. Ranney (Hematology). Finally, it is my sad duty to report the impending retirement on December 31, 1974, of Miss Sara Leslie who has served with such distinction for so many years as Publications Manager and Executive Editor. In April, the Publications Committee recommended and the

Council approved that Stephen Geiger, now Executive Editor of Handbooks, succeed Miss Leslie on January 1, 1975.

Peter F. Curran
Chairman, Publications Committee
July 1973

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EDUCATIONAL OBJECTIVES AVAILABLE

The Education Committee, in the course of reviewing audiovisual aids, has developed an outline of "Educational Objectives in Physiology." Published as a supplement to "The Physiology Teacher" a limited supply of this supplement is available for distribution on request. (Single copies free, multiple copies 1-25 $1.00 per copy, 25 or more in lots of 25 - 50¢ per copy).

IUPS NEWSLETTER

A limited supply of the July 1973 IUPS Newsletter is available in the APS Headquarters Office. Single copies will be supplied on request from APS members.

REPORT ON THE CURRENT ACTIVITIES OF THE APS EDUCATION COMMITTEE

This report summarizes current activities of the Education Committee of the American Physiological Society and includes business conducted at the most recent meeting of the Committee held at the Society Offices in Bethesda on July 12 and 13, 1973.

I. Status of the APS-NMAC Audiovisual Project

One of the major activities of the Education Committee has been the project involving review and evaluation of existing audiovisual materials in the field of physiology and preparation of new audiovisual materials in areas lacking adequate coverage by existing materials. This project has been funded by Contract NO 1-LM-3-4725 from the National Medical Audiovisual Center. The first contract year ran from June 1, 1972 - May 31, 1973, and emphasis was given that year to the evaluation of existing audiovisuals and the development of a set of educational objectives for a course in medical physiology. For the evaluation procedure, 14 review panels were established consisting of several experts in the various sub-specialty areas of the field. These panels then met individually at the FASEB Audiovisual Center throughout the contract year to view and evaluate films, film-loops and slide tapes. In all, 1030 audiovisuals were obtained and evaluated for scientific accuracy, level of presentation and technical quality. Approximately 263 were judged "adequate or better" as teaching devices for use in physiology courses for medical, advanced undergraduate and beginning graduate students, as well as allied health and nursing students. Summaries of the reviews of those audiovisuals considered to be "adequate or better" have been published as supplements to The Physiologist and The Physiology Teacher. The supplement, which is entitled "Audiovisual Aids Useful in the Teaching of Physiology" will also be mailed to the Comparative Physiologists of the American Society of Zoologists and will be advertised in the AIBS magazine. Multiple copies will be available at $1.00 each.

As required by the contract, a set of educational objectives (actually a list of topics) for a course in medical physiology was developed by the Steering Committee for the APS-NMAC contract. These objectives are to serve as a guide for the selection of topics for audiovisual materials to be produced in the future. Further, they may be helpful to some college teachers and those without extensive experience in the field in designing courses in physiology. With this in mind, the Education Committee authorized the printing of 3,000 copies of the objectives (financed by contract funds). Copies have been mailed to the subscribers of The Physiology Teacher and some have been forwarded to NMAC and the AAMC. The latter group plans to obtain opinions about the set of objectives from various clinical specialists. This should prove to be interesting.

The Society received a new contract from NMAC on June 1, 1973, in the amount of $97,000. Of the $97,000, $83,000 are direct costs and the remainder is overhead. The work outlined in the new contract includes the production of 16 slide-tape presentations (at a cost of $1,000 each) in the areas of renal physiology, cardiac physiology and temperature regulation. Also, audiovisual evaluation centers are to be established at four departments of physiology in schools of medicine, methods for evaluation of audiovisuals by students are to be devised and then 24 existing and four new audiovisuals are to be evaluated at the centers by the end of the contract year. Detailed plans for implementing the contract were developed at a meeting of the Contract Steering Committee held on July 11, 12, 1973. Specific topics were selected for production from lists supplied by three specialty panels (renal, cardiac and temperature regulation), and individuals having responsibility for the actual production of the slide-tapes were selected. A set of production guidelines was established to aid each producer and two associate producers in the development of their slide-tape presentations. Also a definitive time-table was established for the preparation of story-boards, scripts, final illustrations and taping sessions, to ensure that we meet the deadlines set by the contract. Work is already in progress on eight of these slide-tape presentations, and it is anticipated that four will be completed for final submission to NMAC by October 23, 1973.

Last Spring, the Committee solicited volunteers for audiovisual evaluation centers by means of a letter sent to members of the Association of Chairmen of Departments of Physiology. A number of departments volunteered for this task. The Steering Committee selected the Medical College of Virginia, Meharry Medical College, Georgetown University and Wayne State University to serve. Each center will receive $2, 000 from the contrcat to help off-set the cost of the work involved. Representatives from these centers met in Bethesda at the beginning of September to establish guidelines and methods by which medical students will evaluate the educational effectiveness of the ausiovisual materials they are given to view. The representatives also reviewed at that time the 24 existing audiovisual materials selected by the Steering Committee for evaluation by the centers. During the coming year, the centers will also evaluate the first four slide-tape presentations now being prepared under the APS-NMAC contract.

Funds are not available in the new contract to continue the review of audiovisual materials being produced commercially and independently. We had hoped to continue the review process in order to up-date our present list of adequate audiovisuals in physiology. We hope to obtain funds for continuing review either from the National Fund for Medical Education or by negotiating a sub-contract from the NLM contract held by the AAMC for the review of audiovisual materials in all of the basic medical sciences. It is worth mentioning that the APS project has served as the model for the larger project now being undertaken by the AAMC.

II. Development of an Educational Package on Human Physiology for High School Students

For some time the Education Committee has been interested in extending its program to the high school level. One idea given much thought by the Committee has been to prepare an educational package in human physiology or biology that could be used as an alternative track in the high school biology curriculum or to replace the woefully inadequate materials used to teach health and hygiene at the high school level. The

Committee explored this idea with the Biological Sciences Curriculum Study, and it was enthusiastically received. BSCS, having prepared the educational packages used for the teaching of biology in many high school systems, has the technical machinery and expertise necessary to put a package together on human physiology. Two other ingredients are necessary: scientific expertise and money for the development of the package by BSCS. Clearly, the scientific expertise for this endeavor is available in APS. The money is another matter. The Committee explored the possibility of funding for this project with officials of the Office of Education and HSMHA. HSMHA was quite interested in the project and invited us to submit a preliminary proposal. If HSMHA were to provide support for the project, they would want APS to be the primary contractor and then have BSCS be a subcontractor for the development of the education package. A sub-committee has been appointed, headed by Dr. Patricia Farnsworth, to prepare a preliminary proposal to be submitted to HSMHA. The proposal will be discussed at the November meeting of the Education Committee and a final draft will then be submitted to Council. If Council approves the proposal, we shall then submit it to HSMHA.

The Education Committee is very enthusiastic about this project. It would provide a means by which the Society could make an important and significant contribution to the education of the public. Further, like our audiovisual project, it would give many members of APS an opportunity to have direct input into the educational activities of the Society.

III. The Career Brochure

The Career Brochure was finally completed in early Spring and 10,000 copies were printed. Copies were distributed to the membership at the Business Meeting in April. Also copies were distributed at the Spring Meeting of the Association of Chairmen of Departments of Physiology. Comments about the Brochure from members of the Society have been generally favorable.

The Brochures have been made available to departments of physiology in lots of 100 for $50. So far, 1200 copies have been sold, and the money retrieved will help off-set the cost of publication. Of course, the Brochure is being distributed to prospective students free of charge.

IV. The Physiology Teacher

The Physiology Teacher continues to prosper and be a self-paying proposition. The Committee has decided that The Physiology Teacher should be copy-righted. Also, there will be some change in the editorial staff, since Associate Editors Crooke and Panuska have resigned. The Education Committee is exploring possible replacements at the present time.

V. The Refresher Course

The 1973 Refresher Course was held at the Fall Meeting in Rochester, and the topic was Environmental Physiology. Dr. Bodil Schmidt-Nielsen was the organizer. The topic selected for the 1974 Refresher Course is the "Physiology of Vision," and Dr. M. Wolbarsht of Duke University has agreed to be the organizer. The Committee will have a tentative program to present to Council at their February meeting.

VI. Regional Workshop at UNC

A long-standing activity of the Education Committee has been the sponsoring of workshops on the teaching of physiology for college teachers. The Committee will again sponsor such a workshop to be held at the University of North Carolina at Chapel Hill this coming Fall. The workshop is being organized by Dr. John B. Anderson and will emphasize the teaching of environmental physiology. The faculty for the workshop has been recruited from the universities and agencies in the Research Triangle area. The workshop will be available to college teachers in the southeastern area. The Education Committee is providing $500 from its budget to the support of this project.

VII. Annual List of Review Articles in Physiology

The Education Committee is also considering compiling a list of review articles in physiology that would be published in The Physiologist and The Physiology Teacher three times a year. Such lists would be helpful to teachers of physiology in remaining reasonably current in areas other than those of their immediate interest. Feasibility and ways and means are being sought to carry this effort out.

Jack L. Kostyo, Chairman

ACTIVITIES OF THE PUBLIC AFFAIRS COMMITTEE

The Public Affairs Committee (PAC) of the APS (Chairman, Robert Crane) and the PAC for FASEB (APS Representative, Lawrence D. Longo, and APS Executive Officer, Orr E. Reynolds) were established to provide a responsive interface between the Federation and the American public and its representatives in Government. In view of the decreased funding for basic research during recent years and termination of training grants as of July 1, 1973, the need for such activity should be evident.

During the past year the FASEB Public Affairs Committee met four times. Some of the activities of the committee included the following:

1. Met with Robert Q. Marsden, then Director of NIH; Robert S. Stone, present NIH Director; H. Guyford Stever, Director National Science Foundation; Storm Whaley, Associate Director for Communications, NIH; Paul H. O'Neill, Assistant Director, Office of Management and Budget; Robert M. Johnston, Legislate Assistant to Congressman Paul G. Rogers; Walter A. Hahn, Jr., Office of Technology Assessment.

The PAC had two to three hour dialogues with each of these individuals on issues relating to research funding, training grants, contracts vs. grants, peer review and the politicization of biomedical science.

2. Three members of APS testified before Congressional Committees regarding funding for biomedical research.

Robert K. Crane testified before the Senate Appropriations Subcommittee for Labor - HEW regarding the Fiscal Year 1973 Budget. Dr. Crane stressed the dollar benefits of biomedical research noting the enormous savings reaped from relatively modest sowing of research in poliomyelitis, tuberculosis, measles, Rh disease, viral hepatitis, renal transplantation and other conditions. Crane concluded by noting, "The only believable way to achieve the goal of having full medical care and medical cure available to everybody is to convert care into cure. The expensive halfway measures of today's medical practice must be converted into relatively inexpensive and easy methodologies. The only way in which this conversion can come about is by doing the research that will provide an understanding of the mechanism of disease and lead to a cheap and effective cure. The only way in which the research will get done is to spend money to support it. This is the strategy which, there is some hope, can succeed and this is the strategy that should be adopted. Support for research and manpower should match the dimensions of the problem and the demands of the goal. The President's 1973 budget proposals fall far short of being an effective strategy for achieving the goal of full medical care and medical cure for everyone within a time frame that is meaningful to those of us now alive and at a price we can afford." The text of Dr. Crane's testimony was published in Federation Proceedings 32: 10-11, 1973.

Daniel C. Tosteson's statement was delivered to the House Appropriations Subcommittee for Labor-HEW on May 16, 1973 regarding the

Fiscal Year 1974 Budget. Dr. Tosteson emphasized the importance of basic research, both for improved understanding for its own sake as well as helping to solve specific disease problems. He cited a number of advances made possible because first rate scientists were asking significant questions not directly related to subsequent applications, and why this approach is important today when so much research is mission oriented. Tosteson also stressed the necessity of continued research training and institutional support. His recommendations to the Committee were:

a) Maintain support for regular research grants by all institutes of the National Institutes of Health at least at the level established for Fiscal Year 1972.

b) Maintain support for research training grants and fellowships by all institutes of the National Institutes of Health at least at the level established for Fiscal Year 1972.

In both of the above cases, it will be necessary to add 12% to the 1972 level in order to take into account inflation and increased cost of research and training.

c) Maintain capitation payments to medical, osteopathic and dental schools at the level of 70% of the entitlement under the Comprehensive Health Manpower Training Act of 1971, and restore the level of the general research support grant to the level of Fiscal Year 1972.

Lawrence D. Longo testified before the House Appropriation Subcommittee for Labor-HEW on May 17, 1973. Dr. Longo presented an analysis of NIH Budgets over the past eight years, particularly as they affect the National Institute of General Medical Sciences and basic research. He discussed specific problems such as the decreased funds available for competing grants, the increasing percentage of approved grants that are not funded, the need for continuation of fellowships and training programs and the politicization of science. He presented a cost-benefit analysis of the benefits to society by money spent on basic research in three disease conditions, the intrauterine diagnosis of mongolism (Down's syndrome), rubella (German Measles) vaccine and use of intrauterine diagnosis of fetal maturity to prevent prematurity and subsequent respiratory distress in the newborn. He concluded by stressing the need for maintaining the NIH Budget at the Fiscal Year 1972 level, allowing for inflation, and increasing appropriations for basic research. The text of this statement will appear in the November issue of Federation Proceedings.

3. In addition the Committee engaged in a number of other actions including:

a) Submitting statements to Congressional Committees and the Administration regarding proposed legislation affecting biomedical investigators.

b) Prepared a critique of the "Report of the NIH Program Mechanisms Committee" dated February 14, 1973. The Report was developed by a group of University based consultants to analyze aspects of the funding procedures of NIH, i.e. the initiation of contracts, review of their scientific merit, etc. The critique, written by Orr E. Reynolds recommended: 1) an outside group be appointed by the Office of Secretary of HEW to review and make recommendations regarding the objectives, priorities and accomplishments of each Institute's programs; 2) the results of the annual reviews be given wide circulation; 3) goals and mechanisms, such as grants and contracts, be subjected to peer review; and 4) whenever and wherever possible uniform criteria among the Institutes be adopted.

c) Received and helped disseminate the report of the Task Force, "Contributions of the Biological Sciences to Human Welfare." This was published as Part II of the November-December, 1972 issue of Federation Proceedings. Copies of this thoughtful document were sent to most members of Congress, a number of members of the Executive branch, and many other Governmental officials.

d) Considering the development of a Biology Coalition for Public Affairs. Many scientists recognize the need for a political action arm that will work for the cause of biomedical science on Capitol Hill and with the Administration. The Federation is prevented from such activity by its tax exempt status. Delegates from groups that are not members of the Federation such as the American Society for Cell Biology, the Biophysical Society, the Neuroscience Society and the Society for Microbiology are working with FASEB to form such a biomedical scientific lobby somewhat along the lines of the Federation of American Scientists.

e) Submitted the name of Daniel C. Tosteson to serve on the Technology Assessment Advisory Council, of the Technology Assessment Board of the Congress.

f) Recommended to the FASEB Executive Committee that it establish a Congressional Fellow program. Under this program scientists might serve either as an administrative aide to a Congressional Committee dealing with legislation or appropriations affecting the biomedical sciences or as an aide to a given member of the House or Senate. Such a person might work in this capacity while on sabbatical, shortly following retirement, or at any other period in his career provided he was a scientist of recognized achievement. (The American Physical Society and the American Association for the Advancement of Science have inaugurated similar programs).

g) A Scholars-in-Residence program is being considered by the Committee. Such in-house scholars could spend six months to a year working on problems such as a cost-benefit analysis of the contributions of basic research to health, or other significant issues of interest.

In conclusion, at times the PAC feels like Fred Allen's definition of a committee, "a group of the unprepared, appointed by the unwilling, to do the unnecessary." While the overall objective of the Public Affairs Committee is clear, it is difficult to implement. In general, the Federation has a good relationship with Congress. Chairmen of key committees such as, Paul Rogers, Daniel Flood, and Warren Magnusen probably do about as much as they can to support the cause of biomedical science. It seems that the major problems in the support of basic research lie with a lack of understanding of its value by the Administration and the general public. It is important that as physiologists, we work to increase this understanding. All members of the Society can help this cause by writing letters to governmental leaders on specific issues, as for instance, when requested by the FASEB Newsletter, or the FASEB correspondents.

Lawrence D. Longo

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PHARMACOLOGY OF THERMOREGULATION: SECOND SYMPOSIUM

An International Symposium to be Held on
15-18 April 1974

PLM Hotel Saint Jacques, 17 Boulevard Saint Jacques
Paris 14e, France

For further details, registration and reservation forms please write to the organizers:

Prof. J. Jacob, Institut Pasteur, 25, Rue du Docteur Roux,
75015 Paris, France

Prof. P. Lomax, Dept. of Pharmacology, UCLA School of Medicine,
Los Angeles, California 90024

Prof. E. Schönbaum, P.B. 249, Oss, The Netherlands

REPORT OF PORTER DEVELOPMENT COMMITTEE

The Porter Development Committee awarded the following predoctoral fellowships during the year 1972-73:

Laura D. Altheimer, Dept. of Physiology, Emory University
Jean L. Flagg, Dept. of Physiology, Harvard Medical School
Cordell S. Fray, Dept. of Physiology, Harvard Medical School
Pamela J. Gunter, Dept. of Physiology, Emory University
Lorraine M. Miller, Neuro- and Behavioral Sciences Ph.D. Program, Stanford University
Nathaniel G. Pitts, Dept. of Animal Physiology, University of California, Davis
Shirley D. Sharrock, Dept. of Physiology, University of Florida
Russell J. Tearney, Dept. of Physiology, Howard University College of Medicine

Dr. Tearney received his Ph.D. in June 1973 and is now Assistant Professor of Physiology, Howard University College of Medicine.

Harvard Apparatus Co. equipment was supplied to the following institutions to help expand laboratory teaching in physiology:

Department of Biology, Atlanta University, Atlanta, Ga.
Department of Zoology, Howard University, Washington, D. C.
Department of Physiology, Howard University College of Medicine, Washington, D. C.
Department of Physiology, Meharry Medical College, Nashville, Tenn.
Department of Biology, Kentucky State University, Frankfort, Ky.

Funds were also made available in support of the cooperative teaching program organized by Dr. Jack Kostyo, Dept. of Physiology, Emory University and Dr. William B. LeFlore, Dept. of Biology, Spelman College, Atlanta, Ga. We are most appreciative of the assistance provided by the following members of the staff at Emory:

Dr. Susan Fellner
Dr. Stephen J. Hersey
Dr. Donald Humphrey
Dr. Jack L. Kostyo
Dr. John W. Manning
Dr. Yorimi Matsumato
Dr. Jimmy D. Neill
Dr. John Pooler
Dr. Vojin Popovic
Dr. Gilbert A. Rinard
Dr. Leona G. Young

and Dr. Eleanor I. Franklin, Dept. of Physiology, Howard University College of Medicine.

As a result of this cooperative program, two students from Spelman are now candidates for the Ph.D. in Physiology at Emory University - Ms. Lura D. Altheimer and Pamela J. Gunter.

In addition, funds were provided for the following Porter Visiting Professorships in the Dept. of Physiology, Tuskegee University, Tuskegee, Alabama:

Dr. Gerhard A. Brecher, Dept. of Physiology, University of Oklahoma Health Center.
Dr. LaVal N. Cothran, Dept. of Physiology, Howard University College of Medicine.
Dr. H. Lawrence McCorrey, Dept. of Physiology, University of Vermont.

We extend our thanks for their invaluable contribution to the Physiology teaching program at Tuskegee.

We should like to take this opportunity to thank publicly the Harvard Apparatus Foundation, the sole support for the program.

E. W. Hawthorne
A. C. Barger
Co-Chairmen

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INTERNATIONAL SYMPOSIUM ON PULMONARY CIRCULATION

The Czechoslovak Society for Respiratory Physiology and Pathology has organized the International Symposium on Pulmonary Circulation II sponsored by Societas Europaea Physiologiae Clinicae Respiratoriae.

The Symposium will be held in Prague, Czechoslovakia, on June 17-19, 1974.

Three topics will be discussed: 1) Long-term development of pulmonary hypertension in chronic obstructive broncho-pulmonary disease, 2) Pulmonary hypertension at altitude, 3) Pulmonary circulation in left heart failure.

Preliminary application forms can be obtained from:

The Czechoslovak Medical Society J.E. Purkyne
Sokolská 31,
120 26 Praha 2,
Czechoslovakia

REPORT OF THE COMMITTEE ON ANIMAL CARE AND EXPERIMENTATION

In August 1972 the Chairman met with Dr. C. O. Finch, Senior Staff Veterinarian of the U.S. Department of Agriculture, Animal and Plant Inspection Services-Animal Care Staff to learn what impact the Animal Welfare Act of 1970 would have on basic science research. As a result of these meetings a report on The Act was published in The Physiologist (15: (4), 324, Nov. 1972). The Committee also provided Dr. Finch with valuable information to be used in his deliberations with congressional committees regarding new standards for animal housing which are being considered for inclusion into The Act. This was accomplished by asking competent scientists who had performed chronic experiments which included evaluating effects of caging animals for extended periods to submit objective data resulting from their studies. These data are important to help balance the subjective claims of animal welfare groups regarding both physiological and "psychological health" of caged animals.

On February 11, 1973 at the annual meeting of the National Council of the National Society for Medical Research (NSMR), of which APS is a member, Dr. Dale F. Schwindaman, who replaced Dr. C. O. Finch (after the latter's retirement) as Senior Veterinarian of the Animal Care, reported on the current status of the Animal Welfare Act.

Dr. Schwindaman dealt very candidly with the problems of the USDA in implementing the Animal Welfare Act. He reported that there were now more than 2,000 "units" (as USDA defines separate administrative entities) carrying on research covered by USDA regulations. Without giving a specific figure he reported that many had not as yet complied with the certification requirements, due on February 1, 1973 with respect to reports of attending Veterinarians, Institutional Committees and responsible Administrative Officers, regarding the professionally acceptable use of anesthetic, analgesic and tranquilizing drugs. Discussion by members of the Council revealed that many veterinarians believed that there was an implication or perhaps even a requirement that veterinarians should personally watch every animal experiment in order to be able to sign the certification form that the USDA requires be signed. It was pointed out by members of the Council that there were not enough veterinarians in the entire country to carry out such inspection even if they were all employed full time in this activity.

Dr. Schwindaman also reported that the USDA is considering incorporating "psychological health" as well as physiological health in its criteria for "minimal acceptable standards" for humane treatment of animals, especially with respect to stipulations as to acceptable cage size for animals. He reported that the hearings held in connection with "exercise requirements" had not yielded any conclusive objective evidence of physical detriment from continuous caging, but that "psychological" detriment was another question. He suggested that cage height standards might be changed, especially for "random source" dogs, meaning any animals not specially bred for use in research. In discussion he was asked whether the USDA had made or obtained estimates of cost to the country involved in any such rules for changes in cage dimensions. In his reply he said they had not, but that economic considerations were not their problem.

Dr. Schwindaman assured the Council members that no decisions on these questions had yet been made in the USDA and that in any case any new regulations would be put in the Federal Register so that there would be opportunity for objections to be filed and considered before finalization of new regulations.

The Committee also reviewed four papers in which experimental procedures on animals were questioned by the referees. The Committee was of the opinion that with appropriate clarifying statements regarding methods used with animals three of the papers would conform to the APS Guiding Principles in the Care and Use of Animals. The Committee decided that the experimental procedures as described in one paper did not conform to APS Guiding Principles and recommended the paper not be published in an APS sponsored journal.

Harold R. Parker, Chairman
July 1973

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X CONGRESS OF THE EUROPEAN SOCIETY FOR EXPERIMENTAL SURGERY

The 10th Meeting of the European Society for Experimental Surgery will be held in Paris on April 6-9, 1975.

For further information please contact the Organizing Committee:

Pr. Agr. J. P. Cachera, Laboratoire de Chirurgie Experimentale, Hôpital Henri Mondor, 51, Avenue du Maréchale de Lattre de Tassigny, 94000 Creteil - France.

A REPORT FROM THE PRESIDENT-ELECT, 1972-73

Physiology and the Engineering Sciences

DANIEL C. TOSTESON

The theme of this tour was to explore the developing interactions between physiology and the engineering sciences. To this end, I visited two institutions with both well established Departments of Biomedical Engineering and Departments of Physiology, i.e., the Johns Hopkins University, (JHU) and the University of Southern California (USC). I also visited two universities with active programs of research and education in the engineering sciences as they relate to biology and medicine but with neither Departments of Biomedical Engineering nor Physiology, i.e. the Massachusetts Institute of Technology, (MIT) and the California Institute of Technology, (CALTECH). The tour also included a visit to an industrial research laboratory where application of the engineering sciences to physiological problems is emphasized, i.e. the ALZA Corporation in Palo Alto, California.

In each place, the visit was made not only informative but also cordial by the scientist who agreed to serve as host. These were F. S. Grodins and J. P. Meehan, Jr. (USC), R. J. Johns and V. B. Mountcastle (JHU), M. Eden (MIT), F. Strumwasser (CALTECH) and J. Urquhart (ALZA). At each institution, I spoke with many scientists, too numerous to mention by name in this report, who gave freely of their time to share with me their thoughts about the relation between physiology and the engineering sciences. To all, I have expressed not only my personal thanks but also the gratitude of the APS for receiving its President-Elect so kindly and effectively.

The state of the system at the interface between physiology and engineering sciences is dynamic and polymorphous. It is dynamic both in the sense of increasing intensity of effort in research and education in fields which have long been recognized to be at this interface (e.g. systems analysis applied to problems in physiological regulation), but also in the sense of exploration of new facets of interaction between these disciplines (e.g. engineering techniques and concepts applied to the production of biological macromolecules). It is polymorphous both in the wide range of administrative arrangements employed to deal with scholarly work at this interface and also in the diversity of concepts and operations thought to comprise "biomedical engineering" (from voltage clamp experiments on the membranes of cell bodies of neurones in Aplysia to the design of improved systems for the management of hospital outpatient clinics).

Much of the polymorphism in structure and content of academic programs at the interface between physiology and the engineering sciences seems to derive from the breadth of the spectrum of concepts of biomedical engineering. Indeed, even the suitability of the term has been challenged by some engineer-scientists who argue that it tends to separate rather than to unite the biological and engineering sciences. Two limits to the spectrum of self-images seem recognizable. On the one side, there are those who take biomedical engineering to be the application of the conceptual and operational tools of engineering to the solution of fundamental biological problems. Frequently, the activities of scientists who practice this brand of biomedical engineering are literally undistinguishable from physiologists. On the other side, there are those who conceive of biomedical engineering as the use of engineering skills to solve a variety of important practical problems, usually with heavy emphasis on instrumentation, in experimental biology and particularly in clinical medicine. Most of the informants thought that both of these limits should be represented in biomedical engineering programs. They readily acknowledged that the great difference in these approaches imposes a strain on educational programs in the field. However, most also felt that the strain is not so intense as to require entirely separate curricula for the two limiting types of biomedical engineer. One M.D. physiologist-engineer maintained that the cement which holds the segments of biomedical engineering together is systems analysis, a set of concepts which is useful at all levels in the hierarchy of biological organization, from cells to societies.

I draw two major conclusions from this study of the interactions between the biomedical and engineering sciences. 1) The interaction has been most fruitful when the engineering elements have been most completely integrated with the biomedical elements. For example, close geographic and organizational proximity between the engineers and their biomedical colleagues seems to promote symbiosis. 2) The intensity and range of work in the engineering sciences related to physiology will certainly increase during the years ahead. The American Physiological Society should continue and strengthen its efforts to encourage such work, and, in particular, to stimulate the exchange of information between the participating groups through appropriate meetings, publications,etc.

ELECTROPHYSIOLOGICAL STUDIES OF A SYNTHETIC STRAND OF CARDIAC MUSCLE*

MELVYN LIEBERMAN
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In 1967, Johnson and Sommer (9) described the ultrastructure and electrophysiological implications of the geometry of a strand of naturally occurring cardiac muscle. In this study, they discussed at great length, the limitations of the strand for applying voltage-clamp techniques to determine the nature of the ionic conductances of the membrane. Much to their chagrin, this particular strand could not be treated electrophysiologically, as a single cable-like structure of membrane because of its complex geometry.

Subsequently, an extensive search of cardiac muscle from a variety of animals (19, 20) failed to uncover a preparation of cardiac muscle ideally suited for voltage-clamp studies (8). It was at that point in time that I became a part of the Laboratory of Cardiac Cellular Physiology at Duke. Shortly thereafter, we began to discuss the possibility of exploiting the recent advances of tissue culture methodology with the hope of developing a synthetic preparation of cardiac muscle suitable for electrophysiological studies. Encouraged by culture methods reported in the literature for a variety of different tissues (2, 18, 23), our laboratory then began systematic attempts to orient the growth of cultured cardiac cells into a strand of minimal morphologic complexity.

In today's discussion, I will briefly review some of our recently published findings concerned with the formation and ultrastructure of the synthetic strand (13, 17). Then, I will present, in detail, our recent unpublished findings a) which describe the passive electrical properties of its membrane, b) those which relate to the generation of its action potential, and finally, c) the possible applications to voltage-clamp experiments. I will not have time to consider yet another intriguing feature of the synthetic strand, that is its ability to serve as a useful model system for studying mechanisms of slow conduction in cardiac muscle (11).

The method for preparing spontaneously active strands of cardiac muscle begins with the isolation of cells from trypsinized 11-13 day old embryonic chick hearts and their subsequent resuspension in conditioned Medium 199 of known ionic composition, controlled pH and osmolarity (13). Linear orientation of these cells is obtained by seeding them on agar-coated culture dishes in which grooves were cut in the agar film.

Time lapse cinematography was used to follow the formation of actively contracting synthetic strands (Fig. 1, (17)). Dissociated cells preferentially attach within the grooves either singly or as very small aggregates and then coalesce to form a spontaneously beating strand up to 30mm in length.

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* Taken from the introductory remarks given at the session on Cardiac Electrophysiology at the 1973 Federation Meetings.

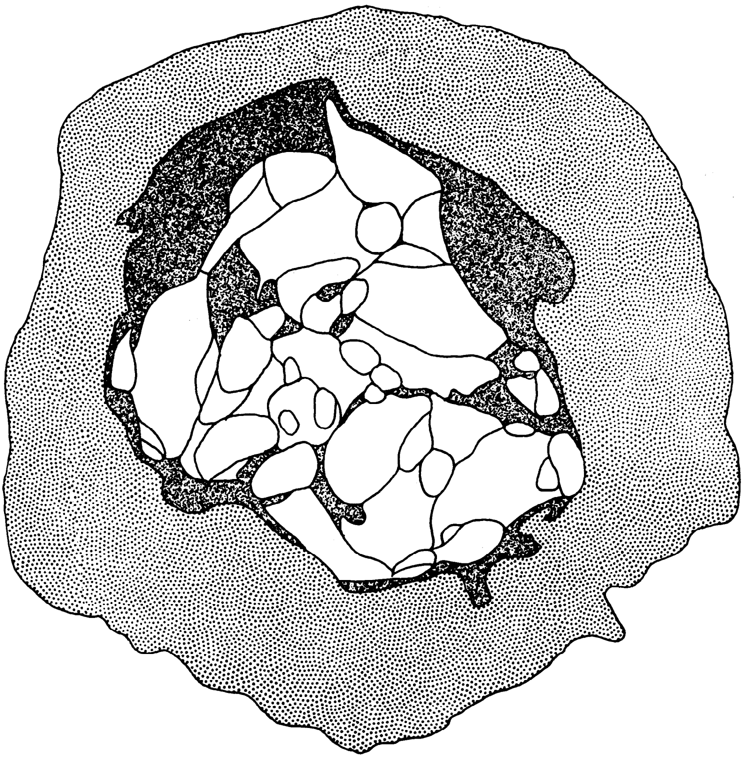

Fig.1. Drawing of a low magnification composite of electron micrographs of a transverse section of a strand. The clear area defines the inner core of muscle cells. The shaded area represents the extracellular space which is surrounded by an epimysial annulus (stippled).

Polarization photomicrographs of segments of the strands clearly demonstrate a linear and parallel organization of the myofibrils (Fig. 1 (13)). Figure 1 shows a schematic representation of a strand which was cut in cross-section and examined with the electron microscope. The strand approximates a right circular cylinder and consists of an inner core of muscle cells surrounded by an epimysial annulus approximately 10μ wide.

Electron micrographs of the strands clearly demonstrate that by a number of ultrastructural criteria, the muscle cells have differentiated normally (17). In most cells, the myofibrils are aligned with the long axis of the strand and are well-developed (Figs. 4, 5 (17)). Elements of the sarcoplasmic reticulum (SR) appear prominently both adjacent to the Z lines and I band as well as in close apposition to the sarcolemma (Figs.

11, 13 (17)). Peripheral couplings appear as flattened saccules which exhibit periodic densities between themselves and the surface membrane (Figs. 14, 15 (17)) and are reminiscent of those found in adult avian myocardial cells (7, 20). No transverse tubular system is present in cardiac muscle cells of the strand.

Three types of specialized intercellular contacts are observed between the muscle cells in the strand: a) fasciae adherentes, the most frequently occurring specialized junctions, resemble an early stage in the development of the intercalated disc (Figs. 14, 17-19 (17)), b) desmosomes are well-structured and numerous (Figs. 4, 18, 19 (17)), and c) nexuses (i.e. gap junctions) are pentalaminar structures in which the apposed cell membranes are separated by a gap of about 20Å in width (Figs. 14, 18-21, (17)).

Having established the fact that the synthetic strands represent reconstructed fibers of developing cardiac muscle with a linear and relatively simple geometry, we proceeded to undertake a study of the passive electrical properties of their membranes. The point in question was to determine to what extent could the strand be described as a one-dimensional cable.

The experimental apparatus used in this study is diagramatically shown in Figure 2. The preparation was stimulated extracellularly through a bevel-edged glass microelectrode (tip diameter $\sim$50μ). Two glass microelectrodes (40-60 MΩ) were used either to record transmembrane potentials or inject current into the cell using bipolar reed relays to switch between a constant current generator or a guarded input probe amplifier. Two peripherally placed silver wires formed a return electrode for the extracellular stimulating electrode and a reference electrode for the microelectrodes (12). A rectangular current pulse, (50-100 msec duration) was injected via one intracellular microelectrode during the interval after every 4th or 6th action potential and the resultant displacement of membrane potential was recorded by the second microelectrode situated at varying distances along the preparation. Conduction velocity was defined as the time between the points of which the rate of change of potential was maximal in action potentials recorded by two microelectrodes divided by the distance between them.

Let us now consider the methods used to obtain the measured parameters for the cable analysis of the synthetic strands. Figure 3 shows a typical example of the waveform of the voltage displacement in response to a rectangular pulse of hyperpolarizing current recorded at various distances from the site of injection of current. A plot of the voltage displacement at the end of the current pulse against the current for various distances shows that for hyperpolarizations up to 30mV, the relationship is always linear (Figure 4). If a horizontal line is drawn at a given current through the family of current-voltage lines, and the voltages given by the intercepts of such a line are plotted logarithmically against distance the result is the straight line relationship shown in Figure 5. The scatter of points was typically small as shown in this case illustrated. The length constant, λ , was obtained from the reciprocal of the slope of these lines and the input resistance, R_O, obtained by extrapolating this line to the voltage axis at zero interelectrode distance and dividing by the current injected.

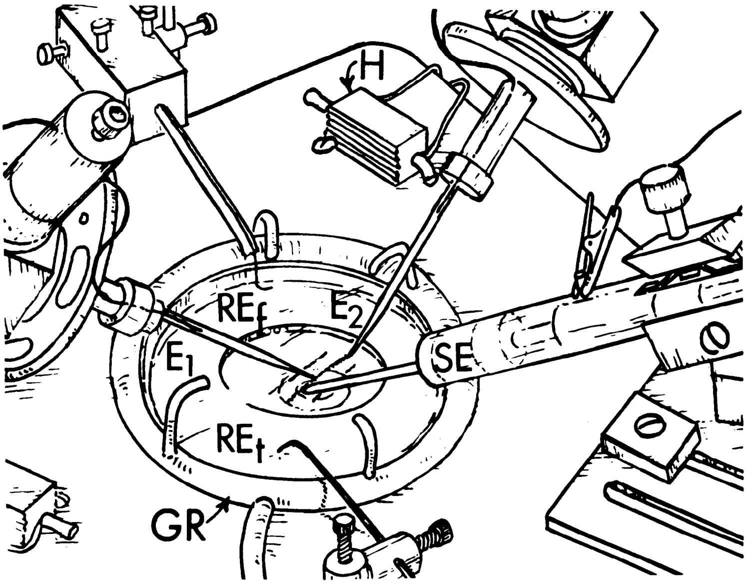

Fig.2. The experimental apparatus for the electrophysiological studies. SE, extracellular stimulating electrode; E_1,E_2, recording microelectrodes; RE_t, RE_f, return and reference electrodes; H, heat source for warming microscope stage; GR, gassing ring for air/CO_2 mixture. (Modified after Fig.1 (14)).

Measurements were also made of the time course of potential changes following the application of a step of current. Figure 6 shows that the plot of the time to half-maximum of these potentials against distance was linear, agreeing quite well with the results of Hodgkin and Rushton for nerve axon (6). Two useful quantities from this kind of plot are the inverse of the slope which gives the propagation velocity of the half-value of the electrotonic potential and the Y-intercept of this curve (Gage and Eisenberg (4)). The time constant of the foot of the action potential was determined according to the method of Tasaki and Hagiwara (22); the logarithm of the voltage of the foot of the action potential plotted against time was described by a linear relationship.

A summary of the values obtained for the measured parameters used in the cable analysis of the synthetic strands is presented in Table I. These results justify the application of one-dimensional cable theory to describing the electrical properties of the synthetic strand. Indeed, as shown in Figure 7, the waveforms of the displacement of membrane potential recorded at various distances from the site of injection of a step function of current in one synthetic strand were satisfactorily fitted by solutions of the partial differential equation for a one-dimensional cable (6).

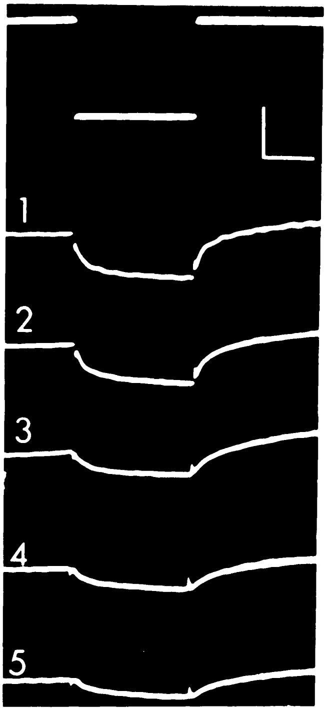

Fig.3. Electrotonic potentials recorded at increasing distances from the site of injection of a hyperpolarizing current. (1) 0.10mm, (2) 0.20mm, (3) 0.50mm, (4) 0.70mm, (5) 0.93mm. Vertical calibration: 10na, 20mV. Horizontal calibration: 50msec. (Sawanobori, Lieberman, Johnson, unpublished observations).

Calculation of the absolute values of specific membrane properties from these experimental results are usually based on a number of assumptions because of the uncertainties in estimating the total surface area of the preparation. Using measurements obtained from light and electron microscopy, we have overcome this difficulty and have been able to obtain values both for the sarcolemmal length per unit cross-sectional area of muscle core (β=8.76x10^3 cm^{-1}) as well as myoplasmic area per unit cross-sectional area of muscle core (ψ=0.74) (Sawanobori, Lieberman, Johnson, unpublished observations). The results of the derived cable parameters from measured parameters are summarized in Table II and are clearly in line with the conclusions reached by Mobley and Page (14) for naturally occurring cardiac muscle.

Let us now consider the active membrane properties of the synthetic strand and characterize its behavior as regards the generation of its action potential. Although it is often stated that cultured heart cells are useful preparations for studying the basic electrophysiology of cardiac muscle, the literature contains a number of reports which negate the usefulness of employing cultured heart cells as a model system (for summary, see (21)). As a result, it was necessary to test the electrophysiological response of the synthetic strand to a number of well-defined cardioactive agents. In summary, cells in the strand respond in a predictable manner to the presence of acetylcholine (10μg/ml), epinephrine (10μg/ml), isoproterenol (4μg/ml), quinidine (2μg/ml), as well as to changes in the external K^+ concentration (Lieberman, Sawanobori, Johnson, unpublished observations). In addition, the strands were responsive to valinomycin (0.2μg/ml) and cytochalasin B (10μg/ml) (12) in a manner clearly in agreement with the action of these drugs in other systems.

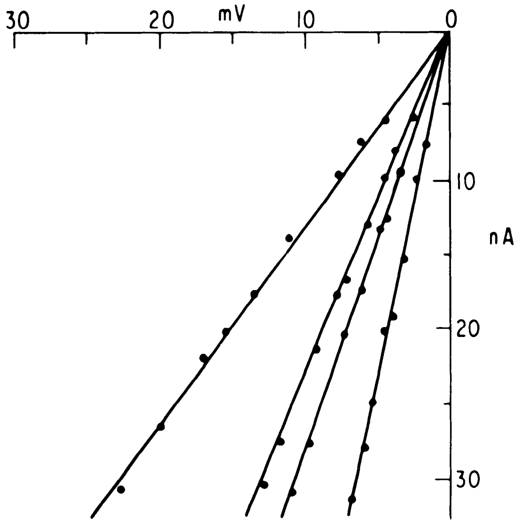

Fig.4. Current-voltage relationship at various distances from the site of injection of hyperpolarizing currents. Ordinate: current intensity (nA). Abscissa: displacement of membrane potential (mV). (Sawanobori, Lieberman, Johnson, unpublished observations).

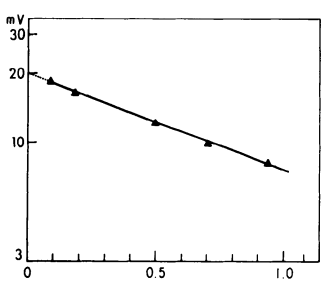

Fig.5. Decay of electrotonic potential with distance. Ordinate: displacement of membrane potential on a logarithmic scale (mV). Abscissa: distance from the site of injection of current (mm). Dotted line represents extrapolation to zero interelectrode distance for determination of the input resistance, R_0, of the strand. (Sawanobori, Lieberman, Johnson, unpublished observations).

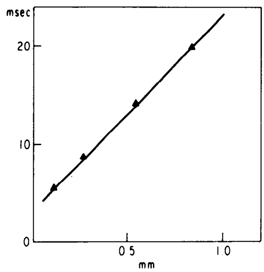

Fig.6. Plot of time to half-maximum of the electrotonic potential (ordinate) against distance from the site of injection of current (abscissa). (Sawanobori, Lieberman, Johnson, unpublished observations).

TABLE I

CABLE ANALYSIS OF SYNTHETIC STRANDS OF CARDIAC MUSCLE: SUMMARY OF MEASURED PARAMETERS

λ, length constant	(mm)	1.16±0.06 *	(14) +
R_O, input resistance at zero electrode separation	(MΩ)	0.98±0.05	(14)
ν, propagation velocity of half-value of the electrotonic potential	($cm \cdot sec^{-1}$)	6.33±0.60	(14)
$T^{O}_{1/2}$, time to half-maximum of the electrotonic potential at zero electrode separation	(msec)	7.73±0.66	(14)
T_{AP}, time constant of the foot of the action potential	(msec)	0.49±0.06	(7)
θ, conduction velocity	($cm \cdot sec^{-1}$)	33.6±2.5	(7)
$d^{\bullet}$, muscle core diameter	(μ)	47(31-64)‡	(14)

* Mean values ±standard error

\+ Number of preparations

• [$d=D-2\bar{\varepsilon}$] D=overall diameter of strand
$\bar{\varepsilon}$=average thickness of annulus of epimysium (10μ)

‡ Range of measurements

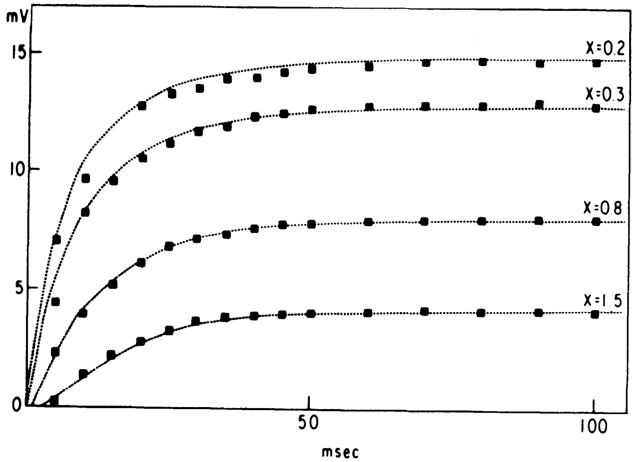

Fig.7. Plot of the displacement of membrane potential with respect to time recorded at various distances from the site of injection of current (x=fraction of the length constant). Square symbols represent recorded values corrected for a pacemaking drift in membrane potential. Dotted lines are obtained from numerical solutions of the Hodgkin-Rushton cable equation (8). (Sawanobori, Lieberman, Johnson, unpublished observations).

TABLE II

CABLE ANALYSIS OF SYNTHETIC STRANDS OF CARDIAC MUSCLE: SUMMARY OF DERIVED PARAMETERS

C_m, specific membrane capacitance,^{x}	($\mu F \cdot cm^{-2}$)	1.29 ± 0.38*	(7)$^{+}$
R_m, specific membrane resistance^{xx}	($k\Omega \cdot cm^2$)	36.9 ± 5.4	(14)
R_i, specific myoplasmic resistance^{xxx}	($\Omega \cdot cm$)	223 ± 36	(14)
T_m, membrane time constant ($R_m C_m$),	(msec)	32.3 ± 6.8	(7)

* Mean values $\pm$ standard error

\+ Number of preparations

X $C_m = c_m/A$, in which $c_m = \lambda / 2 R_o T_A p \theta^2$ (after Tasaki and Hagiwara, (22)

A, cross-sectional area of muscle core per unit length of preparation ($cm^2 \cdot cm^{-1}$).

xx $Rm = 2 R_o \lambda A$.

xxx $R_i = 2 R_o S/\lambda$. S, myoplasmic area in muscle core (cm^2).

What then can be said about the generation of its action potential? Tetrodotoxin, which is known to specifically block the Na permeability channel responsible for excitation in the squid giant axon (15) also abolishes electrical activity of cells in the synthetic strand, which are both spontaneously active and electrically driven. At doses of 10^{-3}-10^{-4}g/ml, the input current-voltage relationship becomes essentially linear. Figure 8 demonstrates the effect of a somewhat lower dose of tetrodotoxin (2.5×10^{-5}g/ml). Although this finding would point to sodium as the charge carrier, the response of the strand to Na-free media, clearly identifies it. This is shown in Figure 9. Electrical activity is abolished and the absence of both an anode-break response as well as an active membrane response following a large depolarizing current is clearly evident. Finally Figure 10 shows a linear input current-voltage relationship in the absence of Na^+. It is of interest to note that these results are similar to those obtained by Harrington and Johnson (5) from tiny strands of rabbit ventricle using a double sucrose gap.

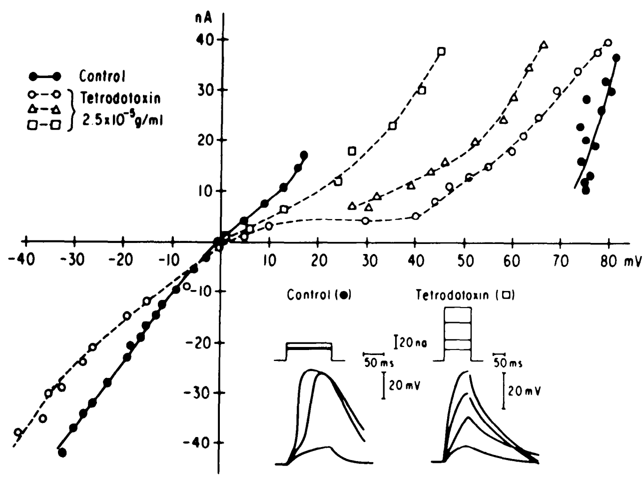

Fig.8. The effect of tetrodotoxin (2.5×10^{-5}g/ml) on the relationship between the amplitude of a rectangular pulse of current and the resultant maximum displacement of membrane potential. Dotted lines connect the values obtained during a period of one hour(o,Δ,□,respectively) following the addition of tetrodotoxin. The inset shows tracings of the current pulse (upper trace) applied through one intracellular microelectrode and the resulting transmembrane potential change (lower trace) recorded from a nearby second intracellular microelectrode. Zero on the membrane potential axis is the membrane potential in the absence of current. The discontinuity in the control current-voltage relationship reflects regenerative activity (generation of an action potential). (Lieberman, Sawanobori, Johnson, unpublished observations).

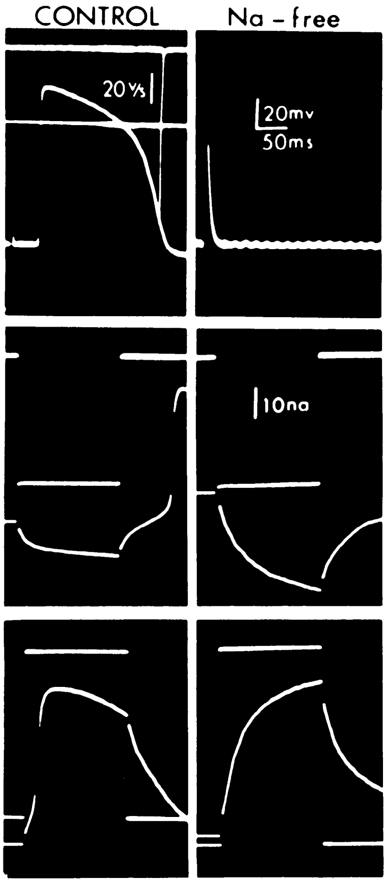

Fig.9. The effect of a Na-free environment on the synthetic strand. Upper panels: transmembrane potentials in response to extracellular stimulation. Middle panels: transmembrane potentials in response to hyperpolarizing currents. Note the absence of an anode-break response in Na-free solution. Lower panels: transmembrane potentials in response to depolarizing currents. Note the absence of an active membrane response in Na-free solution. (Lieberman, Sawanobori, Johnson, unpublished observations)

With this in mind, it is perhaps worthwhile pointing out that the compound, D-600, reported to be a specific Ca^{++} blocking agent (3), in our hands, acts exactly like TTX and zero-Na (Lieberman, Sawanobori and Johnson, unpublished observations).

The next logical question to ask would be to what extent is this Na-current following a depolarization a function of voltage and time? Kootsey and Johnson (10) have recently described a new type of membrane model in which the repolarization phase of the cardiac action potential is essentially a time-independent system of conductance changes. We plan to carry out a series of iterative experiments in which the theoretical and experimental studies will be done simultaneously, an approach which if I may paraphrase Noble and Tsien (16) "is as it should be."

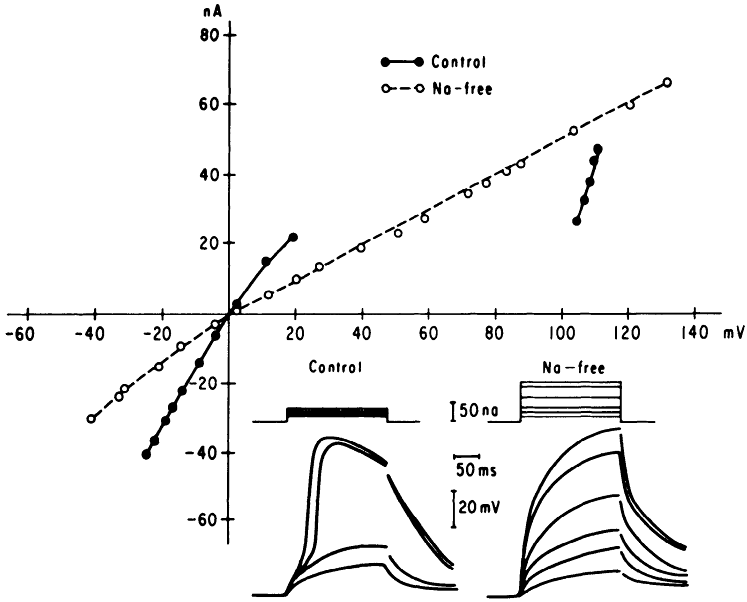

Fig.10. The relationship between the amplitude of a rectangular pulse of current and the resulting displacement of membrane potential (recorded close by) at the end of the current pulse before and after exposure of the strand to a Na-free solution. (Lieberman, Sawanobori, Johnson, unpublished observations).

In these studies we plan to exploit the naturally occurring end of the synthetic strand and employ the three-electrode voltage-clamp technique of Adrian, Chandler and Hodgkin (1). In parallel with the experimental voltage-clamp studies, we will carry out equivalent theoretical experiments using a computer simulated one-dimensional cable with, as a starting point, membrane having the properties of the kind described by Kootsey and Johnson (10). Experimental results will be compared with theoretical results using deviations to force modifications in the theoretical membrane properties on the cable geometry to make theory fit with fact. In this way, using this iterative "old-time" scientific procedure, our theoretical concept and understanding can go hand in hand with fact.

SUMMARY

We have seen that a synthetic strand of cardiac muscle can be described in terms of one-dimensional cable theory. The preparation has several noteworthy physiologic properties which are not complicated by geometric and morphologic inhomogenities. Therefore it appears that

the synthetic strand can serve as a useful biological model for studying the generation of the cardiac action potential.

ACKNOWLEDGEMENTS

I should like to express my appreciation to those individuals who, since 1967, have actively collaborated in the studies concerning the formation and ultrastructural studies of the synthetic strand and likewise to those who participated in different aspects of the electrophysiological studies (Figure 11). Research reported in this paper has been supported by grants from the National Institutes of Health (HL12157), North Carolina Heart Association and an Established Investigatorship from the American Heart Association (71160).

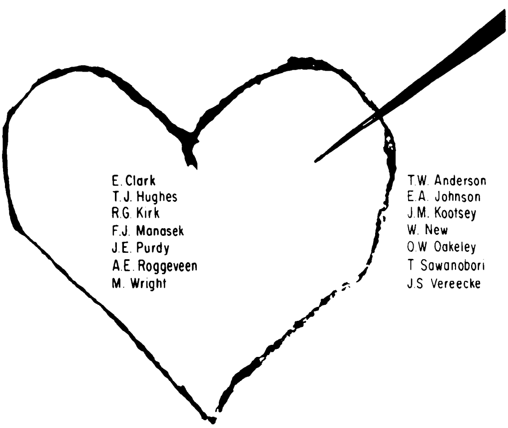

Fig.11. Acknowledgement of colleagues and associates who have contributed to the developmental, ultrastructural and electrophysiological investigations of the synthetic strand of cardiac muscle.

REFERENCES

1. Adrian, R.J., W.K. Chandler, and A.L. Hodgkin. Voltage-clamp experiments in striated muscle fibres. J. Physiol. (Lond.) 208: 607-644, 1970.
2. Carter, S.B. Principles of cell motility: the direction of cell movement and cancer invasion. Nature (Lond.) 208: 1183-1187, 1965.
3. Fleckenstein, A. Specific inhibitors and promoters of calcium action in the excitation-contraction coupling of heart muscle and their role in the prevention or production of myocardial lesions. In: Calcium and the Heart, edited by P. Harris and L.H. Opie. New York: Academic Press, 135-188, 1971.
4. Gage, P.W., and R.S. Eisenberg. Capacitance of the surface and transverse tubular membrane of frog sartorius muscle fibres. J. Gen. Physiol. 53: 265-278, 1969.
5. Harrington, L., and E.A. Johnson. Voltage clamp of cardiac muscle in a double sucrose-gap: a feasibility study. Biophys. J. 13: 626-647, 1973.

6. Hodgkin, A. L., and W. A. H. Rushton. The electrical constants of a crustacean nerve axon. Proc. Roy. Soc. B. 133: 444-470, 1946.
7. Jewett, P. H., J. R. Sommer, and E. A. Johnson. Cardiac muscle. Its ultrastructure in the finch and hummingbird with special reference to the sarcoplasmic reticulum. J. Cell Biol. 49: 50-65, 1971.
8. Johnson, E. A., and M. Lieberman. Heart: excitation and contraction. Ann. Rev. Physiol. 33: 479-532, 1971.
9. Johnson, E. A., and J. R. Sommer. A strand of cardiac muscle. Its ultrastructure and the electrophysiological implications of its geometry. J. Cell Biol. 33: 103-129, 1967.
10. Kootsey, J. M., and E. A. Johnson. The repolarization phase of the cardiac action potential: an essentially time-independent system of conductance changes. Biophys. Soc. Abstracts 13: 130a, 1973.
11. Lieberman, M., J. M. Kootsey, E. A. Johnson, and T. Sawanobori. Slow conduction in cardiac muscle: a biophysical model. Biophys. J. 13: 37-55, 1973.
12. Lieberman, M., F. J. Manasek, T. Sawanobori, and E. A. Johnson. Cytochalasin B: its morphological and electrophysiological actions on synthetic strands of cardiac muscle. Develop. Biol. 31: 380-403, 1973.
13. Lieberman, M., A. E. Roggeveen, J. E. Purdy, and E. A. Johnson. Synthetic strands of cardiac muscle: growth and physiological implication. Science, Washington, D. C. 175: 909-911, 1972.
14. Mobley, B. A., and E. Page. The surface area of sheep cardiac Purkinje fibres. J. Physiol. (Lond.) 220: 547-563, 1972.
15. Narahashi, T., J. W. Moore, and W. R. Scott. Tetrodotoxin blockage of sodium conductance increase in lobster giant axons. J. Gen. Physiol. 47: 965-974, 1964.
16. Noble, D., and R. W. Tsien. The repolarization process of heart cells. In: Electrical Phenomena in the Heart, edited by W. C. deMello. New York: Academic Press, 133-161, 1972.
17. Purdy, J. E., M. Lieberman, A. E. Roggeveen, and R. G. Kirk. Synthetic strands of cardiac muscle: formation and ultrastructure. J. Cell Biol. 55: 563-578, 1972.
18. Rosenberg, M. C. Cell guidance by alterations in monomolecular films. Science, Washington, D.C. 139: 411-412, 1963.
19. Sommer, J. R., and E. A. Johnson. A comparative study of Purkinje fibers and ventricular fibers. J. Cell Biol. 36: 497-526, 1968.
20. Sommer, J. R., and E. A. Johnson. A comparative ultrastructural study with special reference to frog and chicken hearts. Z. Zellforsch. 98: 437-468, 1969.
21. Sperelakis, N. Electrical properties of embryonic heart cells. In: Electrical Phenomena in the Heart, edited by W. C. deMello. New York: Academic Press, 1-61, 1972.
22. Tasaki, I., and S. Hagiwara. Capacity of muscle fiber membrane. Am. J. Physiol. 188: 423-429, 1957.
23. Weiss, P. Cell contact. Int. Rev. Cytol. 7: 391-423, 1958.

ACUTE MYOCARDIAL INFARCTION

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"Acute Myocardial Infarction: A Transcribed Demonstration" is the first volume in a library of medical education color video-taped programs which employs a unique new format for presentation of transcribed material. The Transcribed Demonstration* has been developed by the Division of Biomedical Engineering of the Baylor College of Medicine, Department of Physiology. The format allows simultaneous reproduction of color television and audio with three channels of physiological data such as the electroencephalogram, electrocardiogram, blood pressure, respiration, etc. This new medium provides the audience with a hard-copy, graphic record of the physiological parameters from the demonstrated material which is viewed at the time of presentation and can then be taken from the presentation for further study, analysis and review.

In the first program, Acute Myocardial Infarction is produced in the heart of a dog, allowing direct visualization of the heart as well as graphic recording of the EEG, ECG and systemic arterial blood pressure. Multiple, dramatic changes are presented by both the television monitor and the graphic records; discussion of these changes are presented regarding the following five categories of pathophysiology:

1) Cardiac tissue changes secondary to loss of cardiac perfusion (example, cyanosis of infarcted area)
2) Loss of cardiac contractility (example, ballooning of the infarcted area)
3) Altered electrophysiology of the myocardium (example, S-T segment changes)
4) Onset of cardiac arrhythmias (example, ventricular fibrillation)
5) Compromise of central nervous system with low cardiac output (example, loss of EEG)

The time course of these events is reviewed and their significance is discussed during the presentation.

This Transcribed Demonstration may be borrowed. A written description of the technical details for presenting this demonstration is also available. Interested parties should contact Dr. L. A. Geddes or Dr. W. A. Tacker, Jr., Dept. of Physiology, Baylor College of Medicine, Houston, Texas regarding the loan of this as well as other programs and necessary equipment.

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HIBERNATION, SPRING 1973*

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Temperature regulation and animal behavior are topics of mammalian hibernation of major concern to me today. Although representing a small subject portion of hibernation, they are currently areas of research in which we have sufficient knowledge to make large advances in our understanding of hibernation. Of course I should comment on how these two aspects contribute to the overall understanding of mammalian hibernation and mammalian physiology. The American Physiological Society has emphasized the important issue of how various physiological systems integrate to result in a functioning individual. Now, more than ever before, we must examine the extent to which the environment may impinge on the individual and change the interactions which we refer to as physiology. In other words we must be cognizant of the extent to which physical and social environments influence activity and interactions of physiological systems.

Mammalian hibernation is an excellent example of the interrelationship between biological systems and the environment. There has been a series of mammalian hibernation symposia (South, Hannon, Willis, Pengelley, and Alpert, 1972; Fisher, Dawe, Lyman, Schönbaum, and South, 1967; Suomalainen, 1964; and Lyman and Dawe, 1960) which provides a comprehensive examination of the subject. Hibernation is a dominant factor in the lives of mammalian hibernators; as they are hibernating, reproducing, or preparing for hibernation. The relevance of mammalian hibernation to the overall subject of mammalian physiology is perhaps obvious to all, but reproduction is an area which particularly exemplifies some of the flexibility of mammalian systems and the extent to which mammalian hibernation studies are relevant to worldwide concerns. Many bats copulate in the fall before hibernation and birth occurs in the spring as a result of sperm storage or delayed embryogenesis or both (Wimsatt, 1972). Sperm storage may be accomplished by oviduct or uterine cells specialized in providing an optimum sperm storage environment. Studies on reproduction of mammalian hibernators like the study of any other aspect of hibernation are dependent upon an overall understanding of the processes at various levels of organization. The specialization of these cells is critical to the ability of the whole animal to accomplish hibernation and reproduction. In a similar vein, temperature regulation like reproduction of the hibernator represents a unique situation. The uniqueness is that hibernators are capable of poikilothermia and homeothermia and represent situations in which simple and complex biological systems are responding to the physical environment.

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* Taken from the introductory remarks given at the session on Hibernation and Cryobiology at the 1973 Federation Meetings.

Light and temperature are two features of the physical environment which have had a marked influence on the evolution of biological material. In response to light, biological systems have developed clocks and rhythms which control many activities. We must regard physiological responses to temperature in a universal manner very much as we consider physiological responses to light. In response to temperature, biological systems have developed many temperature-sensitive and temperature-compensating mechanisms. There are innumerable expressions of the response of biological systems to temperature and as physiologists we can express these responses as approaching poikilothermia or homeothermia. We must realize that just as the biological clock occurs in different forms so also does temperature regulation occur in different forms. Poikilothermia and homeothermia are theoretical extremes on a continuum. No animal has perfect homeothermia; and as information on poikilotherms becomes more extensive, it is apparent that most poikilotherms express some degree of homeothermia either by behavioral or physiological responses.

Poikilothermia

Plants and aquatic animals are perhaps the most likely organisms to fit the definition of poikilothermia. Recent studies describe physiological thermoregulation in philodendron and arum lilly plants (Nagy, Odell, and Seymour, 1972; Buggeln and Meeuse, 1971). The increased oxidative metabolism in the arum lilly keeps plant tissue temperature above 38 C in 4 to 39 C ambient temperatures. This response of plants is similar to temperature regulation in a sphinx moth (Heinrich, 1970). A review of the literature by Vernberg and Vernberg (1970) provides good examples of temperature avoidance and physiological temperature regulation among aquatic invertebrates. Sturbaum and I have been studying a land, box turtle, Terrapene ornata, and have been amazed and excited by the responses of these animals. They clearly have an extensive physiological capacity for temperature regulation including copious salivation. This frothing is an integrated response influenced by both the environmental and core temperatures. The experiment described in Figure 1 involved preheating the turtles to 30 C core temperature prior to exposure to experimental temperatures. Note that in 37 C ambient, core temperature exceeded 37 C and no frothing occurred; whereas in hotter environments, frothing started before the tortoises reached 37 C core temperature. Another rather subtle but impressive point is that these animals approach thermal equilibrium in a 48 C environment such that they can tolerate this environment for at least 3 hr. In great contrast Citellus teretecaudus, ground squirrels native to deserts and arid lands, succumb to heat exhaustion in a 46 C environment within 2 hr, although they are described as having genetic and physiological adaptions to hot environments (Hudson and Wang, 1969). Low metabolic rate is an important factor in these extreme tolerances for heat stress. These turtles are twice the ground squirrel size and therefore have a higher heat gain from the environment but the turtle has a metabolic heat of 1 cal $kg^{-1}hr^{-1}$ (Sturbaum, 1972) whereas the ground squirrel has 5 cal kg^{-1} hr^{-1} (Hudson, 1964). These and undoubtedly other factors make the tortoise more tolerant of these severe thermal stresses than the ground squirrel.

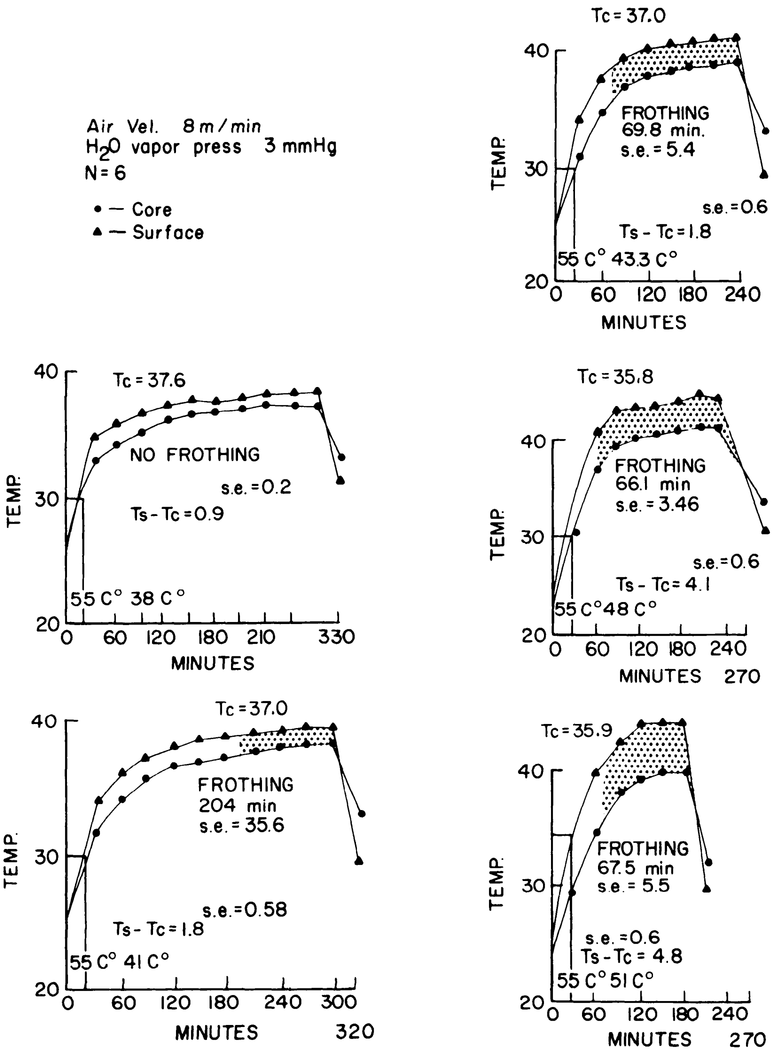

Fig.1. Mean temperatures of animals exposed to various experimental environments after preheating in 55 C to 30 C core temperature.

Evolution represents the product of animal-environment interaction. It is dangerous for physiologists to consider the subject of evolution of physiological capacities, if for no other reason than the fact that physiologists evolved late in the evolution of animal life. We have little data on evolution of physiological systems. We must be critical of ourselves when we examine present-day animal species and theorize as to the development of physiological systems (Twente and Twente, 1964). However, studies of poikilotherms are impressive in pointing out that we can have well-defined and highly organized temperature-regulating organisms other than birds and mammals. This is similar to rhythms and timing mechanisms in essentially all simple organisms. Perhaps because mammalian physiologists study complex responses of mammals to heat and cold stress, we consider all temperature-regulating centers as being complex. Many animals generally considered to be poikilothermic have accurate temperature-sensing and integrating mechanisms (Boyer, 1965). It is best to assume that all biological material has the potential, either by physiological or behavioral mechanisms, to respond to temperature just as they have the capacity to respond to light.

Homeothermia

Recent review articles and publications (Gale, 1973; Lomax and Schönbaum, 1973; Bligh and Moore, 1972; Smith, Hannon, Shields, and Horwitz, 1972; Janský, 1971; and Hardy, Gagge, and Stolwijk, 1970) provide a great deal of information. There is ample evidence to support the points that (i) temperature-regulating mechanisms at best approach homeothermia, (ii) there are many tissues involved in detecting and regulating body temperature, (iii) there are many examples of poikilothermia among homeotherms, and (iv) behavior is an important part of homeothermia as well as poikilothermia. Before considering specifics of temperature regulation among mammalian hibernators, I should like to note some of the evidence which indicates the extent of poikilothermia among nonhibernators. The direct response of smooth muscle to temperature may be considered a poikilothermic activity of great importance to homeotherms (Kenshalo, 1970). Smooth muscle relaxes when warmed and contracts when cooled. Furthermore the location of cutaneous vascular smooth muscle approximates the location of thermoreceptors. The neural input to the temperature-regulating center is dependent upon the variable temperature obtained in the periphery which at least in part is changed by direct effect of temperature on smooth muscle. The area concerned with the set-point temperature in the hypothalamus represents a biological entity which is poikilothermic as evidenced by the activity of the center being determined to some extent by the temperature of its immediate environment. Thus there are aspects of homeothermia which invoke poikilothermia.

It is ironic that one of the best examples of homeothermia is possibly given by an antarctic fish. The organisms, Trematomus bernacchii and T. hansoni, apparently live their entire life span well within a thermal environment ranging from 2.0 to -2.0 C (Somero and DeVries, 1967; Littlepage, 1965). The average annual temperature of McMurdo Sound located at the southwest corner of the Ross Sea is -1.9 C with a standard deviation of 0.1 C and it appears reasonable that most individuals of these two species spend their life time in this environment. These uniform body temperatures are accomplished by selecting the preferred ambient temperature. This example of homeothermy emphasizes the importance of behavior in temperature regulation. Behavior is extremely important for small (< 1 kg) terrestrial animals. Behavior determines whether or not physiological temperature regulation is going to be required. Thus small animals can conserve considerable energy in cold environments and conserve water in hot environments simply by changing their behavior. Men have been known to change life styles by installing air conditioning units in response to moderate or severe temperature exposure. In man, changes in behavior are identified as the most important responses to thermal stress and particularly the responses to multiple stresses of temperature, carbon monoxide, noise, social pressures, etc. (Hertig, 1971). Although the mammalian hibernator is often regarded as having a unique capacity to approach either homeothermia or poikilothermia, actually man and many other mammals demonstrate poikilothermia by (i) cooling of extremities, (ii) limited physiological temperature regulation in infancy, and (iii) other examples cited above and elsewhere. Responses to temperature as responses to light can occur in many different forms.

Temperature Regulation of Mammalian Hibernators

Recent studies of thermoregulation among mammalian hibernators emphasize flexibility or variability in temperature regulation of these animals. This variability is to a large extent the result of fluctuation between physiological and behavioral temperature regulation in hibernating and active animals although some of the variability must be due to changes in the nature or "state" of the physiological system which is regulating the temperature. Also there is the possibility of biochemical changes which alter the necessity for physiological regulation.

The temperature-regulation physiology of the active mammalian hibernator is a product of evolution, current genetic characteristics, and the ecological niche of the animal. Recent publications from Hudson's laboratory describe differences in temperature regulation among eight species of ground squirrel from different ecological areas (Hudson, Deavers, and Bradley, 1972; Hudson and Deavers, 1973). It is pertinent to note that these studies were conducted on animals conditioned to laboratory situations. Ray Hock told us many times in personal discussions and in at least one publication (Hock, 1969) that animals housed in laboratory conditions can expect to demonstrate their genetic characteristics whereas under field conditions you will find the real nature and capacity of physiological systems. Thus the low metabolic rate and increased thermal conductance of ground squirrels native to hot environments described in Hudson's laboratory is an expression of the genetic characteristics of these animals. It is perhaps somewhat surprising that data collected on *C. lateralis* and *C. spilosoma* in Hudson's laboratory (Hudson and Deavers, 1973; and Hudson, Deavers, and Bradley, 1972) compare favorably with unpublished data collected in our laboratory by Thomas J. Crowley (Fig. 2). It is also of interest that data collected by Yousef and Bradley (1971) on *C. lateralis* agree well with data collected on *C. spilosoma* by Hudson's group and Crowley (Fig. 3). The *C. lateralis* in Figure 3 were collected near Reno, Nevada in a habitat which is as close to the *C. spilosoma* habitat as *C. lateralis* ever approach. These oxygen-consumption data support the hypothesis that mammalian physiological systems are flexible and can be adapted to diverse environments. Golden-mantled ground squirrels inhabit montane areas and in Hudson's and my laboratory have little metabolic response to cold most likely because they are decreasing their thermal conductance during cold exposure. In contrast, the oxygen consumption data collected by Yousef and Bradley (1971) demonstrate a marked rise in oxygen consumption in response to cold exposure. Perhaps this is also the closest the metabolic response of C. lateralis will approach the metabolic response of C. spilosoma.

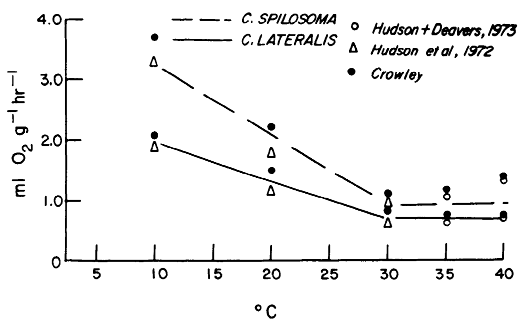

Fig.2. Ambient temperature and oxygen consumption data collected on ground squirrels in two laboratories. Lines are fit manually and data points represent mean values on 3 to 13 specimens of each species.

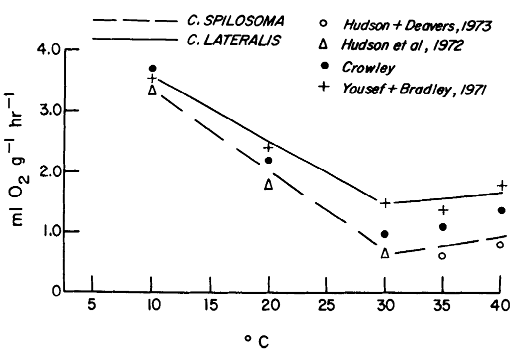

Fig.3. Ambient temperature and oxygen consumption data collected on ground squirrels in three laboratories. Lines are fit manually and data points represent mean values on 3 to 13 specimens of each species.

We examined the capacity of field and laboratory animals to tolerate swimming in cold water at 25 C (Young and Riedesel, 1967). The difference between field and captive animals of the same species was greater than the difference between species (C. lateralis versus C. spilosoma). Our data also suggested that C. lateralis retain the capacity to lower body temperatures during summer months. However, summer animals brought into the laboratory become, in the course of 3 to 4 weeks, homeothermic which includes the capacity to shiver in 25 C water. The fact that ground squirrels may have lowered body temperatures during summer months may appear to contradict the idea of an endogenous annual rhythm (Pengelley, Bartholomew, and Licht, 1972). Actually, there is good evidence to support an annual endogenous rhythm in hibernators;

but this biological phenomenon is subject to change by environmental factors. A late spring snow storm or campers setting up camp near a golden-mantled-ground-squirrel burrow are good examples of situations which will cause animals to hibernate at times when the annual rhythm would dictate no hibernation. Wang (1973) released Richardson's ground squirrels, C. richardsoni, and body temperatures in the field were similar to temperatures recorded in the laboratory. Unfortunately his field recordings were for only two days. There are a number of advantages for field animals to retain the capacity to lower body temperature. One is conservation of energy during inactive periods. Another important difference is the marked decrease in evaporative water loss with the lowering of temperature (Hudson, Deavers, and Bradley, 1972 ; Yousef and Bradley, 1971).

There are numerous metabolic responses associated with temperature regulation. Some years ago when concerned with serum magnesium ion concentration and temperature regulation of hibernating animals, it was advantageous to consider the chemical environment, temperature, and time to be interrelated variables (Riedesel, 1960). The interdependence of time, temperature, and the chemical environment becomes more apparent today in view of studies conducted in a number of laboratories. The interaction of time and temperature includes (i) changes in temperature regulation which occur with acclimatization to various thermal environments, and (ii) the maximum and minimum temperatures tolerated by animals changes with the duration of the exposure. Interaction of the chemical environment and time to influence many biological systems is illustrated by (i) dehydration which accompanies heat exposure and results in changes in temperature regulation, and (ii) the time required for enzymatic processes varies with the presence and concentration of the catalyst. Interaction of temperature and the chemical environment is supported by data that describe (i) the concentration of isotonic solutions varying with temperature (Adolph and Richmond, 1956), (ii) ion concentration influencing temperature regulation in cats and other organisms (Myers and Veale, 1971, 1970), and (iii) ions and plasma osmotic pressure influencing temperature regulation of working human subjects (Greenleaf, 1973; Senay, 1968).

One of the largest breakthroughs in temperature regulation in recent years has been the advent of studies involving changes in chemical metabolism and temperature regulation. Description of the onset of hibernation as a result of a chemical trigger (Spurrier and Dawe, 1973; Dawe and Spurrier, 1972) is impressive. The source and chemical nature of the trigger is elusive, but there is little doubt but what the trigger conditions body tissues for onset of hibernation. Elevation of serum magnesium during hibernation was one of the first changes in electrolyte metabolism to be associated with temperature regulation. Today there is considerable evidence regarding calcium ions (Myers and Veale, 1970), and also perhaps sodium and potassium ions influencing the operation of the temperature-regulation center at least under particular conditions. The story of the role of electrolytes in temperature regulation may become more apparent when more studies which examine the electrolyte concentration in arterial blood have been conducted. A recent study (Coester, Elliott, and Luft, 1973) describes marked decreases in potassium ion concentration of arterial plasma within 1 to 3 min after cessation of severe exercise. Sweat of men declines most rapidly at the end of exercise and the drop in serum potassium is a reasonable causative factor.

Selective catabolism of body tissues is important in situations involving water loss or no water intake. The consideration that different body tissues provide different amounts of water has led Rigler (1972), Bintz (1968), and myself (Riedesel and Rigler, 1972 ; Bintz, Bintz, and Riedesel, 1971) to consider shifts in whole-animal metabolism as a major factor enabling ground squirrels to tolerate starvation and no free water intake. The computations in Table I have been considered by Bintz (1968) and Rigler (1972). Emphasized is the large difference in water balance an animal can experience by selecting or not selecting his thermal environment within 2 C. The C. lateralis utilizing adipose tissue as an energy source is in negative water balance in 25 C environment but is in water balance at 23 C (Table I). Thus behavioral selection of ambient temperature can dictate tissue catabolism. Riedesel, Klinestiver, and Benally (1964), Bintz (1968), and Rigler (1972) have noted that ground squirrels adjust to limited water intake within a short period of time, 1 to 3 days. These adjustments include increased utilization of urea and conservation of proteins. Additional studies are needed to describe the neurochemical and endocrine changes which control the metabolic responses of hibernators to the physical environment. The biochemical diversity demonstrated by mammalian hibernators during hibernation and water deprivation makes these animals excellent research tools for investigation of endocrine and neuronal systems involved in controlling biochemical pathways. Identification of the behavioral and metabolic changes which occur in field conditions will be difficult, but the application of telemetering equipment should greatly aid these studies (Folk, 1971).

TABLE I

Water balance resulting from catabolism of 100 g each of adipose and skeletal muscle tissue[1]

Tissue	Free water (g)	Solids (g)	Metabolic water (g/g of solid)	Total metabolic water (g)	Total free and metabolic water (g)
Adipose	25	75	1.07	80.2	105.2
Muscle	75	25	0.40	10.0	85.0

	O_2 required/ g of solid (liters)	Total O_2 required (liters)	Insensible respiratory water loss[2] (g/liter O_2) 23 C Rat	23 C C. lat.[3]	25 C C. lat.[3]	Total insensible respiratory water loss (g) 23 C Rat	23 C C. lat.	25 C C. lat.
Adipose	2.01	150.7	0.94	0.70	0.83	141.7	105.5	125.1
Muscle	0.95	23.7	0.94	0.70	0.83	22.3	16.6	19.7

	Urinary nitrogen (g)	Water lost in N excretion (g)	Total water lost during catabolism of solids (g) 23 C Rat	23 C C. lat.	25 C C. lat.	Net water[4] (g) 23 C Rat	23 C C. lat.	25 C C. lat
Adipose	-	-	141.7	105.5	125.1	-36.4	-00.3	-19.9
Muscle	4.0	25.8	48.1	42.4	45.5	+36.9	+42.6	+39.5

[1]Modified from Bintz et al., 1971

[2]Dry air

[3]Yousef and Bradley, 1971

[4]Net water gain (+) or loss (-)

We are indebted to Mrosovsky (1971) for setting forth the idea of hibernation as an example of patho-physiology. I think some of his theories need to be altered but nonetheless we can expect to have patho-physiology from limited as well as over activity. The fact that bouts of hibernation are limited to from a few to 21 days may be an expression of the fact that animals in hibernation are approaching pathological conditions. At the other end of the activity spectrum we would expect animals running great distances each day to approach pathological conditions. In fact, we may do well to think of maximum activity and hibernation as being at the extreme ends of an activity scale. Our challenge today is to identify the various factors which enable animals to spend considerable periods of time with 50- to 100-fold reduction in life processes. A junior high school student whose name I failed to learn, suggested that, "Maybe animals have to hibernate because they'd go crazy spending so much time at home in their burrows without television or anything else to do." Awareness of eminent pathology may initiate entrance into and arousal from hibernation.

Behavioral, physiological, and biochemical processes can be expected to be involved in the temperature regulation of a hibernating animal just as these processes are involved in active animals. There has been a great void in our knowledge regarding the role of behavior in onset, maintenance, and arousal of hibernation. As an introduction into the investigation of the role of behavior among mammalian hibernators, McNamara (1972) conducted studies which describe hibernation as an asset regarding retention of learned behavior. Ground squirrels (C. lateralis) which hibernated during cold exposure retained learned behavior better than did animals which did not hibernate (McNamara and Riedesel, 1973). These studies have many important implications and I'd like to present a few. (i) Processes involved in memory are apparently temperature-independent processes. (ii) Memory retained throughout a bout or winter of hibernation may very well be critical for a ground squirrel to identify thermal environments which he can tolerate. (iii) Memory retained during hibernation may be important in an individual animal's recognition of his social status. Pengelley and Fisher (1967) conducted a simple experiment which challenges the thinking of many investigators. They took hibernating squirrels from the laboratory hibernaculum, tossed them in the air, caught them, and placed them back into the hibernaculum. The first few days of this routine caused the animals to arouse but after a few days the animals stayed in hibernation throughout the handling and tossing. This experiment plus the report by Wang and Hudson (1971) that torpid, deafened chipmunks (Tasnias strictus) have a body temperature 2.4 C lower than undeafened, torpid chipmunks, raise interesting questions. For instance, what is the extent of awareness of a hibernating animal? Spontaneous arousal must involve awareness and volitional activity on many occasions. The burst of muscle action potentials described by Lyman and O'Brien (1972) to mark the onset of arousal from hibernation, apparently are initiated by a variety of stimuli. Other studies concerned with the onset of spontaneous arousal clearly demonstrate that no single stimulus accounts for all arousal. Inherent biological rhythms as well as the internal chemical environment including biogenic amines (Beckman and Satinoff, 1972), glucose (Prewitt, Anderson, and Mussachia, 1972); Galster and Morrison, 1970), and the level of activity in the central nervous system, are capable of influencing arousal.

Recent studies of physiological temperature regulation during hibernation have presented controversial data. Lyman and O'Brien (1972) describe hibernating ground squirrels (C. tridecemlineatus and C. lateralis) as being poikilothermic that is, they have no response to cooling of peripheral areas or the hypothalamus. In contrast, Mills and South (1972) describe increases in oxygen consumption of hibernating marmots (Marmota flaventris) in response to hypothalamic cooling. We can say these differences are due to species difference which means we don't know the real reason for the differences. I suspect we will find that differences similar to these will be explained by the "state" of temperature-regulating mechanisms. The "state" of temperature regulation may range from poikilothermia to homeothermia in many animals. The ornate box turtle appears to be poikilothermic in many environments but has a great capacity for homeothermia in severe heat stress (Sturbaum, 1972). The state of the temperature-regulating center in hibernating animals may very well shift as a result of awareness of the animal. The extent to which biochemical processes may influence arousal from hibernation has been discussed above. However, it is perhaps worth noting that the chemical trigger which initiates hibernation may also be involved in arousal. Furthermore, chemical communication is a key mechanism for communication within the central nervous system (Hinde, 1970).

Many patterns of behavior can be triggered by release of specific chemicals into cerebral spinal fluid or blood circulating in the brain (Beckman and Satinoff, 1972). The selection of a hibernaculum has always been good evidence of the role of behavior in the biology of mammalian hibernators. Unfortunately there is limited information in this area of temperature regulation. A recently published symposium entitled "Physiological and Behavioral Temperature Regulation" (Hardy, Gagge, and Stolwijk, 1970) and a publication, "Comparative Physiology of Thermoregulation Volumes I and II," (Whittow, 1970, 1971) contain a wealth of information; both publications have sections concerned with behavioral aspects of temperature regulation. Unfortunately, only 5% of these publications consider animal behavior. Each physiologist has an obligation to identify behavior as an integrated activity which determines the extent of thermal stimulus or thermal stress applied to physiological systems. A recent study by Bartholomew and Rainy (1971) illustrates the extent to which patterns of behavior can contribute to control of body temperature. Laboratory experiments pertinent to the role of behavior in temperature regulation can be conducted. Corbit (1970) has presented evidence that receptors which are effective in changing physiological temperature regulation are also effective in changing behavioral temperature regulation. The preferred temperature of homeotherms and hibernators can be described (Gumma, South, and Allen, 1967). Animals make accurate assessment of the thermal environment and proper adjustment in behavior is made. Bats in hot attics have been described as being thermal regulators or thermal conformers (Studier and O'Farrell, 1972). Adair (1971) has described behavioral responses of monkeys trained to respond to thermal stimuli to four areas of the skin as well as the rectum, viscera, and midbrain. An intereresting conclusion of Adair's is that thermal receptors in the viscera provide signals and about one third as strong as those from the preoptic area. Investigators in the area of behavioral temperature regulation must have extensive patience and be cognizant of the environment just as the animal does. Two books on animal behavior should be helpful (Hinde, 1970; and Marler and Hamilton III, 1966) in pursuing fruitful research on mammalian hibernators.

The following sentence involves rewording of a sentence written by Dr. W. S. Hillman (Hillman, 1973) while he was writing on the subject of light and photoperiodism - the many similarities between responses to temperature in various organisms probably result not from a common mechanism but from similar ecological and evolutionary situations in which temperature regulation operates.

Don't think of temperature regulation as something which evolved but rather think of temperature regulation as a process which can be accomplished by a wide diversity of mechanisms. Most animals are able to utilize any one of a multitude of mechanisms available to each animal. Whichever mechanism or mechanisms are operating in an animal, the temperature regulation becomes an integral part of its life style.

REFERENCES

Adair, Eleanor R. Evaluation of some controller inputs to behavioral temperature regulation. Int. J. Biometeor. 15: 121-125, 1971.

Adolph, E. F., and J. Richmond. Water exchanges of isolated tissues at low temperatures. Am. J. Physiol. 187: 434-444, 1956.

Bartholomew, George A., and Michael Rainy. Regulation of body temperature in the rock hyrax, Heterohyrax brucei. J. Mammal. 52: 81-95, 1971.

Beckman, Alexander L., and Evelyn Satinoff. Arousal from hibernation by intrahypothalamic injections of biogenic amines in ground squirrels. Am. J. Physiol. 222: 875-879, 1972.

Bintz, Gary L.: Uptake and retention of tritiated water by tissues of laboratory rats and Citellus lateralis. Ph.D. Dissertation, Univ. of New Mexico, Albuquerque, 121pp, 1968.

Bintz, Gary L., Lorelei B. Bintz, and Marvin L. Riedesel. Respiratory quotient as an index of selective tissue catabolism. Comp. Biochem. Physiol. 38: 121-127, 1971.

Bligh, J., and R. E. Moore, Editors. Essays on temperature regulation. North-Holland: Amsterdam, 186pp, 1972.

Boyer, D. R. Ecology of the basking habit in turtles. Ecology 46: 99-118, 1965.

Buggeln, Richard G., and Bastiaan J. D. Meeuse. Hormonal control of the respiratory climacteric in Sauromatum guttaturn (araceae). Canadian J. Botany 49: 1373-1377, 1971.

Coester, N., J. C. Elliott, and U. C. Luft. Plasma electrolytes, pH, and ecg during and after exhaustive exercise. J. Appl. Physiol. In press, May, 1973.

Corbit, John D. Behavioral regulation of body temperature. In: Physiological and Behavioral Temperature Regulation, edited by J. D. Hardy, A. P. Gagge, and J. A. J. Stolwijk. Thomas: Springfield, pp. 777-801, 1970.

Dawe, Albert R., and Wilma A. Spurrier. The blood-borne "trigger" for natural mammalian hibernation in the 13-lined ground squirrel and the woodchuck. Cryobiology 9: 163-172, 1972.

Fisher, K.G., A.R. Dawe, C.P. Lyman, E. Schönbaum, and F.E. South, Jr., Editors. Mammalian Hibernation III: Proc. 3rd Int. Symp. on Nat. Mammal Hibernation. Edinburgh: Oliver & Boyd Ltd. 530 pp., 1967.

Folk, G.E., Jr., M.A. Folk, and W.O. Essler. Experiences with implanted physiological radio-capsules. Proc. Inter. Symp. Biotelemetry. Nijmegen, The Netherlands, VIII-4: 76-77, 1971.

Gale, C.C. Neuroendocrine aspects of thermoregulation. Ann. Rev. Physiol. 35: 391-430, 1973.

Galster, William A., and Peter Morrison. Cyclic changes in carbohydrate concentrations during hibernation in the arctic ground squirrels. Am. J. Physiol. 218: 1228-1232, 1970.

Greenleaf, J.E. Blood electrolytes and exercise in relation to temperature regulation in man. In: Pharmacology of Temperature Regulation, edited by P. Lomax and E. Schönbaum. Basel, Switzerland: Karger. In press, March 1973.

Gumma, M.R., F.E. South, and J.N. Allen. Temperature preference in golden hamsters. Animal Behavior 15: 534-537, 1967.

Hardy, J.D., A.P. Gagge, and J.A.J. Stolwijk, Editors. Physiology and Behavioral Thermoregulation. Springfield: Thomas, 944 pp, 1970.

Heinrich, Bernd. Nervous control of the heart during thoracic temperature regulation in a sphinx moth. Science 169: 606-607, 1970.

Hertig, B.A., and D.W. Badger. Interaction of carbon monoxide and heat stress. Abstract No. 7, A.I.H.A. Journal 32 (Abst. Sect.) 4, 1971.

Hillman, William S. Light, time, and the signals of the year. BioScience 23: 81-86, 1973.

Hinde, Robert A. Animal Behavior. New York: McGraw-Hill, 876pp., 1970.

Hock, Raymond J. Temperature regulation of xeric, mexic, montane, and uniquitous Peromyscus species. In: Physiological Systems in Semi-arid Environments, edited by C.C. Hoff, and M.L. Riedesel. Albuquerque: Univ. of New Mexico Press, pp. 53-69, 1969.

Hudson, J.W. Temperature regulation in the round-tailed ground squirrel, Citellus tereticaudus. In: Mammalian Hibernation II. Proc. 2nd Int. Symp. Natur. Mammal. Hibernation, edited by P. Suomalainen. Finnish Acad. Sci., Ann. Acad. Scientiarum Fennicae, Ser. A, IV, Biological 71: 217-233, 1964.

Hudson, Jack W., and Daniel R. Deavers. Metabolism, pulmocutaneous water loss and respiration of eight species of ground squirrels from different environments. Comp. Biochem. Physiol. 45A: 69-100, 1973.

Hudson, J.W., D.R. Deavers, and S.R. Bradley. A comparative study of temperature regulation in ground squirrels with special reference to the desert species. Symp. Zool. Soc. London 31: 191-213, 1972.

Hudson, J.W., and L.C. Wang. Thyroid function in desert ground squirrels. In: Physiological Systems in Semiarid Environments, edited by C.C. Hoff and M.L. Riedesel. Albuquerque: Univ. of New Mexico Press, pp. 17-33, 1969.

Jansky, L., Editor. Nonshivering Thermogenesis. Prague: Acadmia. 310 pp., 1971.

Kenshalo, Dan R. Cutaneous temperature receptors - some operating characteristics for a model. In: Physiological and Behavioral Temperature Regulation, edited by J.D. Hardy, A.P. Gagge, and J.A. J. Stolwijk. Springfield: Thomas, pp. 802-818. 1970.

Littlepage, Jack L. Oceanographic investigations in McMurdo Sound, Antarctica. In: Antarctic Seas II, edited by George A. Llano. Am. Geophysical Union. Baltimore: Garamond/Pridemark Press, p. 6, 1965.

Lomax, P., and E. Schönbaum, Editors. The Pharmacology of Thermoregulation. Basel, Switzerland: Karger. In press, March 1973.

Lyman, C.P., and A.R. Dawe, Editors. Mammalian Hibernation: Proc. 1st Int. Symp. Nat. Mammal. Hibernation. Bull. Mus. Comp. Zool. at Harvard College No. 124. Harvard Univ. Press. 547 pp., 1960.

Lyman, Charles P., and Regina C. O'Brien. Sensitivity to low temperature in hibernating rodents. Am. J. Physiol. 222: 864-869, 1972.

Marler, Peter, and William J. Hamilton III. Mechanisms of Animal Behavior. New York: John Wiley & Sons. 771 pp., 1966.

McNamara, M. Colleen. The Effect of Hibernation on Memory in Spermophilus lateralis. M.S. Thesis, Albuquerque: Univ. of New Mexico, 106 pp., 1972.

McNamara, Colleen, and Marvin L. Riedesel. Memory and Hibernation in Citellus lateralis. Science 179: 92-94, 1973.

Mills, Steven H., and F.E. South. Central regulation of temperature in hibernation and normothermia. Cryobiology 9: 393-403, 1972.

Mrosovsky, N. Hibernation and the Hypothalamus. New York: Appleton-Century-Crofts, 287 pp., 1971.

Myers, R.D., and W.L. Veale. The role of sodium and calcium ions in the hypothalamus in the control of body temperature of the unanaesthetized cat. J. Physiol. (London) 212: 411, 1971.

Myers, R.D., and W.L. Veale. Body temperature: possible ionic mechanism in the hypothalamus controlling the set point. Science 170: 95-97, 1970.

Nagy, K.A., D.K. Odell, and R.S. Seymour. Temperature regulation by the inflorescence of philodendron. Science 178: 1195-1196, 1972.

Pengelley, E.T., George A. Bartholomew, and Paul Licht. Problems in the chronobiology of hibernating mammals. In: Hibernation and Hypothermia, Perspectives and Challenges. Proc. 4th Int. Symp. on Nat. Mammal. Hibernation, edited by F.E. South, J.P. Hannon, J.R. Willis, E.T. Pengelley, and N.R. Alpert. Amsterdam: Elsevier, pp. 713-716, 1972.

Pengelley, E.T., and K.C. Fisher. The ability of the ground squirrels, Citellus lateralis, to be conditioned to stimuli while in hibernation. J. Mammal. 49: 561-562, 1967.

Prewitt, Russell L., Gary L. Anderson, and X.J. Musacchia. Evidence for a metabolic limitation of survival in hypothermic hamsters. Proc. Soc. Exptl. Biol. & Med. 140: 1279-1283, 1972.

Riedesel, Marvin L. The internal environment during hibernation. In: Mammalian Hibernation, edited by C.P. Lyman and A.R. Dawe. Bulletin of the Museum of Comparative Zoology at Harvard College, Harvard Univ. Press. 124: 421-435, 1960.

Riedesel, M.L., L.R. Klinestiver, and N.R. Benally. Tolerance of Citellus lateralis and C. spilosoma for water deprivation. In: Mammalian Hibernation II. Proc. 2nd Int. Symp. Nat. Mammal. Hibernation, edited by P. Suomalainen. Finnish Acad. Science. Ann. Acad. Sci. Fennicae, Ser. A, IV, Biological. 71: 375-388, 1964.

Riedesel, M. L., and G. L. Rigler. Bioenergetics of mammalian hibernation. In: Studies in Environmental Physiology, edited by G. E. Folk, and D. B. Dill. Desert Research Inst.,Nevada. pp. 3-13, 1972.
Rigler, Gerald L. Protein Catabolism and Urea Utilization in Water-Deprived and Fasted Ground Squirrels and Rats. Ph.D. Dissertation, Univ. of New Mexico, Albuquerque. 116pp., 1972.
Senay, L. C., Jr. Relationship of evaporative rates to serum (Na^+), (K^+) and osmolarity in acute heat stress. J. Appl. Physiol. 25: 149-152, 1968.
Smith, R. E., J. P. Hannon, J. C. Shields, and B. A. Horwitz, Editors. Bioenergetics. Proc. of International Symp. on Environmental Physiology, Dublin. Fed. Am. Soc. Exptl. Biol. Washington, D. C. 195 pp. 1972.
Somero, G. N., and A. L. DeVries. Temperature tolerance of some antarctic fish. Science 156: 257-258, 1967.
South, F. E., J. P. Hannon, J. S. Willis, E. Pengelley, and N. R. Alpert, Editors. Hibernation and Hypothermia, Perspectives and Challenges. Proc. 4th Int. Symp. on Nat. Mammal. Hibernation. Amsterdam: Elsevier, 1743pp., 1972.
Spurrier, Wilma A., and Albert R. Dawe. Several blood and circulatory changes in the hibernation of the 13-lined ground squirrel, Citellus tridecemlineatus. Comp. Biochem. Physiol. 44A: 267-282, 1973.
Studier, Eugene H., and Michael G. O'Farrell. Biology of Myotis thysanodes and M. lucifugus (Chiroptera: Vespertilionidae) - I. thermoregulation. Comp. Biochem. Physiol. 41A: 567-595, 1972.
Sturbaum, Barbara A. Thermoregulation in the Ornate Box Turtle Terrapene ornata. Ph.D. Dissertation, Univ. of New Mexico, Albuquerque. 82pp., 1972.
Suomalainen, P. Editor. Mammalian Hibernation II: Proc. 2nd Int. Symp. Nat. Mammal. Hibernation. Finnish Acad. Sci. Ann. Acad. Scientiarum Fennicae, Ser. A, IV, Biological No. 71. 453pp., 1964.
Twente, J. W., and J. A. Twente. An hypothesis concerning the evolution of heterotnermy in bats. In: Mammalian Hibernation II. Proc. 2nd Int. Symp. Nat. Mammal. Hibernation, edited by P. Suomalainen. Finnish Acad. Sci. Ann. Acad. Scientiarum Fennicae, Ser. A, IV, Biological 71: 435-442, 1964.
Vernberg, F. John, and Winona B. Vernberg. Aquatic invertebrates. In: Comparative Physiology of Thermoregulation. Vol. I: Invertebrates and Nonmammalian Vertebrates, edited by G. Causey Whittow, Academic Press: New York. 333pp., 1970.
Wang, Lawrence Chia-Huang. Circadian body temperature of Richardson's ground squirrel under field and laboratory conditions: a comparative radio-telemetric study. Comp. Biochem. Physiol. 43A: 503-510, 1972.
Wang, Lawrence Chia-Huang, and Jack W. Hudson. Temperature regulation in normothermic and hibernating eastern chipmunk, Tamias striatus Comp. Biochem. Physiol. 38A: 59-90, 1971.
Whittow, G. C., Editor. Comparative Physiology of Thermoregulation. Vol. I: Invertebrates and Nonmammalian Vertebrates. New York: Academic Press, 333pp., 1970.
Whittow, G. C., Editor. Comparative Physiology of Thermoregulation Vol. II: Mammals. New York: Academic Press, 420pp., 1971.

Wimsatt, W.A. Some interrelations of reproduction and hibernation in mammals. In: Dormancy and Survival. 23rd Symp. Soc. Exptl. Biol. Cambridge Univ. Press, pp.511-549, 1972.

Young, J.J., and M.L. Riedesel. Waterbath studies on field and captive Citellus lateralis. Physiol. Zool. 40: 189-193, 1967.

Yousef, M.K., and W.G. Bradley. Physiological and ecological studies on Citellus lateralis. 39A: 671-682, 1971.

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The 12th World Congress of the International Society for Fat Research (ISF) will be held in Milan, Italy, September 2-7, 1974 by invitation of the Italian Oil Chemists's Society (Società Italiana per lo Studio delle Sostanze Grasse).

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RELATIONSHIP BETWEEN LUNG MECHANICS AND VENTILATION DISTRIBUTION*

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Although the relationship between lung mechanics and ventilation distribution is of considerable current interest to pulmonary physiologists, it is not a new subject. Indeed, Dixon and Brodie published a classic paper exactly 70 years ago dealing with this topic (1) 12 years before Rohrer's famous treatise (2). As they were among the first investigators to become interested in this topic, and because I do not believe that they have received due credit for their remarkable contribution I will review their paper at some length. You will find that they anticipated many topics currently of interest to pulmonary physiologists.

To the best of my knowledge, Dixon and Brodie were the first to distinguish experimentally between changes in the lung's elastic properties and changes in flow resistance when overall mechanical properties of the lungs were altered by experimental manipulation. The experimental set-up which allowed them to do this was ingenious. They encased a lobe in vivo in a volume displacement plethysmograph and recorded the volume changes of the lobe. They measured tracheal pressure relative to atmospheric pressure and pointed out that: "an alteration in the ... volume of air entering or leaving the lobe at each respiratory cycle, may be brought about by .... 1) a change in the air supply, either in the pressure or in the time during which it is allowed to distend the lobe. 2) an alteration in the distensibility and elasticity of the alveolar wall, or 3) an alteration in the resistance between the trachea and alveoli. The first of these is .... under direct control .... that we are not dealing with any important change in the distensibility of the alveolar walls is easily determined by allowing a large volume of air at known pressure to distend the lobe before and after any particular observation. We have shown that the alveolus ultimately dilates to the same volume under the two conditions."

Thus they were able to determine that the changes they measured were due to changes in flow resistance rather than in elastic properties. Using this preparation they studied the influence of many experimental conditions on airway smooth muscle. They stimulated the stellate ganglion and contrary to more recent findings (3) they obtained no effects whatsoever, but they did show that the vagus nerve contained sympathetic fibers in the cat. They studied reflex bronchoconstriction usually by stimulating the nasal mucous membrane and stated that "Bronchoreflex effects are of considerable importance .... in the pathology of spasmodic asthma. We desire to point out the impossibility of an attack whilst the patient is under the influence of atropine. During an attack an injection

*Taken from the introductory remarks given at the session on Respiration Mechanics II at the 1973 Federation Meetings.

of atropine will quickly abort it." The role of reflex bronchoconstriction in asthma is currently receiving considerable attention (4), and a re-evaluation of atropine as a therapeutic agent would seem to be in order. They studied the action of many drugs on airway smooth muscle and in addition, the effect of inhaling CO_2 and of hypoxia.

Their major contributions, however, were primarily on the influence of bronchoconstriction produced by vagal stimulation on lung mechanics. One way in which they looked at this was to apply a square wave of pressure to the lobe and observe the rate at which the volume changed in response to the square wave and, as stated earlier, the total volume change when the lobe was given enough time to respond fully. Results they obtained in one experiment are illustrated in Fig. 1.

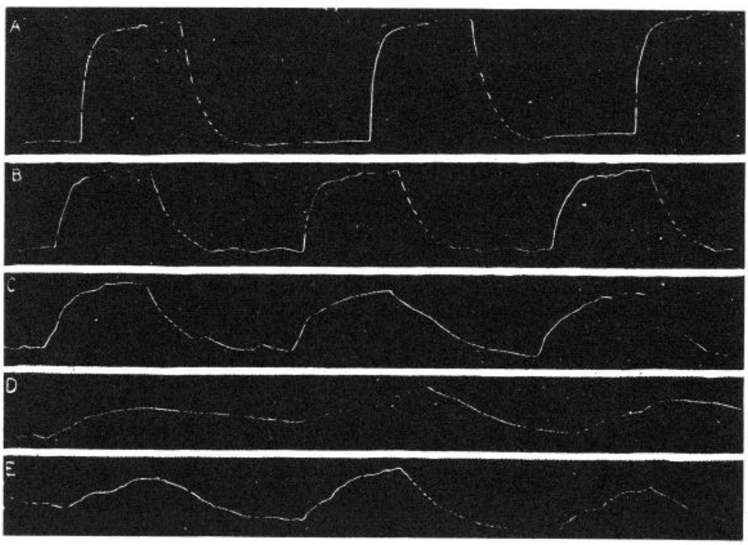

Fig. 1. Reproduction of Fig. 31 from Dixon and Brodie (1). This is a record of lobar tidal volume versus time. Strip A is a control recording. Strip B, C and D show progressive reduction in flow rates with the onset of vagal stimulation. Strip E illustrates the beginning of recovery following cessation of the stimulation.

They clearly recognized the importance of time. For a given change in pressure they demonstrated as shown in Fig. 2, that the resulting change in volume of the lobe decreased as the time available for that lobe to distend decreased and/or the resistance to flow increased, keeping time and frequency constant. Thus they demonstrated the important relationship between volume change, airway resistance and respiratory frequency. For a given change in pressure in lobes that were constricted, the tidal volume was normal provided that the frequency was sufficiently slow but decreased as respiratory frequency increased.

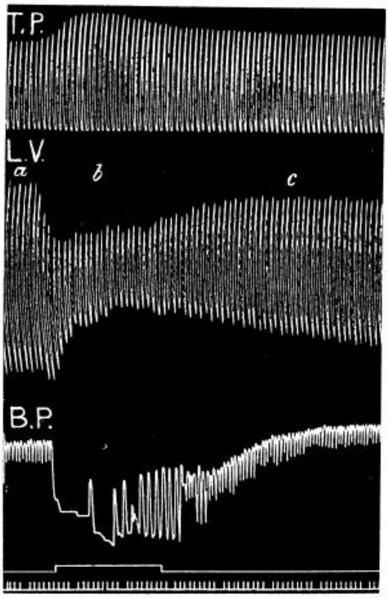

Fig.2. Reproduction of Fig.10 from Dixon and Brodie (1). This is a record of tracheal pressure (T.P.), change in lobar volume (L.V.) and blood pressure (B.P.) during and after ipsilateral vagal stimulation. The period of stimulation is indicated by the step rise in the event marker at the bottom of the tracing.

In another remarkable experiment they encased a lobe from the right lung in the plethysmograph, and stimulated the left vagus while maintaining artificial ventilation with constant tidal volumes. The transpulmonary pressure swings increased with the result that the tidal volume of the lobe on the non-stimulated side increased. The results of this experiment are shown in Fig. 3. Having previously demonstrated a decrease in the volume change in lobes on the same side as the stimulated vagus the pathophysiologic significance was clear. They pointed out that in conditions where some airways are obstructed and others are not, there is an alteration in the distribution of ventilation so that the alveoli beyond obstructed airways receive less ventilation whereas the alveoli beyond non-obstructed ones receive more. Furthermore, by implication this alteration in ventilation distribution is frequency dependent. At low frequencies it would have no influence whereas at high frequencies it would have a major influence.

Although the implications of Dixon and Brodie's work were clear, the relationships between mechanics, ventilation distribution and respiratory frequency received little further attention by respiratory physiologists for over 50 years - until the classic paper of Otis et al. in which these relationships were worked out in detail and the concept of time constants was introduced to pulmonary physiology (5). In this paper the observations that dynamic lung compliance was independent of frequency in normal lungs but fell systematically with frequency in patients with airways obstruction was explained at least in part. The fall in compliance with frequency was shown to be due to inequality of time constants of lung units arranged in parallel. In normal subjects frequency independence of compliance was attributed to equality of time constants. More important, frequency independence of compliance implied that the distribution of ventilation did not change with respiratory frequency. At slow frequencies it was determined solely by the compliance of the airspace and that this remained true even at very rapid frequencies. Thus the concept grew that, in normal lungs, the mechanical parameter of overriding importance in ventilation distribution was regional lung compliance, and that measurements of ventilation distribution under static conditions were applicable to dynamic conditions as well. The corollary was clear. Because time constants were approximately equal, the airways were essentially passive conduits which offered flow resistance and contributed a dead space but in normal lungs were of little importance in determining ventilation distribution.

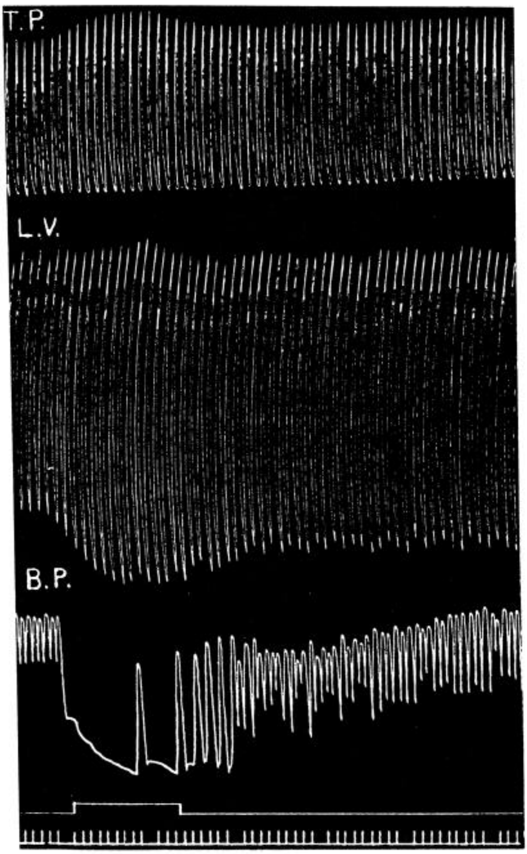

Fig.3. Reproduction of Fig.24 from Dixon & Brodie (1).This is a record of tracheal pressure, change in lobar volume and blood pressure during and after contralateral vagal stimulation. The period of stimulation is indicated by the step rise in the event marker at the bottom of the tracing.

This was surprising in that many investigators have postulated (and occasionally still do) that the physiological role of airway smooth muscle was to control ventilation distribution and that the airways constituted a neat control system by which ventilation could be matched to perfusion. This appealing notion lacked an essential element - any hard evidence that it was the case. In retrospect the notion is somewhat naive. Any control mechanism which balanced ventilation to perfusion would not be particularly effective if the parameter controlling the distribution of ventilation was dependent on respiratory frequency. It might produce an appropriate balance at one respiratory frequency but this balance would become inappropriate as soon as frequency changed.

A much more reasonable way to control ventilation distribution by smooth muscle would be local reduction in compliance by alveolar duct constriction with a counterbalancing increase in resistance to maintain the time constants, constant. Whether this occurs or not is unknown. Alveolar duct constriction has yet to be conclusively demonstrated in human lungs. Nevertheless, the observation by Severinghaus and colleagues (6) that the ventilation decreased to a lung whose pulmonary artery way occluded, can better be explained by alveolar duct constriction than by bronchoconstriction in large airways, because they found that the redistribution was not frequency dependent.

In any event an interesting situation developed. In normal lungs the airways were thought to play virtually no role in the distribution of ventilation because ventilation distribution was independent of frequency and was determined by regional compliance. By contrast, in diseases characterized by airways obstruction the airways play a major role in determining the distribution of ventilation which changes with respiratory frequency. Similarly although airway smooth muscle is implicated as a major villain in airway disease, even today we have no clear idea as to its physiological role.

Investigations within the last few years have altered our notions on the influence of respiratory frequency on the distribution of ventilation in normal lungs. Anthonisen and his colleagues showed that the intrapulmonary distribution of an inhaled ^{133}Xenon bolus administered at RV was highly dependent on inspiratory flow rate. More importantly they showed that a bolus administered at FRC was distributed according to regional compliance when inhaled slowly but that the distribution was even when inhaled at maximal inspiratory flow rates (7). Similar observations have subsequently been made by others. This did not particularly upset those, who like myself, thought that ventilation distribution was compliance determined and independent of frequency, because we regarded maximal inspiratory flow rates as unphysiological. We thought that there might be some influence of flow rate on ventilation distribution at very high flow rates but that this would have little influence over physiological inspiratory flows.

Such a concept is no longer tenable. Bake et al. demonstrated to the meetings of this society last fall, that there was a marked influence of flow on the distribution of an inhaled ^{133}Xenon bolus administered at FRC over a flow range from 0.2 - 1.5 lps (8). At low flow rates the distribution was compliance determined - i.e., the apex received less than the base. As flow rates increased there was a progressive redistribution so that at flow rates as low as 1.5 lps the distribution was approximately equal to apex and base. Thus over the inspiratory flow rates commonly encountered under physiological conditions the distribution of the bolus was highly flow (and therefore frequency) dependent.

How can these observations be reconciled with the observation that compliance is independent of respiratory frequency? A bolus essentially tags an "instant" in the respiratory cycle. If given at the right time it can demonstrate asynchronous behavior which has negligible physiological significance. Consider a two compartment model being oscillated sinusoidally with a small phase lag and a small difference in the change in volume of the two compartments as illustrated in Fig. 4. There is a short period of time in which one compartment is filling while the other compartment is still emptying. If the bolus were administered during this period a gross inequality of the distribution of this bolus would be observed. Yet the degree of asynchrony and the difference in the tidal volume of the two compartments might be insufficient to cause a significant degree of frequency dependence of compliance. It appears that in terms of physiological significance the bolus distribution is too sensitive a test, whereas frequency dependence of compliance may be too insensitive. Where does the truth lie and what parameter should be measured to determine the physiological significance of the effect of respiratory frequency on ventilation distribution in normal lungs?

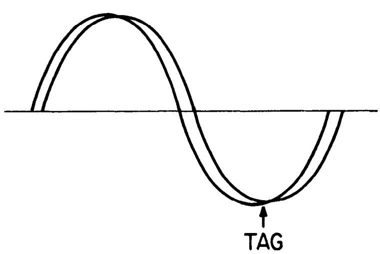

Fig.4. Individual volume change of a hypothetical two compartment model where one compartment is lagging the other and has a somewhat smaller tidal volume. If a tag is introduced at a point in time when one compartment is filling while the other is still emptying (as indicated by the arrow) the distribution of the tag will be entirely to the compartment which is filling indicating grossly uneven distribution.

Obviously the important parameter is the distribution of tidal volume. We have used a two compartment electrical analogue constructed and analyzed by Mr. Brian Murphy to answer this question. It is illustrated in Fig. 5. The compliances were chosen to approximate those of the apex and base of the lung and the resistances so that dynamic compliance would be 80% of the static value at a frequency of 90 bpm. This is the generally accepted lower limit of normal. The distribution of tidal volume between the two compartments is expressed as the percent change in distribution from that obtained under static conditions. At 35 bpm there is a 50% redistribution of tidal volume which in this model indicates that apex to base ventilation distribution is even, rather than compliance determined. A frequency of 35 is not uncommon during moderately heavy exercise. Based on these findings I conclude that measurement of compliance at different respiratory frequencies is too insensitive to detect real changes in ventilation distribution in normal lungs as respiratory frequency changes, and that indeed, in normal lungs, respiratory frequency has a real influence on the distribution of tidal volume.

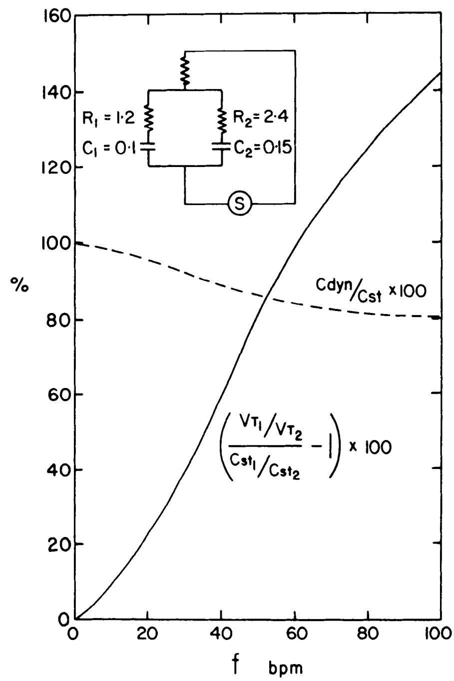

Fig.5. Behavior of a two compartment electrical analogue as cycling frequency is increased from static conditions to 100 cycles/min. The analogue is illustrated in the inset at the top. C_1 and C_2 are the compliances and R_1 and R_2 the resistances of compartment 1 and 2 respectively. Dynamic compliance Cdyn as a percentage of the static compliance Cst is indicated by the dashed line. The percent change in the distribution of tidal volume compared to that under static conditions is shown by the solid line where V_{T1} and V_{T2} represent the "tidal volume" of the two compartments. At a frequency of zero VT_1/VT_2 is determined by the ratio $C_1/C_2 = 0.67$. At a frequency of 35 cycles/min.there is a 50% redistribution of tidal volume so that $VT_1/VT_2 = 1$.

From the results of Bake et al. one may conclude that at inspiratory flow rates greater than 0.2 lps the lower zones of the lung lag behind the upper. This phase lag is progressive up to 1.5 lps and remained essentially constant at higher flows. If part of a lung lags behind neighboring parts, this must induce either a distortion of the chest wall (which is mechanically linked to the lung) or else the lung itself distorts to assume the shape of the thoracic cavity and fill in the "gap" left by the lagging parts. That it produces a distortion in the chest wall is suggested by the results obtained by DuBois and colleagues several years ago when they found the lower thorax to lag the upper thorax, when the respiratory system was oscillated sinusoidally (9). If the distortion is in the chest wall this will result in an amplification of the pleural pressure applied to the part which is lagging and the magnitude of the amplification will depend upon the distortability of the chest wall and the magnitude of the distortion. The mechanism is illustrated in Fig. 6. It will act in a direct way to reduce the phase lag. This notion was first introduced by Zidulka, Demedts, et al. a year ago (10). They demonstrated that immediately upon blocking the lobar bronchus in a dog there was substantial amplification of the pleural pressure applied to the lobe as a result of the phase lag in lung expansion and the resulting distortion induced in the chest wall. Clearly the lungs were not sufficiently distortable to allow the chest wall to retain its normal shape. Thus interdependence between lung and chest wall was clearly demonstrated. This is really extending the concept of interdependence among lung units, as introduced by Mead (11), to interdependence between lung and chest wall. At the present state of our knowledge we have precious little information which would allow us to make reasonable predictions about the distortability of lungs and chest wall in conditions other than complete occlusion. If, however, as Zidulka et al. have shown, there is amplification of pleural pressure when the phase lag is maximal, it appears likely that there will also be amplification for smaller phase lags. Thus over physiological inspiratory flows, differences in the dynamic pleural pressure applied over apical and basal regions are probably present and act to minimize the phase lag.

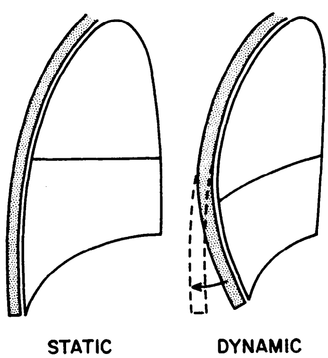

Fig.6. Mechanism by which dynamic pleural pressure changes may be amplified to a region of the lung which lags behind neighboring regions. The left picture illustrates the normal configuration of lungs and chest wall under static conditions at a given lung volume. The right picture illustrates the configuration at the same lung volume under dynamic conditions with the lower lobe lagging the upper. This may induce a distortion in the chest wall. To the extent that the chest wall resists distortion and attempts to assume the static configuration, the pleural pressure applied to the lower lobe will be amplified.

To summarize: The old concept that respiratory frequency has no influence on ventilation distribution in normal lungs is no longer tenable. Dependent regions of the lung lag behind superior regions at flow rates greater than 0.2 lps. In all likelihood such phase lags induce distortions in the chest wall which results in amplification of the pressure applied to lagging regions which in turn act to reduce the phase lag.

Our knowledge has improved considerably since Dixon and Brodie. However, it is remarkable that they anticipated so many areas currently of interest to respiratory physiologists.

In conclusion I will quote their paper once more. " ..... if two exactly similar balloons, one distended considerably, the other to a lesser extent, be connected to one another, the less distended one empties itself into the more distended. Whether we have a similar phenomenon at play in the movements of pulmonary alveoli is a point to which we return later." A tantalizing comment - particularly so as they never do return to this point. If they had, perhaps the surfactant scientists would owe as much to these investigators as the airway investigators do.

REFERENCES

1. Dixon, W.E., and T.G. Brodie. Contributions to the physiology of the lungs. Part I. The bronchial muscles, their innervation, and the action of drugs upon them. J. Physiol. (London) 29: 97-173, 1903.
2. Rohrer, F. Die strömungswiderstand in den menschlichen Atemwegen und der Eindfluss der unregelmässigen Verweigung des bronchialsystems auf den Atmungsversluf in verschiedenen Lungenberzirken. Arch. Ges. Physiol. 162: 255-259, 1915.
3. Beckman, D.L., K.F. Mason, and J.W. Bean. Sympathetic influence on lung compliance and airway resistance in cats. Federation Proc. 32: 415, 1973.
4. Gold, W.M., G-F. Kessler, and D.Y.C. Wu. Role of vagus nerves in experimental asthma in allergic dogs. J. Appl. Physiol. 13: 719-725, 1972.
5. Otis, A.B., C.M. McKerrow, R.A. Bartlett, J. Mead, M.B. McIlroy, N.J. Selverstone, and E.P. Radford, Jr. Mechanical factors in the distribution of pulmonary ventilation. J. Appl. Physiol. 8: 427-443, 1956.
6. Severinghaus, J.W., E.W. Swenson, T.N. Finley, M.T. Lategola, and J. Williams. Unilateral hypoventilation produced in dogs by occluding one pulmonary artery. J. Appl. Physiol. 16:53-60, 1961.
7. Robertson, P.C., N.R. Anthonisen, and D. Ross. Effect of inspiratory flow rate on regional distribution of inspired gas. J. Appl. Physiol. 26: 438-443, 1969.
8. Bake, B., L.D.H. Wood, B.G.J. Murphy, P.T. Macklem, and J. Milic-Emili. Effect of inspiratory flow rate on vertical ventilation distribution. The Physiologist 15: 75, 1972.
9. DuBois, A.B., A.W. Brody, D.H. Lewis, and B.F. Burgess, Jr. Oscillation mechanics of lungs and chest in man. J. Appl. Physiol. 8: 587-594, 1956.
10. Zidulka, A., M. Demedts, and N.R. Anthonisen. Lobar obstruction in dog lungs. Federation Proc. 31: 321, 1972.
11. Mead, J., T. Takishima, and D. Leith. Stress distribution in lungs: a model of pulmonary elasticity. J. Appl. Physiol. 28: 596-608, 1970.

NOTES ON THE CENTROGENIC DRIVE IN RESPIRATION*

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Regulation of respiration is a rather wide field in itself, ranging from neurophysiology to the mechanical aspects of ventilating the lungs, to the chemistry of blood and other body fluids, and reaching into the problems of regulation of acid-base balance. In a way of opening our session, I would like to comment on what seems to me to permeate this wide field of respiratory regulations.

Firstly: When studying the regulation of pulmonary ventilation, we are examining - in the broadest sense - the variation in the performance of the respiratory pump, in various conditions. One takes into consideration a) the mechanical factors involved in ventilating the lungs; by this I mean the mechanical properties of the respiratory pump, namely, the elastic properties of the lung and of the chest wall, and the flow-resistive forces that have to be overcome by action of the respiratory muscles; b) one considers the factors involved in the "chemical" regulation of respiration; i.e. the chemical stimuli reaching the respiratory centers, directly or indirectly, via chemical transducers. And one correlates these "stimuli" with the variable output of the respiratory pump.

Secondly: The very notion of control of pulmonary ventilation presupposes some direct or indirect links between the lung, the effector organ, on one hand, and the regulator (the respiratory control and the transducers) on the other: one tries to quantitate some afferent information reaching the center that can be correlated with the variable output of the respiratory pump. Thus, with respect to the mechanical factors involved, afferents in the vagus and some extravagal afferents have been in the center of stage, while with respect to the chemical regulation, traditionally, and for many years, the chemical stimuli originating in the arterial blood have been considered of primary significance (4, 5, 6, 7). It seemed quite logical to identify the chemical stimuli with the respiratory gases in arterial blood, since the blood appears to be the natural link between the lungs, the effector organ of gas exchange, and between the regulator, the respiratory center. In recent years, this picture has been modified, and the prevailing view now is that the O_2 drive indeed resides in arterial blood, affecting the "peripheral" chemoreceptors (1), while the combined "CO_2-pH" effect on resting ventilation has to do with the acidity of the cerebral extracellular fluids, the CSF and the cerebral ISF (2, 3, 8, 10, 12, 13).

Next, I would like to say a word about the chemical regulation of respiration, and to share with you some of my discomfort about the following fact: one can visualize the system of chemical regulation of

* Taken from the introductory remarks given at the session on Regulation of Respiration I at the 1973 Federation Meetings.

respiration - at least in descriptive terms - as if it served two different and apparently unrelated purposes. I recall how the late Dr. Perkins used to put it (14):

On one hand, you can view the lung as a variable "oxygen getter" and "CO_2 eliminator," apparently operating at a constant composition of arterial blood gases. I am, of course, referring to the type of respiratory regulation one observes during muscular exercise, as the simplest example of this facet of the respiratory regulation. We are all familiar with this puzzling phenomenon, and with the frustrating difficulties in identifying "the stimulus."

On the other hand, Dr. Perkins used to say, you can view the system regulating the lung ventilation as a tool for rapid adjustments of acid-base imbalance of "metabolic" origin. Or to put it in other words, you could describe the system as a variable CO_2 eliminator operating at a given metabolic rate ($\dot{V}CO_2$). By lowering, or increasing, the concentration of carbonic acid in body fluids, the respiratory system compensates for imbalance in non-volatile acids. In this aspect of the regulation of the resting pulmonary ventilation, the emphasis in recent years has been on the "central" chemoreceptors (12, 14, 15) that sense the minute changes in acidity of the cerebral extracellular fluids, behind the blood-brain barrier, during acid-base disturbances of "metabolic" origin. There are still disagreements whether this imput into the "central" chemoreceptors gives only a partial (11), or a complete (2, 3, 13) account for the observed changes in the resting pulmonary ventilation, and, of course, there still remains much to be discovered about the functioning of the so called blood-brain barrier (9) in regulating the acid-base balance of the cerebral fluids (cerebrospinal and cerebral interstitial fluids).

Finally, I would add to Dr. Perkins' list that we still live with the perennial puzzle of how this regulatory system fails in situations leading to chronic CO_2 retention.

I hasten to admit that all this is an oversimplified view, that there are many other factors that go into the "equation" besides what I am calling "mechanical" and "chemical" problems of the regulator (higher centers in CNS, overall state of activation of CNS, hormones, etc.). However, these are probably factors of secondary importance and the answers to the basic puzzle of the respiratory adaptations, with all probability, are not there.

I think that you would agree that it is pretty uncomfortable to live with this state of "split mind" when thinking about the regulation of respiration, with no unifying concept in sight that would cover all the aspects of regulation of pulmonary ventilation, whether dealing with the mechanical properties and problems of the pump, or whether dealing with the two apparently separate facets of what one calls the chemical regulation of pulmonary ventilation.

Finally, let me mention the last point that I want to bring up, namely: what is it that we are really measuring as an indicator of the output of the regulator? When studying the chemical regulation of respiration, one traditionally measures the minute ventilation, V, i.e. liters of gas moved by the respiratory pump in a unit of time, and one correlates this value with the "chemical signal" under study. You are aware of the controversies about what is the relevant $\dot{V}$, total ventilation $\dot{V}_E$, or the "effective" ventilation, $\dot{V}_A$. Here, I believe, one can identify another state of "split mind" in our approach to the problems of respiratory regulations. One argument would go that $\dot{V}_E$ is relevant in this respect, since it is a close reflection of the neuro-motor output reaching the respiratory muscles in response to a given "chemical" stimulus. In other words, $\dot{V}_E$ is the measure of how much has to be done in response to a given stimulus.

The other argument would state that $\dot{V}_A$ is relevant, especially in experimental settings where one analyzes how changes in ventilation are reflected in the composition of body fluids, thus completing and closing the negative-feed-back loop of the regulatory system. In other words, $\dot{V}_A$ is seen as a measure of how much is being achieved in response to a given chemical stimulus.

However, I suspect that neither of these approaches is the most profitable way of looking at the "output" of the regulator, interpreting it in terms of $\dot{V}$ (be it $\dot{V}_E$ or $\dot{V}_A$). I submit that there is an infinite number of combinations of tidal volumes (V_T) and respiratory frequencies (f), to achieve any given value of $\dot{V}$, at least theoretically, the upper limit for V_T would approach the vital capacity, with the lowest value of f, while the low limit for V_T would approach the dead space, requiring the highest respiratory frequency. Now, what at any given instant is being determined by the rhythmic neuro-motor output from the respiratory center is indeed the size of the tidal volume, and the respiratory frequency. There is no way of metering out, at any instant, a minute ventilation, in response to a given stimulus, be it either in terms of total ventilation, $\dot{V}_E$, or effective ventilation $\dot{V}_A$. At any instant, the regulator can only determine how deep a given breath should be, and how soon the next breath would come.

It may well be that we are obscuring some essential links between the "chemical" and "mechanical" aspects of the respiratory regulations by interpreting the output of the regulator in the abstract term of $\dot{V}$.

REFERENCES

1. Dejours, P., Y. Labrousse, J. Raynaud, and A. Teillac. Stimulus oxygène chémoréflexe de la ventilation à basse altitude (50 m) chez l'homme. J. Physiol., Paris. 51: 163-261, 1959.
2. Fencl, V., T.B. Miller, and J.R. Pappenheimer. Studies on the respiratory response to disturbances of acid-base balance, with deductions concerning the ionic composition of cerebral interstitial fluid. Am. J. Physiol. 210: 459-472, 1966.
3. Fencl, V., J.R. Vale, and J.A. Broch. Respiration and cerebral blood flow in metabolic acidosis and alkalosis in humans. J. Appl. Physiol. 27: 67-76, 1969.
4. Gray, J.S. The multiple factor theory of the control of respiratory ventilation. Science 103: 739-744, 1946.

5. Gray, J.S. Pulmonary Ventilation and its Physiological Regulation. Springfield: Thomas, 1950.
6. Haldane, J.S., and J.G. Priestley. The regulation of the lung-ventilation. J. Physiol. (London) 32: 225-266, 1905.
7. Heymans, C., J.J. Bouckaert, and P. Regniers. Le sinus carotiden et la zone homoloque cardio-aortique. Paris: Doin et Cie, 1933.
8. Leusen, I. Chemosensitivity of the respiratory center. Influence of changes in the H^+ and total buffer concentrations in the cerebral ventricles on respiration. Am. J. Physiol. 176: 45-51, 1954.
9. Leusen, I. Regulation of cerebrospinal fluid composition with reference to breathing. Physiol. Rev. 52: 1-56, 1972.
10. Loeschcke, H.H., H.P. Koepchen, and K.H. Gertz. Ueber den Einfluss von Wasserstoffionenkonzentration und CO_2 - Druck im Liquor cerebrospinalis auf die Atmung. Pflüger's Arch. Ges. Physiol. 266: 569-585, 1958.
11. Mitchell, R.A., C.T. Carman, J.W. Severinghaus, B.W. Richardson, M.M. Singer, and S. Shnider. Stability of cerebrospinal fluid pH in chronic acid-base disturbances in blood. J. Appl. Physiol. 20: 443-452, 1965.
12. Mitchell, R.A., H.H. Loeschcke, W. Massion, and J.W. Severinghaus. Respiratory responses mediated through superficial chemosensitive areas on the medulla. J. Appl. Physiol. 18: 523-533, 1963.
13. Pappenheimer, J.R., V. Fencl, S.R. Heisey, and D. Held. Role of cerebral fluids in control of respiration as studied in unanesthetized goats. Am. J. Physiol. 208: 436-450, 1965.
14. Perkins, J.R. The relation of cerebrospinal fluid to respiration. A brief historical introduction. In: Cerebrospinal Fluid and the Regulation of Ventilation, edited by C. McC. Brooks, F.F. Kao, and B.B. Lloyd. Oxford: Blackwell Scientific Publications, pp. 7-41, 1965.
15. Schlafke, M.E., W.R. See, and H.H. Loeschcke. Ventilatory response to alterations of H^+ ion concentration in small areas of the ventral medullary surface. Resp. Physiol. 10: 198-212, 1970.

LALOR FOUNDATION RESEARCH FELLOWSHIP PROGRAM FOR 1974

The Lalor Foundation has announced a new procedure for its 1974 grants for research in its areas of emphasis in mammalian reproductive physiology.

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(a) early amniocentesis in fetal development, or other means for detection and evaluation of dysgenic factors or prospects of congenital disabilities, and means toward their disposition; or

(b) uterine and cervical physiology relevant to pregnancy interruption, particularly for second trimester terminations.

Forms and details for institution application are available from The Lalor Foundation, 4400 Lancaster Pike, Wilmington, Delaware, 19805. Deadline for filing is January 15, 1974. Appointments will be announced March 15, 1974.

C. Lalor Burdick, Director

COMPUTER ASSISTED EDUCATION*

CONTENTS

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COMPUTER ASSISTED EDUCATION

PART I: WELCOME AND COMPUTER FUNDAMENTALS

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It is my privilege to welcome you to a teaching session on Computer Assisted Education sponsored by the American Physiological Society. My charge from the Education Committee was to pitch this teaching session for persons without previous computer experience, therefore, Part I consists of some computer fundamentals followed by an overview of the kinds of educational tasks which can be facilitated by enlisting the aid of computer equipment. Part II consists of four shorter presentations which describe some of the challenges involved in developing computer assisted educational systems and courses. These four speakers will be joined by two other experienced persons for a panel discussion with opportunities for audience participation. Part III will consist of short presentations of the actual teaching programs which will be available for the nine simultaneous demonstrations of specific educational programs which constitute Part IV. The latter have been selected to provide diversity of subject matter, computer equipment, and educational philosophy.

It has been for me a fascinating experience to put together this teaching session; I only hope that you will find it challenging and rewarding. I wish, at this time, to acknowledge the support of all who have assisted in making this teaching session possible. They are too numerous to mention individually but I would like to single out support from the American Physiological Society through Dr. Jack Kostyo, Chairman of the Education Committee, Dr. Orr Reynolds, Executive Secretary, and Dr. William De Hart from the Education Office.

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Now let us discuss some computer fundamentals. Man is threatened by that which he does not understand! Nowhere is this more true than in the digital computer field. Certainly these devices have characteristics which render them distinctly non-human. First, let us talk about the speed of the digital computer. An adding machine or a rotary calculator performs arithmetic at speeds analogous to that of a human being. Thus persons who are unusually gifted may perform calculations mentally and keep up with calculating machines, if the numbers are not too large. By contrast, the speed of even the earliest digital computers exceeded human capacities. Since then we have gone through four generations of computer design. Electromagnetic relays were replaced by vacuum tubes which gave way to transistors and were themselves superseded by integrated circuits. Each of these substitutions yielded improvements with regard to speed, so that today the duration of a single cycle of machine operation is measured in nanoseconds, the one billionth part of a second. It is difficult for the human mind to comprehend that a man-made machine can actually carry out within a single second many hundreds of thousand steps.

In the second place, let us mention the precision of the digital computer. Two factors make the computer very precise in its operation with numbers. a) It is capable of dealing with very large numbers without having to round them off to smaller numbers during the course of a calculation. The process of rounding off which is used in manual calculation is one of the principle sources of error in the final answer. b) Large computers have a checking quantity known as parity, which provides an internal safeguard against an incorrect transfer of a number from one portion of the system to another. If the parity check is not fulfilled, the computer automatically copies the number again until a proper parity tally is obtained. Thus the degree of error in a modern computer is generally less than one part in a million.

Thirdly, let us describe the storage capability of the digital computer. Unlike human memory, storage in the computer is positive and permanent. When this is coupled with a large potential size of storage, depending on the individual computer and its intended use, we arrive at one of the reasons why it is difficult for human beings to understand computer capabilities. Digital computers have several different levels of memory depending on how rapidly the information must be made available: the main memory, which is often called core memory because it is made up of ferro-magnetic beads or cores; disk memory, which consists of spinning platters with surfaces that can be specifically magnetized; and tape memory where the information is stored on magnetic tape that can be reeled from place to place automatically by the computer. The main memory is the fastest and also the most expensive: It has the disadvantage that the information cannot be removed from the computer without first transferring it to another form of memory. The disk memory, although several orders of magnitude slower than core memory, can store large amounts of information at reduced cost. In both core and disk memory the information is said to be randomly accessible because any individual item can be retrieved without first having to sort through a large number of other items. Tape memory is not randomly accessible and is very slow compared to disk memory, but it has the advantage of being a convenient way to store information outside the computer in a form which permits easy re-entry as desired.

Now let me make a few remarks about information representation in the digital computer. The modern digital computer is inherently a simple counting device. In order to satisfy engineering requirements of speed, simplicity, and reliability, the counting is done with elements that are only capable of two states. Although various terms have been used to express these states depending on the frame of reference, ultimately the representations 0 and 1 are used to designate the state of the counting elements. Since only two states are possible, we say that numerical representation in the machine is binary. This is an important point to appreciate: the only language the machine can understand is a language whose entire alphabet is comprised of the two characters, 0 and 1.

Just as in ordinary language we tend to group letters into words, so in computer language the zeroes and the ones are grouped into words with one important difference. For a given model of computer, every word is the same length as every other word. The number of characters in a computer word is often referred to as the number of bits. Thus to say that a computer has a 16 bit word, means that the zeroes and ones are grouped 16 at a time for processing by the machine. Occasionally, especially with computers that have a large number of bits per word, the term byte is used to designate a subdivision of the word: 32 bit words are often subdivided into bytes each of which contains 8 bits. The use of the expression byte is also related to storing letters in the computer since 8 bits are generally required to designate one ordinary letter.

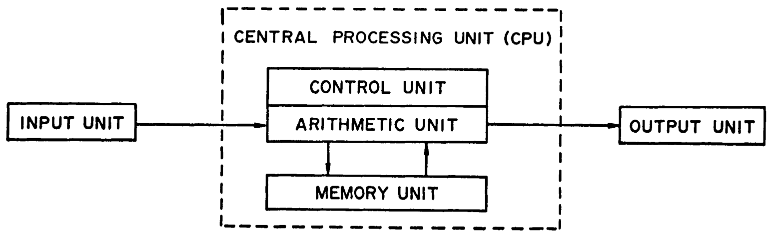
Even when clusters of zeroes and ones are broken up into words or bytes, they are unintelligible to the average human being. Therefore numeric representations of sequences of zeroes and ones have been used to help practitioners of computer technology grasp what information or instruction is being stored in a particular register of the machine at any given time. Two popular such representations are the octal and the hexadecimal number systems. The former is based on grouping bits three at a time and is well suited to computers with 12, 18, or 36 bit word length; the latter, based on grouping bits by fours, is used for computers whose word lengths are multiples of four or eight. In Table 1 can be seen examples of these various number representations. Note that in the octal system there are no eights or nines; similarly in hexadecimal, the letters A through F are added to create a number system with 16 digits. Although these numeric representations seem awkward to those of us who are used to the decimal number system, they represent such an improvement over remembering sequences of zeroes and ones that computer programmers use them routinely for certain kinds of programming tasks.

TABLE 1

NUMBER REPRESENTATIONS FOR SEQUENCES OF ZEROES AND ONES

DECIMAL (Base 10)	BINARY (Base 2)	OCTAL (Base 8)	HEXADECIMAL (Base 16)
0	0	0	0
1	1	1	1
2	10	2	2
3	11	3	3
4	100	4	4
.			
7	111	7	7
8	1000	10	8
9	1001	11	9
10	1010	12	A
.			
15	1111	17	F
16	10000	20	10

It will now be advantageous to describe, in an admittedly simplistic manner, the building blocks which are common to all digital computers. In Figure 1 these components are depicted in a diagram which indicates the relationships between them. All computer components are divided into two general categories: the central processing unit which is often called the "mainframe" or the "CPU", and all other devices which are called peripheral units or simply "peripherals." The CPU consists of three sections: a control unit, an arithmetic unit, and the computer's main memory.



We can gain an appreciation of how computers operate by indicating the necessary sequence of events to accomplish a simple task such as the addition of two and five.

1. First the instruction that addition is to be performed must be entered into the input device and transferred to the arithmetic unit.

2. The control unit must be advised that the sequence of zeroes and ones which now resides in the arithmetic unit should be interpreted as an instruction as opposed to primary data.

3. In preparation for addition the arithmetic unit would now be reset to zero.

4. The first number, namely two, would be entered in the input device and transferred to the arithmetic unit in the appropriate binary form.

5. The second number, five, would then be transferred from the input device. Since the arithmetic unit has not been reset to zero between steps 4 and 5, we now have in the arithmetic unit a sequence of zeroes and ones which represents the sum of the numbers we have entered.

6. In order for someone to know that this operation had in fact been carried out, it is necessary for the control unit to cause the value currently in the arithmetic unit to be transferred to the output unit preferably converted from binary representation back to the decimal number system.

In our simple example the memory unit was not required. When more complicated procedures are to be carried out, the memory unit is used not only to store sequences of instructions called programs, but also to save any intermediate values required in the course of the calculations. It may be difficult to appreciate, but all computer programming ultimately must be reduced to simple incremental steps as illustrated in the example above. It is important for us to realize that there are two major categories of computer utilization.

As computers were developed, it became clear that these expensive devices required efficient utilization to justify their large initial cost. Two approaches to this problem emerged: the first, which permits the computer to schedule individual tasks one after the other, is called "batch-processing"; the second, which provides for a number of tasks to be accommodated by the computer apparently simultaneously, is called "time-sharing." Batch-processing is most suitable for such large tasks as payroll production, sending out bills, creating computerized files, or generating periodic reports. Time-sharing, on the other hand, excels in those tasks which involve flexibility and minute to minute intervention by the human being undertaking the tasks; therefore it is used for inventory control, patient interviewing, citation retrieval, and computer assisted education. The largest computer facilities are able to undertake both batch-processing and time-sharing at the same time; but this is not true of all computer centers.

For the most part, this teaching session deals with time-sharing rather than batch-processing applications, but I would be remiss if I did not at least define for you the full gamut of activities that are involved in designing computer-assisted learning experiences. These fall in four areas which we will hear more about in Part II of this teaching session:

a) the computer equipment, or hardware, as it is often called
b) operating systems and computer languages which are a portion of what we mean by software - the instructions to the equipment,
c) the developing of the actual teaching material - this has been called courseware by some, and finally,
d) evaluation, the means by which we learn what we should be doing differently.

II. APPLICATIONS OF COMPUTERS IN EDUCATION

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The introduction of the computer into the instructional system has been effected on an experimental basis. Several factors have contributed to this slow integration of computers. The sophistication and costs give a good rationale for the limited use of computers for instructional purposes. The computer requires almost continuous operation to make it a cost-effective machine. The business community has been able to take advantage of such a situation by operating computer facilities 24 hours a day. In education this has not been the case. Education traditionally has been geared to a nine-month year, five-day week, six one-hour instructional periods per day. As a result, the computer in an educational setting is idle most of the time. Thus, the costs become prohibitive. However, this need not be the case. The computer can be cost-effective in educational systems.

I will discuss two major areas in reference to the role of educational computers. The first area will be the direct instructional support of computers; the second will be the indirect instructional support of computers. Direct support refers to using the computer in an instructional environment. Indirect support refers to using the computer as an additional resource in noninstructional activities.

Direct Instructional Support

Computer support of instruction can be segmented into three current types of activities: a) computer-managed instruction (CMI), b) computer-assisted instruction (CAI), and c) learning simulations. The rationale for presenting CMI initially is a growing awareness that this instructional use of computers offers the most cost-effective model as well as the best potential for incorporating the other two types, namely, CAI and learning simulations (5, 3).

CMI. Computer-managed instruction can be defined as an automated approach to individualized instruction that implements the functions of a) diagnostic evaluation with learning prescriptions, b) the limited use of CAI for drill and practice or conceptual development, c) counseling of the student about adaptive learning strategies, d) the development of a scheduling system for optimally matching students with learning resources, and e) the development of an appropriate student instructional record system. While CAI encodes the learning materials within the computer system, CMI depends upon a rich resource of conventional printed and multimedia materials being available. CMI uses the capability of a computer to monitor the progress of a student through a program of instruction, testing at many points, and using CAI techniques for remedial purposes. The resulting performance data base allows constant creation of more appropriate versions of the instructional program.

A number of projects have utilized CMI in their operations, such as Flanagan's Project Plan (2), Coulson's work at Systems Development Corporation (1) and O'Dierno's work at the New York Institute of Technology (6). In these projects, students were guided to their learning materials based on progress information supplied by the computer to their teachers. Student instruction and testing were all performed with conventional paper and pencil procedures, and the data were fed through optical scanners into the CMI system. In turn, reports were supplied to the instructor and/or student.

The significant feature of Florida State University's approach to CMI is that the majority of the diagnostic evaluations and learning prescriptions takes place within a computer terminal-oriented interaction between the student and the CMI system. This allows for the inclusion of CAI techniques when desired within the overall approach. Secondly, it has the virtue of insuring that the students are responsible for correcting errors in the information flow both coming in and going out. And lastly, it allows a more facilitated feedback when the student receives his next learning assignment immediately.

The individualization process under CMI is primarily based on an operational understanding of the diagnosis, evaluation, and learning materials prescription techniques offered via an interactive terminal. Using an interactive terminal, such multiple dependent measures as error rates, error patterns, and latencies, plus the methodological techniques of sequential testing (7), and learning optimization models (4) can be employed. These hopefully will lead to a better representation of the diagnostic evaluation and learning prescription process.

CAI techniques (that is, the encoding of actual learning materials to be presented to the student) can be used within the CMI approach to a) provide an improved dialogue in regard to learning relationships especially concerning the interrelationships among the behavioral objectives utilized within the course, b) provide a dialogue in regard to adaptive strategies to be employed by the student, and c) provide for conceptual remediation.

In reference to instructional counseling, students can be given an opportunity to constantly interact in regard to an overview of a CMI course and to gain information regarding their own progress. Students can ask questions about learning problems, adjustment processes, and their concerns for future learning activities. Such questions are most important from the student's point of view (5).

The CMI system can be provided with a schedule which matches human resources and learning material resources in an optimal manner. And, the overall development of a student record system with a CMI course will provide feedback information to students, counselors, faculty, and research and development personnel who are attempting to develop and revise CMI curricular offerings.

In terms of cost-effectiveness, CMI courses can be developed with a minimal amount of expense when compared to total computer courses such as CAI. CMI programming involves test administration with appropriate evaluation for student assignment on off-line materials. The cost advantage is that a large number of students need only a few terminals, plus storage on the computer is small when compared to total CAI type courses. Minicomputers (single terminal-computer units) to the largest machines can be used at rates comparable to usual instructional costs, i.e., costs per student hour. These cost rates are based on high enrollment courses, and assume amortized development expenses (e.g., 5-10 years). In summary, CMI courses are now cost-effective alternatives to traditional instructional procedures.

CAI. Computer-assisted instruction refers to the direct use of computers as a disseminator of knowledge to the learner. CAI involves the interaction of a student online with a computer terminal. In designing CAI materials the designer has the following type of alternatives: a) selection of an appropriate media device for presentation of curriculum, b) the control of the rate of presentation, c) control of the sequence of elements within the curriculum, d) concurrent recording of all learning behaviors, and e) a decision mechanism that determines the rate and sequence by which curriculum elements are presented to the student. The use of CAI in an instructional setting is limited only by the capabilities of the hardware, and more importantly, the content area. In designing materials for CAI, the content should not be sacrificed to keep it on-line.

Recent advances in the hardware and software area make it possible to use computers more extensively for direct instruction than in the past. Two examples are the Plato and TICCET systems. The Plato system, developed at the University of Illinois, uses a terminal that allows for not only CRT displays, but also audio and visual displays from a slide projector. This system, although still in the development stage, does allow for a more flexible approach to the design of CAI. A second approach is designed for the interaction of the computer with television. This is the TICCET System, which is being developed cooperatively by Brigham Young University and the Miter Corporation. This system is designed to use the capability of the television screen and audio with a connected teletype, all controlled by a central computer. Such a system will allow for the future uses of the computer in the individual home by cable television. Both of these systems rely upon large numbers of learners to keep the costs at a reasonable level. The two systems are still in the developmental stage with the Plato system probably nearer to actual usage.

Other possible uses of CAI are with minicomputers. These are now available on the market by a number of builders who put together small individual computers which do not require the large central processing unit that is required for the two previous examples. A major advantage of the minicomputer is the individual control. The minicomputers provide ease for developing in-house materials at a low cost. Also, the efficiency of the minimachine makes it possible for dedicated use, i.e., the only user is the person interacting with the terminal, whereas on a larger central system the many users complicate the utilization of the machine in terms of allocating time. This has been somewhat solved by the use of time-sharing systems, but 40% of the system is usually allocated to the time-sharing monitoring functions. Both approaches have advantages and disadvantages, the potential user should consider the following: a) initial hardware costs, b) years of possible use, c) software development costs, d) other possible users (e.g., in large systems, instructors have to compete with research data analyzers who usually have more money), e) access to the system, and f) the immediate on-line instructional hours, and what is planned for the future.

The first major contribution to CAI was the development of the IBM 1500 Instructional System, the system in operation at the Computer Applications Laboratory at Florida State University. This system was designed specifically for use of computers in on-line instruction. However, the costs and the availability of instructional programs prohibited the wide use of the system resulting in IBM discontinuing the development of CAI computers. Throughout the country there are users of this system and over a number of years, a large number of programs have been developed which now demonstrate cost-effectiveness of computer-supported instruction. Other computer systems are available. Most of these have been developed by individual centers or laboratories in which hardware as well as software modifications were made on the basic designs.

Given the limitations of the CAI system in terms of the type of content which can be presented and the type of terminals available, the CAI system is still years away from being implemented as a major alternative in instruction systems. The costs of operating the system on-line per student is high except when used by large numbers (in the hundreds). The costs of developing CAI programs is also high because of the extensive labor needed for design and programming. The evidence that it is an effective system is strong, but at the present time it does not offset the costs. The future trends for CAI are the development of terminals which allow for a greater or larger variety of display capabilities, such as the Plato and the TICCET systems. These two systems are still in the future, and the costs are still debatable.

Learning simulations. A third use of the direct support of instruction by computers is in the area of learning simulations. Simulations are attempts at artificially presenting a real life situation to provide students with an opportunity to learn and play the role of a significant participant. Simulations can be divided into a variety of activities depending on the learning objectives desired. The simulation process allows the instructor to present real world type activities in the learning process. At the same time, a simulation requires that students themselves vicariously participate in a process which could normally not be available. Thus, a learner could be asked to respond to a simulation of a certain process displayed on the terminal, and have this response evaluated as to its effectiveness or to its correctness.

There are advantages and disadvantages of learning simulations. The advantages are: the presentation of situations too dangerous for real life, the design of scarce or costly events, and the testing of complicated or unmanageable situations (e.g., the simulated landing on the moon for a physics class). Simulation activities have the advantage of taking real live situations, putting them in a simulated context, and allowing the student to react to those prior to participating in a direct activity. Before allowing a student, say in biology, to go through the process of dissecting an animal, this could be simulated on the computer with the student going through the process of dissection by use of graphics. Thus, his approach and his activities could be evaluated prior to actually dissecting an animal. Also, it would allow for the quality control of students participating in other real life situations. The disadvantage of the learning simulation activity is the limitation of the computer itself, i.e., presenting the artificial situation rather than the real. Thus, in an artificial representation there is always the question of how the student would react given the real situation.

Simulation took on added meaning and value with the advent of the computer. The development of the computer gave man a tool with which to compress or expand time and manipulate parameters and variables of tremendous complexity. Man can make as many changes in his simulation model as he wishes, either by doing it himself or by programming the computer to do it automatically. Instructional simulations are a valuable tool in education because they can make learning more real and relevant to the world in which the student lives. By manipulating a model of some portion of the real world, a student is allowed to make his own decisions regarding certain variables. His decisions could have some drastic effects if allowed to occur in the real world. The student learns by asking the question, "What would happen if ... ?"

In terms of cost, the simulation process could be enormously effective. The military-industrial complex have been using computer simulations since the early 1950's. Only recently has the educational establishment incorporated this level of instruction in the system, mainly as games for the advanced students. Given the savings available in simulations over real life participation, increased usage is only hampered by the sophistication of simulation logic and programming. The solution to this problem is an active training in computer languages and programming by members of all disciplines.

Indirect Instructional Support

As stated in the introduction, to make computers cost-effective in education, additional uses of the computer need to be designed. Such diverse areas as counseling, testing, and information retrieval are representative of the possibilities available.

Counseling. The first consideration in designing a counseling system is to define the nature of the counseling process and the potential computer applications. Counseling is the process of determining a person's current and past behavioral activities, i.e., what he is doing now, and then predicting the future activities of that particular person. The testing involved in diagnosis could be on an individualized basis on a computer terminal. The student could get immediate feedback where appropriate. Time involved in diagnosis and in prescription is reduced by having the interactive process occurring simultaneously. Depending upon the sophistication of the programming, the feedback on a person's responses could give the counselor suggestive ways of dealing with the problem. The type of testing given to an individual could employ some of the uses of learning simulation. A counselor could administer instruments such that the student is not aware of the type of information being collected. A counseling system which incorporates instantaneous diagnosis and prescriptions would certainly reduce manpower costs, and improve the affective climate of the service. Given the standardization of most testing, the amortized development costs make this indirect use of computers in education immediately available.

Computerized testing. Another area that computers are used in instruction is testing. Some of the earliest applications of computers in education were in the area of testing. The easily quantifiable nature of test results made these early applications obvious and logical extensions of the data analysis routines. Though somewhat unsophisticated, many of the early applications are still in use. However, computer applications in testing have continued to grow both in scope and in complexity. Some of the traditional methods of testing have been transferred to CMI-CAI activities, for example, multiple-choice-type tests. This would be the same as taking a paper/pencil multiple-choice test, except that additional data can be collected, such as, time, error patterns, sequencing, etc. More sophisticated advances in testing allow for individualized testing in which the instructional strategies could be adapted to meet individual differences. For example, on a pretest each student's performance differs according to the variety in previous knowledge acquisitions. The student scoring low in a particular section of the pretest would be automatically directed to the corresponding section within the program. Advantages of the computer are that it would allow immediate feedback to the student on his entering behavior, and immediate response to the program remediation in which the student should be involved. The pretest measuring could interact with other pretask measures (e.g., aptitude scores, grades, personality traits) available on the individual student, thus a more specific evaluation could be made. Likewise, once the student is in the task, measures could be taken to modify his sequence through a particular course of material. This processing component is very valuable because it does allow for the evaluation of the individual student and for individual diagnosis or prescription. The output available depends upon the objectives of the course, such as immediate feedback concerning the rightness of the answer.

The interactive capabilities of the computer give the student the opportunity to make additional choices in an instructional system. Many programs allow learner control over decisions within a particular segment of course offering. Given feedback on pretest or intermediary performance, could help the student in making decisions about continuing activities in a course. Learner control is limited without this type of detailed feedback on individualized learning progress.

In the direct instructional support systems described earlier, testing is an integral part. However, testing can occur in noninstructional areas, and it is in these areas that computers have rarely been used. Computerized testing on nationwide examinations, such as the graduate GRE exam, could give the students immediate feedback on scores, thus, the decision-making process by individuals could be speeded up. Other exams given by colleges and universities to entering students could be scored immediately, making use of the computer system in noninstructional times, e.g., evenings and weekends, and other nonschool times throughout the year. By prearrangement of appointment times, testing could be on-line, and would not exceed the current costs involved in most university testing services.

Information retrieval. A third important area of indirect instructional support is in information retrieval systems. This type of system allows for the storage of information or data in such a way that it can be recalled in an efficient or optimal manner. Libraries have been making extensive use of this type of system use by classifying and identifying books and other information. The capabilities of the computer made it possible to locate information at a faster pace than manual systems, plus the computer could identify in more detail appropriate resources. Generally, the more hierarchically the information in a discipline can be divided, the more beneficial a retrieval scheme. A retrieval system which is characterized by a multitude of decision points and multitude of entries, would provide maximum access to potential users. From the complicated branching system of the Dewey-Decimal system to a linear listing of facts and specifications, the computer would be cost-effective.

The use of digital telephones and a centralized retrieval system (perhaps state-wide) would reduce even further the cost of obtaining stored information. It is envisioned that word or phrase descriptors could be used as storage and retrieval labels. Such a system should be especially attractive to the academic scientific community because of the importance and the problems associated with obtaining recent and relevant research.

In summary, the initial costs and time involved are excessive. The project would involve long-term costs, involving a complex accounting system, but the end product seems to outweigh the costs. The costs are high, and will stay high, but when used in a total computer system, it can be supported by higher income projects.

Social Factors

The use of computers in education presents social problems, as well as operational and costs factors. For example, due to the information explosion and the creation of large data banks, it is no longer practical nor necessary for teachers to emphasize the transmission of facts. This facet of education can be handled more efficiently by computers. But the introduction of technology into the educational system has developed affective problems. One of these is a fear that computers will have a dehumanizing effect of students and teachers, and that they may even replace the teacher all together. The use of computers in education does mean a change in the roles of the teacher. Technology will replace the teacher in certain aspects of disseminating information. The research data are clear, computers can present information that is effectively and efficiently learned, plus the flexibility of the system does allow for individualized instruction which is not available in the traditional class-room. With the introduction of technology, the role of the teacher becomes that of an instructional manager, i.e., rather than personally disseminating the subject matter, the teacher selects and monitors learning activities appropriate to the individual student. In addition, the teacher would participate in the original design of the system, acting as a content specialist, and then participating in the revision of the materials in terms of the impact on the learning process.

At the university level many of the undergraduate courses with large enrollments deal mainly in the presentation of factual information which is fairly stable. Thus, much of what is taught in the system could be individualized by using some form of computer-supported instruction. The teacher would then have more time to participate in the individual process of working with students. On the graduate level, the use of computers for instruction would be limited because of the limited number of graduate students per class. This makes the process of putting materials on the computer very expensive, except in those areas where there is going to be an immediate high volume of students and at the same time a relatively slow change of content. Meeting those criteria, the computer could be used on the graduate level. How does this influence the individual instructor or professor? Again, the technology removes some mundane activities and allows the professor more time for his research activities, and individual work with the students. What about the impact of technology on the individual? The end-of-course attitudinal survey of the undergraduate students in an FSU biology course showed that this was the first time since they had been in college that they had participated in an individualized learning situation. They felt they were getting the feedback on their performance which they needed.

Computers can be a cost-effective tool in the learning process if sufficient applications are designed and implemented by educators. Two major areas, direct and indirect, were selected to demonstrate the variety of uses in education institutions. Presented first, in the direct support of instruction, was computer-managed instruction. CMI is a monitoring system that diagnoses the learner on-line and prescribes off-line instruction. CAI, as the second application discussed, is an on-line procedure which does both diagnosis and prescription, plus the presentation of content. Learning simulations, the third, were described as learning environments artificially designed to represent real world conditions. Direct support of instruction is cost-effective given high enrollment courses. Even with such courses available, additional uses of the computer are necessary to achieve maximum operational costs. Other applications of the computer were discussed in relation to counseling, testing, and information retrieval.

There are certainly many uses of the computer in educational environments. Described were uses in the academic community of higher education, but computer technology could be cost-effective in other post-secondary institutions; for example, community colleges, vocational-technical schools, neighborhood computer centers, etc. As the number of users increases, the greater will be the variety of applications.

REFERENCES

1. Coulson, J. E. Progress report for the instructional management system. May 10, 1968. Santa Monica, California: System Development Corporation, 1968.
2. Flanagan, J. C. Project PLAN: A program of individualized planning and individualized instruction. Paper presented at Project ARISTOTLE Symposium, Washington, D. C., December 1967.
3. Gallagher, P. D. An investigation of the relationship of learner characteristics and success in a computer-managed instruction course. Paper presented at the meeting of the American Educational Research Association, Minneapolis, 1970.
4. Groen, G., and R. C. Atkinson. Models for optimizing the learning process. Psychological Bulletin, 1966, 66: 309-320.
5. Hagerty, N. A feasibility study: Implementation and optimization of a computer-managed instruction system in graduate education. Paper presented at the meeting of the American Educational Research Association, Minneapolis, 1970.
6. O'Dierno, E. N., et al. Phase I report on a research study to develop a system for individualizing and optimizing learning through computer management of the educational process, New York Institute of Technology, 1968.
7. Tennyson, R. D. A review of experimental methodology in instructional task sequencing. AV Communication Review, 1972, 20(2), 147-159.

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PART II: CHALLENGES OF CAE DEVELOPMENT

I. INTRODUCTORY REMARKS

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As we resume our teaching session on computer assisted education, I would like to call your attention to a report by Anastasio and Morgan entitled Factors Inhibiting the Use of Computers in Instruction published by EDUCOM, the Interuniversity Communications Council. They described a status quo cycle which I have adapted and reproduced for you in Figure 2. The brunt of the argument is that we are caught in a vicious cycle. I hope by the end of the afternoon you will be sufficiently encouraged to realize that progress is being made in spite of the difficulties; but there are areas of challenge with regard to computer assisted education development and this is what we hope to focus on for the remainder of the morning.

Earlier, I defined four areas of activity. Since these also identify different types of costs inherent in developing computer-based educational systems, I would like now to amplify what activities are involved for each. With regard to hardware, the costs relate to the computer mainframe, computer memory, bulk-storage peripherals, data-communication equipment, and terminals. In the area of system software, there are costs involved in having access to an operating system with sufficient flexibility for educational time-sharing, general purpose language processors, and specific computer assisted instruction languages. From the point of view of courseware, the cost items include determining educational objectives, deciding on the style of the interaction, writing the courseware, programming the courseware, debugging the program, and finally, revising the program which is usually required. Lastly, in the area of evaluation there are costs related to assessing the adequacy of the hardware available, the suitability of the system software under a multi-user load, the flexibility of the programming language in providing different styles of interaction, the ease with which non-programmers adapt to the programming system, whether or not educational objectives are being met, and recommendations for system and/or program revisions.

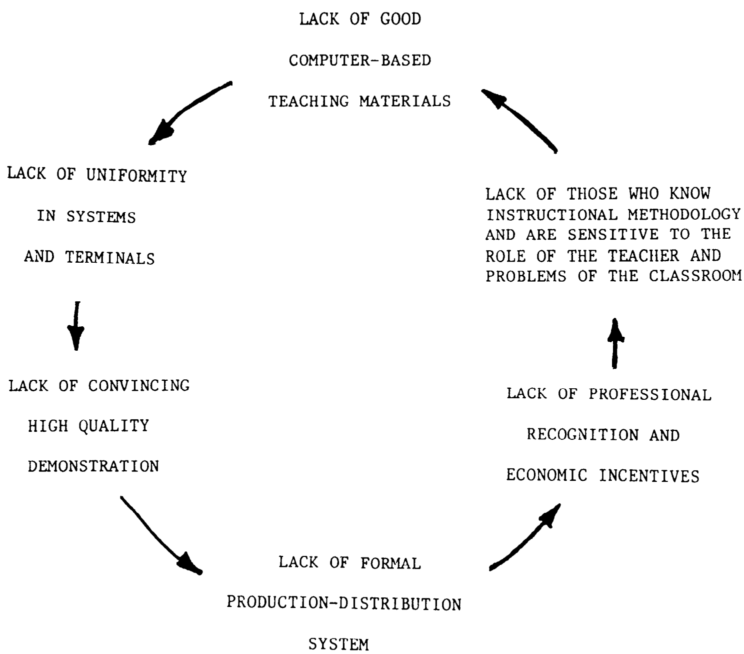

Fig.2. Adapted from: Anastasio and Morgan. Factors Inhibiting the Use of Computers in Instruction. EDUCOM (1972).

As is probably obvious but bears emphasizing, savings in one of these four cost areas inevitably lead to increased costs in one or more of the other cost areas.

The next three speakers will focus on various aspects of selection criteria for making decisions in these four areas. The fourth speaker will provide us with a progress report on an experiment which may critically influence the subsequent development of computer assisted education.

II. HARDWARE TECHNOLOGY FOR COMPUTERS IN EDUCATION: ONE OF THE SOLUBLE PROBLEMS

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The last slide (See Fig. 2) presented by Dr. Tidball is useful because it summarizes the obstacles to widespread CAI use (1). It indicates to me a beautiful introduction for a discussion of hardware as a potential problem area for computer usage in education. Note that nowhere is hardware cited as a primary issue. The significance for us is that problems that are attendant upon the field of computers in education are really much more systemic in nature than they are based upon a particular technology which has been available for quite a while. I can sympathize with the plea from a member of the audience for the use of analog computers. I think there is a good deal of need for this kind of capability, but I think that in the field of hardware we are probably a lot farther along than we are in dealing with any of the other systemic related problems in the field of computers in education.

The basic theme then to my discourse is indicated by a single sentence: That there is no particular absolute answer to the choice of hardware or the use of computers in education. A person who wants to start, or the institutional entrant, into the field of computers in education must ask a number of questions of himself. And this is what I would like to deal with in the short time here this morning. What are the questions that you have to ask yourself? They relate to how you want to take advantage of the computers to amplify the quality of the instructional environment. Generally, the questions can be grouped into two categories: user requirements and facilities considerations. Figure 3 illustrates the fact that there are a number of contingent issues to be considered but no necessary order in which they must be taken. Thus, you can start with any specific category and move around the circle, just making certain that no category is neglected. In addition, you, the user, must establish the relative importance of the questions.

I'd like to review first the components of the computer system discussed earlier by Dr. Tidball. I want to consider the nature of these parts and, secondly, where they shall be located. Taken together these issues are relevant to the degree of control you have over your own technological base. Your decision is relevant to the dollars it will cost you to use that technology; and it is relevant to the availability and priority of the system for you.

First, the central processing units are your main capabilities for arithmetic operation. Core storage provides you the capability of executing your programs - this is called fast core. Secondary storage consisting of drums or other devices are slower in nature (additional auxiliary storage disc units) for storing the instructional materials and support routines not as frequently accessed. In addition to the above as part of your central system, all sorts of peripheral equipment like tapes, printers, other input/output devices like terminals round out the system.

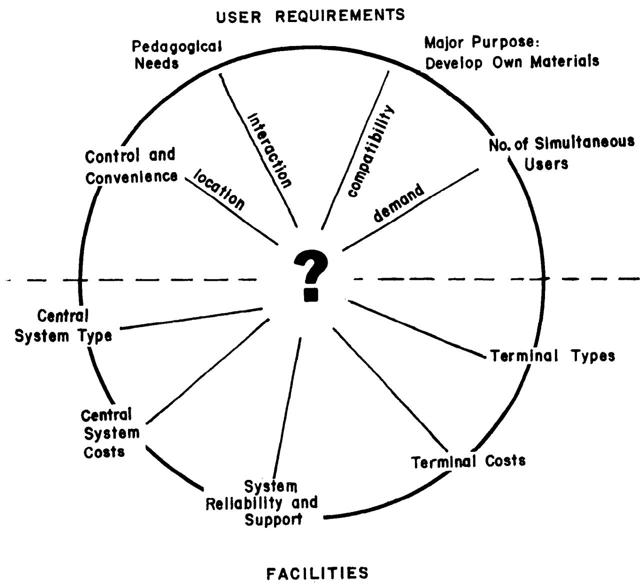

Fig.3. A Potpourri of Decisions for the Potential Educational User of Computers.

To illustrate cost allocations in terms of central system components consider a good example provided by Levien (5). A large system, an IBM 370 maxi computer, might yield the support required for 1000 simultaneous users at a total cost of approximately \$390, 000 per monthly rental. If there are roughly 1000 potential simultaneous users with 75% average utilization, then this results in 750 students programmed on line per hour. And if we can then consider that possibility of 300 hours per month utilization of the system (every month of the year), then there are approximately 225, 000 student hours of instruction per month. The hardware cost, then, turns out to contribute something like \$1.39 (+35¢ per hour operating costs) per student contact hour. If you then project into the future (following the Levien example), a 44% reduction every four years in operating costs, coupled with a 33% annual reduction in the price of computers, it turns out that the central hardware cost (based upon CPU, storage, and peripherals) over the next ten years, even in the most conservative estimates, will approximate 4-5¢ per student hour (Levien gives 2-3c per student hour). That's simply one example taken in detail to emphasize for you that with increasing numbers of simultaneous users and large number of hours of use per month, the central hardware costs will play a very minor role in functional system costs in the 1980's.

Now what about the other aspects of computer hardware, for example, the peripherals? The peripherals in CAI refer to the terminals, the input/output devices. Very often the selection is made based upon one's familiarity with one or two devices. Frequently, too little thought is given to the instructional needs of the application as a criterion for terminal choice. If the selection is teletypes, note that they make a poor graphic terminal. Despite this they are often chosen because they are the type of terminal that may be most readily available or that no decision maker has seen in operation. They also are rather inexpensive compared to other terminals. You can purchase one as low as $500 (if you could pick up a used model 33 teletype). The point is, however, that terminal technology has advanced beyond the state where you can be satisfied with something that is a very slow, character-by-character presentation device. There are a number of graphic capabilities available through inexpensive digital type plotters, video terminals, vector CRTs, etc. It seems the potential for instructional applications that combine both graphic and alphanumeric material is often overlooked because of the belief that a graphic capability is beyond the means of a particular user. You can purchase graphic displays from around $5, 000 to $8, 000. There are a number of different types. A few years ago the cheapest graphic terminal cost well over $10, 000.

One of the areas that deserves much more consideration than normally given is the means provided the user to communicate with the system. That is, if the means of communication is awkward and artificial, then the user's interest will dwindle. In physics, for example, there are a large number of symbols and common notation requirement. It's unnatural that a physics student not be allowed to use the notation while interacting with the computer. There are some terminals like the IMLAC or Anagraph terminals which have programmable keys, allowing individualized character sets. Many terminals have the capability of assigning special functions to particular keys. And a single key can generate the mathematical operation, such as a matrix inversion.

There are other capabilities like a touch panel, which is both a very exciting means of communication and rather easy means of indicating the choice by the student. The terminal of the Plato IV system of the University of Illinois has such a feature. The creation of the line drawings by an engineering student can be a rather tedious task, when all the coordinate points have to be specified. But by using a light pen or other kind of pointing device, the student can directly draw the image on the face of the screen. Pegagogically, if the input required of the student is very long and time consuming with respect to the output that he receives in turn from the system, much of the attraction of that computer for the student is lost. The significance is that a readily available standard keyboard design may be inadequate for many types of instructional usage. The fact is that you should not immediately and meekly accept the keyboard as given by the vendor - it is clearly the case that there are variations available.

The output capability of the terminal I touched on earlier is just as important to the educational process as the input communication channels. You can integrate and should, in many cases, specify audio output. This was integrated into the Model 33 teletype at Stanford at one time to give instructions to children who had no reading skills. In medical application where students are learning to interpret X-rays, the ability to superimpose alphanumeric output and line data on the X-ray itself is beneficial to the learning process. Again, I think you will find that there are terminals available to provide this today. With the demonstration of the CHARGE terminal which we brought with us (HumRRO publication in press), you will see some possibilities for advanced generative graphics to allow you not just line graphics, but actual color and surface graphics. This illustrates the state-of-the-art as it is now.

A whole host of questions relate to system reliability and support.[1] Is there a program of continued development and support provided by the vendor? What instructional language and operating system support the computer? Have any other users, students and faculty, had experience with the system? What has been their reaction? Are local and teleprocessing capabilities available? Is the system one of a kind or is it a standard brand?

These are the capabilities that are available to you. But you must make the user decisions. What are the requirements that you have? Where shall these capabilities be located? How much of the central system should be near you? How much would you be willing to surrender to somebody else? This is dependent upon your purposes for the use of these terminals and for the use of this system. In other words, you can go to a commercial time-sharing system. You can get in for as low as $600 a month and have the terminal at your disposal for 24 hours a day (e.g., TYMSHARE, Inc.). The type of terminal, generally speaking, is a teletype. You will not have control over the kinds of materials that exist except that which is in the library of the time-sharing system. You may be able to contribute your own development to that, but that would require another arrangement. On the other hand, you can go to an on-site system, such as the type I described earlier, which could go as high as the aforenoted $390,000 a month. You could obtain a smaller system which could cost you perhaps $50,000 a month. The question then that arises is if it is on-site, should you share the system with administrative users, and research users? Or are you going to require this dedicated for instructional purposes? In turn, what are the relevant dimensions for deciding this? The first question, I guess, you could ask yourself is: Are you going to be using other programs developed by people not in your institution as the majority of use? Or, are you primarily going to develop and use your own programs? Or, are you going to look towards mass dissemination of your materials for other people's use? This clearly is going to demand that you consider the compatibility of your own hardware system, and whether or not it is a standard system. Do you have the available staff in order to produce the materials and to maintain and operate the system? Therefore, you have to consider the educational and the technical skills available and those required on your staff. Next, consider the cost as I indicated earlier. If you go to the time-sharing system, then you've got a line charge portion that you pay, plus the cost of leasing the terminal. Or, if you have a local system, then you have to share the CPU costs that you pay, as well as the ter-

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[1] Adapted from personal communication with Dr. Harvey Long.

minals and possible line cost depending upon where you are in relation to the location of the central system, even if it is in your own school. Next, what are the number of simultaneous users that is going to be required on this system. Clearly, it is advantageous to distribute the cost as broadly as possible, but how many do you require? Whether or not authors will be able to use the system simultaneously with students is another consideration, because your system is going to differ accordingly. Are you going to be in a research environment where you can tolerate high costs? I gathered from one of the questions raised earlier with regard to the training of physicians that we are all concerned with more than the cost of the system at the point in time of training. More important, what is the criticality of the graduates making an error subsequently in practice and how do you evaluate that in terms of the cost of the training that you provide these people? Actuarial tables have been used for years by insurance companies to place values on specific injuries, but I know of no one in education who has attempted to make analogous estimates. It's an interesting kind of dollar figure for someone to determine.

It is the case, in any event, that graduate or professional training is one of the most expensive, and if there is a place where uses of the computer in education can indeed be cost effective, it is at that level today. We estimated a few years ago (4) anywhere between \$2.75 on up to \$5.00 or \$10.00 per student hour in traditional instruction dependent upon the type of professional school. Based on our earlier estimates, you can get computerized instruction for as low as \$3.00 - or even \$2.75 per student hour easily competitive if there are a large number of student contact hours on that particular system. Projections are being made for 50¢ to \$1.00 per student hour (TICCIT or PLATO IV) but these figures are not yet a reality. At an undergraduate level of instruction, Bunderson has estimated \$2.00 per student hour for a complete tutorial CAI course (2). Bunderson's estimates were based on 1500 students sharing a 32-terminal system (IBM 1500). Jamison, et al. with a drill-and-practice usage in elementary schools, derived empirical costs of \$3.40 per contact hour based on an RCA System with 192 terminals (3).

If system costs are clarified, what kind of control do you want over the system? Is it necessary or desirable for you to have control over the entire system? How much priority availability of resources do you want? What is the critical convenience level for you to say, "I'm going to use that system because it's available to me at any time, the terminal is in my office, I like it, it's easy to use, etc?" You as the developer, on the one hand, may say, "Gee, I'd like to have one in my office that I can get to any time I want." You as the administrative decision maker, however, see the dollar signs clicking away and therefore want maximum utilization of that computer, because only when there is increased utilization do you lower the cost per contact hour. Thus, there is a trade-off in system cost/performance between the cost per student hour, or per user hour, the number of simultaneous users and the critical convenience level to a department which may have special needs for tailoring the materials, or for having access, etc.

Having made the agonizing decisions on critical convenience and system costs you might address the questions of system requirements from a pedagogical point of view. If you don't have a need for graphic capability, then a teletype might suffice. Note this yields a line-by-line presentation. On an inquiry basis, that is, where the student or the author can make more of a broad scale, natural language inquiry into the system, conduct dialogues with it - you're going to have a good deal of system requirements for storage, system and language software, flexible and rapid terminal device, etc. At this point you may wish to recheck your computer vendor's support packages. Possibly, some drill-and-practice segments won't demand that much capability for you - where you augment a given course with some segments of skill maintenance. For example, if it's simply a matter of having the student learn terminology in some cost-effective way, you could easily use a teletype. On the other hand, you may want a full-blown, interactive tutorial for an entire course of instruction and other system requirements become important (time-sharing, data management, complex files). A comprehensive central system is needed to enable the managing of branching requirements, record updating, etc., within that tutorial system. The requirements for simulation are also unique and different. Here a graphic capability could be most useful, especially in the medical field when dealing with the examination of anatomical and neuro-physiological relationships.

In short, you the user must decide: How does the simulation, how does the drill and practice, how does the tutorial, how does the inquiry fit into your pedagogical scheme? Then you can determine the capabilities and constraints of particular hardware and software which will support it satisfactorily. The computer technology is available, choice of a particular vendor's computer will give you certain language and system software. It's a question of purpose, which only the instructional designer, the administrator and student users can answer.

Lastly, I wish to address the concept of networking. Networking can provide the user with the capability for sharing resources not possessed locally. Applied to instructional needs, it enables the teacher or the student to access a widespread library of courses and support programs that may be available elsewhere. Where you don't have the capabilities on campus, you can augment your capabilities by going to other institutions. It lowers your costs. But you surrender some control. Additionally, forming cooperative groups, forming the kinds of user capabilities on a superinstitutional basis can do wonders for enhancing the discipline identification and, in turn, discipline-oriented curricular developments. Thus, embryologists at one school of medicine can talk to embryologists at another school. On a national scale you can then pool your resources and create critical masses of personnel resources and facilities to further curricular reform. You've got an excellent example of a beginning in the medical school area which you'll hear about subsequently today from the speaker from the National Library of Medicine.

But the most far reaching implications of national networking are in very broad areas of educational system reform. They can provide virtually an alternative learning system, and society can take a major step towards implementation of personally relevant instruction. In medicine, as in other fields, we could provide a nationwide learning resource pool. The student could have access to a library of courses which are not available at a particular institution but available on a national academic network. The student could obtain education on demand. This concept has the possibility for becoming a reality.

The essence, then, of my talk is that the recent advances in computer hardware (and software) are adequate to support a wide range of learning experiences. At the present stage of educational technology the real concerns are for education to consider the user arrangements required and desirable whereby the technical capabilities that are available can be made useful for the desired learning and development activities of the student, faculty members, and administrative decision makers.

REFERENCES

1. Anastasio, E.J., and J. Morgan. "Factors Inhibiting the Use of Computer in Instruction," Final Report to the National Science Foundation, EDUCOM Interuniversity Communications Council, Inc. 1972.
2. Bunderson, C.V. "Justifying CAI in Mainline Instruction" paper presented at the NSF Sponsored Conference on Computers in the Undergraduate Curricula, June 17, 1970.
3. Jamison, D., P. Suppes, and C. Butler. "Estimated Costs of Computer Assisted Instruction for Compensatory Education in Urban Areas,"Educational Technology, September 1970, pp. 49-57.
4. Kopstein, F., and R.J. Seidel. "Computer-Administered Instruction Versus Traditionally Administered Instruction: Economics." AV Communication Review, Vol. 16, No. 2, Summer 1968, also published as HumRRO Professional Paper 31-67, June 1967.
5. Levien, R. The Emerging Technology, McGraw-Hill Book Company, 1972, pp. 470-473.

III. OPERATING SYSTEMS AND COMPUTER LANGUAGES FOR EDUCATIONAL APPLICATIONS

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Your next speaker will be your Chairman! Perhaps a word of explanation is appropriate to justify this late addition to the program. I had hoped, in Part II of this Teaching Session, to find three speakers who would provide you with a broad exposure to the challenges of developing educational technology from the points of view of hardware, system-software and courseware. I believe that Dr. Seidel has done an excellent job of reviewing hardware for you in just that broad manner, but he would have preferred to speak on courseware. Similarly, Dr. Octo Barnett, whom you will hear from in a moment and who knows far more about system-software than I do, was not sure that that topic was appropriate to this audience and, besides, he too preferred to speak about courseware. Nevertheless, I was convinced that our teaching session would be incomplete without some coverage of this area; therefore when Dr. Victor Bunderson was unable to come, also on very short notice, I decided to attempt the talk myself. I offer apologies in advance if either the subject is too technical or my own experience is too limited to do it proper justice.

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We have already split off that portion of software which relates to application programming under the designation of courseware. It now remains for us to discuss the challenges involved in the system-software area. For those of you who have well-developed computer science operations in your home environments, your ability to influence choice of system-software may be somewhat low; on the other hand, if you decide to acquire a small mini-computer and come up from the bottom as we did at George Washington University Medical Center, you will have to devote considerable time and effort to this area. If we define what we mean by an operating system this should become more evident.

A digital computer, all by itself, is a rather helpless device. It is entirely dependent on a set of instructions which permit it, or a human operator, to determine what task it is going to perform next. That portion of the total software is known as the "operating system" and varies widely in complexity and capability with the size of the computer and the number of features available on the machine. In its simplest form the operating system enables a user to load a program into the main memory unit of the computer and then tells the computer at what location in memory to begin execution. More sophisticated operating systems permit several programs to be processed simultaneously, which is called multiprogramming, and to keep track of many separate tasks even when they are being accomplished at vastly different speeds.

For educational applications an operating system should meet certain optimum requirements. It should be capable of supporting the number of simultaneous users appropriate to the educational objectives. It should be capable of supporting different computer languages because no single computer language is ideal for every task. It should be capable of providing student recovery for those occasions when the student doesn't know where he is in the program and does not know how to resume learning activity. Finally, the operating system should provide sufficient information about the actual use of the courseware so that evaluation of teaching effectiveness can be based on actual experience and that experiencial clues are available to those portions of the program which need further modification.

Let us now talk for a moment about computer languages. As indicated earlier, the only language that the computer understands is binary or "machine language" as it is sometimes called. The next step in intelligibility is what is known as "assembly language." Here the communication with the machine is done with a restricted set of abbreviations, called mnemonics. These are combined with alphanumeric names or symbols to represent locations in the computers memory and much of the difficult numerical work of programming is thus eliminated. A program written in assembly language is called a source program. Then the power of the computer is used to translate, the technical term is compile, the assembly language source version of the program into a machine language version of that program. Although assembly language programming preserves the full flexibility of a digital computer's capabilities, it is the most time-consuming way to program and is generally used only by computer professionals.

A third level of intelligibility is provided by languages such as FORTRAN, COBOL, or BASIC which are called high-level languages. The communication in these languages is closer to natural English language, especially where the applications have a mathematical context. Some high-level languages such as APL or FOCAL are known as interpreter languages: the binary is created at each step of the program. Others, such as FORTRAN or Pl-1, require that the entire program be compiled into a single machine language version at one time. Thus any small variation in the program necessitates compiling a new set of binary instructions to the machine.

We must also review a number of special purpose languages which have been designed for computer-assisted-education activities. The prototype here is COURSEWRITER, a language well-suited for the presentation of items as frames, which has built into it some of the features mentioned earlier as desirable for the operating system. As originally implemented, it lacked interactive flexibility and access to computational power; but as one of our panelists has demonstrated at Ohio State University, it has been possible to overcome some of these limitations. The major feature of this type of language is the concept of an "author mode." The idea here is that the programming system is so easy to learn, that faculty members without programming experience will readily prepare their own lessons. An alternate approach to helping non-technical subject experts to write computer courseware has been that employed at the University of Illinois at Champaign-Urbana. The PLATO system has codified teaching logic and tutorial strategies into a series of "data formats" which are especially convenient to use. This is of particular interest, because, as you will see this afternoon, PLATO has a very sophisticated graphic capability built into its unique terminal.

Yet another category of computer languages are also used for writing educational courseware. These are inherently computational languages which were not originally designed for this purpose, but which are easy to learn and have considerable flexibility. Examples of these are APL, BASIC , MUMPS and FOCAL. As you can see from your program, several demonstrations scheduled for Part IV this afternoon utilize this approach.

It should be clear by now that if the purpose is to create an instructional program to help medical students review their progress in learning physiology, that task can be done on a variety of computer equipment, with a variety of operating systems, in a variety of programming languages. Despite this multiplicity of possible approaches, the final application programs might appear to be identical to the student.

Another way of saying this is that good application programming attempts to minimize the restrictions imposed by the equipment, the operating system, or the computer language. Of course, the size of the CPU, the amount of available memory, and the extent of bulk storage, have a great deal to do with the flexibility of the computer system. But with good design, the student using an interactive computer system need not be concerned with these matters. We say that the way in which the system accomplishes its work has been rendered transparent to the ultimate user. This, the theoretical goal of application programming, is never realized completely; however just as one need not understand how his automobile actually works to drive it, one can derive considerable utility from a computer terminal without having to understand how the system is accomplishing each specific task. The analogy is useful to make an additional point. One does have to learn how to drive an automobile. The knowledge required to do this is a small fraction of what must be known to repair it or to design a new one. So it is with interactive computing. A basic minimum of skill is needed to know how to make the connection to the computer system and how to interact with it successfully, but this is a small fraction of what one needs to appreciate if one desires actually to write application programs. Similarly, writing application programs in a high-level or a special purpose language is a relatively simple task. Therefore many faculty members will learn enough about the languages they use frequently to make the minor modifications in their application programs which individualizes them for their own particular requirements.

The ability to refine continually a program until it does exactly what one desires it to do is the great virtue of the computer, particularly when it is used interactively. Then, because our requirements do change with time, the ability to modify a program after it is considered completed is also important. This is called software maintenance and is every bit as necessary as equipment, or hardware, maintenance. One should never become involved in developing an application program without a clear understanding of who will be responsible for software maintenance. Software that does not need to be altered exists only in the mind of the less-than-entirely-scrupulous salesman of computer technology.

To conclude these remarks I would like to review some of the features which are desirable from the point of view of a computer-based instructional system. In general an improvement in one feature may reduce the extent to which another is achieved. This explains, in part, why we have a multiplicity of hardware and software systems: each having its own particular advantages which were considered desirable in the environment in which it was developed.

1. Number of simultaneous users - this value may vary from one, the case for a stand-alone, mini-computer; to over one thousand, as is the case for the large statewide system being developed in Illinois.

2. Response time - by this we mean how long a user must wait before the computer will respond to his message. Values up to 10 or 20 seconds have been found acceptable but when this increases into the minutes range, users begin to wonder if they have been disconnected.

3. Programming ease - Here we refer to the crucial elements which determine whether or not the non-technical subject matter expert will be willing to develop his own lessons.

4. System compatibility - an important variable related to the likelihood of making use of courseware developed at another institution. It is possible that "networking" will resolve some difficulties in this area but there is no assurance, at the moment, that the large costs of maintaining inter-institution networks will always be defrayed by an interested third party such as the friendly National Library of Medicine.

Now then, as we increase the number of simultaneous users on a system, we increase not only the cost of an installation but also the response time for each user.

As we specialize the system for particular programming ease by creating author modes which make it easier for the teacher to do his own programming and housekeeping routines which keep track of student responses, we increase equipment costs and our dependence on a staff of professional programmers.

As we attempt to increase the flexibility of the programming system through the use of interpretive languages with their sophisticated computational power we increase the response time for each user.

As we attempt to provide a second medium with improved resolution for visual display, we commit ourselves to a choice of terminal configuration which decreases system compatibility with other installations.

As we decrease response time through the use of compiler techniques we increase the complexity of the programming system and make it more difficult to make subsequent improvements in the computer language bein used.

Finally, I am most anxious that these comments not be interpreted in a context of despair: "If it's that complicated, I want no part of it!" On the contrary, I encourage you to appreciate that these various approaches have been developed because there is no perfect solution which fits all computer assisted education requirements. Just as in the transportation field we have a gamut of possibilities from bicycles to jetliners, so in computer-based instructional systems we have great variety. This has the advantage that there are systems available for every budget and for distinct educational objectives. In the panel discussion which follows and this afternoon during the demonstrations, I hope you will also have opportunities to explore the level which might be most appropriate for your own needs.

IV. STRATEGIES, POTENTIALS, AND PROBLEMS OF COMPUTERIZED ASSISTED INSTRUCTION

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In the application of computer technology to medical education, there are two maxims that must be seriously considered.

The first maxim is that it is neither desirable nor necessary to make a distinction between computer-based teaching and computer-based testing. This follows from the Socratic doctrine that the best form of teaching occurs when the student is involved in an interactive dialog and is given frequent comment and criticism on his performance. Such criticism requires specific evaluation of performance and thus is a type of test. Likewise, the optimal test is one when there is feedback as to the appropriateness of student performance; such feedback is a true component of teaching. One of the major strengths of a computer-based instructional system is that it is possible to combine these two usually separate educational elements.

The second maxim is that in the great majority of situations, the computer-based program should not be considered as an entity unique unto itself. The optimal use of computer technology usually occurs when the computer-based element is a complementary or supplementary activity to other elements in the educational program.

In reviewing the application of computer technology to medical education (referred to as CAI or computer-aided instruction), the various programs can be classified in 6 different sets.

The first is the use of the computer to assist the management of the instructional activity - here the computer is used to guide and monitor the student's course through the educational curriculum. Two good examples of this are the basic science curriculum at Ohio State University Medical School and the Open University in England.

The second type of computer application is a rather traditional approach to teach and test the student in the simple recall of factual information. This is by far the most common use of CAI, particularly at the elementary school level.

The third type of application concerns the use of the computer to teach and test the ability of the student to analyze and make simple interpretations of data. Most of the current use of CAI in medical education is of this class.

The fourth type of application uses the computer system as a simulator of a physiological or biochemical process - for example, an analogue computer can be used to simulate the cardiovascular control system or the glucose regulating mechanism.

The fifth form of computer application is the simulation of the patient encounter. This type of simulation emulates the classical case method of teaching where the computer represents the patient in either a diagnostic or a management challenge. Using the computer as a patient simulator has many of the same advantages as using a Link trainer to teach and test a pilot to fly and to make appropriate decisions when confronted with a variety of environmental stresses.

The last class of CAI in medicine is using the computer to provide diagnostic and treatment guidance. In this application various clinical and laboratory data about a single patient are given to the computer and it responds with the appropriate interpretation and management advice.

The major areas of potential usefulness of the computer in facilitating medical education are in the last three categories since in these applications, the computer can provide an experience which cannot be easily duplicated by any other educational techniques. In the area of simulation, the computer can be uniquely valuable for the teaching of appropriate problem-solving skills; this is one of the most important responsibilities and one of the more difficult tasks we have as medical educators.

A major component of medical practice is inherently information processing activity; the practice of medicine requires a very high level of competence in the collection of data, in interpretation of data, and in decision making. This problem-solving ability is very difficult to teach in the abstract. One of the strongest criticisms medical students offer about the basic science curriculum is that it is not relevant to their perception of the problem-solving activity of medical practice.

In the teaching of the basic sciences, as in the teaching of clinical medicine, the student must learn to appreciate the dynamic, time-changing characteristics of human functioning in health and disease. In both types of educational experiences, the student must be given the opportunity to learn by personal experimentation, by personal interaction with an appropriate model. In both types of educational experiences it is often expensive, and time consuming to provide appropriate biological models. In both types of experiences it is frequently difficult to provide a full range of examples of pathophysiology or of disease states, and it is often difficult to allow the student to explore the full range of possible experimentation.

In teaching problem-solving skills, it is important to monitor closely the student's actions and give a continuing interpretation of his performance. Appropriate criticisms and feedback are an essential part of any experiment with a model whether in the laboratory or at the patient's bedside. However, in both environments, the cost of this feedback is usually very high and often requires a heavy commitment of faculty time.

The simulation of the biological or clinical model by using some substitute technique is not a novel idea. Many different approaches have been used such as animal experiments, written problems, or case histories. However, simulation using a digital computer offers a number of exciting new potentials.

In digital computer simulation, the student's interaction with the computer may be of the form of the typical multiple choice response; however, the computer can also accept a student's response as an item number from a much longer list, or as a narrative English text response. This greater degree of flexibility in input greatly reduces the cueing of the simulation and makes the interaction more realistic.

Another major advantage of the computer simulation is that the simulated model can react and change in a much more variable sequence than is possible in a written example. This responsiveness of the model can be made a function not just of the last student response but also a function of the whole interaction up to that time. Thus, in a simulation of a didease process, the clinical state of the simulated patient can change as a simulated time function of the disease process. In addition, the clinical state of the simulated patient can change in response to the different therapies chosen by the student.

The computer offers significant advantages over an animal model in that at any desired point in the simulated interaction, the computer can interrupt the student to offer suggestions or to comment on the student's choices up to that time. The dialogue can also be initiated in the other direction in that the student can interrupt the simulation and ask for help in interpreting the status of the model or for advice as to the appropriate next action to take.

Another advantage of the computer simulation over an animal model is that the simulation can be completely specified and standardized for every student. The computer can keep an exact, detailed and complete record of the student's performance and can score the student's interaction in a reproducible and unbiased fashion.

Lastly the computer model offers the potential of a much more varied and wider scope of simulation than possible with the animal model. The computer simulation can be made available to the student at a variety of locations, not just in the laboratory, and at a variety of times, not just for a single scheduled exercise. The National Library of Medicine –

sponsored experiment in networking is a dramatic example of making the CAI activity widely available.

It would be grossly misleading to discuss this topic without also considering the problems we face in making computer simulation a viable and widely available resource. These problems can be considered under four different categories:

a) Subject matter definition
b) The implementation of a model into a computer program
c) The execution of the computer program
d) Evaluation

In terms of subject matter definitions, the relevant issues concern definition of educational objectives and formulation of the strategy of the interaction. There is a very rich menu of approaches that can be used and we have just begun to explore the various alternatives. It is in the area of formulating strategies of simulation that the beginning faculty user of CAI requires the most help and advice. Once a particular strategy is defined, it is relatively straightforward, although very time consuming, to develop the specific content material. Probably the most time consuming element is the development of the material for the computer to use in interpreting the student's performance and the material the computer supplies the student for help in understanding the simulation. The development of a scoring algorithm is also a very challenging and time consuming task.

In terms of implementation of the model into a computer program, the faculty member is very much dependent on the circumstances of availability of computer technology in the local environment. There is a wide variety of computer technology, both in terms of hardware and software, that can be used. However, independent of the particular technology available, several generalizations are true: first, the author must anticipate that the development of a teaching program is not a one-time effort; second, considerable time is required for debugging the program, modifications of content, and further evolution of the model; third, a teaching program, like a lecture, must be responsive to student feedback; fourth, in implementing the CAI activity on any computer system, it is important to plan for on-going collection of data in regard to student use - who, when, what programs; and lastly, it is very useful to provide the option of allowing the student to type in comments at any point in the interaction - these comments provide valuable criticisms and suggestions to the subject matter author.

In terms of execution of the program, the student is most concerned with the operational characteristics of the system and the terminal. The usual student has no concern with the particular choice of programming language or whether the computer is located next door or a thousand miles distant. The concerns of the student are more related to having the terminal available in a location that is convenient to his normal activities. He is particularly concerned that the system be ultra-reliable, continuously available, and most importantly, easy to use.

The evaluation of a computer-based educational program is not a simple task. The present state of the art of evaluation is very primitive and is often limited to measuring the actual amount of student use, the attitude of the users, and the attitude of experts toward the educational experience. It is usually possible to show a positive effect on content retention. However, the demonstration of acquisition of problem-solving skills is much more difficult since the techniques for measuring problem-solving ability are very limited. In a certain sense, the only way to measure problem-solving improvement is through using the same computer system that is used to teach problem-solving - this circular argument is unsatisfactory but often the only course available.

The cost-justification of a computer-based program is probably the most difficult task of all. It is very rare that any good data is available on either detailed costs or on cost effectiveness of any educational activity; most decisions are made on the basis of tradition, and personal biases. The ideal objective is to demonstrate that the computer program results in cost reduction, but this objective is usually realizable only in a few limited situations, or when an expanded class size has overwhelmed the educational resources then available. The major arguments for cost justification are usually posed in terms of making new content material available, making a new educational experience available, or else making the educational experience available in a form that is more acceptable to the user. The ability of the computer system to provide detailed audit trials of the student's interactions is an additional benefit which often makes the cost of the system more acceptable.

In summary, I would suggest that the application of computer technology to medical education is an area of enormous potential importance. We are just beginning to exploit the ability of the computer system to sustain a meaningful dialogue with a student, to manipulate information and to emulate a dynamic, responsive, sophisticated biological or clinical model. Problem-solving is one of the most highly developed traits of man; the teaching of problem-solving is one of the greatest challenges to us as educators. It is my conviction that computer technology can and will be a tool of enormous usefulness in this responsibility.

V. THE LISTER HILL EXPERIMENTAL CAI NETWORK - A PROGRESS REPORT

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Lister Hill National Center for Biomedical Communications
National Library of Medicine

In July 1971 the Steering Committee of the Council of Academic Societies of the Association of American Medical Colleges issued a 97 page report, "Educational Technology for Medicine: Roles for the Lister Hill Center"(1). The Report made 53 recommendations; one of these, number 3.1, read:

"The Steering Committee advocates the organization of a biomedical communications network designed to meet some of the needs of medical education and medical practice and to capitalize on the current state of development of various phases of communications and computer technology. Of primary importance is the requirement to maintain a high level of learning experiences for growing numbers of students to whom medical, dental, nursing and other health career schools are committed."

The report was presented to the Board of Regents of the National Library of Medicine, who appointed a Priorities Review Committee to study the report. This committee presented four recommendations to the Board for consideration at their November 22-23, 1971 meeting. Their four recommendations were adopted unanimously by the Regents, as the first formal step in implementing the recommendations. The second of the four recommendations read:

"The Committee advocates the organization of a biomedical communications network fundamentally conceived as providing the mechanism by means of which inter-institution cooperation and sharing of resources will be used to meet some of the needs of medical education."

Exegesis and implementation of this text started in September of 1971; the implementation is the topic of today's paper.

The hard core of the Lister Hill Experimental CAI Network today consists of four contracts: one with a commercial timesharing computer service and three with institutional centers of CAI expertise. These three institutions - Massachusetts General Hospital, Ohio State University College of Medicine, and the University of Illinois Medical Center in Chicago - are all represented on today's program. Their demonstrations of Application Programs, however, do not indicate the scope of what they have to offer over our network, to wit:

Massachusetts General Hospital: diagnostic simulations for medical students and physicians covering areas such as abdominal pain, coma, cardio-pulmonary resuscitation, diabetic ketoacidosis, jaundice, anticoagulant simulator, cardiac simulation, idiopathic respiratory distress syndrome in the newborn, jaundice, pediatric cough and fever.

Ohio State University: material in two sections, the first containing over 50 short courses accompanied with slides on topics for a variety of medical and health care personnel; the second a tutorial self-evaluation to accompany an especially designed course of study for the first two years of medical school.

University of Illinois at the Medical Center: part one is composed of over 2500 multiple choice questions (CRIB or the Computerized Random Item Bank) divided by specialty and sub-specialty; part two (CASE or the Computer Activated Simulation of the Clinical Encounter) is a set of simulated clinical encounters with free vocabulary query.

Our contracts with the institutions providing CAI are in two parts: a) provides for user indoctrination, up to and including teaching users how to write their own units of instruction, and general hand-holding; b) requires the contractor to provide 5 ports on his computer for connection to the network, these ports to be available 20 hours a day, 7 days a week.

The communications contractor is required to connect the CAI institutions' computers to his network, and to provide access to these computers through his node cities. His charges are based on connect time, and numbers of characters transmitted. I find it interesting that they are irrespective of distance, like an 8¢ stamp, which may be used to send a message across the street or across the continent. One corollary of this is the warmth with which we welcome network users in the Pacific time zone. The three hour difference helps smooth the load on our ports, and it doesn't cost any more!

Our users are expected to provide their own terminals, and their communication costs to the nearest node on the time-sharing network. This simple statement glosses over a myriad of difficulties. Terminals, at $2,000 - $3,000 each, are not exactly as common in medical schools as pH meters. Since our communications contractor is not yet an eleemosynary institution, his nodes are in cities which are expected to generate commercial traffic. This tends to favor users in California, Texas and the Northeast. We do have a node in Seattle, which does some good for the Pacific Northwest, but our users in the Southeast, Southwest, and Middle West have to watch their pennies on communication costs.

Organizing the CAI network was the Library's first encounter in depth with computer-assisted instruction. We had had extensive, and expensive, experience with mechanized information retrieval systems where it is relatively easy to transfer retrieval programs and data bases from one computer to another. We had thought that it would be equally simple to transfer the CAI programs from their home computers to a single central computer. We were told, in extenso, that "CAI programs are different!" We learned that the CAI programs should be treated as experimental prototypes, which still needed to live in a laboratory atmosphere. Moreover, our contractors wanted to know what use would be made of their precious programs. They did not want them to be treated as interesting toys; they wanted them to be integrated into the curricula of the using institutions in a meaningful way. Moreover, two of the three contractors wanted faculty members of using institutions to learn how to write additional units of instruction, and contribute them to the common pool; the third wasn't all that interested in other people's programs, but wanted primarily to gain access to a wider body of students. The ensuing dialectic process - the creative synthesis of antitheses - resulted in the present configuration of the network.

We now have two classes of users, "trial" and "operational." The Trial Users get two months free trial, with the only requirement, after filling out a rather streamlined background data sheet, being that they promise to give us a report after the two months. They have the options of discontinuing the service, renewing for another two months or, hopefully, deciding that they want to become Operational Users.

Operational Users have additional steps they must undertake. They sign a Memorandum of Understanding, which pledges them to deliver monthly and annual reports on their use of the system. They prepare an Educational Material and Evaluation Plan, which tells how they propose to use the CAI material, and how they are going to judge whether it was worth the trouble. As you will remember, our prospective contractors wanted users who would write additional units of instruction. So, a would-be operational user must be endorsed by one or more of our three contractors.

As you can imagine, we have many more Trial Users than Operational Users. At the moment, the ratio is 4:1, with forty Trial Users and ten Operational Users. The programs are used for three general purposes (some institutions use them for more than one purpose):

Teaching - 29.
Writing new units of instruction - 12.
As of the latest reporting period (Jan. 15, 1973 to Feb. 15, 1973) the network computers showed the following usage pattern:

Massachusetts General Hospital	805 hours
University of Illinois Medical Center	542 hours
Ohio State University	182 hours
	1529 hours*

The average terminal encounter lasts 30 minutes, which gives us 3,000 encounters. It probably represents at least twice that number of students; some of our users report that the students cluster 5 deep around the terminals, with decisions reached by group consensus. Approximately 5% of current usage is by physicians; 78% by medical students. The remainder of the time is used by nurses, dental students, allied health personnel and non-medical troops.

We have received Educational Material Use and Evaluation plans from the following institutions; our first batch of operational users has

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* Editor's Note: As of August 8, 1973 average use of the network has increased to approximately 2000 hours per month.

been selected from this set:

The Medical Center, University of Alabama in Birmingham
American Heart Association
CAPO Project - Bolt Beranek and Newman
Case-Western Reserve University
National Board of Medical Examiners - American Board of Internal Medicine
Michigan State University
University of Pennsylvania
The University of Texas - Dallas
Stanford University School of Medicine
State University of New York - Downstate Medical Center
University of Texas Medical Branch - Galveston
College of Medicine, University of Utah
Medical College of Virginia
University of Washington

I have described the Lister Hill Experimental CAI network as it appears to the user; I have hinted at the dialectic process which leads to its present configuration and operating rules. One question remains unanswered; why are the Lister Hill National Center for Biomedical Communications and the National Library of Medicine sponsoring the network?

A partial answer would be that computer assisted instruction might well be a good thing for future libraries to offer their patrons. Librarians have certainly taken audio-visuals in their stride, although a video tape projector, say, is far more difficult to acquire, operate and keep in repair than a book. MEDLINE and its predecessor, AIM-TWX, have taught medical librarians to live with computer terminals. Terminals plus audio-visuals can be made to equal CAI. Q. E. D..

There are a number of questions we hope to answer by operating the network. Let me list some of them:

If CAI services are made available over a time-sharing communications network, will people be willing to sample them?

Can the material offered over the network be integrated in a meaningful and useful way into existing curricula? Can it produce measureable benefits? Will it produce changes in the ways medical schools teach?

What is the mechanism whereby new CAI material may be generated most efficiently, and cost effectively?

What is the best mechanism for reviewing and updating material placed on the network to assure quality? We have no assurance that good quality will ensure success; we do know that poor quality will ensure failure.

What is the mechanism whereby gaps in the data base can be identified and filled?

How should the system be organized and managed? What is the best way to ensure interaction between users and providers so that the desires of both will be heard and acted on?

What is the most cost-effective distribution (networking) mechanism?

How can the network be made economically viable, i.e., how can it be placed on at least a partially self-sustaining basis?

A normal scientific paper is divided into four parts: History and Background; Experimental Method; Experimental Results, and; Conclusions. This progress report can give only the first two parts. Perhaps, some day, the paper can be completed.

REFERENCES

1. Stead, E. A., Jr., C. McG. Smythe, C. G. Gunn, and M. H. Littlemeyer. "Educational Technology for Medicine: Roles for the Lister Hill Center." Journal of Medical Education. 46: (7), Part 2, July 1971, pp. 1-97.

VI. PANEL DISCUSSION WITH AUDIENCE PARTICIPATION

The panel consisted of the previous speakers with the addition of Dr. James Griesen from Ohio State University and Dr. Paul Tenczar from the University of Illinois at Champaign-Urbana.

Dr. Tidball: The panel is now open for questions from the audience.

Participant: When the present capacity of the network is exceeded, will the application programs be available for dissemination on other computers?

Dr. Wooster: We are limited by financial reasons to the number of entry ports we currently have. When that capacity is exceeded, there are a number of tricks that we can employ; most of these tend to make trial users second class citizens which is probably a bad idea. If a local CAI fireball has caught a Dean for a 3 p.m. demonstration and he cannot access the system, this has actually happened twice, that is defeating. On the matter of transferability, let me refer you to Dr. Griesen.

Dr. Griesen: There were very few ports at Ohio State until the last couple of months. We seemed to be particularly plagued with compatible, technological problems, and problems of lack of compatibility. It wasn't until February that our system was working to its capacity. We are working on some provisions so that we can control by software the priority for certain ports. Dr. Wooster mentioned the University of Washington; they are engaged in a comprehensive replication and adaptation of our independent Study Program. In this program, students definitely need access to computer based self-evaluation materials. They have 20 students enrolled in a program and these students are pursuing this program for their sole source of basic science education. Now if one of their users is blocked out because all the ports are being used by people who are playing games on our system, we have a real problem balancing quality of use versus freedom to access and play with the system. We hope to control this through software scheduling and having prime hours for certain users. Secondarily, regarding the materials, virtually all of the materials on our smorgasbord are available. We have distributed these materials to over 20 universities, and if you are interested in a particular program, you can write and we will send you a computer tape. Now of course, this presumes that you are also operating a Coursewriter 3 system on IBM equipment. You are also welcome to get prints or any type of version that you would like so that you could adapt to another system. We have had limited success in adapting materials. I must say that the Acid Base Balance Program which we got from Dr. Bleich has been very popular on our system and it took only a moderate amount of reprogramming to make it available on our system. Dr. Bleich has been quite willing to let us redistribute this to Coursewriter users. So there is much more potential in this, than we have engaged in to date. Now the other major category of our CAI material is the self-evaluation system materials that go with our Independent Study Program. We are engaged in a dissemination contract with the Bureau of Health Manpower Education where we are revising all of the materials of the Independent Study Program, including the self-evaluation materials on the computer. These will be available by November. I think the question of transferability is a very tough one. It is much tougher than what most people really give cognizance to. Computer systems and languages really have such individual variations, I would almost be prepared to defend the thesis that transferability would be much better done through networking.

Dr. Tidball: Other comments from the audience.

Dr. Wooster: I would like to ask Dr. Griesen, what has been the utilization of the system from the community hospitals. How many hours are being generated from community hospitals?

Dr. Griesen: In our local state network, the average utilization per hospital per month is somewhere around 100 hours.

Dr. Wooster: Is this participation mainly coming from the health staff or the attending staff?

Dr. Griesen: Neither, it is coming primarily from nurses, med-techs, and other people who are seemingly more in need of this type of training. Some of it is physician usage certainly, but I would have to guess that probably 90% of our hospital utilization does come from nurses and allied health personnel.

Participant: If a student applies to a medical school which has very strong potential in certain areas, but is weak in the specific area the student is interested in, this student can't make a great deal of progress while he is in that medical school unless a computer-assisted education program can resolve this difference. The only other alternatives would be to send the student away from the medical school or give him the learning experience in his internship.

Dr. Griesen: One of the poorest things that we do in medical school is to teach what I call sequential problem solving. Students learn how to make diagnoses but they have difficulty in deciding which information task they should do next. The computer-based instructional system can be useful for this particular activity.

Dr. Tidball: Dr. Tenczar has asked for an opportunity to say a few words about the PLATO system.

Dr. Tenczar: I feel, representing the PLATO system, a little slighted here. You have been talking about the Lister Hill Network; I believe you logged 1500 hours last month. We are going to log 1500 hours today. We are running in 10 states, in 20 different cities, and 50 different buildings and rooms at this present time. We invite you to see our demonstrations later this afternoon.

Dr. Griesen: If the requirement is to integrate CAI into the educational program of the institution, does this really mesh with the requirement to hold Operational Users to the odd hours which may not be the readily accessible student contact hours.

Dr. Wooster: The Trial Users are going to be the ones who get the odd hours. The Operational Users who are integrating the instructional programs into their curriculum will essentially become first class citizens. The Trial Users will be the second class citizens, but you want to give them enough to keep them alive and to encourage them to become Operational Users.

Dr. Tidball: Having been in the situation of being a Trial User, let me share an experience with you. If you have the responsibility to schedule a laboratory on a given afternoon and you expect to have 12 students and 1 computer terminal available for that session, then access to a port becomes pretty critical. I think this is the justification for having Operational Users who already have met the requirements. They should have preference for access to the ports.

Participant: I would like to hear a little more explanation or discussion about the problems of transferability. It is evident that there is going to be a bind on ports. Is it impossible to interpret from one language to another, so that programs can be transferred to other users on different equipment.

Dr. Griesen: The problem of transferability is being studied right now, with respect to some of these problems that you are mentioning. Right now there is a problem of transferring program materials across five major networks which are Dartmouth, North Carolina, Texas, Iowa and Oregon State. The problems that exist in transferability can be based upon the levels of documentation and the kinds of documentation that one provides for a potential user. The difficulty that arises is to identify exactly what the critical factors are in transferability or dissemination. We have both the technological problems and human problems involved. Within the next year or so we hope to have some answers with respect to the general problems of dissemination.

Dr. Wcoster: One of the arguments is whether you should use a CRT terminal or whether you need a high type of printout. My own personal taste is to get a CRT. In a medical school environment on-line printers are almost mandatory for documentation.

Dr. Griesen: I mentioned that when the University of Washington first made a massive site visit to our place and brought 10 or so faculty members and looked at our CAI materials, they felt they could use them as they were. We ended up creating a separate course with their version of our materials, and they are probably making up to 10% change in most of our computer based materials. Similarly the Medical College of Wisconsin and we are engaged in a joint revision of materials partly because we thought they were inadequate for use in their program. So I think that nobody is going to be completely satisfied with the transferability of CAI materials, particularly the tutorial materials.

Dr. Tennyson: Part of the problem in transferability is not just the machine capability, but whether or not someone else is willing to accept some author's interpretation of the material. That is the major problem.

Dr. Wooster: When the network was originally started, my intention was that we would start with the 3 basic units to which we would then add other university computer centers to the network. Basically we had hoped to adapt a variety of services.

Participant: This problem solving is very good. I think that this is one way to instruct the students, but suppose I don't agree with your treatment or diagnosis, through your CAI system, then right away I tell the students I don't agree with that and the credibility of the equipment and program goes down in my estimation or the student's estimation.

Dr. Barnett: Our computer-based educational activity should never be taken as factual. I don't agree with many of those programs myself, but some of the best educational experiences I have had with the students is where we take the program as a starting point and say we don't think what was said there was correct. I think you have an enormously effective way of involving the students in an exercise of trying to think through the problem. Use the computer as a tool and not as the primary teacher.

Dr. Tidball: I believe that the programs at Mass General have been quite responsive to the COMMENT command which is a built-in feature of that system. This encourages students and faculty members to make suggestions and changes in specific programs. These suggestions will be incorporated in to the programs if felt worthwhile. I think this is the real feature of computer assisted education, the ability to refine the teaching instrument and to be responsive to input from other people.

Dr. Seidel: I think there are two kinds of problems which seem to be going in different directions here. One is evaluation as it takes place within the developing institution by the students and the faculty members concerned with a capability. The other problem is how to deal with the transfer of these materials to other institutions. One of the things that will probably help a great deal is to get to the point where network development processes take place with institutional groups of discipline-oriented developers, that is people from different institutions getting together and providing a review and development process of broad areas around the country. You can have in essence a national feedback capability and not depend upon just the immediate developing local institutions to provide you feedback on a given student. Moreover, I think another issue related to transferability is one of getting people to know the material in a reasonably succinct, well-defined environment such as a workshop and provide the capability for people to come and sample the material and interact with the developer. And lastly you also require some sort of training, to implement the material on a given system, to transfer it from one system to another one, and to provide support following implementation or transfer. These will all bear upon whether or not you can get broad, cross-institutional acceptance.

Dr. Tidball: I think that we would all wish that there were more computers on the network, but there are relatively large costs involved in adding computers onto the network. It certainly is very encouraging when you are trying to set up some sort of demonstration, if the system that you want is unavailable to be able by just changing the code letters, to go to another computer where if not the same program, at least a similar program will be available for the student demonstration that you must be able to run at a particular moment in time.

Are there any other comments from the audience? If not, I would like to close this panel discussion with a quotation from Dr. Karl Zinn who is at the University of Michigan, and I think he summarized some of the things that we have been talking about this morning.

> "Although the problems presented here appear to reside in the inadequacies of the computer and information processing systems, for the most part they will not be solved by development of new computer software and hardware alone. Solutions will be achieved only after scholars and educators examine current methods of teaching and research in each discipline and make adaptations for the new age of informatics. Developments in operating systems and language which facilitate a problem orientation of software will encourage the expert but not solve his problems for him. Total reevaluation of the instructional process and the desired objectives for technicians and scholars are in order if the computer and information processing are to find a suitable place in the educational and professional environment." (1).

REFERENCES

1. Zinn, K. L. Interactive Programming Languages Adapted for Specific Instructional Uses. Canadian Symposium on Instructional Technology. Pg. 370, 1972.

PART III. 10-MINUTE PRESENTATIONS OF APPLICATION PROGRAMS

I. A PROGRAM TO TEACH AND DEMONSTRATE CARDIOVASCULAR CONTROL THROUGH SIMULATION

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A computer program which simulates the reflex control mechanisms of the cardiovascular system (CVS) has recently been developed by Dr. C. J. Dickinson of University Hospital in London. This program has been rewritten by the speaker in the MUMPS language and made available over the National Library of Medicine network. Some of the programs available on the network simulate clinical encounters. Other programs are designed to train the user in making a differential diagnosis. The simulations necessarily leave out aspects of the real situation, but do have certain advantages. They enable the student to learn from his mistakes without having a real patient suffer from them, and are able to simulate in a matter of minutes a process which would actually take hours or days.

Demonstration of the relationships between circulatory system variables is important for instruction in cardiovascular physiology and pathophysiology. These variables traditionally include heart sounds, ECG, pressures, flows, and control mechanisms. In most texts they are illustrated as variables simultaneously recorded through a period of time. This static presentation is improved by demonstration, but an ideal situation is difficult to attain.

Demonstration of the CVS can be done with an animal model or an analog or digital computer model. Each model has its own advantages and disadvantages. In an animal model, one can monitor a number of physiological variables such as ECG and various pressures while making changes in the preparation. This model has the advantages of being vivid and alive. Disadvantages are that much time and effort are necessary for such a demonstration, one seldom finds entirely consistent behavior between animals, and only certain changes can be made in any one preparation.

A computer model of the CVS has the advantages of giving consistent behavior, of being easier to work with, and of being able to separate out variables and to perform changes in variables which could not readily be done on an animal. An analog model of the CVS is an electrical model in which the CVS is represented by batteries, resistors, capacitances, current, and voltages. This model can represent more easily such variables as instantaneous pressures and can quickly simulate the CVS without going through a lengthy series of calculations which a digital computer must do. A digital model of the CVS, such as is used by this program, represents the CVS with a series of equations. Advantages of the digital computer over an analog model include the easy verbal interaction between the user and the model, the fact that variables are easily changed and displayed, and the convenience that many people can use the program at the same time if a time-sharing computer system is available.

The cardiovascular simulation program contains many features which allow the demonstration of the responses of the CVS to perturbances. The program simulates a model patient for a period of time and presents a graph of the patient's blood pressure, heart rate, and cardiac output. At the end of the period, patient symptoms (based on the values of the calculated variables) are printed along with values for all of the calculated pressures and flows for both the present and the immediately preceding period. The user is then given a number of options for changing such variables as arterial resistance, venous resistance, cardiac contractility, intrathoracic pressure, cardiac limit pressure, and blood volume. By changing the values of these variables, the user can have the model simulate certain effects on the CVS of hemorrhage, of positive pressure respiration, of drugs, and of exercise. Another option is that of eliminating or restoring the baroreceptor reflex. The baroreceptor can also be reset to mimic essential hypertension or to mimic cut baroreceptor nerves.

An example of some simulated periods can be found in the Appendix. The user has first lowered the blood volume from 5000 to 3500 ml. and then "frozen" the baroreceptor so that the autonomic nervous system activity will not change. As can be seen, this perturbance results in a drop in blood pressure and cardiac output. At the end of the period, the user "unfreezes" the baroreceptor and sees the effect of the baroreceptor reflex to restore blood pressure.

An understanding of the assumptions made by the model is necessary for one to know the limitations of the program as well as which characteristics of the CVS are well presented. The model does not include certain characteristics of the CVS which are involved in long term regulation such as changes in blood volume due to net flow across capillaries, excretion or intake of fluid, the aldosterone regulation mechanism, or antidiuretic hormone. Also not included are autoregulation of blood flow, the renin-angiotensin regulatory system, the Bainbridge reflex, or non-equilibribrium changes in pulmonic and systemic blood flow - all of which are involved in the short term regulation of the CVS. The model used by the program does represent the heart, the peripheral vascular system, and the baroreceptor reflex.

The equations used to represent the peripheral vascular system are seen in Figure 4. The drop of pressure across a given portion of the peripheral vascular system equals the flow times the resistance of that portion. The average venous pressure P_V is a function of venous capacitance, venous filling volume, and blood volume (see Figure 5). In order to compute the pressures and flows, the model uses these equations as well as two curves - one which describes venous return and another cardiac output. The computer solves for the point where cardiac output equals venous return.

PERIPHERAL VASCULAR MODEL

REPRESENTATION IS BY THE FOLLOWING EQUATIONS

$$P_A - P_{CAP} = CO \times R_A$$

$$P_{CAP} - P_V = CO \times \tfrac{1}{2}R_V$$

$$P_V - P_{RA} = CO \times \tfrac{1}{2}R_V$$

$$P_V = (\text{BLOOD VOLUME IN VEINS} - \text{VENOUS FILLING VOLUME}) / \text{VENOUS CAPACITANCE}$$

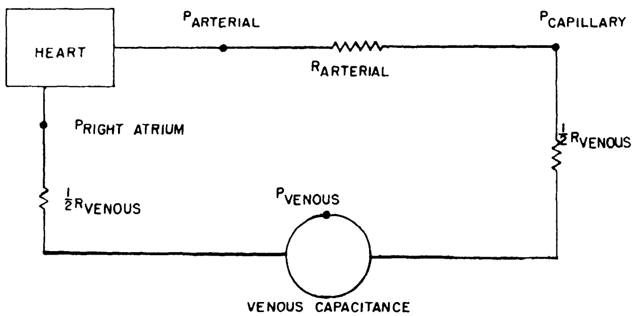

Fig.4. A Schematic Representation of the Model.

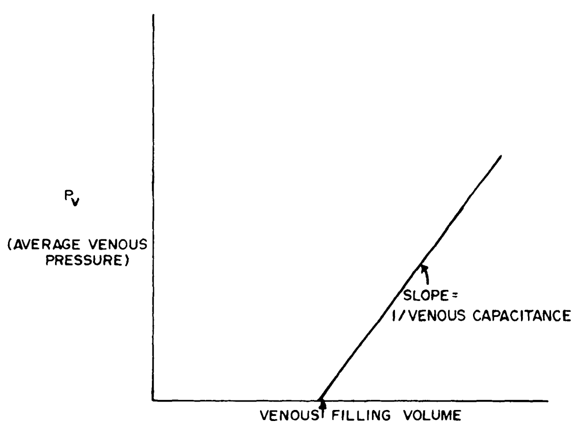

Fig.5. Average Venous Pressure

The venous return curve plots venous return versus right atrial pressure (see Figure 6). If there is no flow, right atrial pressure will equal the average venous pressure P_V. With flow, the right atrial pressure will be lower than P_V by an amount depending upon venous resistance.

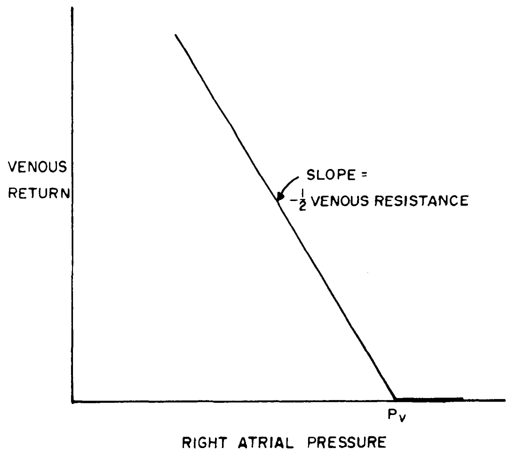

Fig.6. Venous Return Curve

The cardiac output or "Starling curve" (which describes the function of the heart) plots cardiac output versus right atrial pressure (see Figure 7). The curve is defined by the intrathoracic pressure, the cardiac limit pressure, and the cardiac contractility. The model also takes into account the direct effect of arterial pressure on cardiac output. At very high arterial pressures, when there would be an afterload effect, the cardiac contractility is lowered. At very low perfusion pressures, when coronary flow would be decreased, the cardiac contractility is also lowered.

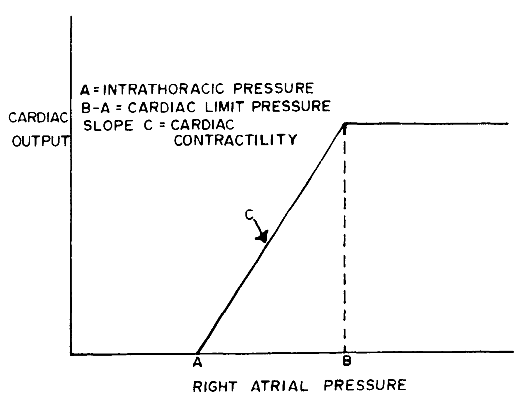

Fig.7. Starling Curve of Cardiac Output

The model simulates the effects of the arterial baroreceptors on the circulatory system (see Figure 8). In response to changes in mean arterial pressure sensed by the baroreceptor, there will be a change in the level of autonomic nervous system (ANS) activity. The level of ANS activity, in turn, affects the values for arterial resistance, venous capacitance, cardiac contractility, and heart rate. For example, if the blood pressure is lowered, the level of ANS activity will rise resulting in an increase in the arterial resistance, heart rate, and cardiac contractility along with a decrease in venous capacitance.

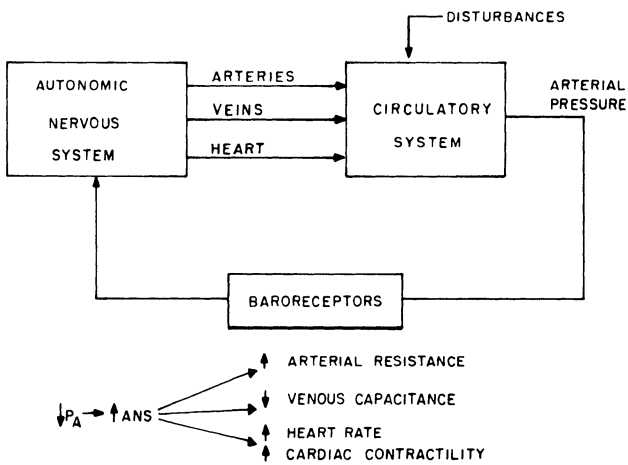

Fig.8. Feedback Control of Arterial Pressure

If the baroreceptor has been reset, the level of ANS activity will react differently to changes in arterial pressure. When the baroreceptor is "frozen" the level of ANS activity will remain constant. If the baroreceptor nerves have been cut, there will be a maximal ANS activity.

Even though it is felt that the program is already a useful learning aid, efforts are being made to make it even more effective. One possibility is to have the program explain verbally which variables are changed and what the response of the CVS is to certain perturbances, for example hemorrhage or a failing heart, and then to go ahead and simulate such a response. Another possibility is to start with a patient with an abnormal cardiovascular system and to have the user try to correct the situation by altering certain variables. Finally the model itself is undergoing modifications so that it will better represent the cardiovascular system and will include regulatory mechanisms other than the baroreceptor reflex.

APPENDIX

```
CARDIAC SIMULATION     04/13/73     4:33 PM

DO YOU WANT INSTRUCTIONS?  N

DO YOU WISH TO CHANGE VARIABLES NOW?  Y

INITIAL VALUES ARE ...
1. ARTERIAL RESISTANCE= 100 %NORMAL
2. VENOUS RESISTANCE=  100 % NORMAL
3. CARDIAC CONTRACTILITY= 100 % NORMAL
4. INTRATHORACIC PRESSURE=  -2 MM  HG
5. CARDIAC LIMIT PRESSURE=8  MM  HG
6. BLOOD VOLUME=  5000  ML

DO YOU WANT TO CHANGE ANY OF THESE VARIABLES?  IF NO,
ENTER "NO".  IF YES, ENTER THE # OF THE VARIABLE YOU
WANT TO CHANGE.

> 6

TYPE IN NEW VALUE FOR FACTOR 6   BLOOD VOLUME  (ML)

> 3500

DO YOU WANT TO CHANGE ANY MORE OF THESE VARIABLES?

> N

DO YOU WANT TO CHANGE BARORECEPTOR?

> Y

IF YOU WANT TO CUT BUFFER NERVES, ENTER "BUF".
IF YOU WANT TO RESET BARORECEPTOR  TO CHRONIC HYPERTENSION,
ENTER "HYPER".  IF YOU WANT TO FREEZE THE BARORECEPTOR
ENTER "BARO".  ELSE ENTER "NO".

> BARO

BARORECEPTOR FROZEN AT PRESENT LEVEL
   SYSTOLIC (S) AND DIASTOLIC (D) PRESSURES - MM HG
    HEART RATE (.)
   CARDIAC OUTPUT (C) - DECILITERS/MIN
 TIME 0  20  40  60  80  100  120  140  160  180  200  220  240  260  280 300
 SECS .   .   .   .   .   .    .    .    .    .    .    .    .    .    .   .
0              C               S<<<
2          C D    S .
4          C D    S .
6          C D   S .
8          C D    S .
F
10         C D    S .
```

```
   I AM VERY TIRED AND EXHAUSTED...I DON'T FEEL LIKE DOING
      ANYTHING
   I FEEL AS IF I AM GOING TO DIE.  MY EYES ARE GOING DARK...

YOUR PATIENT IS PASSING HARDLY ANY URINE

BP SYSTOLIC= +65.35 (+121.92)  DIASTOLIC= +40.94 (+76.58)
MEAN BP= +49.08 (+91.69)  MM. HG
RIGHT ATRIAL PRES. = +0.10  (+1.79)  MM. HG
MEAN CAP.  PRES. = +6.02 (+12.66)  MM. HG
PRES.  ACROSS PULMONARY CAP. = +6.99 (+12.78)  MM. HG
CARDIAC OUTPUT= +2.69 (+4.94) L/MIN STROKE VOL. = +37.21
   (+68.06)  ML
HEART RATE= +72.32 (+72.58)
ART.  RESIST.= +16.00 (+16.00) VEN.  RESIST.= +2.20 (+2.20) MM
   HG/L/MIN
CARDIAC CONTRACTILITY= +1.28 (+1.30)  L/MIN/MM  HG FILLING
   PRES.
AVG.  VEN.  PRES. = +3.06 (+7.22)  MM HG

VALUES FOR THIS RUN WERE ...
1.  ARTERIAL RESISTANCE= 100 % NORMAL
2.  VENOUS RESISTANCE= 100 % NORMAL
3.  CARDIAC CONTRACTILITY= 100 % NORMAL
4.  INTRATHORACIC PRESSURE= -2 MM HG
5.  CARDIAC LIMIT PRESSURE= 8  MM HG
6.  BLOOD VOLUME= 3500 ML

DO YOU WANT TO CHANGE ANY OF THESE VARIABLES?

>N

DO YOU WANT TO CHANGE BARORECEPTORS?

>Y

IF YOU WANT TO CUT BUFFER NERVES, ENTER "BUF".
IF YOU WANT TO RESET BARORECEPTOR TO CHRONIC HYPERTENSION,
ENTER "HYPER".  IF YOU WANT TO UNFREEZE THE BARORECEPTOR
ENTER "BARO".  ELSE ENTER "NO".

> BARO

BARORECEPTOR ACTIVITY BACK TO NORMAL
  SYSTOLIC (S) AND DIASTOLIC (D) PRESSURES - MM HG HEART
    RATE (.)
  CARDIAC OUTPUT (C) - DECILITERS /MIN
  TIME 0  20  40  60  80  100  120  140  160  180  200  220  240  260  280 300
  SECS .   .   .   .   .   .    .    .    .    .    .    .    .    .    .   .
10          C  D   S.
12          C  D   S.
14          C  D   S.
16          C  D   S.
```

```
18           C  D    S.
20            C D     S .
22            C D     S  .
24            C   D    S  .
26            C   D    S    .
28            C   D    S    .
30            C   D    S     .
32            C    D    S     .
34            C    D    S     .
36            C    D    S      .
38            C    D    S       .
40            C    D    S       .
F
42            C    D    S        .
```

I FEEL FAINT WHEN I TRY TO STAND UP
I FEEL BETTER BUT NOT RIGHT YET. CAN'T YOU DO SOME THING ELSE FOR ME

BP SYSTOLIC= +81.52 (+65.35) DIASTOLIC= +56.37 (+40.94)
MEAN BP= +64.75 (+49.08) MM. HG
RIGHT ATRIAL PRES.= -0.11 (+0.10) MM. HG
MEAN CAP. PRES. = +6.66 (+6.02) MM. HG
PRES. ACROSS PULMONARY CAP. = +8.37 (+6.99) MM. HG
CARDIAC OUTPUT= +3.08 (+2.69) L/MIN STROKE VOL. = +25.10 (+37.21) ML
HEART RATE= +122.68 (+72.32)
ART. RESIST. = +18.87 (+16.00) VEN. RESIST. =+2.20 (+2.20) MM HG/L/MIN
CARDIAC CONTRACTILITY= +1.63 (+1.28) L/MIN/MM HG FILLING PRES.
AVG. VEN. PRES. = +3.27 (+3.06) MM HG

VALUES FOR THIS RUN WERE ...
1. ARTERIAL RESISTANCE= 100 % NORMAL
2. VENOUS RESISTANCE= 100 % NORMAL
3. CARDIAC CONTRACTILITY= 100 % NORMAL
4. INTRATHORACIC PRESSURE= -2 MM HG
5. CARDIAC LIMIT PRESSURE= 8 MM HG
6. BLOOD VOLUME= 3500 ML

DO YOU WANT TO CHANGE ANY OF THESE VARIABLES?

>

II. ELECTROLYTE AND ACID-BASE EQUILIBRIUM

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Previous studies have demonstrated the feasability of using a time-shared computer to assist the physician in the evaluation of acid-base disorders (2, 4, 5). More recently, an effort has been made to broaden the applicability of the program to other electrolytes (1, 3). The program accepts clinical and laboratory data and generates in return an evaluation note designed to review with the physician the pathophysiology of the disorders and to assist him in their management. The purpose of the electrolyte and acid-base program is to provide the physician with on-the-job education in a form considered to be useful in solving selected clinical problems.

The program is written in the MIIS dialect of MUMPS, a string-manipulating interpretive language that runs on a PDP-15 computer. The program consists of two sections, one containing instructions to the computer and the other containing a bank of English text. The instructions collect input data, perform calculations, and select and arrange appropriate text strings that are then interleaved with excerpts from the patient's data and printed in the form of an evaluation note.

Distributed throughout the text are inserts that permit the program to modify the evaluation note for a particular patient. Insertion of given or calculated numbers permits adjustments of dosages. Insertion of words such as "relatively," and "probably" shades the meaning of borderline conclusions; other insertions may substantially alter or completely reverse the meaning of the text string. The purpose of the program is to act as a personalized textbook that presents to the physician only those excerpts from the medical literature that pertain to his patient, and to potentiate the usefulness of this information by interleaving it with given or derived information from the data base.

The program may be used from any teletype or teletype-compatible terminal that can be connected to the Bell Telephone System. When the terminal is activated and the program is called the computer transmits electrolyte and acid-base evaluation, the date, the time, and then asks for the serum electrolytes in m Eq/L (Figure 9). After typing "Na =" the computer pauses while the user makes a response. If he knows the serum sodium concentration he types the number, and then pushes an enter button, whereupon the program advances to a request for the potassium concentration. If he did not know the potassium concentration, he would push only the enter button. If he makes a mistake in typing the value, he could erase with a rub-out button, or, as shown in the example, if the value is clearly incompatible with life, the program will ignore it and repeat its request.

ELECTROLYTE AND ACID-BASE EVALUATION JUL 5, 1973 12:37 PM
SERUM ELECTROLYTES (MEQ/L):

NA = 142

K = 2.8

CL = 92

CO^2T = 36

BLOOD PH = 7.48

BLOOD PCO^2 = 48 (CALCULATED FROM CO2T AND PH)

PATIENT'S WEIGHT (IN POUNDS) = 130

IS THERE CLINICAL OR RADIOLOGIC EVIDENCE OF CONGESTIVE

HEART FAILURE?... NO

IS THERE PITTING EDEMA?... NO

IS THERE EVIDENCE OF DEPLETION OF EXTRACELLULAR FLUID

VOLUME?... NO

SERUM CREATININE (MG%) = 1.2

BLOOD SUGAR (MG%) = 112

24 HOUR URINARY POTASSIUM EXCRETION (MEQ/DAY) = 56

HAS HYPOKALEMIA BEEN PRESENT FOR LONGER THAN 2 WEEKS?
... YES

DOES THE PATIENT HAVE SEVERE LIVER DISEASE?... NO

Fig.9. Entry of patient's data. Underlined information was typed by the physician, everything else by the computer. Not shown in the figure are the ways in which the program processes entries that violate required syntax, that are incompatible with life or that are inconsistent with information entered previously.

When sufficient information has been provided the program computes the concentration of unmeasured anions, defined here as the sum of the concentrations of sodium and potassium, minus those of chloride and total CO_2 content. If the anion gap were too small, a polite comment would call attention to the incompatibility and would request the electrolytes again. If the anion gap is normal, the program proceeds without incident. If blood pH is provided, it, together with the total CO_2 content and a form of the Henderson-Hasselbalch Equation are used to calculate the partial pressure of carbon dioxide. If the user were to enter a value that is not in close agreement with this calculated value, the program would make an explanatory comment and would ask for resolution of the discrepancy. If, on the other hand, he presses only the enter button, indicating that he did not measure pCO_2, the computer uses the space to print its calculated value.

The program then characterizes the type and severity of each component of the electrolyte and acid-base disorder. It then asks questions concerning renal function and extracellular fluid volume, followed by whatever additional questions may be needed to determine proper therapy. As soon as its demands have been satisfied, the program prints its analysis (Figure 10 & 11). If the output terminal is equipped for high speed transmission, the entire evaluation can be displayed within seconds. The evaluation begins by defining the components of the electrolyte and acid-base disorders. It then provides a list of diagnostic possibilities, a brief discussion of suggested therapeutic measures, and a small number of pertinent references to the medical literature.

In its present form, the program will process data concerning any combination of electrolyte and acid-base disorders. The data may be presented spontaneously in any order desired or each piece of information may be entered when requested by the program. In either case the data will be checked for evidence of internal inconsistency and additional information will be requested as needed to solve the electrolyte and acid-base aspects of the clinical problem. If certain requested data are not available, the program is designed to draw the most useful conclusions possible based on the data provided, to specify the limitations which pertain to these conclusions, to suggest diagnostic tests designed to circumvent these limitations, and, while awaiting the results, to suggest interim therapeutic measures. The time required to use the program with a Model 33 teletype terminal is approximately 7 minutes.

Experience with the program in our hospital reveals a number of cases in which patient care was favorably influenced (3). On one occasion physicians had decided to administer hypertonic saline to a hyponatremic patient until advised by the program to restrict fluids instead. Consultation was requested, and the latter course adopted. The renal service has received numerous consultations after the program revealed a problem not previously appreciated by the physicians. At times the program outperforms its inventor; it was, after all, written during his lucid intervals, while relevant literature was on his desk, while physicians more knowledgeable than he were nearby.

The generation and continual revision of such a program demands that the actual process of clinical decision-making be formulated with utmost precision. Such a precise formulation requires that the investigator clearly distinguish what is known from what is assumed, and it thus serves as a stimulus to define additional areas where clinical or laboratory research remains to be done.

EVALUATION NOTE

THE PCO^2 OF 48 MM HG AND PH OF 7.48 UNITS ARE COMPATIBLE WITH UNCOMPLICATED METABOLIC ALKALOSIS. THE MOST COMMON CAUSES OF METABOLIC ALKALOSIS ARE:

1) VOMITING OR GASTRIC ASPIRATION

2) DIURETIC THERAPY (THIAZIDES, MERCURIALS, ETHACRYNIC ACID, OR FUROSEMIDE)

3) HYPERADRENALISM (CUSHINGS SYNDROME, PRIMARY OR SECONDARY ALDOSTERONISM, ADRENAL STEROID THERAPY) OR LICORICE INGESTION

4) EXCESSIVE ALKALI INTAKE (ALKALOSIS USUALLY TRANSIENT)

5) POST HYPERCAPNIA (PARTICULARLY IF CHLORIDE INTAKE IS SMALL)

6) HYPERCALCEMIA (POSSIBLE -- LITERATURE NOT CLEAR)

7) BARTTER'S SYNDROME (A RARE DISORDER CHARACTERIZED BY HYPOKALEMIA, HYPOCHLOREMIA, METABOLIC ALKALOSIS, AND, IN SOME INSTANCES, HYPONATREMIA, SHORT STATURE, AND MENTAL RETARDATION)

IF HYPERADRENALISM IS ABSENT IT SHOULD BE POSSIBLE TO CORRECT THE METABOLIC ALKALOSIS BY ADMINISTERING SUFFICIENT CHLORIDE TO REPLACE PREVIOUS LOSSES AND TO ALLOW A URINARY CHLORIDE EXCRETION OF AT LEAST 10 TO 20 MEQ PER DAY. IN AN EFFORT TO ACHIEVE THIS GOAL IT IS SUGGESTED THAT, IN ADDITION TO REPLACING KNOWN CHLORIDE LOSSES, 120 MEQ OF SODIUM, POTASSIUM, OR AMMONIUM CHLORIDE BE GIVEN DURING THE NEXT 24 HOURS, AND THAT SERUM ELECTROLYTES AND BLOOD PH BE MEASURED AT LEAST DAILY UNTIL SIGNIFICANT IMPROVEMENT IN THE ACID-BASE ABNORMALITY OCCURS.

Fig. 10. First section of evaluation note generated by the program immediately after the last entry was made in Figure 9. Since the patient is an adult (weight = 130 pounds), the suggested dose of sodium bicarbonate (usually somewhat less than the estimated deficit) is rounded off to the nearest ampule. Note that the program does not attempt to make a diagnosis, but rather it provides a differential list for consideration by the physician.

THE FINDING OF A LOW SERUM POTASSIUM CONCENTRATION (K = 2.8 MEQ/L) INDICATES THAT BODY POTASSIUM STORES HAVE BEEN SIGNIFICANTLY DEPLETED. FURTHERMORE, THE FINDING OF SIGNIFICANT URINARY POTASSIUM EXCRETION (56 MEQ/DAY) IN A PATIENT WHOSE POTASSIUM DEPLETION HAS BEEN PRESENT FOR AT LEAST 2 WEEKS INDICATES THAT RENAL POTASSIUM CONSERVATION IS IMPAIRED. COMMON CAUSES OF RENAL POTASSIUM WASTING INCLUDE, IN ADDITION TO THE CAUSES OF METABOLIC ALKALOSIS, OUTDATED TETRACYCLINE, RENAL TUBULAR ACIDOSIS (NOT PRESENT HERE), AND THE DIURETIC PHASE OF ACUTE TUBULAR NECROSIS.

IN AN EFFORT TO REPAIR THE POTASSIUM DEFICIT SIMULTANEOUSLY WITH THE METABOLIC ALKALOSIS IT IS SUGGESTED THAT, IN ADDITION TO REPLACING ANTICIPATED POTASSIUM LOSSES AT LEAST 60 MEQ OF THE CHLORIDE RECOMMENDED ABOVE BE ADMINISTERED AS POTASSIUM CHLORIDE. BECAUSE OF THE SEVERITY OF THE HYPOKALEMIA (K = 2.8 MEQ/L), THIS SHOULD PROBABLY BE DONE WITHIN THE NEXT 12 HOURS AND SERUM ELECTROLYTES MEASURED AGAIN AT THAT TIME.

THANK YOU FOR REFERRING THIS INTERESTING PROBLEM TO US.

REFERENCES:

1. GOLDRING, R.M., CANNON, P.J., HEINEMANN, H.O., AND FISHMAN, A.P. RESPIRATORY ADJUSTMENT TO CHRONIC METABOLIC ALKALOSIS IN MAN. J. CLIN. INVEST., 47, 188, 1968.
2. BEESON, P.B. AND MCDERMOTT, W. CECIL-LOEB TEXTBOOK OF MEDICINE. 13TH EDITION (1971), P.1628.
3. GARELLA, S., CHAZAN, J.A., AND COHEN, J.J. SALINE-RESISTANT METABOLIC ALKALOSIS OR "CHLORIDE-WASTING NEPHROPATHY." ANN. INT. MED., 73: 31, 1970.
4. SCHWARTZ, W.B. POTASSIUM AND THE KIDNEY. NEW ENG. J. MED., 253, 601, 1955.

Fig.11. Remainder of evaluation note. References are listed in the order in which the medical decisions to which they pertain are found in the evaluation note.

Finally, this program was developed, not to circumvent the need for a thoughtful clinician, but rather to provide the student, house officer and practicing physician with a continual source of stimulating instruction. The purpose has been to develop an educational tool, one which is as reliable as it is indefatigable, and which is particularly effective because it relates what it teaches to a current clinical problem.

REFERENCES

1. Bleich, H.L. Computer-based Consultation. Am. J. Med. 53: 285, 1972.

2. Bleich, H. L. Computer Evaluation of Acid-Base Disorders. J. Clin. Invest. 48: 1689, 1969.
3. Bleich, H. L. The Computer as a Concultant. New Engl. J. Med. 284: 141, 1971.
4. Goldberg, M. et al. Computer-Based Instruction and Diagnosis of Acid-Base Disorders: A Systematic Approach. J. Am. Med. Assoc. 223: 269, 1973.
5. Schwartz, W. B. Medicine and the Computer. New Engl. J. Med. 283: 1257, 1970.

III. INTERACTIVE TEACHING MODULES FOR ANIMAL BEHAVIOR ON THE PLATO IV SYSTEM

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Introduction

Computer-based education in the biological sciences on the PLATO systems at the University of Illinois dates back to 1968. Two general courses in genetics and evolution have been offered using PLATO III (10). PLATO III and IV programs have been used as adjuncts to other courses in population genetics (3), agricultural breeding (6), veterinary bacteriology (5), demography (7), and introductory biology (2, 12). The PLATO IV system (1) incorporates advances in system software and hardware which promise to make it especially appropriate for the graphic, dialogic and branching operations necessary for producing dynamic, interactive and creative biological courseware. This paper describes some of the newest PLATO IV modules that have been developed by the authors in the area of animal behavior. All have been used in preliminary voluntary class sessions and have received favorable student responses.

Invertebrate Behavior - Klinokinesis

Undirected locomotor reactions form the bulk of the "wired in" behavior of many lower animals. Undirected reactions, where the speed of locomotion or frequency of turning depend upon stimulus intensity, are called ortho- and klinokinesis, respectively (4). A detailed computer simulation study of kineses, for research purposes was performed by Rohlf and Davenport (13).

The PLATO IV module, KINESIS, uses a computer model of the klinokinetic response similar to Rohlf and Davenport's. It is imbedded, however, in a teaching strategy which incorporates 1) introductory lesson material, 2) implicit demands for the collection of an adequate sample size during the investigation, 3) explicit instructions in the appropriate application of the chi-square test, and 4) remedial sequences designed to elevate each student to a level of understanding where the lesson material is meaningful.

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KINESIS allows the student to specify stimulus characteristics for a temperature gradient chamber plotted on the PLATO IV screen. A computer-generated "bug" is then assigned the type of response (repulsion or attraction) to be shown toward the stimulus. At the student's command, the bug is released in the center of the chamber and allowed to take 50-100 animated steps before the trial is terminated. A typical trial with associated track is shown in Figure 12. After each trial, HELP and statistical test options are available. The HELP explains some of the parameters of the experiment. The statistics option allows the student to enter his orientation data (lower left corner of Figure 12) into a 2x2 table for chi-square analysis. With a small sample size, a significant orientation response is not apparent. Instead of being told he is wrong, the student simply discovers that he cannot reject the null hypothesis of random orientation with the information currently at hand, and he is directed back to the temperature gradient chamber to collect more data. Success comes after 25-30 trials and the student is then given a chance either to recycle through the lesson and change stimulus and response characteristics, or to proceed with questions related to the exercise. Sheets on which data are to be recorded and questions for further study are presented in a printed laboratory manual.

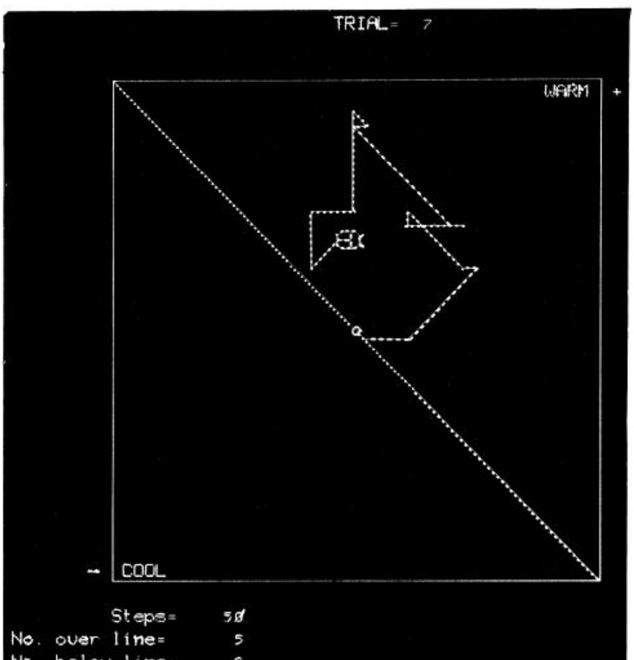

Fig.12. Pathway taken by simulated "bug" based upon a simple kinetic model. The bug started at "0" and took 50 steps. The student previously defined the warm end of the gradient as "attractive" to the bug. The diagonal divides the chamber equally and is the expected 50:50 line.

Social Organization - Personal Space

As an introduction to social behavior, a PLATO IV module named BIRDS is offered. The teaching scheme is built around a model which simulates the simple type of aggression which occurs during the establishment of the "free space" or "personal distance" maintained by an animal as it moves about. The dimensions of individual distances have been shown to be variable, yet quantifiable (9, 11).

The BIRDS module presents introductory material which is followed by a graphic "fence" plotted on the PLATO IV screen. By pressing keys on the keyset, the student can land birds on the fence and make observations of the resulting behavior. The fence, with some interacting birds, is shown in Figure 13. Note well that the aggressive response is a dynamic one which exploits the animation and special character plotting capabilities of the PLATO IV system. The student-PLATO relationship is highly interactive and attention is high. A diagram of the model is available from the authors on request.

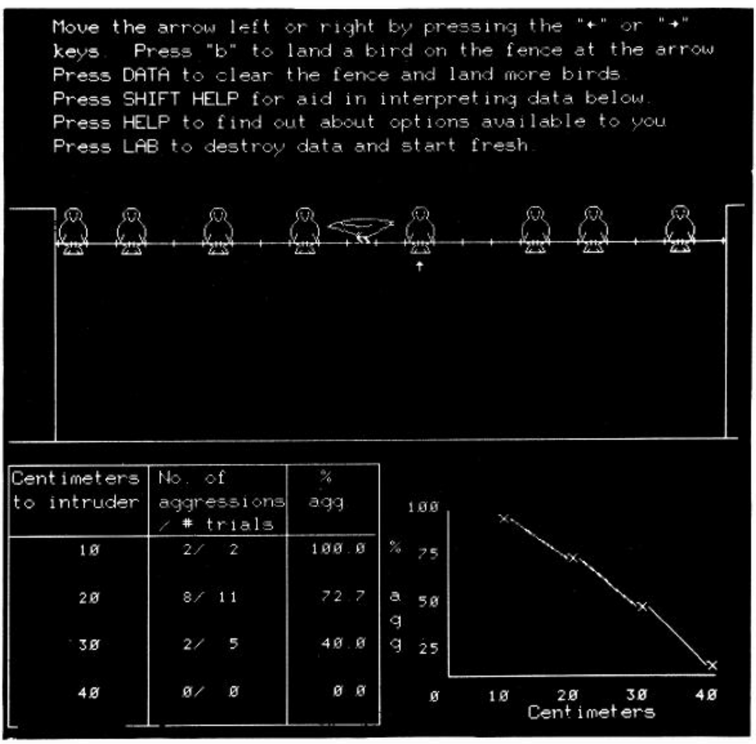

Fig.13. Aggressive interaction between two birds on a fence. Cumulative data based upon all previous interactions are shown in table at bottom left, and graphed at lower right. See text.

The displays at the bottom of Figure 13 are recomputed and replotted each time a bird lands on the fence. The tabulated information is graphed immediately to the right of the table, so that the cumulative results of the interactions observed by students are immediately brought to their attention. A separate, printed laboratory manual contains blank tables and graphs, as well as questions, for the student to answer.

Social Organization - Imprinting

The imprinting phenomenon in some birds and mammals has been observed for years. The studies of several ethologists have shown that the imprinting process is different from association learning in many ways. Imprinting is a special type of learning which fulfills two very vital functions. Social cohesiveness, necessary for the survival of social species, results from young animals imprinting upon their parents or members of the group. Food imprinting, toward natural food early in life, assures the ingestion of appropriate nutritional substances.

The IMPRINT module examines social imprinting in chickens in some detail. Six options are available for study. The first three options examine the time-course of imprinting when a chick is presented with conspecific, counterspecific and inanimate parent objects, respectively. The fourth option examines sexual behavior in a mature rooster consequent to normal and abnormal imprinting experiences. The fifth and sixth options demonstrate the effects of negative reinforcement and drug administration on imprinting. All options are presented to the student as inquiry problems with the computer being used to graphically display an arena containing interacting parents and chicks. Experimental parameters are specified by the student and the computer shows the resulting animated behavior. The student records his observations in a manual and uses the computer to construct graphs based upon imprinting trials. One of these graphs is shown in Figure 14.

Learning

A PLATO IV module entitled MOUSE introduces students to some basic concepts of nonverbal learning by simulating an operant conditioning laboratory. Three options are available. The first option presents on the PLATO screen an overhead view of a small rodent moving about in an enclosed area. By pressing a key, the student causes "food pellets" to be deposited in one corner of the experimental area. The "noise" of the operation of the food magazine can also be produced by another key which does not add food to the "cage." By manipulating these two keys, the student is able to determine that, other than producing an initial display of curiosity, the operation of the food magazine alone has no reward value to the mouse. However, when operation of the magazine always produces food, skillful scheduling of key presses will quickly produce behavior which suggests that the sound of the magazine operation has gained secondary reward characteristics. Following proper magazine training the mouse visits the corner of the cage where food is deposited only after "hearing" the food magazine operate. After initial training of his computer mouse, the student is free to shape any pattern of movement desired (including bar-pressing on a variety of fixed-ratio schedules).

Highly complex patterns may be taught by judicious reinforcement of behavior added to simpler chains of movements. Ritualistic behavior, extinction, and forgetting also appear as in an actual conditioning session for a real animal.

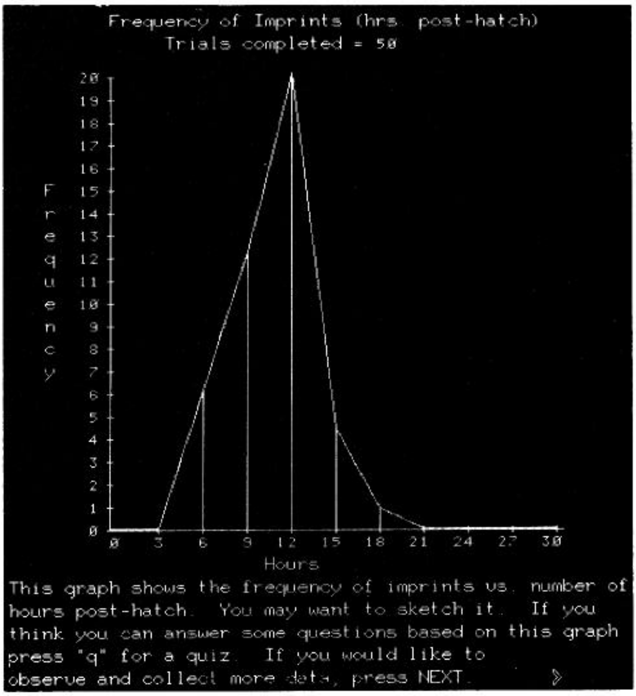

Fig.14. Summary graph of critical period data for 50 imprinting trials. Questions on interpretation follow the graph.

The second option of MOUSE permits the student to observe cumulative response curves such as those resulting from bar-pressing by rats or pecking by pigeons. The student may select a "pure" reinforcement schedule (i.e., fixed ratio, variable ratio, fixed interval, or variable interval) to be applied to an animal pretrained under some specified schedule. Cumulative response curves for the animal are then generated on the PLATO screen at a rate close to that which would be expected for a pecking response in a pigeon. Scalloping and abulia typical of large value FI and FR schedules (Figure 15) are readily demonstrated as are the transitional behaviors produced when shifting from one schedule to another.

The third option of MOUSE lets the student view the conditioning situation from the viewpoint of the experimental animal. A schedule of reinforcement is randomly selected by the computer and the student is asked to try to discover the most efficient pattern of "bar presses" on his keyset in order to make the word "yes" flash on his PLATO screen. This option quite effectively demonstrates that the characteristic response patterns seen in animals under certain reinforcement schedules are usually rather efficient procedures for maximizing reward while minimizing effort or time.

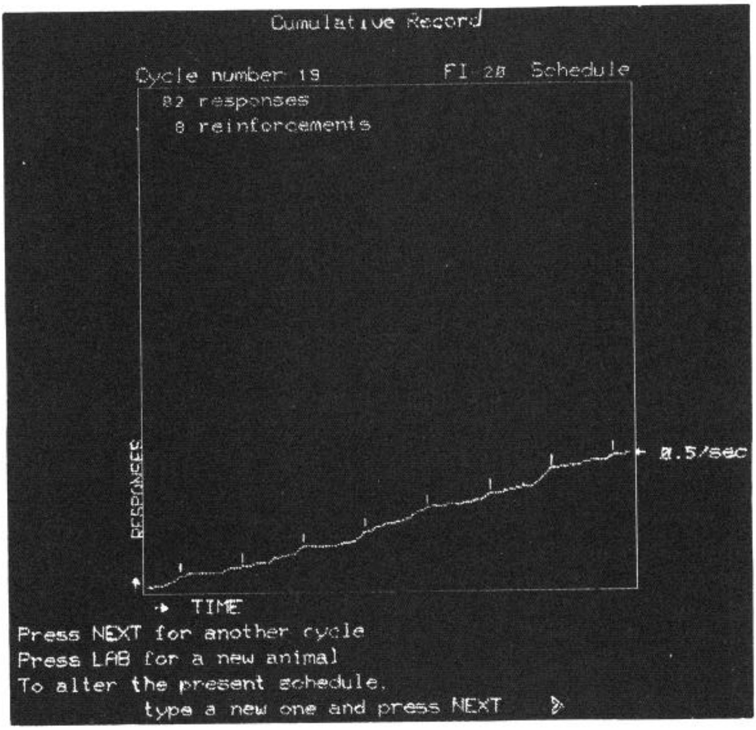

Fig.15. Scalloping of response curve under a FI-20 reinforcement schedule.

The Role of Integrated Teaching Aids

A significant part of our effort is directed toward the production of teaching aids to accompany the computer programs. So far these aids appear as remedial units or sequences presented by the computer when needed, or as printed manuals. The length and depth of each form are highly variable, but each type seems to perform a distinct role.

The remedial (HELP) sequences, accessed by pressing a key labelled HELP, provide immediate perspective to problems that a student may encounter. HELP can be voluntary, or, if multiple errors have been made, a student may be automatically branched through the remedial information. Usually HELP serves to bring students to a level of competence where they can continue with the lesson.

The printed manuals, to date, have been divided into three sections, viz. an introduction, a "how to use the lesson" section, and a section of exercises or problems to be solved using the program. Students enjoy tangible items that can be carried away from the terminal for later study. The manuals provide a place to record data and make notes. They contribute, along with outside readings and "wet" lab exercises, to an attention-holding, multimedium diversity.

"Entia non sunt multiplicanda praeter necessitatem"* - or
A Practical Approach to Teaching Via Computer-Based Simulation

Simulations presented via computer range in complexity from simple "canned" routines which provide a single, fixed example of behavior (much like that provided by an "educational" movie), to real-time implementations of theory. There may be distinct advantages to simulation that go beyond the minimum requirements for a particular instructional sequence. For example, the chance to interact with a complex model may provide a student with his first exposure to the usefulness of a planned series of experiments as opposed to random probes. Also a complete model permits more sophisticated students to move well beyond the minimum instructional requirements. Nevertheless, there is a place for Occam's Razor in computer-based education. There is no standing rule which says that what a student experiences as computer-generated output must be produced from "first principle" computation. The teacher-programmer may utilize approximate algorithms on occasion to produce the effect desired for a student's learning experience. In many cases nothing is gained pedagogically by basing the simulation on "first principles" rather than a simpler approximation. For example, the IMPRINT module uses an approximation (8) of the binomial distribution to produce variation in the critical period data. The same approximation is used in a biology exercise in probability and genetics which involves simulating the flipping of a coin many times to determine the ratio of heads to tails. In this case, the literal application of the model would require the computer to randomly generate a 2-valued number for each flip. Unfortunately, the PLATO IV computer using a random number procedure would spend from 3 to 5 seconds for every 10,000 flips. Such a load could not be tolerated on a system designed to permit the simultaneous operation of thousands of students with the rapid response times necessary for highly interactive instruction. In actual practice, nothing is lost by using a simple approximation to the normal distribution. The student can still interact to the same extent with this demonstration sequence and see results which obey the same ultimate principles, yet the computational load is reduced to negligible proportions.

More complex simulations require a somewhat different implementation of Occam's parsimony. Unlike systems obeying the laws of the physical sciences, few biological systems of any complexity are easily described by a single equation. At the same time, simulation of a complex biological system virtually demands the use of some real-time model, if only because

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*A statement attributed to William of Occam (1280-1349). Known as Occam's Razor, it is loosely translated as "Don't make things more complex than necessary."

the sheer number of possible outcomes makes storage of a finite number of predetermined sequences unmanageable. Fortunately, much simple behavior can be approximated by rather straightforward probabilistic models. The KINESIS module, which permits the student to adjust model parameters, is based on one such probabilistic model.

The option of the MOUSE module which permits real-time generation of cumulative response curves is based on a simple probabilistic model which is less obvious. The probability of a "response" (an upward jog in the response curve) at any given moment is a joint function of crude measures of the expected value and dispersion of the time-delay and number of responses between past reinforcements. One part of the program doles out "reinforcements" whenever the conditions specified by the student are met. Another part of the program makes "responses" as a function of the time-delay (or number of responses) since the last reinforcement and the respective average values for these measures based on past "experience." "Time-delay" or "number of responses" gains control over the response probability in inverse relation to the amount of variation in past experiences. Thus, on a fixed-ratio schedule, dispersion of "number of responses between each reinforcement" quickly becomes zero and ratio-schedule behavior takes over. This simple model was derived by considering the data that a real animal would use to maximize its rewards. An attempt to derive a set of models designed only to superficially imitate the response curves characteristic of each reinforcement schedule would probably have yielded a far more cumbersome computer program.

Our most complex simulation, that which attempts to mimic complex learning in a rodent, is an even clearer example of the relationship between parsimony and reality. It would be virtually impossible to produce an interactive yet realistic simulation of this nature by piecing together a large variety of pre-programmed strings of behavior. In the face of such complexity the only realistic approach involves the design of a model which seeks to imitate not only the face of reality but also the logic. Thus, in the case of MOUSE, the model requires an alterable "memory" and a minimal repertoire of "innate" behaviors (such as random exploration in the absence of information). Yet, despite the growing similarity between model and theory as complexity of simulated behavior decreases, some basic differences remain. Most important is the fact that no simulation has to duplicate all aspects of an animal's behavior. Nor does the model have to correspond in its implementation to the structure of a believable theory of, say, animal behavior. Thus, we do not have to discover the precise model which correctly describes how and why real organisms behave, but only a model which produces realistic data in a limited range of situations. In general, the illusion of the phenomenon is just as pedagogically sound as direct computation. This rationale can pay important dividends of time and efficiency in computer-based teaching, especially where smaller, slower "minicomputers" are used.

ACKNOWLEDGEMENTS

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REFERENCES

1. Alpert, D., and D. Bitzer. Advances in Computer-Based Education. Science 167: 1582, 1970.
2. Arsenty, R. P., and G. H. Kieffer. An evaluation of the teaching effectiveness of PLATO in a first level biology course. CERL Report X-32, December 1971.
3. Chirolas, D., and M. Grossman. Computer assisted instruction in teaching population genetics. J. of Heredity 63: 145, 1972.
4. Fraenkel, G. S., and D. L. Gunn. The Orientation of Animals - Kinesis, Taxes and Compass Reactions. Dover, New York, 1961.
5. Grimes, G. M., H. E. Rhoades, F. C. Adams, and R. V. Schmidt. Identification of bacteriological unknowns: A computer-based teaching program. J. Medical Ed. 47: 289, April, 1972.
6. Grossman, M., and D. Chirolas. Computer assisted instruction in teaching quantitative genetics. J. of Heredity (in press), 1973.
7. Handler, P., and J. Sherwood. The PLATO system population dynamics course. Population Dynamics, Academic Press, New York, 1972.
8. Hastings, C., Jr. Approximations for Digital Computers. Princeton, New Jersey. Princeton University Press, 1955.
9. Hinde, R. A. Behaviour of the great tit (Parus major) and some other related species. Behaviour Suppl. 2: 1, 1952.
10. Hyatt, G. W., D. C. Eades, and P. Tenczar. Computer-based Education in Biology. BioScience 22(7): 401, 1972.
11. Marler, P. Studies of fighting in chaffinches. (3) Proximity as a cause of aggression. Brit. J. Animal Behav. 4: 23, 1956.
12. National Science Foundation. Is the computer ready to teach? Mosaic 3(3): 13, summer, 1972.
13. Rohlf, F. J., and D. Davenport. Simulation of simple models of animal behavior with a digital computer. J. Theoret. Biol. 23: 400, 1969.

IV. SIMULATION OF EXCITABLE MEMBRANE EXPERIMENTS

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The teaching responsibilities of our department include the common problem children: 1) a large undergraduate course for non-majors; 2) a medical school course; 3) a large advanced undergraduate course; 4) first year graduate survey courses. Each of these has their own special characteristics but they share the difficulties of teaching a spectrum of students - some of whom expressly would rather be doing something else, while some others would rather do nothing else. The latter are the fewest, with the bulk of students ambivalently sitting somewhere in between. Specifically, our work with the Plato IV system came out of our interest in improving our large undergraduate course. The responsibility for this course is presently shared by Drs. E. Jakobsson and L. Barr. At the beginning of our involvement, the course had a traditional two hours/week lecture, two hours/week laboratory, and two hours/week discussion format. It was respected on the campus for its high academic standards and treated roughly by student opinion. The main problems, as we saw them, in our elementary course were: 1) the students had difficulty knowing what the faculty wanted of them; 2) many students were too hostile to both the subject matter and the faculty; 3) the lectures, as teaching tools, were of questionable value; 4) less laboratory work was done than was intended; moreover, that done was performed and understood only by a small aggressive minority.

A description of the total attempt to alter this situation goes beyond the scope of this discussion, but it was agreed to convert, as much as possible, the responsibility of teaching on the faculty's part into the responsibility of learning on the students' part. This has left the professors with the great responsibility of identifying and describing what is to be learned. The techniques available for this kind of conversion stem largely from reinforcement-learning theory (1) and we borrowed heavily in our efforts from Keller (2). In short, we divided our subject matter into twenty textbook reading units and eight laboratory units. In these units, we identified, as explicitly as possible, the objectives towards which the student was expected to progress and included several study questions to allow measurement of his progress. When the students think they know what we think they should have learned, they can take a pass-fail test to demonstrate their knowledge. Passing allows the student to go on to the next unit while failing requires re-studying the unit and re-testing until mastery has been demonstrated. Since this course format is exactly what is needed to utilize a CAI approach, Plato IV lessons were seen to fit perfectly into our course.

Although it is possible the Plato IV system can be used in other ways, we expect the greatest educational advantage to occur when a unitized, self-paced mastery system is used. We believe that Plato IV is best used when the units heavily involve the students in sequences of interactions with the computer. These sequences might be realized by using a Socratic, question-answer, dialog or by asking the students to get specific data from a programmed mathematical model that simulates the behavior of something or even modifying or originating a model. Used in this way, Plato IV is not a replacement for either the traditional laboratory exercise or the textbook - it is something which only partially overlaps with each of them, just as the textbook assignment and the laboratory exercise usually somewhat overlap. Given this outlook, it was natural that work on Plato IV would spread quickly to many levels and soon the lessons listed in Table 1 were started.

Table 1

Lesson's Name	Description	Programmer	Advisor
Neuron	An introduction to the excitable membrane's response to electrical stimulation	R. McKown	L. Barr
Bioelec Bioelec 2	An introduction to the electricity basic to electrophysiology	T. Murphy	L. Barr, E. Jakobsson
Glial 3	An introduction to electro-diffusion	T. Murphy	L. Barr
Glial 1	An advanced simulation of a H-H membrane	R. McKown D. Walter	J. Connor L. Barr E. Jakobsson
Fitzhugh	A generalized biophysical modelling program	D. Walter	E. Jakobsson

It should be mentioned that although the student is less threatened by a Socratic dialog with a Plato terminal than by faculty doing the same thing, a student is still in an exposed, tentative, and embarassing position. It has been natural for the programmers to relieve the associated anxieties by introducing humor into the unit programs. The students reaction to this has been good and there is an air of playfulness about our efforts with Plato.

The Plato IV CAI system has provided us with the desirable combination of fast calculations, an easily programmed mode of interaction, and a high resolution display screen (3). These features allowed us to begin our series of Plato IV lessons with a lab simulation in which the student learns about action potentials in nerve and muscle cells.

An action potential is a triggerable fluctuation of the transmembrane voltage of a cell which is characterized by a period of positive feedback between the transmembrane voltage and the underlying ionic conductances. Action potentials have the distinction of being both the principle means of initiating contraction in muscle cells and of providing the rapid communication among cells of the nervous system. The detailed time course of the action potential and the ionic conductances have been the subject of much research for the last half century. The work of A. L. Hodgkin and A. F. Huxley (4) resulted in a model that allows the calculation of the cell's transmembrane voltage as a function of time in response to electrical perturbations. These calculations give action potentials when suitable "above threshold" stimuli are applied to the model. However, since the principal equation of the model requires numerical integration, the use of the model to simulate the excitability phenomena for educational purposes is dependent on the development of CAI systems such as Plato IV. We have developed two Plato IV lessons that use the Hodgkin-Huxley model in two educationally different ways. In the undergraduate lesson, NEURON, the student is unaware of the model - the student views the action potentials as simply coming from the nerve cell displayed on the screen. In the more advanced lesson GLIAL 1, on the other hand, the student interacts intimately with the Hodgkin-Huxley model and can investigate the result of changing various physiological parameters of the model.

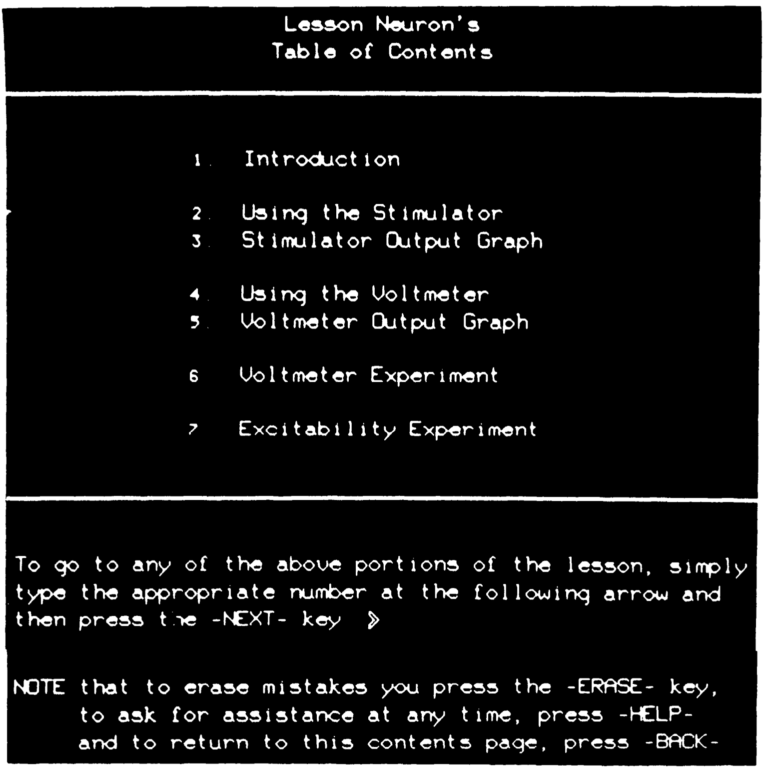

Fig.16. The table of contents page of the Plato IV lesson NEURON (photographed from the screen of a Plato IV terminal).

The major divisions of lesson NEURON can be seen from the table of contents in Figure 16. Although a student may choose to go into any section of the lesson he or she desires, the first-time student is advised to take the sequence indicated on the contents page. In elementary lessons like NEURON we have not assumed that the student is familiar with any of the concepts that he will encounter. Should the student at any point in the lesson, need assistance in answering the questions or understanding the material he may press the HELP key and receive assistance. For example, the help option might branch the student into the appropriate section of another lesson, BIOELEC, that introduces the basic concepts of electricity needed in electrophysiology. Upon completing the appropriate help section in lesson BIOELEC, which is also accessible independently of NEURON, the student may choose to look at other concepts presented in lesson BIOELEC or to return to lesson NEURON. In the event that the student is still having difficulty mastering the material of lesson NEURON, pressing -HELP- the second time (for the same difficulty) results in the message, "You should contact your instructor for additional help." On the other hand, if the student feels that he will not profit from a portion of the program, e.g. "use of the stimulator," then he may skip it. If the student later encounters difficulty in answering the questions that PLATO asks, or if he just feels uncomfortable about having skipped the section, it is only necessary to press the -BACK- key and he will be returned to the "contents page" where he can choose to go through the previously skipped section of the lesson.

It typically takes around 40 minutes for a first-time student to get to the portion of NEURON in which an experiment is performed. This "typical" time is for a student who does not need the help options but does not skip a section. The student of course need not care how long it takes to complete a portion of a lesson because he is self-pacing and can leave the lesson and take up later where he left off. Most students, however, like to go through NEURON in one sitting, i.e. about 1 1/2 hours. By the time the student gets to the experiment he has shown mastery of elementary, but very necessary concepts, such as: the polarity, intensity, and duration of a current "square wave" stimulus; Ohm's Law; and how to interpret a voltage or current versus time graph (see Figure 17).

In the "voltmeter experiment" section of NEURON, the student controls a movable voltage electrode and is asked to measure the voltage between a reference point and other points both outside and inside of the nerve cell which has "...been recently dissected out of a laboratory animal." Before each voltage measurement the student is asked for his own estimate of the voltage to be measured. Later, his estimate is compared with the measured result. The "discovery" of the resting potential is commented on by Plato as being a fundamental property of living cells (see Figure 18).

The student next starts the most "exciting" section of the lesson, the excitability experiment. Here the screen is filled with the equipment needed for a stimulus-response experiment; the stimulator with its output current versus time graph, the voltmeter with its measured voltage versus time graph; the neuron soaking in the bath solution with the stimulus and voltage electrodes sticking inside it, a data table that shows the results of the previous stimulation-response trials, and an area for comments and questions from Plato (see Figure 19). Plato's comment and question displays are generated by our program reading the responses of the H-H model to the student's choice of stimulus parameters. The initial choice of stimulus parameters (polarity, intensity, duration) is entirely up to the student. If the stimulus intensity is too large, the transmembrane voltage goes off scale and the student is advised to "...reduce it to avoid damage to the cell." If the neuron fires an action potential, Plato identifies this sudden fluctuation of the measured voltage as an action potential and suggests to the student experimenter, "keeping the duration fixed at (whatever) milliseconds, try reducing the intensity to see if you can get a different kind of response." If the initial stimulation does not produce an action potential, Plato comments, "... not much of a response," and accordingly guides the student experimenter to larger stimuli until an action potential is observed. Once the experimenter has seen both an action potential and a subthreshold response, Plato suggests that he find, within ten percent, the least intensity which will elicit an action potential given the original duration (Fig. 20). When this has been accomplished and the experimenter has properly identified the "just sufficient" intensity value, the terms "threshold", "suprathreshold", and "subthreshold" are introduced. The experimenter is then asked to keep the intensity fixed at a previous suprathreshold value and find the duration threshold within ten percent.

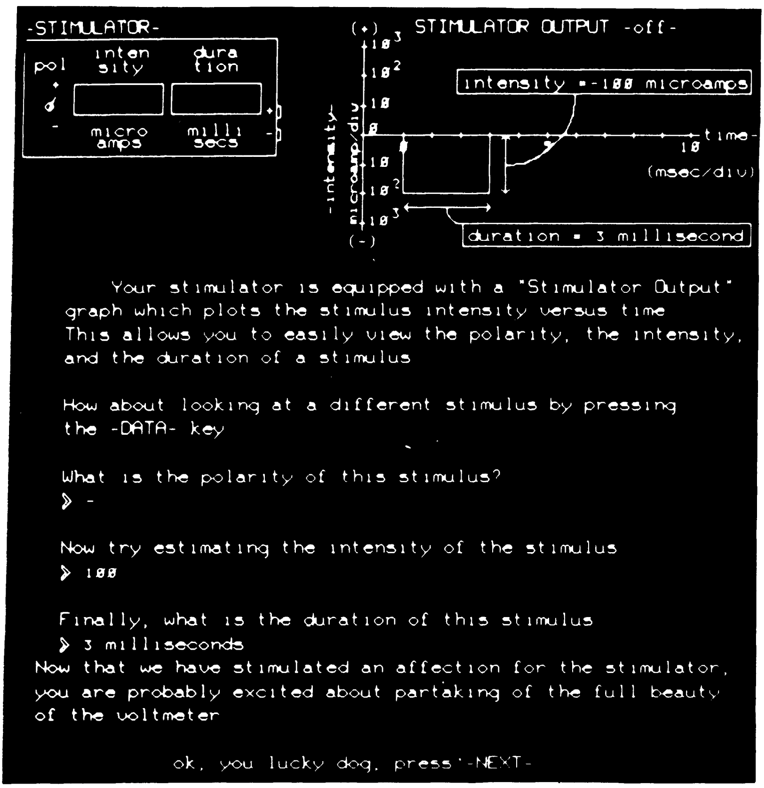

Fig.17. Photograph of a Plato IV display in lesson NEURON that occurs when the student has just demonstrated his ability to interpret the stimulator's output graph. The student's answers, which have been judged correct by Plato, appear at the arrows.

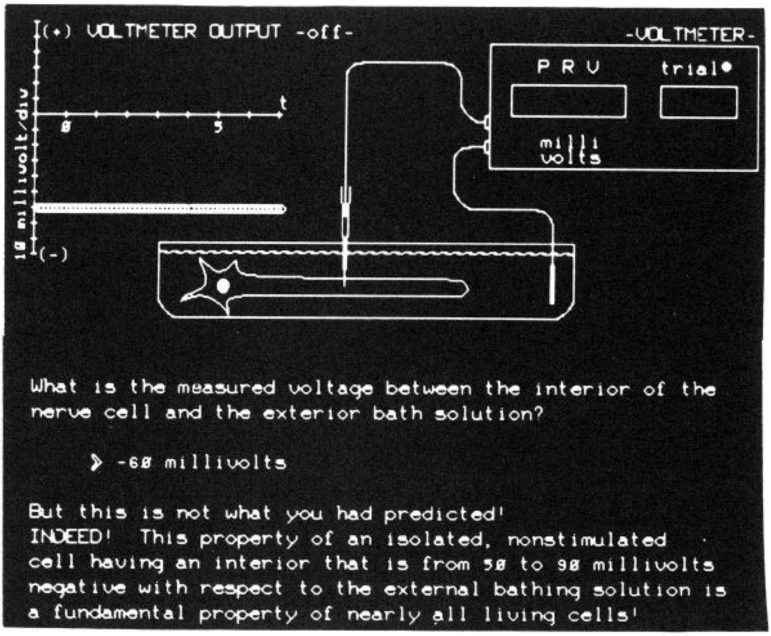

Fig.18. Plato IV display in lesson NEURON wherein the student's discovery of the nerve cell's transmembrane voltage is identified, by Plato, as something of fundamental importance.

At this point, the experimenter is shown how to obtain a plot of his stimulus-response data on an intensity versus duration (I-D) graph. Here the subthreshold, threshold, and suprathreshold stimuli are each plotted with different symbols and the experimenter has the option of having Plato connect adjacent threshold data points with line segments. The experimenter is then encouraged to find threshold stimulus parameters in portions of the I-D curve that he has not yet investigated. The end of the lesson occurs when the experimenter indicates that he is satisfied with the curve connecting the threshold data on the I-D plot, at which time he is given some reading references that he might find enjoyable.

The Plato IV lesson GLIAL 1, which allows extensive student interaction with the Hodgkin-Huxley membrane model, is intended for use by graduate students. In this lesson the student is assumed to have a set of directions, perhaps on a problem set assignment, to guide him through the many options. There are two basically different modes of using the Hodgkin-Huxley model in this lesson corresponding to two different modes of experimentally investigating the electrical properties of excitable cells. Thus, in one mode the responses of the model membrane to electric

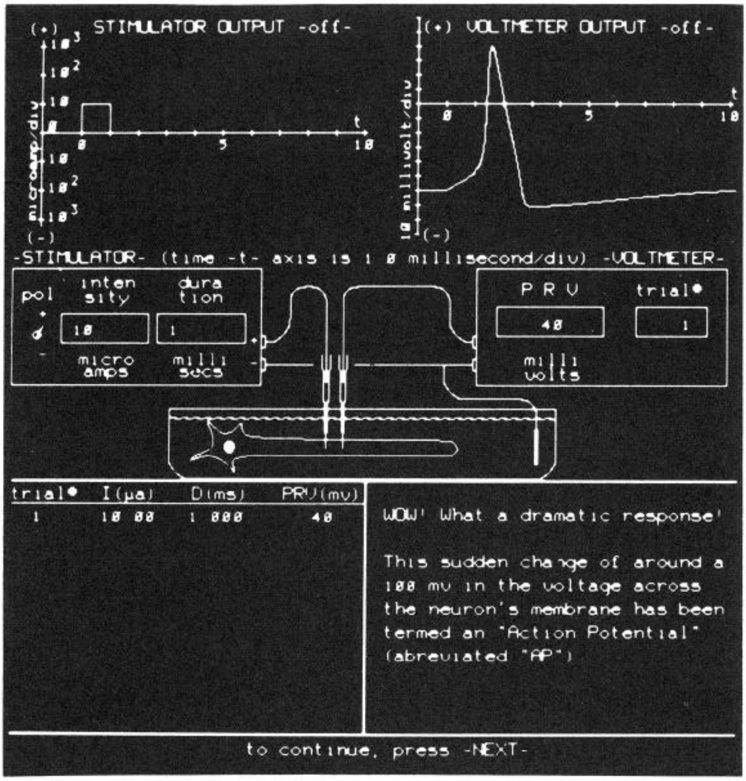

Fig.19. The Plato IV "laboratory" for the stimulus-response experiment The nerve cell's response to the student's initial choice of stimulus parameters has been identified by Plato as an action potential.

currents is a change in the time course of the transmembrane voltage, as was done in lesson NEURON; in the other mode, the responses of the "voltage-clamped" model membrane to steps in the transmembrane voltage is a change in the time course of the membrane current. Of the many possible changes in the Hodgkin-Huxley model parameters that the student can investigate in GLIAL 1, some of the simplest and most popular are the effects of changing the sodium or potassium equilibrium potentials, changing the sodium or potassium membrane conductances, changing the membrane capacitance, changing the rest potential, and changing the "leakiness" of membrane. Provisions also exist for the more advanced operations of adding additional ionic currents to the model and/or fitting the model to data from another membrane (the Hodgkin-Huxley model was constructed for data obtained from a squid giant axon). Figures 21 and 22 demonstrate the "refractoriness" and "repetitive firing" of the H-H membrane. In either the "stimulus-

-response" mode or the "voltage-clamped" mode, the student can see the effect of changing the model by having various dependent variables of the model plotted versus time or versus each other in so-called "phase plots."

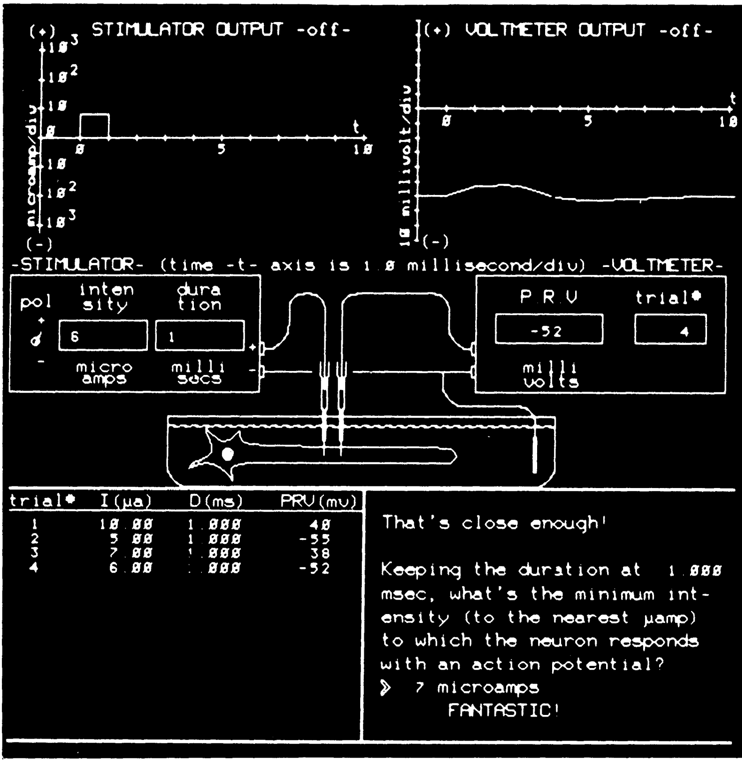

Fig. 20. Plato IV display in which the student has just identified a threshold stimulus and is receiving a "Fantastic!" congratulations from Plato.

A standard family of voltage-clamped current curves that can also be experimentally observed is shown in Figure 23. This particular set of graphs displays the sodium current system when the membrane voltage is stepped from the resting potential of -60 volts to different clamping voltages. Although these sodium current and conductance data can be experimentally obtained for the squid axon, the experiments are prohibitively expensive and difficult for educational purposes. More complicated voltage clamps (involving up to four different clamping voltages) are often specified by the student since it is in this manner that the parameters in this and other membrane models have been experimentally deduced. The potential of CAI systems' modelling programs to not only familiarize advanced students with existing experimental designs, but to allow them to create experimental strategems of their own appears to be educationally unique.

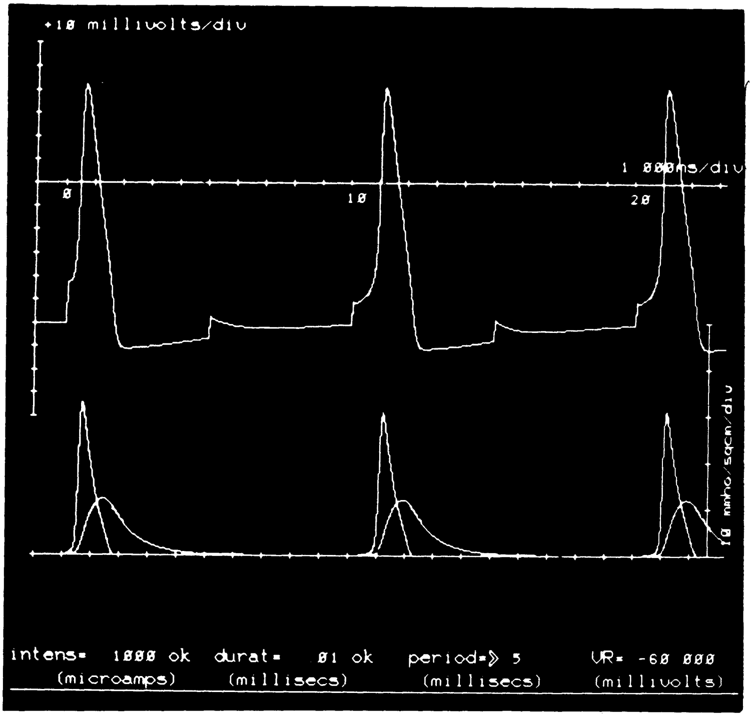

Fig.21. Plato IV display from lesson GLIAL 1 in which the unmodified Hodgkin-Huxley membrane model has been given a high intensity but short duration stimulus that repeats every five milliseconds. The refractoriness of the model is clearly evident from the passive response of the transmembrane potential (top graph) and the sodium and potassium ionic conductances (bottom graph) to the stimuli at 5 and 15 milliseconds.

In summary, we have the beginnings of a library of Plato IV lessons which will allow faculty to prescribe what individual students should learn over a very wide range of subject depth as well as breadth. At the moment, interest in our department in Plato is probably greatest relative to graduate work. The reason is that Plato has provided a more powerful way, via modelling, to teach material at the level just beyond our usual graduate courses. Often we have graduate students who have taken all the required courses and have very good grade averages but who have never gone into anything far enough to be ready to do research. With the flexibility of a library of Plato lessons, we can shed the restrictions of needing a

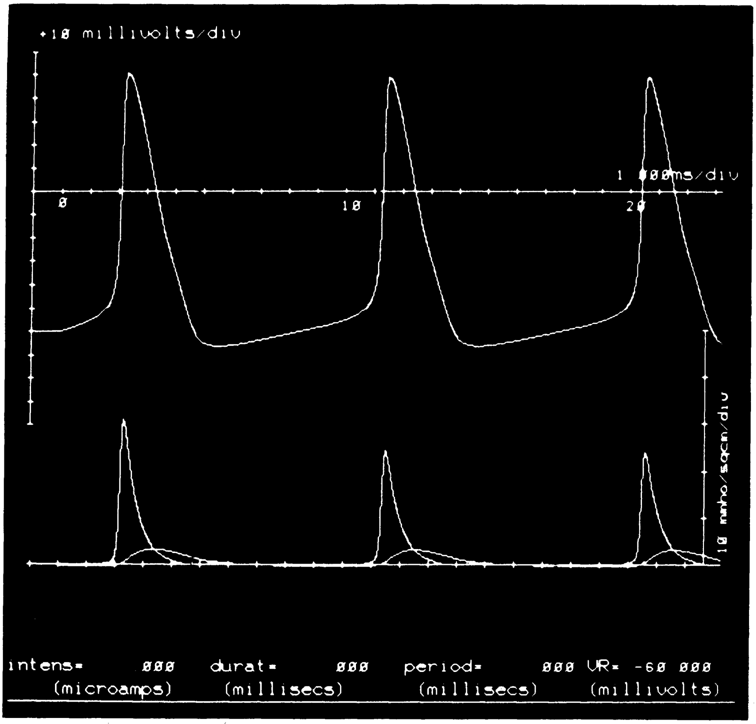

Fig.22. Plato IV display from lesson GLIAL 1 in which the magnitude of the potassium ionic conductance in the Hodgkin-Huxley membrane model has been reduced to one-sixth its normal value. Here the membrane potential has been released at -60 millivolts without any applied stimulus and the model displays a spontaneous, repetitive firing of action potentials.

minimal number of students for a course and then of having to teach to the highest common level, which is often too low. Since, by prescribing lessons, we can specify the level that each student should attain in a subject area, we can decide that no student can go through doing the minimum of everything, but instead that they must come right up to the level of being able to start research in two or three areas of their own choice. The ability to do this stems from the most important aspects of the Plato IV CAI system, that is, one can specify what the students should learn, be sure that they will learn it, and know when they have learned it.

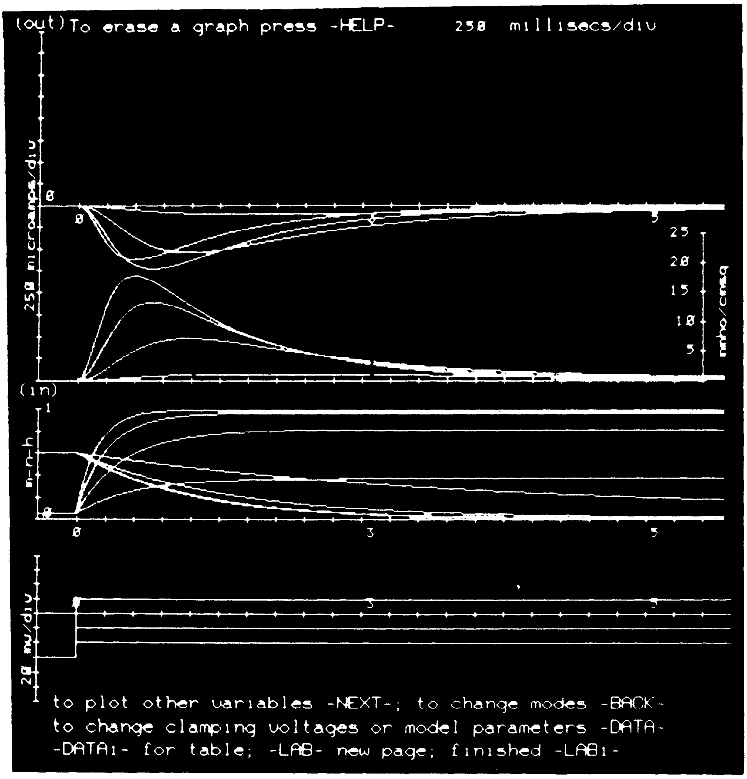

Fig.23. A family of curves for the model membrane's sodium current system obtained in the voltage-clamped mode of Plato IV lesson GLIAL 1. The graphs are, from top to bottom, the sodium current; the sodium ionic conductance; the model's sodium conductance parameters, "m" and "h"; the applied clamping voltages.

REFERENCES

1. Keller, F.S. Learning: reinforcement theory, 2nd Ed., Random House, 1969.
2. Keller, F. S. "Goodbye Teacher...", J. Appl. Behavior Analysis 1: 19, 1968.
3. Alpert, D., and D.L. Bitzer. Advances in Computer-Based Education. Science 167: 1582, 1970.
4. Hodgkin, A.L., and A.F. Huxley. A quantitative description of membrane current and its application to conduction and excitation in nerve. Journal of Physiology 117: 500, 1952.

V. COMPUTER ASSISTED INDEPENDENT STUDY

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Editor's Note: Manuscript for this presentation was not available at the time that this issue of The Physiologist had to go to press.

VI. ESSENTIALS OF CRIB

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University of Illinois at the Medical Center

Editor's Note: Manuscript for this presentation was not available at the time that this issue of The Physiologist had to go to press.

VII. MEDLEARN: AN ORIENTATION TO MEDLINE

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George Washington University Medical Center

The MEDLEARN program is an orientation to the computerized citation retrieval service of the National Library of Medicine called MEDLINE. To those of you who have heard of MEDLARS, MEDLINE stands for MEDLARS-on-LINE. This means that the entire content of approximately 1000 journals for the past three years is available to the searcher who has access to the computer by way of a remote terminal. In Figure 24 is an indication of what is stored by the computer and which categories are able to be used for searching. Thanks to the computer network you heard about this morning, it is not even necessary to call the computer long distance; one needs merely to call the nearest access point of the TYMSHARE Network, which for most areas means a local telephone call.

ABBREVIATION	CATEGORY	X INDICATES SEARCHABLE
AU	AUTHOR	X
TI	TITLE	
SO	SOURCE JOURNAL	
LA	LANGUAGE	X
ED	ENTRY DATE	X
MH	MAIN HEADINGS (MESH)	X
MC	MESH CLASS NUMBER	X
JC	JOURNAL CODE	X
CI	CITATION INFORMATION	

SEARCH STATEMENTS MAY CONSIST OF ANY COMBINATION OF ENTRIES FROM THE SEARCHABLE CATEGORIES. THEY MAY BE ENTERED IN ANY ORDER PROVIDING THE APPROPRIATE LINKING AND FORMAT RULES ARE OBSERVED.

Fig.24. Table of Information Categories

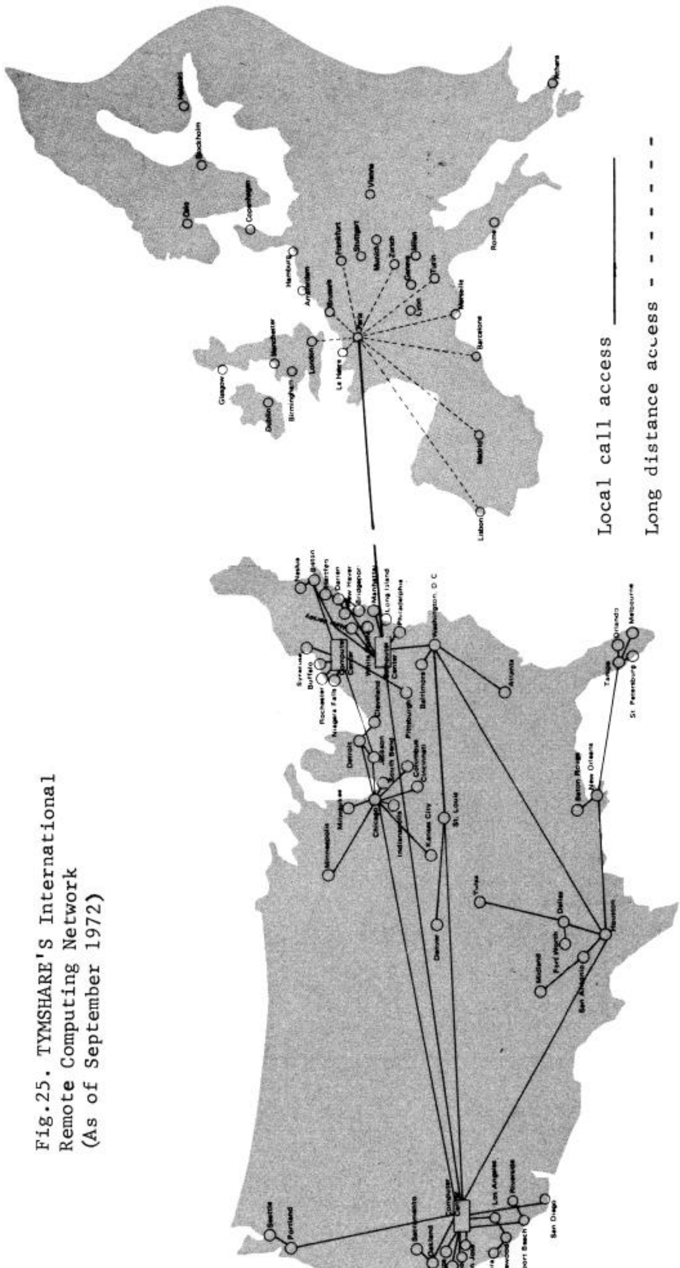

Fig.25. TYMSHARE'S International Remote Computing Network (As of September 1972)

In Figure 25 we see the cities where nodes of access for the network are located. Now MEDLINE, like most information retrieval services, is a relatively complicated program to use. In Figure 26 is indicated the way one proceeds in a MEDLINE search. With repeated use, the procedure becomes automatic and the service is well worth the effort of learning how to make use of it. However, a medical librarian can spend most of her time either running MEDLINE searches or instructing people in MEDLINE use. Because there are certain advantages in having the interested person do his own searching, we have developed a computer assisted learning sequence to teach people how to use this new bibliographic tool.

```
          THE SEARCH MIGHT PROCEED AS FOLLOWS:
SS  1/C?
USER:
LEAD POISONING/OC OR LEAD POISONING/PC
PROG:
PSTG (35)
SS  2/C?

USER:
*LEAD POISONING/OC  OR *LEADPOISONING/PC
PROG:
NP (*LEADPOISONING/PC (MAIN HEADING))
PSTG (9)
SS  3/C?

USER:
"PRINT"

PROG:
AU - LAURER  GR
AU - KNEIP  TJ
AU - ALBERT  RE
AU - KENT  FS
TI - X-RAY FLUORESCENCE: DETECTION OF LEAD IN WALL PAINT.
SO - SCIENCE  172  466-8  30 APR 71

AU - BLUMENTHAL  D
TI - LEAD INGESTION IN NEW ORLEANS CHILDREN
SO - SOUTH MED  J   64  364-5  MAR 71

AU - DAVIS  JR
TI - RELIABILITY OF URINARY DELTA-AMINOLEVULINIC ACID AS A
     MASS SCREENING TECHNIC FOR CHILDHOOD EXPOSURE TO LEAD.
SO - AM J CLIN PATHOL  53  967-9  JUN 70

TI - CHILDREN AT RISK.
SO - NATURE (LOND) 228  1253  26 DEC 70

AU - CHALLOP  RS
TI - LEAD POISONING
SO - N ENGL J MED  283 1055  5 NOV 70
SS   5/C?
```

Fig.26. Typical MEDLINE search.

MEDLEARN is a fairly extensive program with some 40 distinct sections which can be called up as desired by the user. There is not time to give you a complete description of the program, so let me concentrate on some of its special features.

1. The sequence of presentation is determined by the user. This permits different persons to use the program in ways which are most suited to their particular needs. Thus MEDLEARN is versatile.

2. The presentation of new material is interspersed with "queries" which enable the user to make sure he is learning at the expected pace. In addition there is a practice exercise for each of the major didactic portions of the program. Thus MEDLEARN is highly interactive.

3. Four special learning experiences are provided to bridge the gap between learning about MEDLINE and actually using MEDLINE unassisted. These consist of the following:
   a) First simulated MEDLINE SEARCH - this is a short four step search programmed entirely within the MEDLEARN program. It provides users unacquainted with MEDLINE an idea of what a MEDLINE search printout looks like and intersperses interpretive comments as to the meanings of program cues and program messages. Since the user actually enters the searching terms and commands, it is a true simulation of a real MEDLINE experience.
   b) Second simulated MEDLINE search - this is a longer MEDLINE search also entirely programmed within the MEDLEARN program. By this stage in the learning process, the user will know how to look up appropriate main headings in Medical Subject Headings (MESH) the controlled searching vocabulary which is identical to that used for Index Medicus. There are no interpretive comments but a comprehensive series of aids has been programmed to be typed out in response to a "HELP" command. The "help Command Interpreter" is able to know the students previous request to the program and provides a response which is appropriate to that particular point in the search procedure. This degree of assistance is not available in MEDLINE.
   c) MEDLINE search exercises -in this situation the user is invited to disconnect from the MEDLEARN program and to sign-on to MEDLINE. Since both programs are available on the TYMSHARE Network, this is a relatively simple thing to do. Then after attempting four short searching exercises, the user can return to MEDLEARN where feedback is available regarding any difficulties that were encountered.
   d) Restricted MEDLINE search - if the user was able to accomplish the MEDLINE search exercises without too much difficulty, he is then invited to attempt this experience. The search is identical to any other MEDLINE search in procedure, but it is restricted to citations published in the year 1971 so that the database being searched will be identical for every person

attempting this learning experience. Here, as before, the user can return to MEDLEARN for an analysis of his performance and additional instruction if desired.

Thus MEDLEARN attempts to be practical in terms of the educational objective being sought.

4. MEDLEARN has two features designed to assure that the program will be able to be of use beyond the immediate time of its original development. The first of these is an 'Up-Date File' which enables alterations in MEDLINE, and that program is being changed all the time, to be documented for the benefit of subsequent users of MEDLEARN. The second is a "COMMENT" command. This enables users to write a comment to the authors of MEDLEARN with any suggestions for changes or improvements. Thus MEDLEARN will not be outdated, at least, not right away.

5. MEDLEARN is available in two different forms: at a computer terminal and also as a hard copy manual. The two versions are not identical but are intended to complement each other. Thus the knowledge gained in developing this learning experience is not restricted to terminal access.

6. In addition to teaching about MEDLINE, the MEDLEARN program also contains some short descriptive sections on the TYMSHARE Network, the MEDLINE computers, and the computer language FOCAL-10 in which MEDLEARN is written.

At this moment MEDLEARN is still under development, and the program is continuing to be refined, but it is entirely functional. For information about access to this program contact Ms. Rosemarie Woodsmall at the National Library of Medicine.

VIII. A WINDOW INTO THE WORLD

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Human Resources Research Organization
Alexandria, Virginia

Editor's Note: Manuscript for this presentation was not available at the time that this issue of The Physiologist had to go to press.

IX. GUESS THE ANIMAL*

CHARLES F. MEAD
Digital Equipment Corporation

We learn by teaching! Although this is a well-known and generally accepted principle, there have been relatively few attempts to apply it to computer-assisted instruction. I submit that students may be able to learn by teaching the computer as effectively as they can learn with computerized drill and practice or tutorial programs.

I would like to illustrate my point with a computer game. I have made no attempt to derive a pedagogically sound program before I came today - instead, I will leave it up to you to teach our computer the basics of biology during the demonstration this afternoon. The game is called "Guess the Animal." It is not, as you may think, up to you to guess the animal; in this game, that's the computer's task. It is, however, up to you to teach the computer the most effective means of guessing the animal you have in mind.

After quizzing you a bit, the computer will try to guess your animal. If its guess is incorrect, the computer (like your best students) will ask where it went wrong. After you explain its mistake, the computer (possibly unlike your best students) will not forget what you have taught it.

The program will be run remotely on a Digital Equipment Corporation PDP-11 based RSTS minicomputer system.

Let me explain myself with an example. Figure 27 is a sample run of the program. It is apparent that the computer was incorrect in its initial guess of FISH. After digesting a question that will allow the computer to differentiate the "newly learned" DOG from the "already known" FISH, the computer will not err in the same fashion again. In fact, since it is a clever computer, it will not have to ask all questions known to it before it can guess "BIRD", either. Since it now understands that neither a FISH nor a DOG can fly, it automatically guesses BIRD if you tell it your animal can fly.

The structure for such a learning program is really quite simple as shown in the flow chart in Figure 28. Briefly, this shows the operations involved in selecting a guess through successive "yes" or "no" questions. The chart then details the procedures for "learning" a new animal if the computer's guess is incorrect. I will be happy to discuss the flow chart in detail with any of you during the demonstrations.

Responses are stored in the computer memory via a tree-structured file system. For the printout in Figure 27, for example, the file would be successively updated as shown in Figure 29. Note that the response which was a guess in the first iteration becomes a question in the second.

* Note: "Guess the Animal" was programmed for the Digital RSTS (Resource-Sharing, Time-Sharing) computer by Nathan Teichholtz, Digital Equipment Corporation.

PLAY 'GUESS THE ANIMAL' WITH RSTS
THINK OF AN ANIMAL AND THE COMPUTER WILL TRY TO GUESS IT...

ARE YOU THINKING OF AN ANIMAL? YES

DOES IT FLY? NO

IS IT A FISH? NO

THE ANIMAL YOU WERE THINKING OF WAS A ? DOG

PLEASE TYPE IN A QUESTION THAT WOULD DISTINGUISH A DOG FROM A FISH ? DOES IT BARK

FOR A DOG THE ANSWER WOULD BE? YES

ARE YOU THINKING OF AN ANIMAL? YES

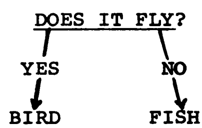
DOES IT FLY? YES

IS IT A BIRD? YES

WHY NOT TRY ANOTHER ANIMAL
ARE YOU THINKING OF AN ANIMAL?

Fig.27. Sample Printout for "Guess the Animal"

FIRST ITERATION:



SECOND ITERATION:

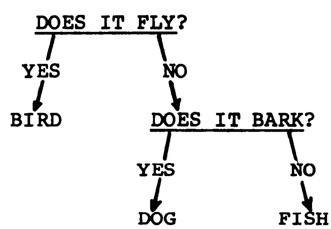
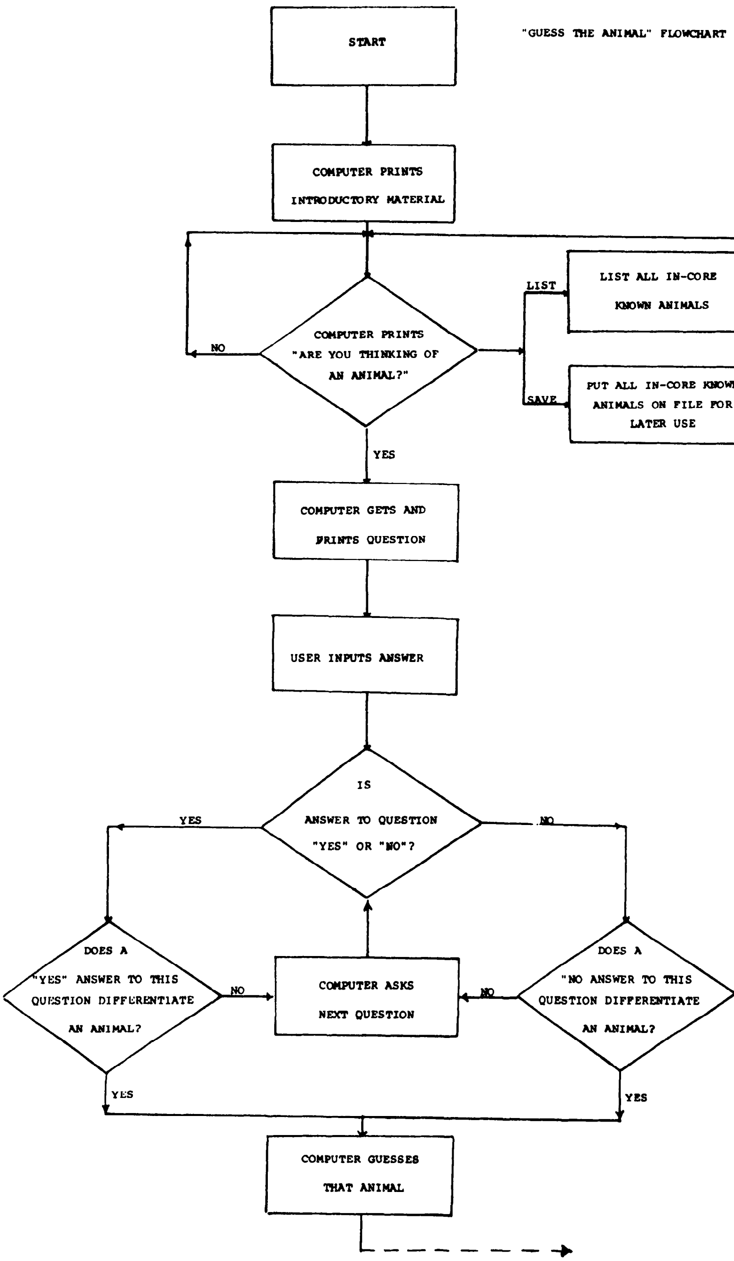
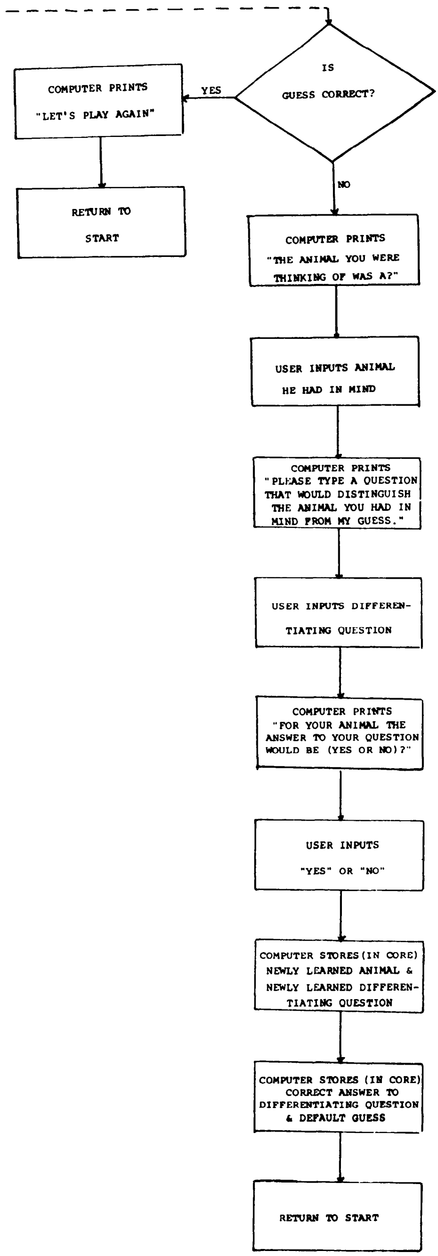


Fig.29. "Guess the Animal" Logic Structure


"GUESS THE ANIMAL" FLOWCHART
START
COMPUTER PRINTS INTRODUCTORY MATERIAL
COMPUTER PRINTS "ARE YOU THINKING OF AN ANIMAL?"
NO
LIST
LIST ALL IN-CORE KNOWN ANIMALS
SAVE
PUT ALL IN-CORE KNOWN ANIMALS ON FILE FOR LATER USE
YES
COMPUTER GETS AND PRINTS QUESTION
USER INPUTS ANSWER
IS ANSWER TO QUESTION "YES" OR "NO"?
YES
NO
DOES A "YES" ANSWER TO THIS QUESTION DIFFERENTIATE AN ANIMAL?
NO
COMPUTER ASKS NEXT QUESTION
NO
DOES A "NO ANSWER TO THIS QUESTION DIFFERENTIATE AN ANIMAL?
YES
YES
COMPUTER GUESSES THAT ANIMAL


IS GUESS CORRECT?
YES
COMPUTER PRINTS "LET'S PLAY AGAIN"
RETURN TO START
NO
COMPUTER PRINTS "THE ANIMAL YOU WERE THINKING OF WAS A?"
USER INPUTS ANIMAL HE HAD IN MIND
COMPUTER PRINTS "PLEASE TYPE A QUESTION THAT WOULD DISTINGUISH THE ANIMAL YOU HAD IN MIND FROM MY GUESS."
USER INPUTS DIFFERENTIATING QUESTION
COMPUTER PRINTS "FOR YOUR ANIMAL THE ANSWER TO YOUR QUESTION WOULD BE (YES OR NO)?"
USER INPUTS "YES" OR "NO"
COMPUTER STORES (IN CORE) NEWLY LEARNED ANIMAL & NEWLY LEARNED DIFFERENTIATING QUESTION
COMPUTER STORES (IN CORE) CORRECT ANSWER TO DIFFERENTIATING QUESTION & DEFAULT GUESS
RETURN TO START

I invite you all to now play with the system, and to use your imaginations as to its instructional implications. I expect that after two hours of training from skilled biologists, our PDP-11 will be capable of providing a very complete overview of the fundamentals of biological classification!

X. INSTRUCTION IN RENAL PHYSIOLOGY ON A MINICOMPUTER-BASED EDUCATIONAL SYSTEM*

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Department of Physiology and Educational Computation Center
University of Texas Medical Branch

It is well documented that Computer Aided Instruction (CAI) can be employed as a highly interactive, effective teaching tool. However both high systems costs and the inability of most faculty to quickly and simply assemble their own CAI material have contributed to the limited utilization of the concept. In an attempt to overcome these difficulties, and still retain the program flexibility required of successful computer aided instruction, a minicomputer based system was designed at the University of Texas Medical Branch. A prototype version of this system was assembled and a simple user oriented language (CAISYS-8) prepared for use with it. The following program was one of a series developed to see if reasonably complex, educationally effective programs could be successfully assembled and executed by such a minicomputer-based system.

This program was designed for use in our freshman medical curriculum at the end of the renal physiology lectures. At this time most of our students have acquired the facts necessary for calculation of clearances, Tm values, or the filtration, excretion or reabsorption rates of various substances. However, they generally have not integrated this material adequately to allow them to reliably execute these calculations. An additional period of individual consultation with an instructor or group conference is required before these calculations are adequately mastered. This program was designed to replace such conferences.

Successful completion of a complex calculation which required that the student employ a majority of the desired mathematic and conceptual manipulations was accepted as evidence of mastery of the material. Students able to perform these calculations at the onset were rapidly diverted to other tasks. Those who did not complete the calculation entered into a step by step analysis of the component calculations until the source, or sources, of their difficulties were determined.

The following is typical of student-machine interactions at the program's start.

---

* This study supported in part by the ESSO Education Foundation via National Fund for Medical Education Grant 95/69.

Machine: Suppose you initiated renal clearance studies on a patient and obtained the following results:

Urine Production 2cc/minute

	Glucose	Inulin	Osmolarity	PAH
Urine	400 mg%	0.6 mg/cc	765 mOs/kg	3.2 mg/cc
Plasma	290 mg%	0.01 mg/cc	293 mOs/kg	.015 mg/cc

Can you calculate the Tm for glucose for this individual?

Student: No

Machine: O.K., let's be sure we know what a Tm is. The Tm for glucose is the maximal amount of glucose that can be __________ by the tubular cells each minute.

Student: Reabsorbed.

Machine: Swell!
Did this give you enough of a hint for you to calculate the Tm for glucose now?

Student: No

Machine: O.K., let's take a look at this calculation. We've established that we are trying to calculate the maximum amount of glucose that tubular cells are capable of reabsorbing each minute. ..

After the student had demonstrated mastery of this concept he was again asked to perform the original calculation. If unable, his ability to execute each of the component calculations was in turn examined. Remedial information, which often incorporated practice calculations, was provided only as the student's performance indicated it to be necessary. For example:

Machine: Can you calculate the rate of glucose excretion?

Student: Sure

Machine: O.K., he was excreting glucose at a rate of __________mg/min.

Urine Flow: 2cc/min

	Glucose	Inulin	Osmolarity	PAH	Na
Urine	400 mg%	0.6 mg/cc	765 mOs/kg	3.2 mg/cc	43meq/l
Plasma	290 mg%	0.01 mg/cc	293 mOs/kg	0.015 mg/cc	142meq/l

Student: 4

Machine: No, you have an error somewhere. Take another look at the question and recalculate your answer.
Your patient's glucose excretion rate was __________mg/min.

Urine Production 2cc/min

	Glucose	Inulin	Osmolarity	PAH
Urine	400 mg%	0.6 mg/cc	765 mOs/kg	3.2 mg/cc
Plasma	290 mg%	0.01 mg/cc	293 mOs/kg	.015 mg/cc

Student: 1.2

Machine: No, that isn't right either. Let's take a look at the principles involved in the calculation.
Suppose you had collected the following data from a patient:

Urine Production Rate: 5cc/minute

	Inulin	PAH	Glucose
Urine	1.37 mg/cc	4.80 mg/cc	300 mg%
Plasma	0.22 mg/cc	0.37 mg/cc	110 mg%

This data tells us that your patient was producing 5cc of urine each minute, and each one of these 5cc's contained 3 mg of glucose.

(300 mg% = 3 mg/cc)

Therefore, he was losing 15 mg of glucose in his urine each minute. (5 cc/minute) (3 mg glucose/cc) = 15 mg/min

Now, let's look at the original problem. Your patient was excreting_________mg of glucose/minute.

Urine Production 2cc/minute

	Glucose	Inulin	Osmolarity	PAH
Urine	400 mg%	0.6 mg/cc	765 mOs/kg	3.2 mg/cc
Plasma	290 mg%	0.01 mg/cc	293 mOs/kg	.015 mg/cc

This program may be viewed as an attempt to simulate a one-to-one instructor: student interaction. Although it is doubtful that such simulations would be as effective as live one-to-one interactions they might well be preferable to handling the same material in large group conferences. An attempt was made to evaluate the apparent effectiveness and acceptability of the program. Volunteers from the freshman medical class were divided into two groups. One group of 33 students served as a control and was given a large group conference covering this material by the author of the program. The other group (20 individuals) was given access to the computer terminal, and allowed to use as much time as they desired. Both conference and computer trained groups were given a pretest before conference or program exposure and a post-test afterward.

Both the pretest and post-test contained questions of three levels of difficulty. The simplest of these required only that the student perform a calculation described previously in text and lecture, (i.e., given a urine production of 1 cc/minute, a plasma inulin concentration of 0.01 mg/cc and a urine inulin concentration of 1.20 mg/cc calculate the individuals glomerular filtration rate). For ease of identification these were called first order questions (Figure 30).

Questions of intermediate difficulty (second order questions) were those requiring that the student recognize a relatively simple relationship, and perform the necessary calculation, without having been told expressly how to do so, (i.e., given plasma and urine inulin and glucose concentrations and the urine production rate, calculate the amount of glucose filtered each minute).

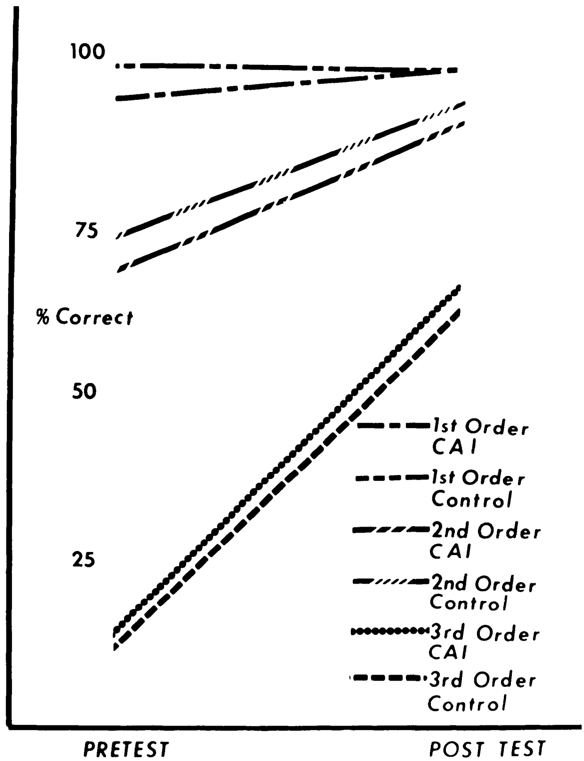

Fig.30. Pretest and Post-test scores. For explanation see text.

The more difficult questions (third order questions) were those requiring still more conceptual and mathematic manipulations, (i.e., given the urine production rate, plasma and urine PO_4, inulin and PAH concentrations calculate this individual's Tm for phosphate).

A synopsis of the pretest and post-test scores of conference and computer trained students is depicted in Figure 30. Neither conference nor computer program exposure improved performance on the simplest questions, (first order questions). Both groups of students handled these calculations with a high degree of accuracy on both the pretest (99% for conference, 93% for CAI group) and on the post-test (98% for each group). The incorrect answers occasionally seen probably indicate random mathematical and data transposition errors, not a lack of comprehension.

The scores for questions of intermediate difficulty did, however, differ between the pretest and post-test for both groups. The conference group scored 73% on the pretest second order questions, with 93% on corresponding post-test questions. This difference was statistically significant ($p < .05$). The CAI group correctly answered 67% of the pretest questions and 90% of the post-test second order questions. This difference too was statistically significant ($p < .05$). No difference was demonstrable between the magnitude of change in performance observed in the conference group and that of the CAI group. The greatest change between pretest and post-test performance was found with the more difficult (third order) questions. The conference group executed 11% of these correctly on the pretest and 62% on the post-test. The CAI group correctly answered 15% of the corresponding pretest questions and 65% of the post-test questions. The improvements in performance between the pretest and post-test were statistically significant ($P < .05$) for both groups. Again, no significant difference could be found between the performance improvements exhibited by the two groups. We interpret these results to indicate that both the conference and computer program exposure significantly increased student performance, but there was no discernible difference between the performance changes produced by the two experiences. The group conference required 55 minutes for all students. Those using the computer expended an average of 32 minutes.

While this difference in exposure time might be greater than anticipated, a substantial difference could be expected. Certainly a large part of any large group conference is devoted to discussion of material already perfectly well understood by a large segment of the student body. The computer program individually tailored the course content to the student's indicated needs and thus spent minimum time reviewing material already mastered.

The students who used the computer program were asked to indicate their preference for this, or conference modes of instruction. All had previously attended numerous conferences of the type experienced by the control group and were familiar with their format. A 5 point scale was used: 1 indicating a strong preference for conference teaching, 3 a neutral position and 5 a strong preference for computer aided instruction. The mean score of this evaluation was 4.70.

This program was prepared to evaluate the capability of our minicomputer-based CAI system, and its user oriented language (CAISYS-8) for the preparation and execution of reasonably complex, educationally effective CAI programs. The program appears to be successful. Students using it substantially improved in their renal problem solving abilities. This improvement in performance was not demonstrably different than that of a control group given a group conference, although the performance modification was accomplished in substantially less time. The students who were allowed to use the CAI program indicated a strong preference for this to traditional large group conference instruction.

These results, as well as preliminary results from subsequent tutorial and patient management simulation programs suggest that educational programs such as this, in which the machine serves as a program logic controller and student evaluation device, not as a data processor, are well within the capabilities of minicomputer-based CAI. These results also suggest that computer aided instruction can be effective and well received at this educational level. Although the outlook appears favorable it remains to be demonstrated that such computer aided instruction will realize its apparent cost-effectiveness, and that the faculty acceptance necessary for it to become a practical adjunct to our current teaching methods can be generated.

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NEWS FROM SENIOR PHYSIOLOGISTS

The following notes were received by members of the APS Senior Physiologists Committee in reply to birthday greetings.

Mabel Purefoy FitzGerald was able to enjoy greetings from her friends on her 101st birthday, August 3rd. Her neighbor, William H. Cannon wrote about her enjoyment of the story about her in the May issue of The Physiologist:

"She was delighted with the article and was able to read it herself. She showed all her friends who were, of course, also pleased with it. To me, her main concern was to thank me for helping make the article possible and the fact that you had mentioned my name, this pleased her immensely, also the fact that her niece's name, Mrs. Brian Purefoy, had been mentioned."

Three weeks later, August 24th, she died peacefully. The funeral service and burial was in Shelston, Buckingham, the family home since 1450.

Sam Pond sent his best wishes to Hy Mayerson and to "physiologists everywhere" and described life in East Winthrop, Maine, his home since he severed his ties to Connecticut:

"We've reduced household care from 7 rooms to 2-1/2. The village and its contents are quiet and friendly. In this academic Hexagon (Bates, Bowdoin, Colby, University of Maine at Farmington and Augusta, and now St. Thomas) we have numerous opportunities for environmental stimulation. With care and conservation we'll survive.

With the State of Maine task force for the elderly I'll help occasionally to increase the residences when the old folks have to give up their homes and find aggregate life more comfortable. Our county (Kennebec) is in more need of technical help so I'm one of several in the newly formed Watershed District, measuring, observing, and experimenting to improve the water quality, reduce putrefaction and help acquaint the natives and transients with the dangers of pollution (by neglect). Our lake is over 10 miles long with a lighthouse and 2 Coast Guard boat-lanes, and 8 other lakes in a chain in need of conservation. So there's plenty of chance to use one's ability and experience in improving human, animal and plant life.

Otherwise, there's still a chance to read, write and to commune with others."

Jerzy Kaulbersz, born July 19, 1891, belongs to a growing group of octogenarian members who remain active. He has ties to the Medical Institute and the Institute of Physical Education in Cracow. He was born in Kalisc, then belonging to Russia, and attended a Russian school until a private Polish school was opened. Eventually after years at several German Universities and at Cracow, he obtained his Ph.D. at Freiberg (br.) and his M.D. in 1920 at Cracow. After military medical service he was appointed to the Cracow medical faculty becoming head of the physiology department. A major interest has been in the physiology of high altitudes. For 50 years, 1921-1971 he has conducted research at several high altitude laboratories. The outbreak of World War II found him at Wayne University in Detroit. He remained in the United States from 1939 to 1947, attended meetings of the Society in this period and was elected to membership in 1944. He has attended nearly all International Physiological Congresses since 1926; this year he presented a paper on pancreatic secretion in hypoxia at the 21st International Congress of Aviation and Space Medicine at Munich. His international ties and his skill as a linguist is indicated by the fact that his 180 publications have been written in Polish, English, French and German. The Society is fortunate to count this distinguished Polish physiologist as one of its members, our only member in Poland.

Alexis Romanoff replied from Ithaca to Maurice Visscher:

"After my retirement from Cornell University in 1960, I continued my unfinished work on the preparation of monographic reference volumes in Avian Embryology. Since that time with partial financial assistance from the NIH, I prepared and published two volumes: 1)"Biochemistry of the Avian Embryo: A Quantitative Analysis of Prenatal Development" (1967), and 2) "Pathogenesis of the Avian Embryo: An Analysis of Causes of Malformations and Prenatal Death" (1972). With the last volume, I have completed my series of studies on the Avian Embryo. The project which was outlined during my college years, prior to 1928, has since been nurtured, amplified and carried out in parts, in the time left over from my other academic responsibilities, especially experimental research and teaching."

Walter Alvarez acknowledged the birthday greeting:

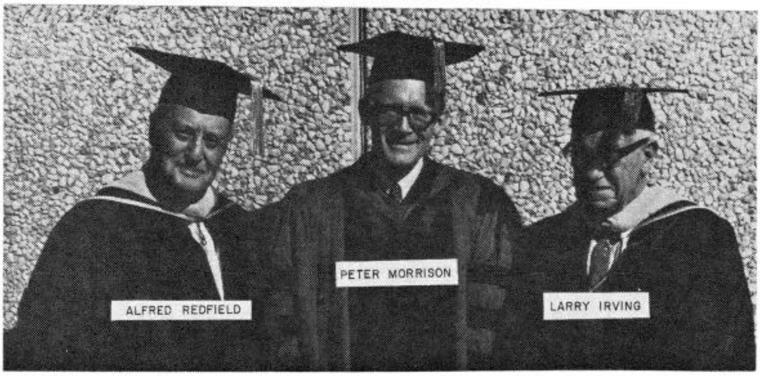
"Dear Maurice: - How kind of you to write me on my birthday. Yes, I am happy to have had the association with you in Modern Medicine. I am glad that I am still able to write much in my eight-ninth year. If the University of California could have given me a living wage I might have remained happily as a physiologist. Today I am mainly a science-writer."

Percival Bailey acknowledged Hal Davis' birthday greeting; the miserable Evanston weather of early May kept him indoors.

Fred Griffith to Hy Mayerson: "Your birthday remembrance was much appreciated, perhaps in part because it did not find me in good health - as it hoped. It found me slowly recovering from a stroke about four months ago that severely paralyzed my right side, including my speech and ability to write (as this testifies). Those who pretend to know about such things seem to think that I'm making a splendid and rapid recovery. If so, I'd hate to be making a poor or slow one.

Perhaps on the basis of this first-hand experience I can add my nickle's worth to the wealth of advice about retirement, viz. never start your retirement with a cerebral stroke! For I had definitely and completely retired at the end of last school year when I began to feel that I was really beginning to slow down and was beginning to be a poor risk (as my behavior later testified).

Alfred Redfield received a notable honor May 29th. At the dinner celebrating the 25th Anniversary of Boston's Science Park, he was awarded the Walker Prize which included a cash award of $5,000. Bradford Washburn, Director of Science Park introduced the keynote speaker, H. G. Steven, Director of the National Science Foundation. Massachusetts Governor Sargent and former Governor Bradford attended. Three years ago Alfred and Larry Irving were awarded honorary degrees by the University of Alaska. They posed with Peter Morrison, Director of the Institute of Arctic Biology, University of Alaska.



Stuart Mudd, in replying to the greeting from Hal Davis gave proof of continuing activity at age 80. He enclosed his autobiographical prefatory chapter for the 1969 Annual Review of Microbiology, "Sequences in Medical Microbiology, Some Observations Over Fifty Years." Then in the J.A.M.A. for July 2, 1973, he had a note on "Delayed Hypersensitivity to Staphylococcus aureus."

E. G. Gross replied to Hy Mayerson: "Thanks for your birthday card. Yes, the years certainly roll around. I was 81 on May 12 but in fairly good health. I wouldn't run a fast race, but get around pretty well.

I retired as Head of Pharmacology at Iowa in 1960. I had a couple of offers of other jobs, but my wife and I decided at 68, it was time to stop worrying over a job. We've spent our winters in Florida and the summers in Iowa City. We have finally purchased a place (a mobile home) in Largo, Florida, and will spend more time there. We have two sons, one a doctor in Alton, Ill., and another a geologist in Denver. We plan to always spend some of our summers visiting our children and grandchildren. Last summer we attended the International Pharmacology Congress in San Francisco. Saw a few familiar faces and thousands of unknowns."

Edmund Jacobson at age 85, continues his investigations of simultaneous chemical and electronic recordings in man in health and disease and also is studying hypertension and coronary heart disease. It is of interest to physiologists to know the life story of senior members who remain active for so many years. Edmund was born and educated in Chicago. After a B.S. degree from Northwestern in 1908 he received A.M. and Ph.D. degrees from Harvard and then returned to Chicago as an Assistant in Physiology. Here he obtained his M.D. degree in 1915. Then he launched a career in medicine and physiology that has brought him national recognition. He remains active as a practicing physician in Internal Medicine and Psychiatry in Chicago and New York City. He directs the Laboratory for Clinical Physiology in Chicago.

From his days at Harvard he has been interested in "progressive relaxation" and in 1921 introduced the application of psychological principles to medical practice, later called "psychosomatic medicine."

In 1929-1937, aided by Bell Telephone Laboratories, he introduced electronic rectification and integration into biology and invented the integrating neurovoltmeter, for the first time measuring action-potentials to small fractions of one microvolt, previously considered "impossible." Employing low microvoltage apparatus, he made the first accurate measurement of muscle tonus in man, nerve impulses in intact man and the direct electrical measurement of mental activities in neuromuscular sites, published as The Electrophysiology of Mental Activities and Introduction to the Psychological Process of Thinking." He introduced electro-oculography with recording of eye-movements awake and during dreams in 1930.

Edmund is a member of numerous professional societies, having been elected to the APS in 1929. He has received many honors, has published many papers and wrote 10 books ranging in time from "Progressive Relaxation" Univ. of Chicago Press, 1929 to Physiological Psychiatry projected for 1974.

A. V. Hill, Honorary member of the Society sent Hallowell Davis a reprint of his "Autobiographical Sketch." This sketch is in print - Perspectives in Biology and Medicine, Vol. 14, No. 1, Autumn 1970, University of Chicago Press.

CHARLES DAVID SNYDER
1871-1973

Professor Charles D. Snyder, who was 101 years old, died in a nursing home March 21, 1973 at Los Altos, California. He was a retired emeritus professor of experimental physiology at the Johns Hopkins University School of Medicine. Professor Snyder was born in Circleville, Ohio, April 30, 1871. His family moved to the state of Washington when he was 12 years old. He received his A. B. from Stanford in 1896 (1), rooming with Herbert Hoover. He taught high school from 1896 to 1905. He obtained his A.M. from the University of California in 1904 and his Ph.D. in 1905. He was given a fellowship to study at the University of Berlin, 1906; the Marine Biological station in Naples, 1906 and at Munich, 1908. He came to Hopkins in 1907 under Dr. Howell in the department of physiology of the Medical School. He was promoted to instructor in 1908; associate, 1909; associate professor, 1911; and professor, 1921. He retired as an emeritus professor in 1941. He served under three chairmen at Hopkins, Dr. Howell, Dr. Marshall, and Dr. Bard.

His research work was of a biophysical nature, ranging from how a grasshopper drinks, temperature effects on cardiac contraction, temperature coefficient on nervous impulse, latency of knee-jerk in man, heat liberated by the beating heart and flashing interval of fireflies (2). He liked to divide his experimental results by factors. In fact, he spent more time with his slide rule than he did in his laboratory. For example, he published (3) a paper on "The Real Winners in the 1936 Olympic Games" in which he divided the winners of each country by the population of the country and came out that Esthionia was the winner of the Olympics. His many publications on the heat production of the heart were never accepted by A.V. Hill. Hill maintained that the cardiac muscle moved on the warm junctions of the thermopile during contraction and therefore did not give valid thermal results. On the wall of his office he had a large pendulum (4) stimulator that came from Keith Lucas' laboratory. He had another stimulator made in Helmholtz's shop. There was a galvanometer in a case marked "Used in the detection of the signals of the first trans-Atlantic cable."

Dr. Snyder was a quiet reserved man who was overlooked easily by the administration. He was forgetful; the story is told that when he was a student in Berlin, he was invited to the home of van't Hoff for dinner. He arrived a week before the invited time. He talked in a low voice and, as a result, his lectures were not heard beyond the first row of students. He was at his best in the student laboratory for he was very patient in his informal explanations to the students. He attracted a few medical students (5) who did special work in his laboratory; the most famous being Keffer Hartline, whose work while a student formed the basis of his award of the Nobel Prize. On his 100th birthday, he was given a party in his home with telegrams from President Nixon, Governor Mandel and other notables.

Dr. Snyder entertained well in his Roland Park home. His guests were generally members of the department of physics and mathematics.

His wife was a daughter of the famous chemist, Jacobus van't Hoff. The conversations at his parties were around student life in Germany in general and van't Hoff in particular. He had three children; his son, Thomas, received his Ph.D. in physics at Hopkins and has become an outstanding designer of nuclear reactors. His two daughters are married, Mrs. Francina Jacobs of Pittsburgh and Mrs. Annaleida van't Hoff of Andover, N.H.It is of interest that one daughter married a van't Hoff. Dr. Snyder's wife died in 1971.

Professor Snyder, with his early background in the German Universities, was very pro-German and anti-British. These attitudes got him into trouble before our entrance into World War II, especially with a group at Hopkins which was entitled "Help Democracy by Aiding the Allies."

Dr. Snyder continued to work in his laboratory at Hopkins until his retirement in 1941. At that time he settled down in his home in Roland Park. He was visiting with his son in California when he died.

Chalmers L. Gemmill

NOTES

1. Dates taken from American Men of Science, II. The Biological Sciences, 9th ed. 1955, 1056.
2. Complete list of his publications may be obtained from Alumni Records Office, The Johns Hopkins University, Baltimore, Md. 21218.
3. The Scientific Monthly, 1936, 43, 372.
4. I went back to Hopkins several years ago in order to locate these instruments. No trace of them could be found in the Department.
5. I published two papers under Dr. Snyder when I was a medical student (1922-26); C.D. Snyder and C.L. Gemmill, Thermomyograms in Response to Nerve Stimulation I. The Initial Rise, as Registered by Einthoven's Galvanometer. Am. J. Physiol. LXXIII, 1925, 556; Gemmill, C.L., The Heat Produced by the Terrapin's Auricle. Am. J. Physiol. LXXX, 1927, 668.

SOME RECOLLECTIONS OF DR. CHARLES D. SNYDER

I first made the acquaintance of Dr. Charles D. Snyder when I entered the Johns Hopkins Medical School in the fall of 1923. I was keen on doing research - research on vision - and skipped the dissecting room one morning to talk to E. K. Marshall in physiology. E. K. sent me to Snyder, who was responsible for "physiological optics" in the physiology course. With characteristic kindness and generosity, Dr. Snyder assigned me to ample space in the optics lab - but I soon elbowed my way into his own basement laboratory. There I eyed greedily his Einthoven String Galvanometer. For his muscle heat work, he sought a fast, sensitive measuring instrument, but one with good impedance match to his thermocouples - contradictory requirements in those days. He was using aluminum strings, made from Wollaston wire, and I soon became quite expert at turning them out for him. This was detrimental to my studies of anatomy and any stray clinical subjects that intruded, but it partially recompensed him for the nuisance I was.

I recorded electrical responses of the eyes of frogs and (for the first time) insects; I also obtained the first electroretinogram (ERG) from a human subject. These were far from Dr. Snyder's main interests, but he was extremely patient and understanding, and encouraged my youthful enthusiasm.

I wanted to work on the mammalian eye, and asked Dr. Snyder to show me how to prepare a decerebrate cat. He promised to, and told me not to try it until he had taught me. But I was impatient, and with a classmate captured a tough old alley cat and set about our surgery one Sunday. Bleeding was a formidable problem, but it soon became better - then very much better. Just as we discovered that we had drowned our cat in ether the door opened and Dr. Snyder walked in - on one of his rare Sunday visits. We were certainly caught red-handed, but he was only mildly censorious, and I believe not at all surprised.

Engrossed in my own interests (what student isn't?) I learned very little about Dr. Snyder's own work although I saw him almost daily over the four years of my medical course. I fear that the metallic galvanometer strings were still not a good match for his very low resistance muscle thermopiles, and I am not sure how successful his efforts were to resolve the time course of muscle heat production. I do remember his ingenious use of luminescent bacteria to gauge the attainment of anaerobic conditions in some of his experiments.

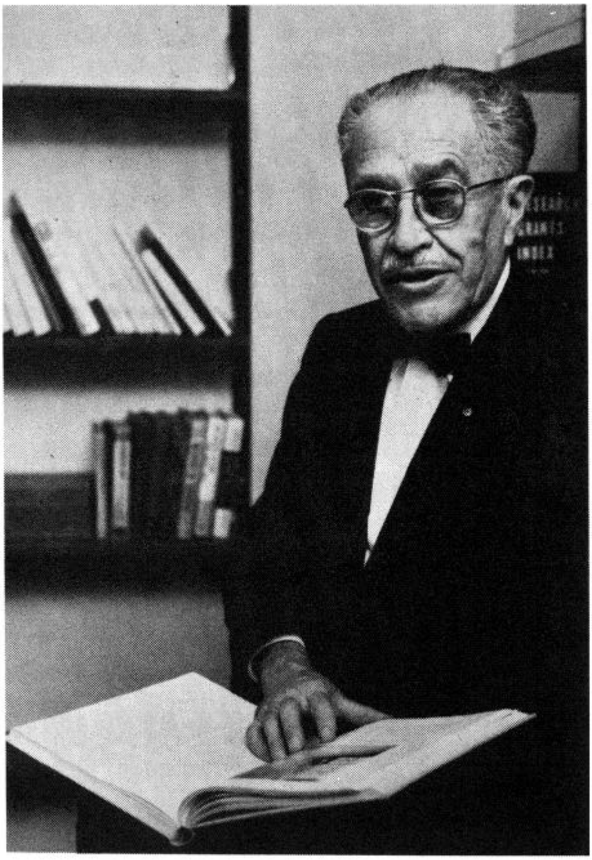
I remember Dr. Snyder as tolerant of a brash student, always kind and encouraging and generous to a fault in providing opportunities and resources for truly independent research, at what must have been no small inconvenience to himself. I also remember pleasant Sunday dinners at his home, and the graciousness of Mrs. Snyder and their two charming daughters and lively son. Trivial events conspired - as they do too often - ever to postpone my intended visits to him in his later years. I remember him most vividly as he was in the 1920's, in his basement laboratory which he so kindly let me share.

Keffer Hartline

LOUIS N. KATZ, M. D. (1897-1973)

An Appreciation

ALFRED P. FISHMAN



Modern physiology began more than three hundred years ago with William Harvey's demonstration of the circulation of the blood. Ever since, circulatory physiology has had its fair share of rugged, brilliant individualists who have not only helped to advance the cause of physiology, but have also exerted strong influence on related fields and activities. Louis N. Katz was one of these. Not only did his laboratory serve as a watershed for an unbroken stream of original research and for the training of more than 500 disciples in cardiovascular physiology and medicine, but his clear vision, boundless energy and extraordinary administrative talent were instrumental in shaping the course of national and international science.

His beginnings were modest. He was born in Pinsk, Poland in 1897, and moved with his family to the United States when he was three years old. He attended local schools in Cleveland and Western Reserve University, entering its medical school in 1918 and receiving the M.D. degree in 1921. During a student elective, he was exposed to Carl J. Wiggers who excited his interest in experimental physiology. But clinical medicine was still his goal and, after graduation from medical school, he completed an internship and assistant residency in medicine at the Cleveland City Hospital and then served as a Demonstrator of Medicine at the medical school. By 1924, he was wavering towards physiology. And, after one year with A. V. Hill at University Hospital in London as a Fellow of the National Research Council and despite two months of "revitalization" in clinical medicine with Sir Thomas Lewis, he acknowledged his interest in physiological mechanisms, joining Wiggers' department in 1925 as a Senior Instructor. He took this step recognizing fully that in forsaking clinical practice for physiology, he was embarking on a career which was "limited in financial opportunity, in public awareness and in popularity."

Although he was not set on a new course, his clinical training contributed a great deal to his orientation in physiology. During his clinical years (1921-1923), he had come into contact with a second strong influence - Dr. Roy Scott, Chief of Cardiology at the Cleveland City Hospital. Impressed by this bright, energetic, inquiring young physician, and sharing his enthusiasm for mechanisms of disease, Scott gave the young house officer free run of the Cardiology Section. This was a rewarding experience and it was no surprise that when Katz returned to Wiggers' department, he kept one foot in clinical cardiology by serving as a Consultant in Cardiology to the St. Lukes Hospital in Cleveland (1928-1930). Although Katz was never to practice clinical cardiology seriously, this dual exposure to physiology and medicine initiated an interplay which was to continue throughout his life. From then on, his research was to have clinical overtones and implications.

In 1930, he moved to the Michael Reese Hospital in Chicago as Director of a newly established "Cardiovascular Department" and Assistant Professor of Physiology at the University of Chicago. Farsighted physicians at the Michael Reese Hospital had decided to establish a research department of cardiology that would reinforce the practice of clinical cardiology. They provided space, one secretary, one technician, limited funds and considerable good will and encouragement. Katz was a natural for the position of Director.

In quick order after his arrival in Chicago, he set his laboratory into operation, created an electrocardiographic station that combined research with service, persuaded generous benefactors to come to his financial aid and set out to develop a center of excellence. His early programs were concerned with the regulation of the coronary circulation, the efficiency of the heart, and in Goldblatt hypertension. He opened his laboratory to scientists who were fleeing from the Hitler horror. By 1940, students were coming from everywhere: some for electrocardiography; others for hemodynamics; many simply for a brief research experience before launching a career in cardiology. Interest was especially high in hemodynamics and in electrophysiology and electrocardiography. Alexander Kolin developed the electromagnetic flowmeter in his laboratory. Original papers quickly appeared on the performance of the heart and its metabolic requirements. His Physiological Reviews article in 1947 on "The Genesis of the Electrocardiogram" was the masterful performance of an expert, and his textbook, "Electrocardiography", published in 1941, rapidly became a standard reference. He and his students worked hard to define the validity of the "central terminal" as an indifferent electrode, the meaning of the "intrinsicoid deflection", the interpretation of records taken using unipolar leads.

In 1939, with the advent of Richard Langendorf, a tradition was born in the electrocardiographic interpretation of arrhythmias. The lineage was ensured in 1949, with the arrival of Alfred Pick. It would be difficult to imagine three more dissimilar personalities and mentalities working for years in close harmony. But they did. And their mutual understanding, respect and cordiality created a harmonious heart station that served as a backdrop for clinical research in cardiovascular physiology and cardiology at the Institute.

Because of the nature of the man, research and teaching were always intimately associated. His approach to both was unique. Research to him was a "calling", "a dignified profession to be pursued only by the consecrated and inspired, in quietude, at a leisurely pace and away from prying eyes." (1). It was characterized as the product of a creative mind rather than of a particular process or locus:

"Research is not done only in the laboratory. It may be conducted at the bedside, in the operating room, and in the field of public health and epidemiology. It is not the place that counts. It is the perspective. It is the original mind asking a question and designing an experiment to find the answer. It should not be pebble-picking - it should be the building of magnificent castles... Research should advance a fundamental concept or it should have an obvious practical value and early application. Research is not gadgeteering. It is the pursuit of ideas." (1).

Training took another, but related, tack: the teacher was a sculptor, doing his best with the material on hand. Strategy was dictated by the nature and qualifications of the trainee. But throughout, it was one of continuous challenge, the intensity modulated according to the capacity, potential and responsivity of the individual. Each trainee was encouraged to participate in a research program. If nothing else, he would share the excitement of discovery and be exposed to the disciplined gathering of data and its organization for presentation or as a scientific paper.

He loved to teach. His presentation of hemodynamics was unforgettable and irreproducible. Most impressive was the annual ritual that followed immediately upon his return from the Spring Meeting of the American Physiological Society: he reviewed, one-by-one, each of the papers that he had heard during the past week. All in the audience of the Institute had seen him at the APS meeting, in the front row, completely engrossed in the ten-minute presentations, listening intently, occasionally shaking his bushy head for or against the speaker, first to his feet when time came for discussion, gently quizzing and supporting the neophyte on the podium but devastatingly critical of the mentor who had allowed a newcomer to appear before the Society without full preparation. Now, back at the Institute, using his marked program as the agenda and the blackboard to simplify complicated ideas and techniques, he meticulously went over each paper that he had heard - extracting its essence, clarifying its message and import, pinpointing uncertainties and omissions and drawing lessons that had been overlooked. It was remarkable how much more the meetings meant after "the boss" finished reviewing them.

Personal relations between "the boss" and "the boys" were quite complicated. He was a formidable figure, bewildering in mental agility, exhausting because of boundless energy, esteemed for high personal and scientific standards, and fearsome because of intolerance of bad work or slovenly thinking. Nonetheless, despite these obstacles to relaxed communication, great attachments almost invariably developed between master and students. And inevitably, upon graduation from his charge, he accepted for each of his disciples the self-imposed charge of champion and protector.

By the end of the 1940's as life at Michael Reese Hospital settled into a steady state, he was ready to extend himself seriously into the affairs of physiology and cardiology outside of Chicago. In the American Physiological Society and the American Heart Association he found natural outlets for his talents.

From 1933 to 1936, he had been involved in the genesis of the Circulation Group of the American Physiological Society. This dinner club consisted of a small, select group who met once per year for unbridled discussion of timely topics and controversies concerning the circulation. Wiggers and his clan dominated the organization. Strong personalities from other camps were not reluctant to express dissenting views. Each meeting was a lively affair, the informality contrasting strikingly with the conventional scientific sessions of the regular meeting. After helping to organize and to energize this group, he served first as Secretary and subsequently held all the important offices. Simultaneously, he grew more and more involved in the affairs of the American Physiological Society. In 1952 he was elected to Council. In 1957 he became President. While President, he established the Bowditch Lecture and gathered sufficient funds to ensure its continuity after he left office; he devoted himself assiduously to improving the administrative operations and financial state of the Society. In 1952 he was elected to Council. In 1957 he became President. purchase of land for the development of Beaumont House which would serve as a permanent home for the Society. By the end of his term, the Society was a healthier organization. After relinquishing the presidency, he continued for many years to serve as the Society's representative on various committees and boards of other organizations. In 1962, he was graduated from the Circulation Group and designated a Distinguished Member.

The American Heart Association and Louis N. Katz were made for each other. In 1942, he joined the Board of Directors. One of his first ventures was to transform the Association from a society for professionals into a national voluntary agency. He seized the opportunity for promoting research in cardiovascular physiology and in cardiology. As a guiding principle, he enunciated the policy that priority in research support should be to creative people rather than to projects, bricks and mortar. He pressed for the creation of the Established Investigatorships and later for the Career Investigatorships. He served on almost every important committee of the Association: Finance, Executive, Policy, Budget, Awards and, inevitably became Chairman of the National Research Committee. In 1953, he was awarded the Albert Lasker Award of the American Heart Association for Distinguished Achievement in Cardiovascular Research. Subsequently, he received the Gold Heart Award, the Research Achievement Award and, in 1951, became President of the Association. But the recognition that brought him most pleasure was the creation in 1968 of the "Louis N. Katz Basic Science Research Prize" for young investigators by the Council of Basic Science.

This heavy extramural commitment did not seriously impede his local activities. In the Institute (his department was so designated officially in October 1961), research and clinical trials expanded in hemodynamics, hypertension and electrocardiography. But a new direction was opening there: he refused to accept atherosclerosis as an inevitable consequence of the aging process. He advocated instead that it is a metabolic disorder which is both preventable and reversible: he and his associates succeeded in producing an experimental animal model of arteriosclerosis, devised new interventions, and subsequently launched clinical trials. As evidence mounted in support of his view, his enthusiasm for preventing and reversing the lesions of atherosclerosis became pervasive and contagious. Inevitably, he became involved in the American Society for the Study of Arteriosclerosis, serving on its Board of Directors from 1947-1953, and finally as its President from 1954-1955. Local extramural activities included the Presidency of the Chicago Heart Association (1954-1957), of the Institute of Medicine of Chicago (1960-1961), and Professorial Lecturer at the University of Chicago (1941-1967).

His concern for individual research contrasted with his global view of physiology and cardiology. Working with his friends, Professor Ignacio Chavez of Mexico City and Paul D. White of Boston, Massachusetts, he became the architect of plans for international cooperation in cardiology. He organized international and inter-American congresses. In 1948, he became the Permanent Honorary President of the Inter-American Society of Cardiology and, in 1962, was designated Honorary Councilor for Life of the International Society of Cardiology.

As he grew older, his talents and accomplishments continued to be recognized in many different ways: Honorary degrees from Western Reserve University (1965) and the Chicago Medical School (1966); the Carl J. Wiggers Award of the American Physiological Society (1967); a host of national and international lectures: The Connor and Lyman Duff Lectures of the American Heart Association (1960, 1970 respectively), and Visiting Professor of Physiology at the University of Chicago (1967-1969).

He became Director Emeritus of the Cardiovascular Institute in 1967. Retaining a small, inconspicuous office in a cul-de-sac of the Institute, he withdrew from the mainstream of research and administration. But he remained accessible to students and staff. His major preoccupation became the preparation of a monumental survey of cardiology - that he undertook with one of his former students and associates, Dr. Earl N. Silber; his part was physiology and pathophysiology. More time became available for his wife, Aline, for intellectual scrimmages with his son, Arnold, and to play the role of father-in-law and grandfather. He took each role seriously and played each part to perfection. Death interrupted the writing but it was almost all done. Indeed, anticipating the close of one book, he had begun to plan another.

How would Louis N. Katz have set priorities on his own accomplishments? He would have dismissed with a wave and a shrug his great personal triumphs as scientist and administrator. He would have become embarrassed and impatient if reference were made to the helpful hand that he had extended, without hesitation, to unfortunate people caught in the turmoil of Europe before, during, and after World War II. But he would have treasured his position as a symbol of intellectual honesty and discipline in science and medicine and as a teacher and catalyst for young investigators.

And, if one were seeking a fitting epitaph for Louis N. Katz, one might borrow his own concluding remarks about William Harvey,

"One of the world's clearest thinkers and observers - a man who defied tradition and the unquestioning acceptance of authority, a man who abhorred dogma and believed more in a posteriori reasoning than in a priori speculation... he truly walked the thorny road through toil to the serene abode of fame."(1).

REFERENCE

1. Katz, L.N. Harvey and Medical Research. J.A.M.A. 160: 1137-1141, 1956.

A LOUIS N. KATZ MEMORIAL LECTURESHIP has been established at the Michael Reese Hospital. Contributions to this lectureship fund should be addressed to Mrs. Beverley Petzold-Cortes, Cardiovascular Institute, Michael Reese Hospital, 29th Street and Ellis Avenue, Chicago, Illinois 60616.

PROF. BERNARDO ALBERTO HOUSSAY

(1887 - 1971)

Professor Bernardo Alberto Houssay, the man responsible for placing Argentina and Latin America on the world map of science passed away on the 21st of September in Buenos Aires, the city where he was born on April 10th, 1887.

He was self-taught and, according to his own account, it was the reading of Claude Bernard's "Introduction a l'étude de la Médécine Experiental" that brought about the miracle which revealed to him his scientific vocation.

Professor Houssay's father, Alberto Houssay, a lawyer, graduated in Bordeaux, and his mother, Clara Laffont, were French. They came to Argentina in 1886 and in the next year, Bernardo Alberto, the fourth of their eight children, was born.

Bernardo, a very bright child, who spoke both Spanish and French, entered the University at the age of thirteen and graduated as a pharmacist in 1904 at 17, and as a physician in 1911, at the University of Buenos Aires.

In the period 1910-1919 he was appointed Professor of Physiology in the School of Veterinary.

In 1919 he became Professor and Director of the new Institute of Physiology at the School of Medicine in Buenos Aires, position that he kept during the periods 1919-1943, 1945-1946, and 1955-1957.

When 33 years old he married María Angélica Catán, a graduate in chemistry and a collaborator in his work. They had three sons. His wife was a devoted companion who shared his life with complete abnegation until her death in 1962.

During the first period 1910-1919, he also worked as a clinician in the Alvear Hospital, but realizing that the only way of developing his scientific career was as full time research worker, he fought for such a position and since 1919, he devoted all his life as a full time research investigator.

The first scientific publication was in 1908 on the Stokes-Adams Syndrome.

From his early beginning he showed tenacity, a tremendous technical ability, an outstanding memory and a great capacity for working.

His works on the hypophyseal gland started in 1910 and he continued them for the rest of his life. Soon after the discovery of insulin in 1921 he found in the hypophysectomized toad (Bufo arenarum Hensel) great sensitivity to this hormone and the resistance given by administration of extract of the anterior lobe of the phypophysis. He repeated and confirmed the experiments in dogs, thereby proving the role of the hypophysis in the regulation of carbohydrate metabolism.

These conditions allowed him to form one of the most well known schools of Physiology in the world, which spread especially in Argentina and Latin America in the field of diabetes and all the branches of endocrinology, both in clinical and experimental aspects.

In 1943, Houssay and many other university professors and personalities, declared their sympathy for freedom, democracy, academic liberty and collaboration among all the American countries.

Due to this declaration he, together with many others was dismissed and had to leave his position as Director of the Institute of Physiology.

Since he refused to leave Argentina, he was helped by some of his compatriots and the Institute of Experimental Biology and Medicine was founded.

Professor Houssay was the first Director since 1944 until his death in 1971.

All of his disciples, doing full time basic research in the physiology sciences, followed him and for the period 1944-1955 the Institute of Experimental Biology and Medicine became the center of Physiology in Argentina. Here his activity and enthusiasm did not decline and in 1947 he received the Nobel Prize in Medicine and Physiology, recognized all over the world.

In 1955 he decided to remain as Director of the above mentioned Institute, leaving his disciplines as professors in the physiological sciences in Buenos Aires and some other faculties of Argentina.

Realizing that the future of the country lay in the development of science and technology, he created in 1968 the National Council for Scientific and Technical Research, an organization which changed and improved all the branches of research in Argentina and is used as an example in many other countries in the world.

In 1959, the XXI International Congress of Physiological Sciences was held in Buenos Aires, and Houssay, its President, was appointed President of the International Union of Physiological Sciences for the period 1959-1962. During these three years he devoted most of his efforts in keeping the IUPS in its outstanding position in the field of Physiological Sciences in the world.

He was nominated as Honorary President of the International Diabetes Federation and it must also be mentioned the dedication in his honor of the VII Congress of the International Diabetes Federation of August 1970 in Buenos Aires. This later proved to be the last distinction he received in his long and meritorious life which came to an end shortly after.

Since his first scientific paper in 1908 until his last in 1971 he published around 800 works. most of them in diabetes, endocrinology and general articles on the importance of science and technology in the development of the countries.

Professor Houssay got several international prizes. He was Doctor Honoris Causa in 28 universities and Honorary Professor in 15, Foreign Member in 11 Academies and Member Honoris Causa of 300 societies.

His contribution in the field of Experimental Diabetes was the reason of his Nobel Prize and the "Houssay dog" is classic in Physiology.

The life of Professor Bernardo Alberto Houssay is a model for the young generations in the whole world since he was always optimistic, fighting for science and technology as the best way for freedom and best understanding among all the communities in the world.

Prof. Ricardo R. Rodriguez

PROF. BERNARDO A. HOUSSAY

Personal Recollections

RAYMOND L. ZWEMER

In 1923 I graduated from Hope College in June and came to Yale in the Fall. I had a course in Endocrinology which at that time was not listed in the dictionary - the course was given by W. W. Swingle. As I became interested in the adrenal I read a paper by Bernardo A. Houssay and John T. Lewis. It was a paper in the American Journal of Physiology - LXIV- page 512. Lewis at that time had been at Harvard. Houssay always gave his graduate students a chance to study elsewhere.

It was twenty years later, January 1941 that I met him. I was on sabbatical leave from the College of Physicians and Surgeons at Columbia University and had been awarded a Guggenheim Fellowship to work with Professor Houssay.

At least five of his co-workers collaborated with me on various problems and he was particularly pleased that I worked on the Bufo Arenarum Hensel toads. There were many jokes about this as the toad had his same initials. He had done a great deal of research on the animal.

Our family has many fond memories of Professor Houssay. We spent eight months in Buenos Aires in 1941. Angelica and Bernardo Houssay were very helpful in getting our children started in the Argentine public schools and even supplied a tutor to speed up the change in language. For years afterward he would tell people that we put our children in the Argentine public schools and they even attained "primero puesta" - first in their class.