

Bob Eisenberg

aka Robert S. Eisenberg

Curriculum Vitae

July 15, 2008

Work co-ordinates

Address

Department of Molecular Biophysics and Physiology
Rush Medical College
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Chicago IL 60612

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Voice: (312)-942-6467
Dept FAX: (312)-942-8711
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Short Biography

Bob Eisenberg received his A.B. (summa cum laude) after three years of study at Harvard College with John Edsall as tutor. He started studying electrical properties of cells at that time, working under the direction of John Pappenheimer and Steve Kuffler. He went to University College London for his Ph.D. under Paul Fatt with Alan Hodgkin as his external examiner (and hero!), Bernard Katz as Chairman, and Andrew Huxley as mentor, for many years. Eisenberg's Ph.D. thesis and later work for a decade or two used engineering methods (impedance measurements) to determine the electrical structure of cells and tissues (skeletal muscle, cardiac muscle, lens of the eye), developing mathematical models to describe the anatomy of the tissue (with the help of Julian Cole and Victor Barcilon), and to measure the structure with statistical sampling methods of stereology (helping Brenda Eisenberg). He served as Chairman of the Physiology Study Section of the NIH for several years, and Director of Research (etc) for the American Heart Association (Chicago Branch). After single channel recording was discovered, he was the inventor and senior designer of the AxoPatch patch clamp amplifier (working with Rick Levis, Jim Rae, and Alan Finkel) which is used by most workers in the field to this day.

Bob has spent many years on multi-scale analysis of ion channels, seeking to predict the current through the channel, in a range of solutions of different composition, over a range of voltages. Working with Zeev Schuss, he showed how the flux over a potential barrier of arbitrary shape could be evaluated analytically, starting from a description of the stochastic trajectories of diffusion. "Eyring models" of transition state theory arise as a special case, hardly easier to compute than the general formulas. Eisenberg (with Wolfgang Nonner and Dirk Gillespie, et al) has shown how the properties of concentrated bulk solutions (as summarized in the Density Functional Theory of the Liquid State) can account for the selectivity of L-type calcium channels and voltage activated Na^+ channels (of nerve membranes for example originally described by Hodgkin, Huxley and Katz) without invoking specific binding sites or quantum mechanical

effects. Recently, he (helping Zeev Schuss and Boaz Nadler) have shown how mean field models can be derived from a model of the stochastic trajectories of ions in solution, using the techniques of probability theory and one easily justified physical assumption. He has recently (1) designed selective channels using nonselective bacterial channels (ompF porin) as the ‘substrate’ (with Hank Miedema, et al, from Groningen), (2) designed abiotic ionic channels (which Zuzanna Siwy builds), (3) helped Weishi Liu apply geometric perturbation theory to ion channels, and (4) used the mathematics of inverse problems to design the selectivity and permanent charge of channels, assisting Heinz Engl and Martin Burger.

Along the way, he helped Amit Singer (working with Zeev Schuss) show why perturbations in the charge distribution of table salt (NaCl) do not produce sparks and electrocute those who touch it. Safety in salt is a consequence of probability theory as users of salt should be glad to know.

Internet Coordinates

Web Sites

Departmental Site: <http://www.rushu.rush.edu/molbio/>
with a ‘Chairman’s Message’ at <http://www2.phys.rush.edu/physiomsg.html>
leading to Personal Site <http://www2.phys.rush.edu/RSEisenberg/physioeis.html>

PNP Online <http://www.pnponline.org/> Interactive software for running Poisson Nernst Planck theory, with Brice Burgess.

FTP Sites

- 1) [Reprints](#) available on this [hyperlink](#)
or by anonymous ftp from <ftp.rush.edu>.
(*sign on as anonymous; for password; use your email address*)
Migrate to [/MoleBio/Bob_Eisenberg/Reprints](#)
or just click on this hyperlink
- 2) *PNP* is available in various flavors,
 - a. *PNP*online is at <http://www.pnponline.org/> thanks to Brice Burgess
 - b. from <ftp.rush.edu> at
[/pub/Eisenberg/PNP](#); [/pub/Eisenberg/Hollerbach](#); [/pub/Eisenberg/Nonner](#),
thank you: D. Chen, U. Hollerbach, W. Nonner and S-W. Chiu.
 - c. See a much more modern (2008) version from Department of Chemistry,
Northwestern University, Laboratories of Mark Ratner and George Schatz
labs <https://www.nanohub.org/resources/2469>
- 3) Files of single channel currents with noise are in [/pub/Eisenberg/Noise](#), written in
collaboration with Rick Levis (*deceased, 2005*).

Education

Elementary School: New Rochelle, New York

High School, 1956-59. Horace Mann School, Riverdale, New York City, graduated in three years with honors and awards in Biology, Chemistry, Physics, Mathematics, Latin, English and History.

Undergraduate, 1959-62. Entered Harvard College with Advanced Placement as a sophomore, concentrated in Biochemical Sciences, Prof. J.T. Edsall tutor and mentor; advisor in Physiology Prof. J.R. Pappenheimer; graduated in three years A.B., *summa cum laude*.

Summer work, 1960-61. Nerve Muscle Program at Marine Biological Laboratory directed by Prof. S.W. Kuffler.

Doctoral work: University College London 1962-65 (Ph.D. in Biophysics: B. Katz, Chairman); Supervisor, P. Fatt; External Examiner, A.L. Hodgkin. Mentor (over several decades): A.F. Huxley.

Personal

Home co-ordinates:

Address: 7320 Lake Street, Unit 5, River Forest IL 60305

Phone: (708)-366-6332

Personal FAX: (801)-504-8665 and also (775)-256-9463

Born in Brooklyn, New York, April 25, 1942: Citizen of the United States.

Social Security Number 075-xx-xxxx.

Married Ardyth Eisenberg, 1991.

Children (mother, Brenda Russell):

Benjamin Russell Eisenberg, born March 17, 1969.

Grandchild, mother Angelle Moutoussamy

Crystal Lynn Moutoussamy, born March 19, 1994

Emily Ruth Eisenberg, born February 8, 1973. Husband, Benjamin Taylor

Jill Anna Trowbridge (formerly Eisenberg), born November 7, 1974.

Grandchildren, father John Trowbridge

James Louis Trowbridge, born August 15, 1997.

Holly Sophia Trowbridge, born July 11, 2000.

Henry Samuel Trowbridge, born January 15, 2004.

Alastair Solomon Trowbridge, born January 10, 2006

Sally Lynn Eisenberg, born June 20, 1979.

Family Christmas Letters: [[2001](#)] [[2003](#)] [[2004](#)] [[2005](#)] [[2006](#)] [[2007](#)]

Academic Positions

Main Positions

Rush Medical College, Chicago IL. Rush Employee ID 010207

1995- Chairman of Molecular Biophysics and Physiology

1976 -.... Endowed Chair "The Francis and Catherine Bard Professor"

1976-1995 Chairman of Physiology

University of California at Los Angeles

- 1975-1976 Professor of Biomathematics and Physiology,
Chairmen: Carol Newton, W. Mommaerts
1970-1975 Associate Professor, Dept of Physiology
1968-1970 Assistant Professor, Dept of Physiology,

Duke University, Durham NC

- Associate, 1965-1968. Department of Physiology, Duke University,
Chairman: D. Tosteson. Post-doctoral fellow of P. Horowicz, along with
P. Gage, C. Armstrong, etc.

Secondary Positions

- Adjunct Professor, Department of Bioengineering, University of Illinois Chicago 2007- ...
Senior Scientist, Argonne National Laboratory (Mathematics and Computer Science
Division, 2005 - ...
Schlumberger Visiting Professor, University of Cambridge (UK) 2002
Visiting Fellow, Corpus Christi College, University of Cambridge (UK) 2002
Visiting Professor, 2000-2003 Computational Electronics, Beckman Institute, University of
Illinois, Urbana Champaign
Visiting Scientist, 1991-1995. Department of Physics, Brookhaven National Laboratory,
Upton, Long Island, NY.

Honors

- Editorial Board, Journal of General Physiology, 1970-1991
Editorial Board, Journal of Computational Electronics, 2001-...
Associate Editor, Comments on Theoretical Biology, 1987- ..
Associate Editor, News in Physiological Sciences, 1988-1992
Harvard College Scholarship
A.B. received *summa cum laude*
Phi Beta Kappa: member of "Senior Sixteen"
L.J. Henderson award for thesis in Biochemical Sciences
Senior Common Room Award for "Most Promising Scholar"
Schlumberger Visiting Professor, University of Cambridge (UK)
Visiting Fellow, Corpus Christi College, University of Cambridge (UK)
Schlumberger Medal, Physical Chemistry
Plenary Lecture at European Mathematics Society/AMAM 2003
Member Executive Board, American Physical Society (2002-2004)
Fellow, American Physical Society (Division of Biological Physics)
Argonne National Laboratory: Director's Seminar
Fellow, Senior, and Life Member of the IEEE
Institute of Medicine of Chicago

Grant Support

Continuous Grant Support (without interruption) thanks to a combination of NSF, NIH, and DARPA from approximately 1970 to present. Miscellaneous additional grants from AHA, MDA, Chicago Heart, etc.

Scientific Administration

AMERICAN PHYSICAL SOCIETY

Councilor (First term: 2000-2004)

Councilor (Second term: 2005-2009)

Member of Executive Board (2002-2004)

Member, Committee on Committees (2003- 2006)

Member, Audit Committee (2004 - 2007), Chair Audit Committee (2005 – 2006)

Division of Biological Physics

Executive Board (2001- ...)

BIOPHYSICAL SOCIETY

Member of U.S. National Committee International Union of Pure and Applied Biophysics (1978-1983)

Member of Council (1983-1986).

Member of Executive Board (1983-1986).

Member of Program Committee (1984).

Chairman of Nominating Committee (1985).

Chairman of Science Public Policy Committee (1985-1987).

CHICAGO CHAPTER OF SOCIETY FOR NEUROSCIENCE

Member of Council (1981-1984), Meeting Organizer, then President.

CHICAGO HEART ASSOCIATION

Member, Vice Chairman, then Chairman of the Research Council (1982-1986).

Member, Vice Chairman, then Chairman of Research Review Committee (1976-1986; 1989).

NATIONAL INSTITUTES OF HEALTH

Member (1979-1981), then Chairman (1981-1983) of Physiology Study Section.

Member *ad hoc* (2004) Modeling and Analysis of Biological Systems (MABS) Study Section.

NATIONAL SCIENCE FOUNDATION

Member, Steering Committee on Biology and Mathematics (1989, 1996).

PENNSYLVANIA MUSCLE INSTITUTE

Member (1980-1982; 1989-1990), then Chairman (1982-1987; 1989-1990) of the External Advisory Board, University of Pennsylvania, Director: A. Somlyo (1980-1987); Y. Goldman (1989-1990).

SOCIETY OF GENERAL PHYSIOLOGISTS

Councilor; Chairman, Membership Committee.

UNIVERSITY OF MIAMI

External review of Graduate Program, Department of Physiology (1988).

Invited Lectures

Albert Einstein College of Medicine
 American Chemical Society, Division of Physical Chemistry
 American Heart Association
 AMA Institute (1966)
 American Physical Society (Division of Biological Physics) March Meeting, 2000
 American Physical Society (Division of Biological Physics) March Meeting, 2006
 American Chemical Society Meeting, San Francisco, 2000
 American Physiological Society Meeting: 1978, 1979, 1983
 Argonne National Laboratory: Director's Seminar
 Association of Chairmen of Departments of Physiology
 Australian National University (Canberra)
 Baylor University
 Biological Chemists of the Federal Republic of Germany
 Biophysical Society, 1991: in Symposium on Ion Channels in Intracellular Membranes
 Biophysical Society, 2007: in Symposium on Modeling as a Tool in Biophysics; Sponsor
 American Physical Society (Division of Biological Physics)
 Biozentrum (Basel, Switzerland): Minicourse on Electrophysiology
 Biozentrum (Basel, Switzerland): Selectivity in Channels (Seminar in Structural Biology)
 Boston University (Department of Mathematics)
 Brandeis University (Biochemistry)
 Brigham Young University (Zoology)
 Brookhaven National Laboratory (Department of Physics)
 California Institute of Technology (Biology)
 California Institute of Technology (Applied Mathematics)
 Cambridge University (England) Physiology: Foster Club
 Cambridge University (England) Chemistry, in the "Lennard Jones Lecture Series"
 Cambridge University (England) Pharmacology
 Cambridge (England): Schlumberger Lecture, 2002
 Cambridge University (England) Centre for Computational Chemistry
 CCNY, Dept of Physics, Mike Lubell Chairman
 CECAM: Ionic Transport: from Nanopores to Biological Channels (Organizers Mounir
 Tarek and Mark Sansom, Lyon (2007)
 Centro de Investigacion y de Estudios del Avanzados (Mexico City)
 Chicago Heart Association Cardiovascular Research Forum
 Chicago Medical School
 City of Hope, Duarte, California
 K.S. Cole Symposium (FASEB, 1974)
 Colorado State University (Fort Collins: Dept. of Chemistry)
 Columbia University, Dept of Chemical Engineering
 Conference on Fluctuations, Escape, and Optimal Control Traverse City MI
 Conference of N.Y. Academy of Science, 1977
 Cornell University Medical School: Department of Physiology

Cornell University: Dept of Chemistry
 Courant Institute (NYU) Seminar “Mostly Biomathematics” (2004)
 DARPA (Defense Advanced Research Projects Agency)
 Many workshops.
 Director’s Seminar, 2001
 DSRC (Defense Sciences Research Council) Workshop on Biosensors
 Dominican University (River Forest IL)
 DuPont Experimental Station, Wilmington DE
 European Mathematics Society: Plenary Lecture at AMAM 2003 (Applied Math ...)
 Participant (not speaker) at EMBO Meeting in honor of retirement of Max Perutz
 at Kings College, Cambridge, 1980
 Emory University
 Fine Structure Society (Rosemont IL 1995)
 Florida State University: Inaugural Workshop for Computational Science, 2000
 FOCUS 2000, DARPA workshop, Session Leader, Speaker, Plenary Session
 Gordon Conference on Smooth Muscle, 1973
 Gordon Conference on Skeletal Muscle, 1980
 Gordon Conference on Skeletal Muscle, 1983
 Gordon Conference on Skeletal Muscle, 1985
 Gordon Conference on Solid State Ionics, 1990
 Gordon Conference on Ion Channels, 1998
 Gordon Conference on Ion Channels, 2000
 Grinnel College, Department of Biology
 Harvard University (Neurobiology)
 Hebrew University, Jerusalem: Fritz Haber Lecturer in Physical Chemistry
 Hebrew University, Jerusalem: Bat Sheva (de Rothschild) Seminar
 Hebrew University, Jerusalem: Protein Dynamics and thermodynamics, participant and
 session chair.
 Henderson Symposium (Basic and Applied Statistical Mechanics of Condensed Matter,
 Brigham Young University, 2004)
 HRL (formerly Hughes Research Lab) Malibu: Physics Colloquium, 1999.
 HRL (formerly Hughes Research Lab) Malibu: Colloquium, 2005.
 ICIAM 6th International Congress on Industrial & Applied Mathematics Zurich 2007,
 Co-organizer, two minisymposia: Direct and inverse problems in channels and
 membranes. Organizer Martin Burger, Co-organizer Heinz Engl.
 IEEE International Conference on Pattern Recognition (1994), presented by Amir Averbuch
 and Moshe Israeli
 Intel Workshop on Early Disease Detection (Sept 2002)
 Institute for Pure and Applied Mathematics, IPAM, UCLA, Ion Channels (2002)
 Institute for Pure and Applied Mathematics, IPAM, UCLA, Inverse Problems, Lecture and
 Workshop (2003)
 Institute for Pure and Applied Mathematics, IPAM, Lake Arrowhead UCLA Conference:
 Inverse Problems Reunion (2005)
 Institute for Pure and Applied Mathematics, IPAM, Lake Arrowhead UCLA Conference:
 Inverse Problems Reunion (2006)
 Institute for Theoretical Physics, University of California, Santa Barbara, Conference on
 Electrostatic Effects in Complex Fluids and Biophysics, 1998

International Conference on Circuit/System Theory, Sydney, Australia (1970)
 International Conference on Computational Nanoscience
 International Conference on Unsolved Problems of Noise and fluctuations in physics,
 biology, and high technology, Bethesda, 2002
 International Filter Symposium, Santa Monica, CA, 1972
 International Workshop on Computational Electronics: IWCE-5, 1997, Notre Dame.
 International Workshop on Computational Electronics, IWCE-6, 1998, Osaka
 International Workshop on Computational Electronics, IWCE-8, 2001, UIUC
 International Workshop on Computational Electronics, IWCE-9, 2003, Roma, Italia
 International Workshop on Computational Electronics, IWCE-11, 2006, Vienna, Austria
 Jacobs University Bremen Germany
 Johns Hopkins (Department of Biology)
 Johns Hopkins (Department of Biomedical Engineering)
 Kansas University (Mathematics, 2005, 2007)
 Laboratory of Molecular Biology, MRC, Cambridge England
 Lancaster University (Dept of Physics)
 Liblice Conference (5th) on Statistical Mechanics of Liquids
 Los Alamos National Laboratory (Center for Nonlinear Studies)
 Loyola University, Dept of Physiology, Maywood, Illinois
 Marquette University: Department of Biology
 Marquette University: Department of Mathematics
 Marine Biological Laboratory, Woods Hole
 Max Planck Institute (Goettingen: Erwin Neher. Am Fessberg series) 2007
 Max Planck Institute (Heidelberg: Ken Holmes, Bert Sakmann)
 Mayo Clinic
 McMaster University: Dept. of Physics (Hamilton, Ontario)
 Medical College of Virginia
 Medical College of Wisconsin
 Medical Research Council, Mill Hill, England
 Merck, Sharpe, and Dhome
 Mesilla Conference on Physical Chemistry (2001), Las Cruces New Mexico
 MIT Bio-Informatics Seminar (with the Whitehead Institute)
 Monash University, Australia: Electrical Engineering
 Monash University, Australia: Department of Physiology
 NASA Ames: Biomolecular Systems
 National Science Foundation (first MOBS Seminar: Modeling of Biological Systems)
 New York University Medical School (Physiology)
 New York University (Biology: Tamar Schlick's Group)
 NATO Advanced Research Workshop. Ionic Soft Matter, Lviv, Ukraine
 NIH NINCDS
 NIH Arthritis Institute
 NIH GMS
 NISTI-NIGMS Digital Biology Speaker (2003)
 NIST Physical and Chemical Properties Division
 Northwestern University: Evanston, Applied Mathematics
 Northwestern Univ Evanston, Mathematics "Conversations in Mathematics & Biology"
 Northwestern University: Evanston, Neurosciences

Northwestern University Evanston, Physics and Engineering Sciences
 Northwestern University: Chicago, Physiology
 Notre Dame, Dept. of Electrical Engineering
 Notre Dame, Dept of Chemistry and Biochemistry
 Novartis Foundation Symposium: Gramicidin and Related Peptides, 1998
 Novartis Foundation Meeting: Physical Models of Ion Permeation, 2000
 Oregon Health Sciences University (Vollum Institute)
 Oxford University (England) Physiology
 Oxford University Biochemical Society (England)
 Oxford University Seminar in Physical and Theoretical Chemistry (England)
 Oxford University Seminar in Chemistry (Hagan Bayley)
 Oxford University OCIAM Mathematics in Medicine 5th Study Group (Oct, 2005)
 Oxford University OCIAM Mathematics in Medicine: Ion Channels (March, 2006)
 PacifiChem (meeting of American Chemical Society, 2000)
 PacifiChem (meeting of American Chemical Society, 2005)
 Polytechnic University (NY) Dept of Chemical Engineering
 Purdue University: Dept. of Biology
 Purdue University: Dept. of Electrical Engineering: Solid State Physics,
 Organizer: Mark Lundstrom
 Purdue University Physical Chemistry Seminar Series, 2008, Organizer Dor Ben-Amotz
 Radon Institute (RICAM) EMS (European Mathematics Society) Linz, Austria, 2006
 Minicourse (3 days) Lectures on Ion Channels
 Radon Institute (RICAM), Linz, Austria, Special Semester on Quantitative Biology (2007)
 Ionic Channels
 Rensselaer Polytechnic Institute Dept. of Mathematics
 Rowland Institute (Cambridge MA)
 Sandia National Laboratory (Laura Frink/Grant Heffelfinger)
 Sandia National Laboratory Biophysical Discussion (Susan Rempe)
 Satellite Meeting (Debrecen) of International Physiological Congress, 1980
 Schlumberger Cambridge Research
 Simon Fraser University (Vancouver) Department of Physics
 SISSA and ICTP Trieste, Italy Theoretical Biophysics and Structural Biology
 Society of General Physiologists Meeting, Woods Hole
 Society of Industrial and Applied Mathematics:
 Invited lecture, Conference on Applied Probability in Science & Engineering Society
 of Industrial and Applied Mathematics
 Invited lecture, symposium on "Ionic Channels in Biological Membranes". Annual
 meeting, 1993
 Invited lecture, Symposium on Ionic Channels, 2001, Annual meeting
 Invited lecture, Symposium Electrodifussion: Modeling, Analysis, Simulation, and
 Applications, 2005, Annual Meeting
 Invited lecture, Symposium Multiscale Modeling of Electrochemical Systems, 2006,
 Annual Meeting
 Invited Lecture, Symposium, Multiscale Nonlinear Problems in Biology, 2007,
 Conference on Dynamical Systems
 SPIE Annual Meeting (1994) *in* Symposium "Mathematical Imaging: Wavelet
 Applications" (presented by Amir Averbuch and Moshe Israeli)

Stanford University (Department of Electrical Engineering)
 State University of New York (Albany)
 State University of New York (Stony Brook)
 Taft School Centennial Symposium
 Technical University of Vienna (Mathematics)
 Telluride Science Research Center Symposium on Biological Ion Channels (2003)
 Telluride Science Research Center Symposium on Biophysical and Biochemical Properties
 of Ion Channels in Epithelia (2004)
 Telluride Science Research Center Symposium Biological Ion channels: Structure and
 Function (2005)
 Texas Instrument Corporation (1966)
 Thomas Jefferson University: Daniel Baugh Institute
 TIDS12 Transport in Disordered Systems 12th Annual Meeting, Marburg, 2007
 TMR Meeting on Kinetics, Goteborg Sweden, 2000, Plenary Speaker
 Tulane University (1967)
 UCLA: Biology Department (1968)
 UCLA: Jerry Lewis Muscle Disease Center
 UCLA: Physiology Department
 UCLA: Molecular Biology Institute
 UCLA: Department of Anesthesiology
 UCLA School of Engineering, Mechanics and Structures
 UCLA Dept of Bioengineering
 University College (London): Biophysics
 University College (London): Physiology
 University of Buffalo (SUNY) Dept of Physiology and Biophysics
 University of Buffalo (SUNY) Dept of Electrical Engineering
 University of California (Berkeley) Chemical Engineering, Chakraborty Group
 University of California (Berkeley) Colloquium in Physics Dept (Marvin Cohen)
 University of California (Irvine) Miledi Group
 University of California (Irvine) Colloquium in Physics
 University of California (San Francisco, Biochemistry, ~ 1970)
 University of California (San Francisco, Biochemistry, 2007)
 University of Chicago: Applied Mathematics. Organizer Victor Barcion
 University of Chicago ‘Computations in Science Seminars’,
 Organizers, L Kadanoff & Wendy Zhang
 University of Chicago: Department of Biophysics. Organizer, George Eisenman
 University of Chicago: Department of Physics (Franck Institute), Leo Kadanoff
 University of Chicago: Department of Physiology Organizer, Harry Fozzard
 University of Chicago: Department of Chemistry Organizer, Graham Fleming
 University of Colorado (Boulder): Applied Mathematics
 University of Colorado (Denver): Physiology
 University of Florida Dept. of Chemistry, Charles Martin’s Nanogroup
 University of Gröningen, Netherlands (Department of Chemistry)
 University of Hawaii (von Bekesy Laboratory)
 University of Heidelberg Bioquant-Vorlesung Seminar, 2007
 University of Heidelberg - Bioms – Bioquant Lecture in the

Workshop on Transport, Signaling and Structure Formation in Cellular Systems:
Mathematics Meets Experiments

University of Illinois (Chicago): Department of Chemistry
 University of Illinois (Chicago): Department of Physics
 University of Illinois Medical School (Chicago): Department of Biochemistry
 University of Illinois Medical School (Chicago): Department of Ophthalmology
 University of Illinois Medical School (Chicago): Department of Physiology
 University of Illinois (Champaign-Urbana): Physiology
 University of Illinois (Champaign-Urbana): Biological Physics
 University of Illinois (Champaign-Urbana): Physics, Beckman Institute
 University of Illinois (Champaign-Urbana): Computational Electronics
 University of Linz, Oesterreich (Austria). Johan Radon Institute of Applied Mathematics.
 University of Maryland (Baltimore): Physiology
 University of Maryland (Baltimore): Biochemistry
 University of Maryland (College Park): Electrical Engineering, Electrophysics Series
 University of Maryland (College Park): Institute for Physical Science and Technology
 University of Maryland (College Park): CSCAMM
 University of Massachusetts (Amherst) Department of Chemistry
 University of Miami: Biophysics and Physiology
 University of Michigan: Michigan Interdisciplinary Mathematics Meeting.
 University of Michigan: Seminar in Applied and Interdisciplinary Mathematics
 University of Münster, Westfälischen Wilhelms-Universität Germany,
 Department of Applied Mathematics
 University of New South Wales, Australia
 University of Notre Dame (Dept. of Electrical Engineering)
 University of Oklahoma
 University of Pennsylvania
 University of Rochester (Physiology)
 University of Rochester (Neurology)
 University of Rochester (Neuromuscular Center)
 University of Sydney, Australia
 University of Texas (Austin), Texas Institute for Computational and Applied Mathematics
 University of Texas (Austin), Physics and Mathematics Seminar
 University of Texas (Austin), Colloquium in Physics (host: Harry Swinney)
 University of Texas (Austin) ICES/Computational Life Sciences and Biology Seminar:
 “Ionic Selectivity: A Physical Analysis of Vital Chemistry” (host: Ron Elber)
 University of Texas (Austin) Center for Nonlinear Dynamics (Harry Swinney)
 University of Texas (Galveston)
 University of Texas (Southwestern: Dallas)
 University of Tokyo (Neuroscience)
 University of Utah
 University of Vermont
 University of Vienna, Department of Mathematics
 University of Washington
 University of Wisconsin Madison (Electrical Engineering)
 University of Wisconsin Madison (Contemporary Biochemistry)
 University of Wisconsin Milwaukee

USA-Japan Seminar Excitation-Contraction Coupling, Tokyo 1971
 Vanderbilt University Colloquium on Physics
 Washington University, St. Louis, Physiology
 Washington University, St. Louis, Center for Computational Chemistry
 Weizmann Institute, Rehovot: Bat Sheva (de Rothschild) Seminar.
 Weizmann Institute, Rehovot: Chemistry Dept
 Western Nerve Net (San Diego)
 Workshop on Wavelets: 16th International Conference of the IEEE Engineering in Biology
 and Medicine Society.
 World Congress on Medical Physics and Biomedical Engineering, 1994.
 Yale University (Department of Physiology)
 Yale University (Section of Neuroscience)
 Yale University (Dept of Mathematics and Computational Science)
 Yangtze Conference on Fluids and Interfaces

Symposia Organized

Chairman, Mini-symposium on **The Lens as a Syncytium**, Biophysical Society Meeting, 1980.
 Co-Chairman, with Brian Salzberg, **Symposium on Fine Processing in the Fine Processes of the Nervous System**, Biophysical Society Meeting, 1984.
 Chairman of Symposium and Luncheon **Calcium Signals in Muscle**, Biophysical Society Meeting, 1985
 Chairman of Symposium. **Nerve Impulse: From Conduction to Channels by way of Conductance** at the 100th Anniversary Meeting of the American Physiological Society, 1987.
 Chairman of Symposium. **Skeletal Muscle Physiology: an Update** at the 100th Anniversary Meeting of the American Physiological Society, 1987.
 Chairman of Minisymposium. **Moving through (Biological) Channels**, Society of Industrial and Applied Mathematics Conference on Applied Probability in Science and Engineering, New Orleans, 1990.
 Chairman of Minisymposium. **Ionic Movement through Biological Channels**. Society of Industrial and Applied Mathematics, Annual Meeting. Chicago, 1990.
 Organizer of Workshop: **From Structure to Permeation in Open Ionic Channels**. Biophysical Society Annual Meeting, Washington D.C., 1993
 Chairman of Symposium: **Ionic Channels: Natural Nanotubes**. American Physical Society Annual Meeting, 2000.
 Chairman and Organizer of **Novartis Foundation Meeting: Physical Models of Ion Permeation**, 2000
 Chairman and Organizer of **Symposium at International Conference on Computational Nanoscience, 2001: Nanostructure Simulation from thin oxides to biological ion channels**.

- Co-organizer of **Yangtze Conference on Fluids and Interfaces** (Chief Organizers Kwong-Yu Chan and D Henderson). Chairman, Ion Channels Session, 2001. see J Colloid Interface Sci. 2002 Vol. 246, p.222.
- Organizer and Chairman of **Nanostructures: biological ion channels to thin oxides**. Nanotech 2003, San Francisco.
- Co-organizer and Chairman (with Dirk Gillespie) of **Physical Models of Ion/Protein Interactions**, American Physical Society (Div of Biological Physics) March, 2003. Austin, TX.
- Chairman (Organizer Maria Kurnikova) **Physics of Ion Interactions with Proteins**, March, 2004, American Physical Society, Montreal Quebec Canada.
- Member, Organizing Committee, NATO Advanced Research Workshop. **Ionic Soft Matter** Lviv Ukraine, 2004.
- Helper to Andrij Trokhymchuk and David Busath, **Festschrift for Doug Henderson**, Brigham Young University, 2004.
- Co-organizer, with Heinz Engl, **RICAM Seminar on Ion Channels**, Johan Radon Institute of Applied Mathematics, University of Linz (Austria), 2004.
- Organizer and Chair, **Multiscale Analysis in Biology: Computation**, American Physical Society, March, 2005, Los Angeles.
- Organizer and Chair: **MultiScale Analysis of Ions in Solutions, Proteins, and Channels: Analysis**, American Physical Society, March, 2005, Los Angeles.
- Problem Presenter: **Mathematics in Medicine Study Group**, Mathematics Institute, Oxford University, Sept. 2005, March 2006
- Organizer and Chair: **Physical Models of Ion Channels**, American Physical Society, March 2006, Baltimore.
- Helper to Chris Breward: Oxford University OCIAM **Mathematics in Medicine: Ion Channels**, March, 2006.
- Member, Organizing Committee for **Special Semester on Quantitative Biology analyzed by Mathematical Methods**: RICAM (Radon Institute for Computational and Applied Math); (Oct 2007- Jan 2008: Johannes Kepler Univ of Linz, Austria) <http://www.ricam.oeaw.ac.at/ssqbm/>
- Co-organizer (with Martin Burger, Peter Pohl, Heinz Engl) of Workshop on Ion Channels, Oct 8-12, 2007
- Co-organizer, with Martin Bazant of Symposium, **Multiscale Modeling of Electrochemical Systems** SIAM (Society of Industrial and Applied Mathematics), 2006.
- Organizer of ARO Sponsored Meeting, **Calibrating Simulations**, at Rush University Medical Center, January 2007.
- Facilitator of Annual Reciprocal Symposia between Biophysical Society and Division of Biological Physics of the American Physical Society, commencing 2007. Planned to be the first in a continuing series.
- Organizer of Symposium (Sponsored by American Physical Society Division of Biological

Physics) **Modeling as a Tool in Biophysics**, at Biophysical Society Annual Meeting, 2007. Planned to be the first in a continuing series.

Co-organizer: **Direct and inverse problems in channels and membranes**, ICIAM 6th International Congress on Industrial & Applied Mathematics Zurich 2007, Organizer Heinz Engl; co-organizer Martin Burger, pair of minisymposiar.

Lecturer Short course on **Channel Biophysics**, 10 hours, ICTP and SISSA Theoretical Biophysics and Structural Biology, Organizer Paolo Carloni.

Co-organizer: Symposium on **Inhomogeneous Electrolytes** Northwest and Rocky Mountain Regional Meeting American Chemical Society Co-organizer Douglas Henderson, June 2008.

Equipment and Software Designed

Wide band amplifiers for microelectrode recording (with several collaborators, see publications 3, 9, 11, 16, 22, and 24).

Software for computing and analyzing impedance measurements with wide band amplifiers (*ibid.*)

Axopatch Amplifier for patch clamp recording, with R. Levis, J. Rae, and A. Finkel, sold by Axon Instruments, Burlingame CA, now part of Molecular Devices Sunnyvale CA.

Perfusing Pipettes, a hardware kit available from ALA Scientific, for perfusing patch pipettes.

PNP Online <http://www.pnponline.org/> Interactive software for running Poisson Nernst Planck theory, with Brice Burgess

Patent Application, PCT/NL2003/000013 Liquid Based Electronic Device (from BioMade, Groningen, Netherlands.)

Patent Application, Mathematical Design of Ion Channel Selectivity via Inverse Problems Technology (with Heinz Engl and Martin Burger, from Rush University Medical Center.)

Professional Societies

American Association for Advancement of Science

American Mathematical Society

American Physiological Society

American Physical Society, Fellow

American Society of Cell Biologists

Biophysical Society

Institute of Electrical and Electronic Engineering, Senior Member

Mathematical Association of America

New York Academy of Sciences

Physiological Society, England (Associate Member)

Royal Society of Chemistry (UK)

Society of General Physiologists

Society for Industrial and Applied Mathematics
 Society of Neuroscience
 Institute for Strategic Studies (London: 1963-1992)

Research Interests

1960's-1980's:

Electrical properties of cells and tissues. The relationship between the structure of biological tissues and the pathways for current flow: measurements of linear electrical properties to determine equivalent circuits of skeletal and cardiac muscle, nerve, the lens of the eye, and epithelia.

The modeling of tissues of complex geometry and the solution—in physically meaningful form—of the differential (or difference) equations which describe such tissues. Thus, models of the three dimensional spread of current in spherical and cylindrical cells; models of the spread of current in the random network of transverse tubules in skeletal muscle; models of current flow in the clefts of cardiac muscle; models of current flow in epithelia; models of current flow in dendritic trees.

The use of advanced mathematical techniques (ranging from singular perturbation theory to—when all else fails—brute force numerical simulation) to provide insight into the physical meaning of complex theory.

1960's-1990's:

Excitation-contraction coupling in skeletal and cardiac muscle; particularly, the junction between the tubular system and the sarcoplasmic reticulum and the mechanism of calcium release from the sarcoplasmic reticulum.

The electrical properties of the sarcoplasmic reticulum and its ionic channels as seen in patch clamp measurements from skinned muscle fibers.

1980's – 2000's -... :

Analysis of ionic channels, experimental and theoretical: properties of single channels in epithelia, particularly “pressure activated” channels. Single channels in sarcoplasmic reticulum of skinned muscle fibers.

Design of patch clamp amplifiers, headstage, holders with “zero excess” noise.

Optimal detection of single channel events using signal detection theory.

Measurement of open channel noise.

Theoretical analysis of ion movement through channels using an hierarchy of models from molecular dynamics to continuum electrostatics.

Simulations of the molecular dynamics of channel proteins.

Stochastic analysis of flux over barriers: first passage times, concentration boundary conditions and ionic fluxes.

PNP model of the open channel. Poisson-Nernst-Planck model of open channels, in which the potential distribution through the channel is calculated not assumed. PH model of the

open channel, the Poisson Hydrodynamic model including temperature changes.

Coupling of fluxes, active transport, gating, and gating currents in a permanently open channel of one conformation as predicted by the PNP model in complex geometries and the PH model.

The stochastic generalization of the PNP model.

Simulations of the molecular dynamics of the entry process models of gramicidin.

2000's -... :

Design and construction of ion channels as useful devices.

Thus, building design tools for understanding current flow in bulk solution, ion channels, and proteins in general.

Computation of macroscopic properties of ionic solutions and channels from higher resolution models, using Langevin-Poisson, Monte Carlo Poisson, or Molecular Dynamics Poisson methods.

Mathematical analysis of macroscopic properties of ionic solutions and channels starting from higher resolution models, using Langevin-Poisson, Monte Carlo Poisson, or Molecular Dynamics Poisson methods.

Simulations and theories of gating and conformational change.

Construction of nonequilibrium statistical mechanics starting from the properties of chaotic trajectories computed with Poisson and molecular dynamics. Statistical mechanics as stochastic processes.

Crowded Charge model of protein function, specifically, ion selectivity and permeation in ion channels.

Administrative Work

UCLA

Member of Committee for Graduate Students.

First Year Advisor for Graduate Students.

Member of numerous review committees for promotions: received commendation from Vice Chancellor Saxon for work on review committees.

Member of Advisory Committee for the Jerry Lewis Muscular Dystrophy Center.

Rush University

Chairman, Department of Physiology, then Department of Molecular Biophysics and Physiology. Recipient and first holder of "The Francis and Catherine Bard Chair of Physiology"

Department has approximately 10 tenure track faculty since 1976 and approximately 7,000 sq ft of usable research space. All faculty with research space (i.e., 4 laboratories) have had NIH or equivalent funding without interruption, thanks to their significant personal productivity. Key members (alphabetical order) in research: Fred Cohen (viral fusion); Tom

DeCoursey (H^+ ion channels); Mike Fill (Ryanodine Receptor); Dirk Gillespie (selectivity); Josefina Ramos-Franco (IP_3 receptor); Eduardo Rios (Ca^{++} movement); in Medical School Teaching, Joel Michael, Tom Shannon, and Dirk Gillespie; in Nursing Teaching Joe Zbilut.

Academic Administration.

Member of College Councils.

Chairman of Promotions and Appointments Committee.

Member, Vice Chair, then Chair of Search Committee for Microbiology Chair.

Vice Chairman of Search Committee for Dean of the Medical College.

Member, Search Committee for Dean of the Graduate College.

Member, Search Committee for Pediatrics Chair.

Member, Search Committee for Microbiology Chair

Teaching

General responsibility for all teaching activities of the Department at Rush, including course and curriculum reorganization. Physiology Lectures for medical and nursing students.

Graduate students:

J. Leung, R. Mathias, E. Engel, R. Levis, R. Milton (with R. Mathias), J. Tang, P. Gates, J. Wang, A. Hainsworth (with R. Levis), P. Dull (summer student), Dirk Gillespie, Amy Del Medico (summer student), Boaz Nadler (in significant part: Zeev Schuss, supervisor); Amit Singer (in significant part: Zeev Schuss, supervisor), Janhavi Giri (Bioengineering, University of Illinois, Circle Campus).

Post-doctoral fellows:

J. Howell, P. Vaughan, B. Mobley, A. Peskoff, R. Mathias, E. Engel, R. Levis, J. Bell, R. Milton (with Rick Mathias), K. Cooper, D.P. Chen, J. Tang, D.Rojewska; D.Gillespie; Z. Kuang, T. van der Straaten (with Umberto Ravaioli), S. Wigger-Aboud (with Marco Saraniti).

Community Activity

AVENUE BANK OF OAK PARK: Director, Member, then Chairman of Audit Committee, Executive Committee, and Marketing Committee (1987-1992).

AMERICAN HEART ASSOCIATION OF METROPOLITAN CHICAGO: Member, Board of Governors, Executive Committee, and President's Cabinet (1984-1986). Member Research Council (1989-1990) and Chairman, Committee on Human Experimentation.

TAFT SCHOOL (Connecticut): Speaker at Centennial Symposium, and Seminar/Discussion Group.

PRESIDENT 7320 Condo Association. (1997– 2003; 2007)

TOWN TALK Telluride Science Research Center (part of Pinhead Lecture Series) 2003.

ARMY RESEARCH OFFICE talk to North Carolina Ventures Program for High Schools 2005

ROBERT S. EISENBERG**PUBLICATIONS**

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(Last update: July 15, 2008)

[\[Laboratory of Robert S. Eisenberg\]](#)

Electrical properties of tissues, mostly experimental:

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2. Eisenberg, R.S. Impedance of single crab muscle fibers. Ph.D. Thesis, University of London (1965).
3. Eisenberg, R.S. Equivalent circuit of single crab muscle fibers as determined by impedance measurement with intracellular electrodes. J. Gen. Physiol. 50: 1785-1806 (1967). [\[PDF\]](#)
4. Eisenberg, R.S. and Gage, P.W. Frog skeletal muscle fibers: change in the electrical properties of frog skeletal muscle fibers after disruption of the transverse tubular system. Science 158: 1700-1701 (1967). [\[PDF\]](#)
5. Gage, P.W. and Eisenberg, R.S. Action potentials without contraction in frog skeletal muscle fibers with disrupted transverse tubules. Science 158: 1702-1703 (1967). [\[PDF\]](#)
6. Horowicz, P., Gage, P.W. and Eisenberg, R.S. The role of the electrochemical gradient in determining potassium fluxes in frog striated muscle. J. Gen. Physiol. 51: 193s-203s (1968). [\[PDF\]](#)
7. Eisenberg, B. and Eisenberg, R.S. The transverse tubular system in glycerol treated muscle. Science 160: 1243-1244 (1968). [\[PDF\]](#)
8. Eisenberg, B. and Eisenberg, R.S. Selective disruption of the sarcotubular muscle: A quantitative study with exogenous peroxidase as a marker. J. Cell Biol. 39: 451-467 (1968). [\[PDF\]](#)
9. Gage, P.W. and Eisenberg, R.S. Capacitance of the surface and transverse tubular membrane of frog sartorius muscle fibers. J. Gen. Physiol. 53: 265-278 (1969). [\[PDF\]](#)
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11. Gage, P.W. and Eisenberg, R.S. Action potentials, after potentials, and excitation-contraction coupling in frog sartorius fibers without transverse tubules. J. Gen. Physiol. 53: 298-310 (1969). [\[PDF\]](#)
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15. Leung, J. and Eisenberg, R.S. The effects of the antibiotics gramicidin-A, amphotericin-B, and nystatin on the electrical properties of frog skeletal muscle. *Biochem. Biophys. Acta. Amsterdam* 298: 718-723 (1973). [[PDF](#)]
16. Valdiosera, R., Clausen, C. and Eisenberg, R.S. Measurement of the impedance of frog skeletal muscle fibers. *Biophys. J.* 14: 295-315 (1974). [[PDF](#)]
17. Valdiosera, R., Clausen, C. and Eisenberg, R.S. Circuit models of the passive electrical properties of frog skeletal muscle fibers. *J. Gen. Physiol.* 63: 432-459 (1974). [[PDF](#)]
18. Valdiosera, R., Clausen, C. and Eisenberg, R.S. Impedance of frog skeletal muscle fibers in various solutions. *J. Gen. Physiol.* 63: 460-491 (1974). [[PDF](#)]
19. Mobley, B.A., Leung, J. and Eisenberg, R.S. Longitudinal impedance of skinned frog muscle fibers. *J. Gen. Physiol.* 63: 615-637 (1974). [[PDF](#)]
20. Mobley, B.A., Leung, J. and Eisenberg, R.S. Longitudinal impedance of single frog muscle fibers. *J. Gen. Physiol.* 65: 97-113 (1975). [[PDF](#)]
21. Eisenberg, R.S. and Rae, J.L. Current-voltage relationships in the crystalline lens. *J. Physiol.* 262: 285-300 (1976). [[PDF](#)]
22. Mathias, R.T., Eisenberg, R.S. and Valdiosera, R. Electrical properties of frog skeletal muscle fibers interpreted with a mesh model of the tubular system. *Biophys. J.* 17: 57-93 (1977). [[PDF](#)]
23. Eisenberg, R.S., Mathias, R.T. and Rae, J.L. Measurement, modeling and analysis of the linear electrical properties of cells. *Ann. N.Y. Acad. Sci.* 303: 343-354 (1977). [[PDF](#)]
24. Mathias, R.T., Rae, J.L. and Eisenberg, R.S. Electrical properties of structural components of the crystalline lens. *Biophys. J.* 25: 181-201 (1979). [[PDF](#)]
25. Rae, J.L., Eisenberg, R.S. and Mathias, R.T. The lens as a spherical syncytium. Ed. Satish K. Srivastava. Elsevier North Holland Inc. **Red Blood Cell and Lens Metabolism**. pp. 277-292 (1980). [[PDF](#)]
26. Mathias, R.T., Rae, J.L. and Eisenberg, R.S. The lens as a nonuniform spherical syncytium. *Biophys. J.* 34: 61-85 (1981). [[PDF](#)]
27. Eisenberg, B. and Eisenberg, R.S. The *T-SR* junction in contracting single skeletal muscle fibers. *J. Gen. Physiol.* 79: 1-20 (1982). [[PDF](#)]
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29. Rae, J.L., Mathias, R.T. and Eisenberg, R.S. Physiological role of the membranes and extracellular space within the ocular lens. *Exp. Eye Res.* 35: 471-490 (1982). [[PDF](#)]
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31. Levis, R.A., Mathias, R.T., and Eisenberg, R.S. Electrical properties of sheep Purkinje strands. Electrical and chemical potentials in the clefts. *Biophys. J.* 44: 225-248 (1983). [[PDF](#)]
32. Hui, C.S., Milton, R.L. and Eisenberg, R.S. Charge movement in skeletal muscle fibers paralyzed by the calcium entry blocker D600. *Proc. Natl. Acad. Sci.* 81: 2582-2585 (1984). [[PDF](#)]
33. Curtis, B.A. and Eisenberg, R.S. Calcium influx in contracting and paralyzed frog twitch muscle fibers. *J. Gen. Physiol.* 85: 383-408 (1985). [[PDF](#)]
34. Milton, R.L., Mathias, R.T., and Eisenberg, R.S. Electrical properties of the myotendon region of frog twitch muscle fibers measured in the frequency domain. *Biophys. J.* 48: 253-267 (1985). [[PDF](#)]
35. Eisenberg, R.S. Membranes, calcium, and coupling. *Can. J. Physiol. and Pharmacol.* 65: 686-690 (1987). [[PDF](#)]

Theoretical Analysis and Modeling of Spread of Current:

36. Eisenberg, R.S. and Johnson, E.A. Three dimensional electrical field problem in physiology. *Prog. Biophys. Mol. Biol.* 20: 1-65 (1970). [[PDF](#)]
37. Eisenberg, R.S. and Engel, E. The spatial variation of membrane potential near a small source of current in a spherical cell. *J. Gen. Physiol.* 55: 736-757 (1970). [[PDF](#)]
38. Barcilon, V., Cole, J. and Eisenberg, R.S. A singular perturbation analysis of induced electric fields in nerve cells. *SIAM J. Appl. Math.* 21: No. 2, 339-354 (1971). [[PDF](#)]
39. Eisenberg, R.S. and Costantin, L.L. The radial variation of potential in the transverse tubular system of skeletal muscle. *J. Gen. Physiol.* 58:700-701 (1971). [[PDF](#)]
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45. Peskoff, A. and Eisenberg, R.S. The time-dependent potential in a spherical cell using matched asymptotic expansions. *Journal of Math. Biol.* 2: 277-300 (1975). [[PDF](#)]
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50. K.E. Cooper, P.Y. Gates, and Eisenberg, R.S. Surmounting barriers in ionic channels. *Quart. Rev. Biophysics.* 21: 331-364 (1988). [[PDF](#)]
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52. J.M. Tang, J. Wang, and Eisenberg, R.S. K^+ selective channel from sarcoplasmic reticulum of split lobster muscle fibers. *J. Gen. Physiol.* 94:261-278 (1989). [[PDF](#)]
53. P.Y. Gates, K.E. Cooper, J. Rae, and Eisenberg, R.S. Predictions of diffusion models for one ion membrane channels. in *Progress in Biophysics and Molecular Biology.* 53: 153-196 (1989). [[PDF](#)]
54. P.Y. Gates, K.E. Cooper, and Eisenberg, R.S. Analytical diffusion models for membrane channels. in **Ion Channels, Volume 2** (editor. T. Narahashi), Plenum Press (1990). [[PDF](#)]
55. D. Junge and R.S. Eisenberg. Uniqueness and interconvertibility among membrane potassium channels. *Comments on Theoret. Biology.* 11: 45-55 (1990). [[PDF](#)]
56. Tang, J.M., Wang, J., F.N. Quandt, and R.S. Eisenberg. Perfusing pipettes. *Pflügers Arch.* 416:347-350 (1990). [[PDF](#)]
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61. Chen, D.P. and R.S. Eisenberg. Charges, currents, and potentials in ionic channels of one conformation. *Biophysical Journal*. 64:1405-1421 (1993a). [[PDF](#)]
62. Chen, D.P. and R.S. Eisenberg. Flux, coupling, and selectivity in ionic channels of one conformation. *Biophysical Journal* 65:727-746 (1993b). [[PDF](#)]
63. Hainsworth, A.H., Levis, R.A., and R.S. Eisenberg. Origins of open-channel noise in the large potassium channel of sarcoplasmic reticulum. *J. Gen. Physiol.* 104:857-884 (1994). [[PDF](#)]
64. Eisenberg, R.S., Klosek, M.M., and Schuss, Z. Diffusion as a chemical reaction: stochastic trajectories between fixed concentrations. *J. Chem. Phys.*, 102(4): 1767-1780 (1995). [[PDF](#)]
65. Elber, R., Chen, D., Rojewski, D., and Eisenberg, R.S. Sodium in gramicidin: an example of a permion. *Biophysical Journal*, 68: 906-924, (1995). [[PDF](#)]
66. Chen, D., Eisenberg, R., Jerome, J., and Shu, C. Hydrodynamic model of temperature change in open ionic channels. *Biophysical J.* 69: 2304-2322. (1995). [[PDF](#)]
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72. Nonner, W. and Eisenberg, B. (1998) Ion Permeation and Glutamate Residues Linked by Poisson-Nernst-Planck Theory in L-type Calcium Channels. *Biophys. J.* 75:1287-1305. [[PDF](#)]
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100. Gardner, Carl, Nonner, Wolfgang, and Eisenberg, Robert S. (2004) Electrodiffusion Model Simulation of Ionic Channels: 1D Simulations *Journal of Computational Electronics* 3: 25-31. [[PDF](#)]
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