

# **Bob Eisenberg**

*aka Robert S. Eisenberg*

## *Curriculum Vitae*

*August 13, 2010*

### ***Work co-ordinates***

#### ***Address***

Department of Molecular Biophysics and Physiology  
Rush Medical College  
1750 West Harrison, Room 1291 Jelke  
Chicago IL 60612

#### ***Phone numbers***

Voice: (312)-942-6467  
Department FAX: (312)-942-8711  
FAX to email: (801)-504-8665  
Skype Phone Number (708)-459-8089  
Email: [beisenbe@rush.edu](mailto:beisenbe@rush.edu)

### ***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 Barcion), 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  $\text{Na}^+$  channels (of nerve membranes for example originally described by effects. Bob (helping Zeev Schuss and Boaz Nadler) has 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.

Bob has also 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,
- (4) used the mathematics of inverse problems to design the selectivity and permanent charge of channels, assisting Heinz Engl and Martin Burger
- (5) worked with Dezső Boda, Doug Henderson, Dirk Gillespie and Wolfgang Nonner to extend the crowded charge model of selectivity from calcium channels to the Na channel of nerve, showing that the same model can explain both (very different) types of channels **without changing any parameters**, just by reproducing the mutation (known from experiment) to change one channel type into another, EEEA  $\leftrightarrow$  DEKA, i.e. Glu-Glu-Glu-Ala  $\leftrightarrow$  Asp-Glu-Lys-Ala. This work shows that a single model with just one set of never changing parameters can account for the selectivity properties of two very different types of channels (Na channel of nerve and Ca channel of muscle). When the side chains in the channel protein are changed in the model, the protein changes selectivity just as it does in life. This work also reveals simply control parameters for the Na channel: the dielectric coefficient changes the contents of the channel, and has almost no effect on Na<sup>+</sup> vs. K<sup>+</sup> selectivity. The diameter of the selectivity filter changes the Na<sup>+</sup> vs. K<sup>+</sup> selectivity and has almost no effect on the contents of the channel.
- (6) shown (with the same collaborators) that calcium selectivity does not arise from the Chung model of the L-type Ca channel because it does not allow its Glu residues to mix with ions.
- (7) suggested that the simple model of selectivity works so well because it computes the important structures of the selectivity filter. These models put the 'side chains' in the position that produces least free energy and thus determines the 'optimal' relation of side chains and permeating ions. These methods compute a self-organized selectivity filter in which the induced fit of side chains and ions is determined by the positions of the ions and side chains at thermodynamic equilibrium. The model computes the structure of the selectivity filter.
- (8) starting applying the energy variational principle developed by Chun Liu and collaborators to problems in ion permeation, selectivity, gating (with Yunkyong Hyon and Chun) and to new subjects of water movement (with Yoichiro Mori and Chun) and vesicle formation and fusion (with Fred Cohen, Rolf Ryham, and Chun). The variational principle allows the coupling of different interacting structures and different physical properties of a single system in a mathematically well defined and (automatically) selfconsistent way. It produces different partial differential equations and boundary conditions depending on the structures, physics, and coupling included in the underlying model. It thus seems ideally suited to the complexity of ions and water in solution, channels, and tissues, as well as to the interactions of multiple systems and physics that produce flow of ions, water, membranes and movement in general in biological systems.

Along the way, Bob 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, among other things, as all salt eaters should be glad to know.

## ***Internet Coordinates***

### ***Web Sites***

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

Thanks to Nanohub at Purdue University, a lecture of Bob's from 2008 is available for viewing at <http://www.nanohub.org/resources/4726/> [Talk]: Ionic Selectivity in Channels: complex biology created by the balance of simple physics. Nanotechnology 501 Lecture Series: Purdue University.

Thanks to the IMA (Institute for Mathematics and its Applications), University of Minnesota, a lecture of Bob's from December 2008 is available (along with accompanying slides) at link [Talks and PDF] or address <http://www.ima.umn.edu/2008-2009/W12.8-12.08/abstracts.html#Eisenberg-Robert>

**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](#)] [[2008](#)] [[2009](#)]

## ***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 N. and Catherine O. Bard Chair of Physiology "

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, Department of Physiology

1968-1970 Assistant Professor, Department 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- ...  
 UIN 658809751  
 Senior Scientist, Argonne National Laboratory (Mathematics and Computer Science Division,  
 2005 - ... Badge number B0 56980 A  
 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  
 Senior and Life Member of the IEEE  
 Institute of Medicine of Chicago  
 Keynote Speaker, Oak Ridge National Laboratory and University of Tennessee, Knoxville.  
 Summer School on Biophysics: Computational and Theoretical Challenges (2010).

### *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***

**FIRST CHAIRMAN OF DEPARTMENT OF MOLECULAR BIOPHYSICS AND PHYSIOLOGY**, appointed 1976, thriving, if not burgeoning, see science at <http://www.phys.rush.edu/physiofac.html>

### **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, 2009)

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, National Meeting, Division of Physical Chemistry  
 American Chemical Society, National Meeting, 2008, Division of Physical Chemistry  
     Symposium: Water Mediated Interactions, Dor Ben-Amotz, H. Asbaugh,  
     Organizers.  
 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 Physical Society (Division of Biological Physics) March Meeting 2009  
 American Chemical Society Meeting, San Francisco, 2000  
 American Physiological Society Meeting: 1978, 1979, 1983  
 Argonne National Laboratory Chemical Sciences  
 Argonne National Laboratory Material Sciences Division  
 Argonne National Laboratory Mathematics and Computer Sciences Division  
 Argonne National Laboratory Biology Division  
 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 (Department of Biochemistry, Host: Chris Miller, 1986;  
     Department of Chemistry, Host: Judy Herzfeld, 2008)  
 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, Department 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: Department. of Chemistry)  
 Columbia University, Department 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: Department 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)  
 Duke University Department of Physiology. Host Dan Tosteson and Paul Horowicz  
 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  
 Frontiers in Mathematical Biology: NSF-NIH Meeting, 2010 CSCAMM University of  
     Maryland , Invited Speaker  
 Free University of Berlin Institute of Chemistry and Biochemical Modeling  
 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  
 Gordon Conference on Water, 2010  
 Grinnell 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 6<sup>th</sup> 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 Mathematics and its Applications (IMA), Solvation Workshop (December 2008) see link [\[Talks and PDF\]](#) or address <http://www.ima.umn.edu/2008-2009/W12.8-12.08/abstracts.html#Eisenberg-Robert>

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)

Kavli Institute of Theoretical Physics, University of California Santa Barbara:  
Evolutionary Perspectives on Mechanisms of Cellular Organization 2010

Laboratory of Molecular Biology, MRC, Cambridge England

Lancaster University (Department of Physics)

Liblice Conference (5<sup>th</sup>) on Statistical Mechanics of Liquids, 1998

Los Alamos National Laboratory (Center for Nonlinear Studies)

Loyola University, Department 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 (Goettingen. MPI for Dynamics and Self-organization. Computational Neuroscience 2009)

Max Planck Institute (Heidelberg: Ken Holmes)

Max Planck Institute (Heidelberg, Bert Sakmann)

Mayo Clinic

McMaster University: Department. of Physics (Hamilton, Ontario)

McGill University: Department of Biomedical Engineering, Jay Nadeau (March 2010)

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)  
NATO Advanced Research Workshop. Ionic Soft Matter, Lviv, Ukraine  
National Taiwan University Taipei “Energetic Variational Approaches to Elastic Complex  
Fluids and Molecular Biology” January, 2010  
New York University Medical School (Physiology)  
New York University (Biology: Tamar Schlick’s Group)  
NIH NINCDS  
NIH Arthritis Institute  
NIH GMS  
NIST-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, Department. of Electrical Engineering  
Notre Dame, Department of Chemistry and Biochemistry  
Novartis Foundation Symposium: Gramicidin and Related Peptides, 1998  
Novartis Foundation Meeting: Physical Models of Ion Permeation, 2000  
Oak Ridge National Laboratory and University of Tennessee, Knoxville. Summer School on  
Biophysics: Computational and Theoretical Challenges (2010).  
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 5<sup>th</sup> Study Group (October, 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)  
Penn(sylvania) State University, Department of Mathematics,  
IMA-PIP Workshop on Numerical Simulation of Complex Fluids and MHD  
Polytechnic University (NY) Department of Chemical Engineering (2010)  
Pierre & Marie Curie University (UPMC) Department of Physical Chemistry (Pierre Turq,  
Jean-Pierre. Hansen) 2009  
Princeton University Program in Applied Mathematics (October 2009)  
Purdue University: Department. of Biology  
Purdue University: Department. of Electrical Engineering: Solid State Physics,  
Organizer: Mark Lundstrom  
Purdue University Physical Chemistry Seminar Series, 2008, Organizer Dor Ben-Amotz  
available at <http://www.nanohub.org/resources/4726/> [PDF]

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 Department. of Mathematics  
 Rice University Colloquium in Computational and Applied Mathematics (March 2010)  
 Rowland Institute (Cambridge MA)  
 Rush Medical College (Physiology, 1975)  
 Rush Medical College (Pharmacology, 2008)  
 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  
 SISSA and ICTP Trieste, Italy. Challenge: correcting Einstein's mistake  
 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 12<sup>th</sup> 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 Department of Bioengineering  
 University College (London): Biophysics  
 University College (London): Physiology  
 University of Buffalo (SUNY) Department of Physiology and Biophysics  
 University of Buffalo (SUNY) Department of Electrical Engineering  
 University of California (Berkeley) Chemical Engineering, Chakraborty Group  
 University of California (Berkeley) Colloquium in Physics Department (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 Department. 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 (Chicago): Department of Bioengineering, 2007, 2009  
 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 Instit  
 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 (Department. of Electrical Engineering)  
 University of North Carolina (Physiology) Host Gerry Oxford and Barry Palotta  
 University of North Carolina (Chapel Hill) Dept of Biochemistry Host Gerhard Meissner.  
 University of North Carolina (Charlotte) Joint Seminar Mathematics and Bioinformatics  
 University of Oklahoma  
 University of Pannonia (Veszprém Hungary): Department of Physical Chemistry Dezső  
     Boda, 2009  
 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 Department  
 Western Nerve Net (San Diego)  
 Westfaelisch Wilhelms University Muenster Applied Mathematics  
 Westfaelische Wilhelms University Meunster  
     Multiscale Simulation for Ion Channels (2009)  
 Workshop on Wavelets: 16<sup>th</sup> 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 (Department 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 100<sup>th</sup> Anniversary Meeting of the American Physiological Society, 1987.
- Chairman of Symposium. **Skeletal Muscle Physiology: an Update** at the 100<sup>th</sup> 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 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 (Division 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 6<sup>th</sup> International Congress on Industrial & Applied Mathematics Zurich 2007, Organizer Heinz Engl; co-organizer Martin Burger, pair of minisymposia.
- Lecturer Short course on **Channel Biophysics**, 10 hours, ICTP and SISSA Theoretical Biophysics and Structural Biology, Trieste, Italy, Organizer Paolo Carloni.
- Co-organizer: Symposium on **Inhomogeneous Electrolytes** Northwest and Rocky Mountain Regional Meeting American Chemical Society Co-organizer Douglas Henderson, June 2008.
- Organizer and Speaker: Workshop “Biophysics of Membrane Bound Channels” American Physical Society, Division of Biological Physics, March 2009.

Co-organizer: National Taiwan University “Energetic Variational Approaches to Elastic Complex Fluids and Molecular Biology” January, 2010, Organizer Tai-Chia Lin

### ***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 was subsequently withdrawn, but it is an interesting idea, nonetheless, in my biased view, PCT/NL2003/000013 Liquid Based Electronic Device (from BioMade, Groningen, Netherlands.) [[PDF](#)]

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

### ***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.

Variational Principles (built on the energetic variational approach of Chun Liu) applied to ions in channels, ions and water in solutions, cells, and macroscopic tissues, and to vesicles and viruses fusing with membranes.

## *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 Medical College

**Chairman**, Department of Physiology, then Department of Molecular Biophysics and Physiology. 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, Chicago).

**Post-doctoral fellows:**

John Howell, Peter Vaughan, Bert Mobley, Art Peskoff, Richard Mathias, Eli Engel, Richard Levis, Richard Milton (with Rick Mathias), Kim Cooper, Peter Gates, Dunapin Chen, John Tang, Danuta Rojewska, Dirk Gillespie,; Trudy van der Straaten (with Umberto Ravaoli), Sheila Wigger-Aboud (with Marco Saraniti), Jim Fonseca.

**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; 2009-2010)

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**

[Reprints](#) available on this [hyperlink](#)

(Last update: August 13, 2010)

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

***Electrical properties of tissues, mostly experimental:***

1. Eisenberg, R.S. and Hamilton, D. Action of  $\gamma$ -aminobutyric acid on *Cancer borealis* muscle. Nature 198: 1002-1003 (1963). [\[PDF\]](#)
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). [\[PDF\]](#)
10. Eisenberg, R.S. and Gage, P.W. Ionic conductance of the surface and transverse tubular membrane of frog sartorius fibers. J. Gen. Physiol. 53: 279-297 (1969). [\[PDF\]](#)
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). [\[PDF\]](#)
12. Eisenberg, R.S., Howell, J. and Vaughan, P. The maintenance of resting potentials in glycerol treated muscle fibers. J. Physiol. 215: 95-102 (1971). [\[PDF\]](#)
13. Vaughan, P., Howell, J. and Eisenberg, R.S. The capacitance of skeletal muscle fibers in solutions of low ionic strength. J. Gen. Physiol. 59: 347-359 (1972). [\[PDF\]](#)

14. Eisenberg, R.S., Vaughan, P. and Howell, J. A theoretical analysis of the capacitance of muscle fibers using a distributed model of the tubular system. *J. Gen. Physiol.* 59: 360-373 (1972). [[PDF](#)]
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](#)]
28. Rae, J.L., Thomson, R.D. and Eisenberg, R.S. The effect of 2-4 dinitrophenol on cell to cell communication in the frog lens. *Exp. Eye Res.* 35: 597-610 (1982). [[PDF](#)]
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](#)]
30. Eisenberg, R.S., McCarthy, R.T., and Milton, R.L. Paralysis of frog skeletal muscle fibres by the calcium antagonist D-600. *J. Physiol.* 341: 495-505 (1983). [[PDF](#)]

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](#)]
40. Engel, E., Barcilon, V. and Eisenberg, R.S. The interpretation of current-voltage relationships from a spherical cell recorded with a single microelectrode. *Biophys. J.* 12: 384-403 (1972). [[PDF](#)]
41. Peskoff, A., Eisenberg, R.S. and Cole, J.D. Potential induced by a point source of current in the interior of a spherical cell. UCLA Engineering Report #7259, 62pp. (1972). [[PDF](#)]
42. Peskoff, A., Eisenberg, R.S. and Cole, J.D. Potential induced by a point source of current inside an infinite cylindrical cell. UCLA Engineering Report #7303, 70pp. (1973). [[PDF](#)]
43. Peskoff, A. and Eisenberg, R.S. Interpretation of some microelectrode measurements of electrical properties of cells. *Ann. Rev. Biophysics. and Bioeng.* 2: 65-79 (1973). [[PDF](#)]
44. Peskoff, A. and Eisenberg, R.S. A point source in a cylindrical cell: potential for a step-function of current inside an infinite cylindrical cell in a medium of finite conductivity. UCLA Engineering Report #7421, 73pp. (1974). [[PDF](#)]
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](#)]

46. Peskoff, A., Eisenberg, R.S. and Cole, J.D. Matched asymptotic expansions of the Green's function for the electric potential in an infinite cylindrical cell. *SIAM J. Appl. Math.* 30: 222-239, No. 2 (1976). [[PDF](#)]
47. Eisenberg, R.S., Barcilon, V., and Mathias, R.T. Electrical properties of spherical syncytia. *Biophys. J.* 25: 151-180 (1979). [[PDF](#)]
48. Mathias, R.T., Levis, R.A. and Eisenberg, R.S. Electrical models of excitation contraction coupling and charge movement in skeletal muscle. *J. Gen. Physiol.* 76: 1-31, (1980). [[PDF](#)]

### ***Electrical Properties of Ionic Channels:***

49. K.E. Cooper, Tang, J.M., Rae, J.L., and Eisenberg, R.S. A Cation Channel in Frog Lens Epithelia Responsive to pressure and Calcium. *J. Membrane Biology.* 93: 259-269 (1986). [[PDF](#)]
50. K.E. Cooper, P.Y. Gates, and Eisenberg, R.S. Surmounting barriers in ionic channels. *Quart. Rev. Biophysics.* 21: 331-364 (1988). [[PDF](#)]
51. K.E. Cooper, P.Y. Gates, and Eisenberg, R.S. Diffusion theory and discrete rate constants in ion permeation. *J. Membrane Biol.* 106: 95-105 (1988). [[PDF](#)]
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](#)]
57. Chen, D.P., Barcilon, V., and R.S. Eisenberg. Constant fields and constant gradients in open ionic channels. *Biophysical J.* 61:1372-1393 (1992). [[PDF](#)]
58. Barcilon, V., D.P. Chen, and R.S. Eisenberg. Ion flow through narrow membrane channels. Part II. *SIAM Journal of Applied Mathematics* 52:1405-1425 (1992). [[PDF](#)]
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60. Barcilon, V., D.P. Chen, R. Eisenberg, and M. Ratner. Barrier crossing with concentration boundary conditions in biological channels and chemical reactions. *J. Chem. Phys.* 98(2) 1193-1211 (1993). [[PDF](#)]

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65. Elber, R., Chen, D., Rojewska, 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). [\[PDF\]](#)
67. Barkai, E., Eisenberg, R.S., and Schuss, Z. (1996). A bidirectional shot noise in a singly occupied channel. (*Physical Review E*(2), 54 1161-1175). [\[PDF\]](#)
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