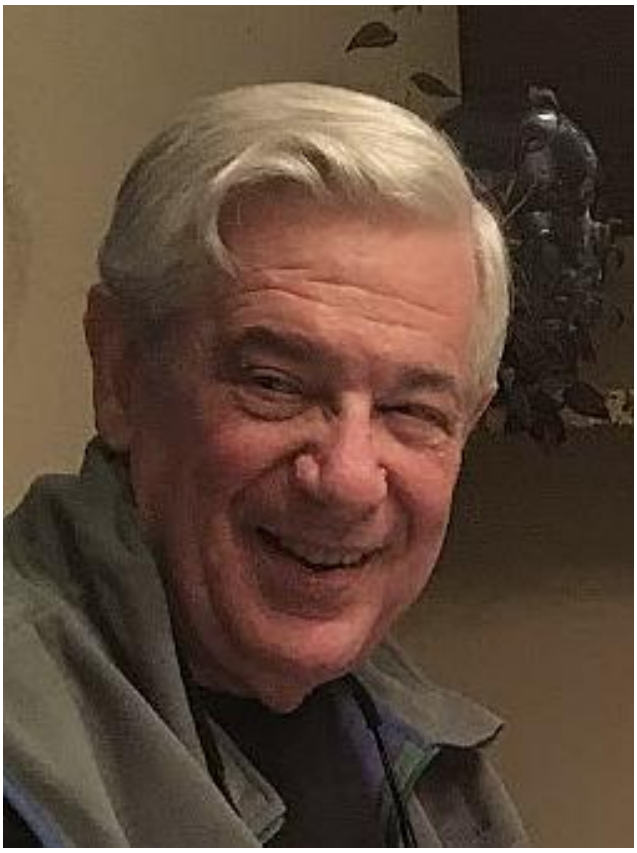
Happy Holidays

Ardyth and Bob Eisenberg

2025



From Ardyth

Our 2025 year, in a word: Domestic. Domestic travels. Domestic life. Domestic treasures.

Early in the year, while watching the country's turmoil, I decided the best antidote for us was to look close to home and cherish all the good in our lives. As a frequent protester in the '60s, I wanted to march again. But, as a practical grandma from River Forest, I knew I didn't want to get whacked by a bunch of thugs with badges. (This isn't hyperbole: They came to our town and arrested yard workers.)

The domestic life door opened January 14, 2025, when Audrey Louise Rose Trowbridge arrived to make us great-grandparents. She and her parents, James and Catherine Trowbridge, live nearby. She brings them to us almost weekly. We're having the delight of seeing her grow from infant to charming (but determined) pre-toddler. She's the first baby I've been around in my adult life, and the first one Bob has been around for 50+ years. We are both totally gaga. This is domestic bliss like no other. Yes, I'm gushing.

Grandson Alastair is at DePaul University here in Chicago. We meet up about weekly to catch up and share a meal. Often we do this at Eleven City Diner – the same place we met up with granddaughter Crystal when she was in college downtown. The tradition continues – including joking with the same hostess.

The rest of the family covers almost the four corners of the country: Son Ben has moved to Washington, DC, for a government job and lives with his daughter Crystal. Emily and her husband Ben T. are still in Michigan, giving us a perfect reason to duck out of Chicago once in a while. Sally has been in Charleston for several years. Jill is reveling in being a Hawaiian again. Grandson Henry is at The Ohio State University and comes to Chicago on breaks. Granddaughter Holly has settled in in Tacoma.

Our travel has all been in the U.S. this year. Bob had work meetings in Pasadena and New York City. (Yes, we're both still working. It's too much fun and too interesting to quit – as you'll see from the list of the papers Bob wrote this year.) We had a quiet weekend in rural Michigan with Emily and her husband. In May, we joined Bob's brother Ed and wife Barbara in Baltimore to celebrate their granddaughters' b'not mitzvahs. The chance to be with two delightful young family members was another time to treasure.

I had the delight of seeing two long-time friends while in California and New York City. In July, I visited Holly and my oldest friend (since the fifth grade!) in Tacoma. In September, another old friend (from Day One of college) and I met in Saratoga Springs, NY, for what's become a tradition. Earlier this month, I visited my last living uncle in Fargo, ND, after he had a serious injury. He's recovering and still cracking jokes and displaying the family stubbornness. Best of all, he told me new family stories.

Bob and I have come to cherish our new domestic routines: We watch the news for about five minutes, start shouting and swearing and then revert to classical music. Coffee at 9:30. Working out with our trainer Brian twice a week. I tease Brian that he shows no

respect for age whatsoever. He takes that as a compliment, which is the way I mean it. Bob and I are both in good shape because of him.

For us, it's been a good year, much enriched by our choice to revel in the dimensions of our family lives. For the country, not so much. Fingers crossed for good outcomes in the midterm elections in 2026, and for a good year for all of you.

From Bob

Family Matters: We are particularly lucky to have grandchildren nearby who seem to enjoy our company despite our tendency to give advice they do not need! Alastair is living in downtown Chicago, next to Millenium Park, and James and Catherine are nearby in Hammond, IN, along of course with our most sociable great grandchild Audrey. We see them almost every week!

Science: Good health, a happy home life, and working with outstanding collaborators help me continue contributing to science. Work has been productive this year, with 11 papers and three slide shows published, and help from Ardyth's remarkable editorial assistance. I'm also finding new science connections at the National Institute for Theory and Mathematics in Biology (nitmb.org), which has opened an office in the Hancock Building.

Papers

Here is a list of the work. There is too much to allow brief summaries. If you are interested, you can download papers from CV RSE *https://ftp.rush.edu/users/molebio/CV/EisenbergCV.pdf*.

1) Eisenberg, Robert S. 2025. Current Flow in Nerves and Mitochondria: An **Electro-Osmotic Approach**, Biomolecules, 15: 1063.

2) Xiao, Shanfeng, Huaxiong Huang, Robert Eisenberg, Zilong Song, and Shixin Xu. (2025). **Potassium Clearance** in Optic Nerve: A Multidomain Model, Frontiers in Bioscience-Landmark, 30: 39722.

3) Xiao, Shanfeng, Huaxiong Huang, Robert Eisenberg, Zilong Song, and Shixin Xu.(2025) **Glymphatic Clearance** in the Optic Nerve: A Multidomain Electro-Osmostic Model Entropy, 27, 1174. https://doi.org/10.3390/ e27111174 also nearly identical arXiv:2510.22271

4) Chang Lin, Zilong Song, Bob Eisenberg, Shixin Xu, Huaxiong Huang (2025) A novel multiscale modelling for the hemodynamics in r**etinal microcirculation** with an analytic solution for the capillary-tissue coupled system arXiv:2512.03446

5) Xavier Oriols, Robert Eisenberg, David Ferry (2025) Kirchhoff`s Forgotten Contributions to Electromagnetism: **Continuity Equation versus Displacement Currents** arXiv:2512.05997

6) Eisenberg, Bob (2025). **True on All Scales: A Tribute to Stuart Rice**. DOI: 10.13140/RG.2.2.11167.47522

7) Eisenberg, Robert S. (2025) **Current Laws and the Maxwell Equations** DOI: 10.13140/RG.2.2.34171.63524

8) Eisenberg, Robert S. (2025) **Truly Incompressible:** Maxwell's Total Current DOI 10.13140 RG.2.2.27505.80487 5-23-2025

9) Eisenberg, Robert S. (2025) **Kirchhoff's Current Law:** A Derivation from Maxwell's Equations. DOI: 10.13140/RG.2.2.17088.85766

10) Eisenberg, Robert S. (2025) **Circuits, Magnetism, and Relativity** are Inseparable. Circuits, DOI: 10.13140/RG.2.2.30693.72169

11) Eisenberg, Robert 2025 **Molecular and Electro Dynamics: Merging the Methods** DOI: 10.13140/RG.2.2.35070.29767

Slide Shows

Many scientists prefer to view slide shows and then dip into the papers. Here are my recent attempts.

1) Eisenberg, Robert (2025) **From Maxwell to Circuits** Slide Show for Seminar in Electrical and Computer Sciences, Illinois Institute of Technology DOI: 10.13140/RG.2.2.32272.93440

2) revised significantly: Slide Show **Circuits and Maxwell Equations** for NITMB National Institute of Theoretical and Mathematical Biology, Seminar Series. April 2025 DOI: 10.13140/RG.2.2.10580.31369

3) Eisenberg, Robert S. (2025) Slide Show: **Chemistry Needs to be an Exact Science** DOI: 10.13140/RG.2.2.18251.86564

Topics

One group of these papers shows we can analyze **water flow in tissues of complex geometry**, using separately established properties of ion channels in structures that are reasonably realistic. This approach has led to a specific hypothesis about **sleep**: We suggest that one role of sleep is to clear waste including surplus local potassium concentrations according to the glymphatic hypothesis. We suggest that the mechanism involved is fundamentally the electro-osmosis present (and well-studied) in so many other tissues, most notably the kidney. We make a complete model predicting experimental results in a wide range of conditions.

Several of the papers are devoted to the ideas of **current flow in circuits**. Amazingly enough, the word "circuit" (and the relevant circuit laws) do not appear in the index of the leading electrodynamics textbooks that have been used for many decades around the world. Speculations about why are not proper subjects in academic papers. Suffice it to say, that until my reference above— "Kirchhoff's Current Law: A Derivation"— no derivation of the circuit laws from the relevant equations of electrodynamics was in the literatures. I argue that, without deriving the laws of circuits, it might be awkward for a textbook devoted to electrodynamics to describe circuits.

This lack of discussion of circuits remains amazing because they form the most numerous application of electrodynamics. There are something like 10^{18} circuits in smartphones on earth. Circuits make up our digital technology and the power distribution systems that modern civilization depends on.

In "Kirchhoff's Current Law: A Derivation," I give a one-line derivation of the circuit equations and show how they approximate reality. With this, I can point out the special mathematical property of total current flow (in two dimensions) that helps keep current flow in circuits, even on a time scale of 0.1 nsec in which the speed of light is significant (see 'Truly Compressible').

The work on **electrodynamics arose directly from a single sentence** from Stuart Rice at a seminar I gave long ago: "**True on all scales**." Eventually, his insight led to a paper showing that total current never accumulates on any time scale studied in physics, even in chemical reactions occurring in 10^{-19} seconds. I do not believe this fact is used in theories or simulations of chemical reactions. It was a privilege to learn from Stuart. I mourn his loss as a friend and colleague.

Most surprisingly, investigating the history of electrodynamics taught us something that we think—immodestly enough—is of great practical importance. Here, 'We' is a group led by Xavier Oriols and Dave Ferry, who have worked on quantum mechanics for many decades and written over ten books and hundreds and hundreds of papers on that subject.

Physicists (see 'Copenhagen Conspiracy' by Dave Ferry) have managed to confuse the issue of what is actually measured when currents are studied in the circuits of our computers—you may have heard of the nonsense of Schrödinger's cat.

We found that an approach used by Kirchhoff in 1857 allows **resolution of this issue,** without ambiguity in our opinion, by analyzing conduction current of electrons. Conduction current is the number of electrons (or charges) that flow in a unit time. The number is governed by the conservation of charge, called the 'continuity equation' in mathspeak. Magnetism in the original form of Ampere's law allows derivation of the displacement current component of total current which in turn allows analysis of tiny fast circuits using a generalization of Kirchhoff's law. The circuits of our computers are in

fact designed this way. We have shown that the **design laws extend to the quantum domain**, using Kirchhoff's approach of 1857.

All this has kept me occupied – perhaps preoccupied – and energized in 2025. I expect it will continue in the coming year as well. I wish you just as interesting and satisfying a year.