



**Whatever the virus does to the world next,
we will handle together**



December 2021

Dear friends and family,

We are approaching Year 3 of the pandemic and Year 7 of The Trump Era. I don't know which is worse, but both produce more uncertainty and uproar than I could have made up for a science fiction novel. It makes the Sixties and the Vietnam War look tame. So let's focus on what's closer to home, where we can find comfort and joy.

Bob and I are both healthy and happy. Being home alone for a year cemented our already-great relationship and we cherish our good fortune more than ever. We are lucky indeed. Bob is still Zooming at least twice a week with mathematicians around the country and the world. He's become the Pied Piper of biomath, spreading ideas for papers wherever he appears and mentoring young students and post-docs. I'm very impressed, even though he's still the guy who messes up my kitchen without even trying. He's back to working out at the gym a couple of times a week and is overcoming the torn Achilles tendon he suffered three years ago and the effects of a year of minimal exercise.

Work keeps coming in for me. There's more this year (hence this late holiday letter). It's all interesting and a lot of it has helped clients with intricate problems that most lawyers wouldn't work on. I'm especially proud that I took on the doltish, intransigent Illinois bureaucracy twice and won, helping two people with significant parts of their lives. I'm still working out twice a week with a personal trainer, because I need adult supervision if I'm going to get any exercise at all.

Bob's and my first foray back into the real world was a trip to visit Bob's daughter Sally and her partner Reid in Charleston, South Carolina. We hope to return in early 2022, covid variants willing. We spent another week in our favorite places in Utah in May, a real and beautiful respite after a year of isolation. And we had our first stay-cation in October, when our friends Brian Salzberg and Ana Lia Obaid visited from Philadelphia. We, they, and several other Chicago friends spent a long weekend downtown, eating, laughing, and poking around Michigan Avenue (in that order of importance).

The best part of the year has revolved around our grandchildren. We have six now: Our newest is Catherine (23), who married James (24) in June. Catherine works as a pre-school teacher and is studying for her master's degree in childhood development. James is brokering freight deliveries with available truckers – think of him as a logistical matchmaker. Chris (27) still lives and works as a programmer in the Washington, DC area. She just bought her first house. Holly (21) is in nursing school and working part-time at a private school. Henry (18) is a high school senior and collecting college acceptances as if they were baseball cards. Alastair (16) is a high school sophomore who took an Italian cooking course this year and made me gluten-free tiramisu. All of them except Chris live a few minutes away (and Holly, literally a few steps away, because she lives downstairs from us). They're all nice and

interesting people (and not just because they're our grandchildren!). Their frequent comings and goings are gift. Bob and I each had the pleasure of taking road trips with Henry and Alastair. They went to Wyoming and South Dakota with Bob, and I took them to Ann Arbor, Michigan for a college visit. They did most of the driving for me because they were accumulating supervised driving time to get their driver's licenses. I like being chauffeured. And now I know why people in their sixties and seventies talk so much about grandchildren. What a pleasure they are.

And so – it's been a very good year for us despite all the external third-degree public uproar and rampant uncertainty. We are grateful for what we have.

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A year like no other.

January 6, 2021: an invasion of the US Capitol, by the Radical Republican Reactionaries, trying to install an unelected President! Obviously, nurtured by the Russians as documented in detail in the book [Intelligence](#), by someone who has read all the intelligence documentation. Thank heaven the FSB/GRU did not send assassins who surely would have succeeded. (Old timers: FSB=KGB). But as terrible as this is and might have been, it is not new stuff to Chicagoans. There really was not that much difference between the Chicago of Daley, the elder, and what Trump as dictator would have done.

But mental health requires we focus on what we can do to keep all in the family healthy, and do some science made much easier by watching Ardyth's career grow into a substantial law practice, performed from her desk, sometimes in less than business dress. Her combination of razor sharp research, clever lawyering and emotional bonding and support of clients seems to produce new cases for every one case solved. As we have learned from the reproduction factor of the virus, that produces rapid growth. Whoever heard of such a thing from a 72-year-old lawyer, working alone at home? Well, not quite alone. I helped a bit with the computer stuff, until she learned to do everything herself. I deal only with the router and network issues at this stage.

I've been lucky enough to work with a group led by Huaxiong Huang (Dean of UIC United International College Zhuhai China) with his more than capable student Yi Zhu and the extraordinary Shixin Xu (Duke Kunshan University near Shanghai) and the gifted Zilong Song (Utah State Logan) using math to understand a classical biophysical problem

You can download the papers below, and some other stuff, some much less technical, from [Dropbox Hyperlink](#) if you want to look at the real thing! I included a letter the NY Times published about a scientist looking at religion that should produce some interesting discussion.

Xu, S., B. Eisenberg, Z. Song and H. Huang (2018). "Osmosis through a Semi-permeable Membrane: a Consistent Approach to Interactions." [arXiv preprint arXiv:1806.00646](https://arxiv.org/abs/1806.00646).

Zhu, Y., S. Xu, R. S. Eisenberg and H. Huang (2019). "A Bidomain Model for Lens Microcirculation

" [Biophysical Journal](https://arxiv.org/abs/1810.04162) **116**(6): 1171-1184 Preprint available at <https://arxiv.org/abs/1810.04162>.

Zhu, Y., S. Xu, R. S. Eisenberg and H. Huang (2021). "Membranes in Optic Nerve Models." [arXiv preprint arXiv:2105.14411](https://arxiv.org/abs/2105.14411).

Zhu, Y., S. Xu, R. S. Eisenberg and H. Huang (2021). "Optic nerve microcirculation: Fluid flow and electrodiffusion." [Physics of Fluids](https://doi.org/10.1063/1.513006) **33**(4): 041906.

Zhu, Y., S. Xu, R. S. Eisenberg and H. Huang (2021). "A tridomain model for potassium clearance in optic nerve of Necturus." [Biophysical journal](https://doi.org/10.1063/1.513006) **120**(15): 3008-3027.

As is so often the case in science, we started without knowing what we were doing. Then, as soon as we figured out what we were doing, we moved on to something else that we did not understand. We started with ‘osmosis’ (how water diffuses in salt solutions like ocean water), and then on to see if we could take the complex structure of the lens of the eye and predict the detailed experimental results from Rick Mathias and his colleagues. After more than a year of hard work, we did: we found that our derivation recovered the engineering model Rick had developed (and proven) many years ago. Then we moved on to how potassium poisons a nerve fiber. It turns out that potassium builds up outside nerve cells when they signal, which was studied by my old friend Dick Orkand at Harvard Neurobiology in the 1960s. After much more work, we took the approach that worked in the lens for two phases (the lens fibers and the spaces outside the lens fibers) and extended it to three phases (the nerve fibers, the space outside the nerve fibers, and now the glia of the nerve). You can type “Glia” into Wikipedia, Google Search or, best, YouTube to see what I am talking about.

And then I opened the journal **Science** and found that some (but emphatically not all) researchers believe that what we had been studying is a main reason for sleep. Proponents of this “glymphatic hypothesis” think that sleep is all about clearing waste from the extracellular space of the brain through the glia into the blood vessels. We had developed the essential theory for that and are now in a position to make a major contribution if we can extend our model to include four phases, now nerve cells, extracellular space, glia, and blood vessels.

Once again, science has shown that the careful study of what may seem irrelevant can become the key to understanding something very important.

Of course, we will not know whether the glymphatic idea is right until the theory is completely worked out and computed, and even then we may not know because the structure of brain may not be known well enough.....but then again science is always about not knowing what you’re doing,.....haven’t I heard that somewhere else?

I’m still on the atomic or mathematical path too. With Luigi Catacuzzeno, Fabio Franciolini, and Poncho (Francisco) Bezanilla, we studied the noise in part of a nerve channel, and

rather excitingly we found how a tiny difference (some 10 atoms or so) in structure controls the speed of the signals in your nerve fibers. That is the atomic stuff.

On the math side, I seem to be making slow progress in showing my colleagues that the Maxwell equations are universal and exact, with zero adjustable parameters and so need to be the foundation of the understanding of matter with electrical charge. Nearly all matter has electrical charge, because electrons are what hold matter together.

Just as important, Chun Liu and Yiwei Wang helped us make a dramatic extension and simplification of an idea that has vexed electrodynamics since the time of Faraday, if not Ben Franklin. The mystery of electrical polarization (as Faraday and I suspect Franklin called it) is gone, reduced to a stress strain theory of charge: electric fields change where charges are, just like forces change where matter is, and both can use the same mathematics. Scientists like to fondle their research problems and resent those who solve them, so I suspect our work will not be popular.

As we face the possibility of another horrible covid-induced shutdown, I take solace in my work, my family, my life, but most of all my wife. I am blessed by them.