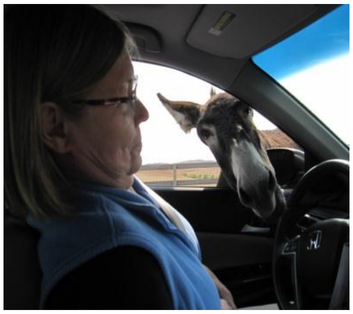




From top to bottom: South Dakota wildlife gets up close and personal; at a faculty tea; walks in the forest.

December 2012

We are now in that classic time warp known as the holidays, where whole weeks, even months, can whiz by while your eyes make one blink. (The other classic time warp is childhood, where offspring transform from pre-schoolers to college students while you doze. We discovered this one a few months ago.) I'm not sure I can write this whole letter without blinking, but I'm going to try. (And if you get this in January, you'll know I blinked!)

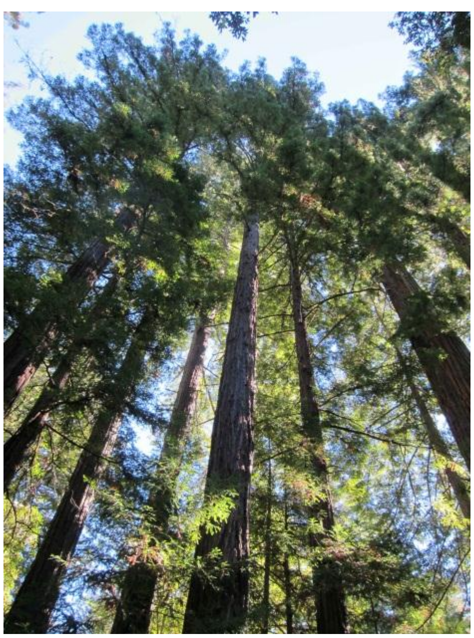
Here's a quick look at our year: road trips (yes, plural), a round-number birthday for Bob, good health, an out-of-Chicago living experience, six weeks with a teen-aged boy in the house, and lots of family and fun. Bob traveled more often than I did, but I went to some pretty rare places, like Minnewaukan, North Dakota, on my own.

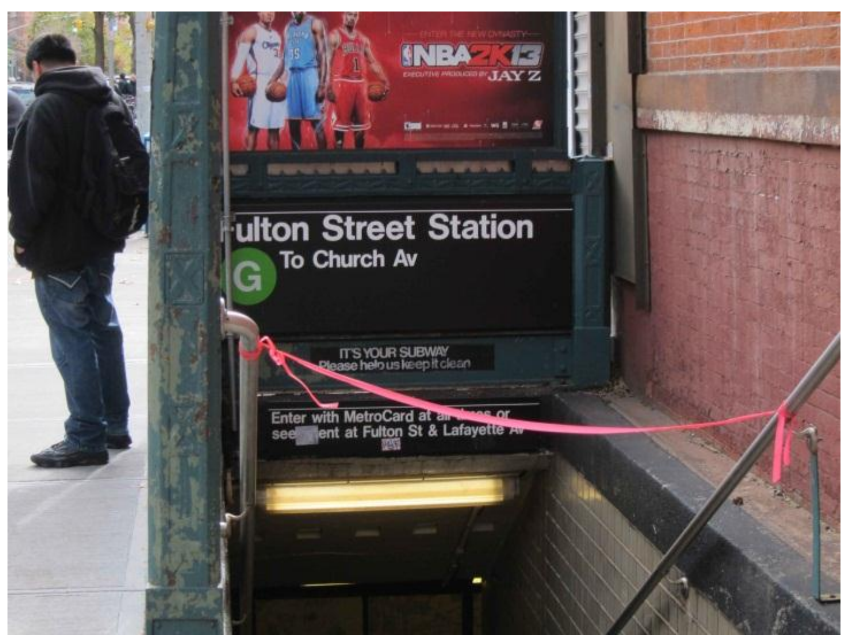
The big news of the year is Bob's appointment as a Miller Visiting Professor in Physical Chemistry, at UC Berkeley. We're living here for the fall semester and enjoying the California life, with lots of weekend trips to visit redwoods and historic sites, and almost daily expeditions to the best produce and bread outlets known to modern palates. A special shout-out to Rich Saykally, who suggested that Bob apply for this opportunity.

Getting to Berkeley was our second big road trip of the year. We made a leisurely drive across the country and took in some of the classic sites, like Mt. Rushmore and Devil's Tower. Our first road trip, in March, was Ben's birthday present to Bob. He drove us to Gettysburg, PA, for an all-day tour of the battlefields. (I still think the real gift was being willing to sit in the car with three people for 11 hours.) Afterwards, Bob's brother and wife came down from New York to round out the celebration. Then Bob and I visited Washington, DC, Longwood Gardens and Winterthur (where we learned that not all of Pennsylvania has the density of cabs that Chicago does, and made an unplanned car rental).

But the best part of the year has been the delight and love we've shared with family and friends. Our granddaughter Chris (formerly known as Crystal) started college. I helped my last living aunt celebrate her 95th birthday along with cousins galore and once again thanked the Broneskes for having such sturdy genes. We went to daughter Sally's NYC Marathon party, even though the marathon was cancelled at the last minute (and we made it to Brooklyn from Berkeley despite storm Sandy). And the subway was closed (see picture). Our grandson James, now 15, lived with us during the summer and went to summer school down the street. Best of all, ten of my favorite graduate school friends converged on Berkeley in November for a mini-reunion, and a good time was had by all.

Bob and I are having a good time, too, running around the state of California, and finding new routines and new experiences. We're going back to Chicago for Christmas, and then we're in Berkeley until the end of January – just in time for winter. Our memories and stories will keep us warm. We extend that warmth to you and your loved ones. May it last through all of 2013!





Scientists, like everyone else, do well when we know something. When we know the equations of air and water flow, we can design airplanes by math, without the uncertainties and expense of wind tunnels. We can design tall buildings that tower over the 4 story gothic cathedrals of Europe. We can build transistors and integrated circuits that make our remarkable digital technology (see (1) ***Transistors Alive***).

Scientists do not do badly when we do not know something. We know how to ask questions and check the answers. Eventually, we make progress. Most of science is guess and check.

But scientists do very badly when we think we know something and we do not. If we all think that the earth is the center of the solar system and universe, we can fix up our theories and make them (sort of) work. If politicians and theologians get involved, or classical academics, we get stuck. We can get stuck even by ourselves.

This year I realized (after about 56 years of being stuck) that a lot of chemistry and thus biochemistry and biology are built on an idea that is wrong. Dick Moxley heard me worry about this a very long time (1960-1962) ago and I thank him forever for his listening and love.

Chemists and biologists are taught that a chemical reaction is written as the 'law' of mass action with rate constants

$$L \underset{\overleftarrow{k}}{\overset{\vec{k}}{\rightleftharpoons}} R$$

But most of biochemistry, biology, and a lot of chemistry, deals with experiments in which the rate constants turn out not to be constant, when you change conditions. Explanations are sought everywhere (in quantum mechanics, in protein properties, in channel single filing) …. **except in the law of mass action itself.**

But the law of mass action is wrong, simply wrong, when L and R are electrically charged or concentrated in salt solutions (like all the solutions in biology especially where they are important (15)). Then, the constants must vary for theoretical reasons (called screening/shielding and also because of the finite diameter of the ions).

The constants have been measured for a long time. The constants have been known not to be constant for a long time, since the first world war. In fact, the constants are constant only if L and R are ideal infinitely dilute uncharged gases.

Nothing dissolved in water is like that. Nearly all biology occurs in solutions like seawater that are nothing like infinitely dilute uncharged gases.

In fact, if the rate constants were really constant—when L was converted to R according to the law of mass action—no electrical potentials would change, no current would flow, and all the laws of electricity would fail. Scientists know that the laws of electricity (called Maxwell's equations) are right to around twenty significant figures. Nonscientists know that the laws of electricity must be right. Otherwise their memory 'sticks' (with nearly one trillion transistors, that switch nearly 100 million times a second without significant error) would not work.

In fact, the law of mass action does not contain variables to describe location, as my famous pure math colleague at Berkeley Craig Evans said (***Evans/entropy.and.PDE.pdf***) more convincingly than I have, and so it cannot deal with lots of things.

All this matters a lot to everyone, even if they do not know it. Until chemical reactions are described by math with location and time, chemical devices (with inputs and outputs like transistors), will be more or less impossible to build—because devices always have inputs and outputs at different locations—and our biochemical and biological knowledge will be incomplete and our technology severely limited. If an analogous mistake had been made by Shockley in semiconductor physics (as it was in the constant field of Mott (20), used in one form or another by physiologists and biophysicists ever since), we would not have transistors, digital electronics, computers, tablets or computer games today.

These strong ideas have been entertained with great interest by the chemical community this year, and the facts behind them are not in dispute.

Indeed, I think the ideas are not new at all, and have been evident to leading physical chemists since Bjerrum and Debye (1920's)—who certainly knew that ionic solutions were not ideal gases, and that ionic solutions were essential to life—but are being stated more plainly with the alarming implications spelled out explicitly and clearly, perhaps for the first time. The relevant papers (2-4) have been solicited and refereed by members of the National Academy of Sciences (USA), etc. They led to my appointment as a Miller Institute (visiting) Professor in Chemistry in Berkeley, and to a series of papers designed to acquaint chemists, mathematicians, physiologists, and biophysicists with their implications (2-9).

Personally, I am getting bored being an expositor. It is much more fun to try to actually understand things like this phony law and make them work right (10-19). I give thanks to everyone—family, friends, collaborators, and Deans and Administrators—who make this possible and wish you all a Merry Christmas and Prosperous and Happy and Healthy New Year.

References

If anyone wants to read more, papers are available on ***My Website*** and the more general ones can be downloaded (I hope) by clicking on the symbol ***[PDF]*** in the following reference list. If that does not work, drop me an email at ***bob.eisenberg@gmail.com*** or ***beisenbe@rush.edu*** and I will send along the file(s).

1. Eisenberg, B. 2012. Ions in Fluctuating Channels: Transistors Alive. Fluctuations and Noise Letters 11:76-96 Earlier version available on http://arxiv.org/ as q-bio/0506016v0506012. [PDF]

2. Eisenberg, B. 2012. Ionic Interactions in Biological and Chemical Systems: a Variational Approach. Transactions of the Faraday Society (*in the press:* DOI:10.1039/C2FD20066J): available at http://arxiv.org/abs/1206.1517 cite as 1206.1517v1201. [PDF]

3. Eisenberg, B. 2011. Crowded Charges in Ion Channels. In Advances in Chemical Physics. John Wiley & Sons, Inc. 77-223 also available at http:\\arix.org as arXiv 1009.1786v1001 [PDF]

4. Eisenberg, B. 2011. Mass Action in Ionic Solutions. Chemical Physics Letters 511:1-6. [PDF]

5. Eisenberg, B. 2013. Ionic Interactions are everywhere. Physiology (a journal of the American Physiological Society):in the press. [PDF]

6. Eisenberg, B. 2012. A Leading Role for Mathematics in the Study of Ionic Solutions. SIAM News 45:11-12. [PDF]

7. Eisenberg, B. 2012. Life's Solutions. A Mathematical Challenge. Available on arXiv as http://arxiv.org/abs/1207.4737. [PDF]

8. Eisenberg, B. 2012. Living Devices: The Physiological Point of View. Available on arXiv as http://arxiv.org/abs/1206.6490. [PDF]

9. Eisenberg, B. 2011. Lifeõs Solutions are Not Ideal. Posted on arXiv.org with Paper ID arXiv:1105.0184v1. [PDF]

10. Berti, C., D. Gillespie, J. P. Bardhan, R. S. Eisenberg, and C. Fiegna. 2012. Comparison of three-dimensional Poisson solution methods for particle-based simulation and inhomogeneous dielectrics. Physical Review E 86:011912.

11. Berti, C., D. Gillespie, R. S. Eisenberg, and C. Fiegna. 2012. Particle-based simulation of charge transport in discrete-charge nano-scale systems: the electrostatic problem. Nanoscale Research Letters (*in the press*). .

12. Giri, J., J. Tang, C. Wirth, C. Peneff, and B. Eisenberg. 2012. Single-channel measurements of an N-acetylneuraminic acid-inducible outer membrane channel in Escherichia coli. European Biophysics Journal 41:259-271.

13. Horng, T.-L., T.-C. Lin, C. Liu, and B. Eisenberg. 2012. PNP Equations with Steric Effects: A Model of Ion Flow through Channels. The Journal of Physical Chemistry B 116:11422-11441.

14. Hyon, Y., J. E. Fonseca, B. Eisenberg, and C. Liu. 2012. Energy variational approach to study charge inversion (layering) near charged walls. Discrete and Continuous Dynamical Systems Series B (DCDS-B) 17:2725 - 2743.

15. Jimenez-Morales, D., J. Liang, and B. Eisenberg. 2012. Ionizable side chains at catalytic active sites of enzymes. European Biophysics Journal 41:449-460.

16. Kaufman, I., D. G. Luchinsky, R. Tindjong, P. V. E. Mcclintock, and R. S. Eisenberg. 2012. Multi-ion conduction bands in a simple model of calcium channels. Posted on arXiv.org with Paper ID arXiv 1209.2381

17. Lin, T. C. and B. Eisenberg. 2012. A new approach to the Lennard-Jones potential and a new model: PNP-steric equations. (*submitted*).

18. Ryham, R., F. Cohen, and R. S. Eisenberg. 2012. A Dynamic Model of Open Vesicles in Fluids. Communications in Mathematical Sciences 10:1273-1285.

19. Tindjong, R., I. Kaufman, P. V. E. Mcclintock, D. G. Luchinsky, and R. S. Eisenberg. 2012. Nonequilibrium rate theory for conduction in open ion channels. Fluctuation and Noise Letters 11:83-93.

20. Mott, N. F. 1939. The theory of crystal rectifiers. Proc Roy Soc A 171:27-38