Happy Holidays!!!

Ardyth and Bob Eisenberg

Hi from Ardyth

There's plenty I could say in this letter about elections, talking heads, and who's qualified to run the government or set public policy. But this time of year, what's close to home is what matters.

Most important – and closest to home – is the success of Bob's heart surgery last December. He's been working out with a personal trainer since March and now lugs weights around the gym and does multiple sets and repetitions of all kinds of exercises. It's impressive. The trainer, lovingly called "Brian the Terrible," has worked with me for years. As I tell him, he has no regard for age: He just has you do what he thinks you can do. Bob and I are both the better for it, physically and mentally.

This has been the year for interesting visits to some lesser-known places. In January we took a winter break in Springdale, Utah, a couple of miles from Zion National Park. The weather was chillier than we'd expected, but visiting the park with fewer tourists made up for that. We used up about a gazillion bytes taking pictures of the views. As interesting as the park was the golf course at the Thunderbird Resort east of Zion in the middle of nowhere. It started as a restaurant in 1931. In 1962, the widow of the founder created the golf course as a way to keep the land in the family (and protect it from neighbors who wanted to get their hands on it). That info's not on the website -- https://www.thunderbirdutah.com/ -- we learned it from the woman's granddaughter, who runs the gift shop.

The closest airport to Springdale is in Las Vegas. We had to spend the night there on our way home. We chose the Tropicana, not knowing it would soon be pile of rubble and the future home of the Oakland Athletics. Las Vegas is as exotic as the Thunderbird Resort, in its own way. We much preferred the latter.

We trekked to Indianapolis on April 8 to see the total eclipse. It was worth the trip, but madcap, to say the least. We bought advance tickets to the Indianapolis Motor Speedway, where NASA and Purdue were sponsoring a watch day and special programs.

What could possibly go wrong? Let me count the ways: Having only one gate open to handle the ticketholders. An unusually hot day. A fancy lunch, overbooked and – it turned out – looking **away** from the eclipse. Then we realized we'd be leaving the Speedway at the same time as 40,000 of our closest friends – far worse than the mismanaged trickling in had been. We fled back to the hotel and watched from its backyard with a handful of other guests. These are just the lowlights. There's a longer version of the story. Suffice it to say, the morning has set the bar for how bad a trip can be. But Bob and I laughed through it all, and still roar every time we hear the word, "Indianapolis."

In May, while visiting family in Idaho, we stopped at Shoshone Falls – worthy of its nickname, the Niagara Falls of the West. A bonus later, near Boise, was my brother Bob's guided tour of petroglyphs in an archeological park.

We've also visited Bob's daughter Emily and her husband Ben in Michigan. I made what is becoming an annual trek to Saratoga Springs, New York, for a spa weekend with lots of girl talk with a friend from college. Bob visited in Berlin for ten days to work with mathematicians. I skipped going, with much regret, because of my workload. You know the work is busy if I'd skip one of my favorite places in Europe! But the work is interesting and that's what keeps me at it.

Despite this running around to off-the-beaten path places, what matters most is our time with family this year. It's an honor – and pure fun – that the local grandchildren – James and Catherine, Alastair, and Henry – visit so often. We usually host a weekly "Eisendinner": Whoever is in the neighborhood comes and hangs out and eats and helps clean up. (Of course, I'd feed them even if they didn't clean up, but it's impressive that they do it naturally.) We cherish these times – and this time in our lives. There will be even more to cherish in 2025: James and Catherine are having a baby in January and making us great-grandparents. What could be more amazing and exciting than that?

Hi from Bob!

Science

Ever since I was a teenager, I have wondered how electrical circuits worked, first in my electric trains, and then in a home-built robot that worked, a bit. My wonder increased a lot as the circuits of 1955 shrunk 1,000,000,000 times while becoming 1,000,000,000 times more capable and bringing a computer into my hands as a cell phone that no one could have imagined in 1955 or have designed even in 2000.

This improvement in technology is far beyond anything else in human history. The industrial revolution that replaced horsepower with steam and then electrical power increased capability by say one thousand times.

The question is, what made this improvement possible? The answer is that the circuits of our computers accurately follow the laws and simulations of electrodynamics. Trial and error is replaced by mathematics. Design is millions of time faster and more successful.

It is one of the joys of my life that I can now answer that question—why and how do circuits work—in detail, in equations and math, not just generalities.[1-4]

Circuits work almost perfectly because they embody the universal properties of electricity and electrodynamics, with little and manageable approximation. Electrodynamics is universal and nearly exact because it is joined at the hip to Einstein's relativity. Relativity describes all of space and electrodynamics is universal for that reason. [You should be mystified here. I can explain easily if you wish to ask me at bob.eisenberg@gmail.com .]

Electrodynamics implies that electric current flows in loops, although it took me decades to understand that. (And I add, with a wholesome dose of immodesty, that most textbooks do not understand that either.) Those loops are a property of what is called "solenoidal fields" that do not diverge or converge, so the flowlines of the loops of

current never cross, never start or end. Charges and currents flow in endless loops as they circuit through solenoidal fields.

In some cases, flowlines can interact in a complicated confusing way, that are hard to analyze or use for technology. But the interactions are greatly simplified if the loops are physically separated into different circuits. Circuits usually use different wires to separate flowlines of currents. Note that the word ‘circuit’ and the word ‘loop’ can be synonyms.

Flowlines separated into circuits follow simple laws approximately, called Kirchhoff’s laws. They follow Maxwell’s current law exactly, as I have shown.[1-4] These laws allow the design of our computers by mathematics and simulations, not trial and error.

Those laws allow engineers to design the technology that makes our lives much easier than it used to be. Kirchhoff’s laws are used to design the circuits that bring power and light to our homes. Kirchhoff’s laws are used to design the circuits that process information in our computers and smart phones. The circuits work as they are supposed to even when they switch 1,000,000,000 times a second and are only a few hundred atoms long. If the laws of electricity were like other physical laws, they would have errors of a few per cent and be valid over a range of say one thousand-fold in size. The laws of electrodynamics have as little error as any in science. Errors are certainly less than one part in one hundred million and are valid from microvolts to megavolts and beyond.

The laws of those computer circuits are essentially the same as the laws used to design telegraphs, and that Edison and Westinghouse/Tesla used to bring light to our nights more than one hundred and fifty years ago.

So, imagine my surprise when I found that **those laws, and circuits, are not mentioned in the index of the most widely used textbooks of electrodynamics**.

I have tried to remedy that this year [4] by presenting a simple derivation of the properties of circuits (and Kirchhoff's and Maxwell's current laws) that can easily be taught in the tradition of electrodynamics. The derivation is rigorous and does not make assumptions about the properties of matter or dielectrics.

Biology

Along the way, I applied those principles of current flow to biology's chemical factories, called mitochondria. Mitochondria are organelles: little cells within cells that have membranes like the membrane of the cells that surround them. Mitochondria are found in almost all cells. They generate the chemical that is the nearly universal storehouse of chemical energy in life called ATP.

Five elaborate molecular machines are in those membranes. Electrons flow in those machines (and positively charged water called 'protons', as well). These machines have been studied very well for a very long time, in probably >10,000 papers, but somehow or other workers in this field were not aware that electron flows (and current flows in general) had been understood for even longer. Indeed, work on nerve cells had shown that current flow in biology follows the same laws as electron flows in circuits, including the telegraph circuits used by our great great grandfathers. My collaborators (Shixin Xu, Zilong Song, led by Huaxiong Huang) and I have shown in some detail [5] how that the laws of physics that work so well for nerve cells also describe one of the molecular machines called cytochrome c oxidase.

I am trying to bring the reality of physics to the study of mitochondria and ATP generation as a whole [6]. The wonderful success of molecular and structural biology as ***qualitative*** science has made this possible. But that very success has come at a price. Many biologists today choose not to bother with the difficulties of quantitative analysis because of the striking success of qualitative work.

Most biologists today have never heard of the laws of electrical physics that make their nervous system work, and of course mitochondria as well. The enormous growth of

electrical technology has occurred because quantitative analysis was available and easy to use. Biology and medicine will grow similarly when they learn to be quantitative. Electrodynamics is the place to start, I think, taking advantage of the simplicity and accuracy of the Kirchhoff and Maxwell laws of current that have been used to analyze nerve cells, as well as computer circuits for a very long time.

There are no biological, vitalist, or theological [7] exceptions to the laws of physics, including Maxwell's equations. Those laws should not be feared. They should be used to our advantage.

The World

It has been a memorable year for someone like me reading a biography of John Quincy Adams by Randall Woods.

Quincy Adams was a Secretary of State, President, and son of a President. Both Presidents named Adams were founding fathers committed to a government by law and balanced powers. They were raised in the New England tradition of John Winthrop (Harvard) of seeing Boston (for them the same as America) as a citadel of integrity, a "City on a Hill" [New Testament: Matthew 5:14].

We Americans have slid a long way from the heights of the "City on a Hill". But that is nothing new as far as I am concerned.

I for one never looked up to Boston or America as a citadel of integrity. The Boston I knew had a mayor actually in jail, James Curly. It protected Whitey Bulger (a multiple murderer) for many years. And Boston society long followed A. Lawrence Lowell (President of Harvard) in his belief "Jews could not be Americans" see https://bit.ly/41wJ7DB)

Utah Road Trip

Ardyth beautifully describes our travels but is sparse with words describing the road from Zion National Park to the Thunderbird Resort in Mt. Carmel Junction, Utah (population 113). The road was surrounded by white rock, red rock, thousand-meter cliffs, checkboard mesas, decorated with snow, peaks glimpsed through clouds. Unforgettable. YOU can see it at https://bit.ly/3Zwx6vc then click on **Checkerboard Mesa,** then the lower left panel of the video labelled >0:38**.** Not easy to see in the summer when saturated with people, but easier to see in the video just referenced.

I first visited Zion in 1968 when it was empty, and first wife Brenda and I camped in a tent at the foot of the cliffs in the Grotto Picnic area and climbed Lady Mountain to the top (now forbidden) with the help of cables and a ladder.

Eight years later we carried baby Jill and toddler Emily down the trail from Upper Emerald Pools, as Ben strolled along. Emily, then 3 years old, insisted on walking from

Upper to Lower Emerald Pools (roughly 1.3 miles) and she made it a bit beyond before she collapsed (dead asleep, unawakenable) into Brenda's arms. Jill was on my back the rest of the way. Ben was amused taking everything in stride.

And then, some 55 years later, Ardyth and I visited Zion, drove to Mount Carmel Junction, and left Thunderbird Lodge/Golf Course driving a mile or so to neighboring Orderville, population 591. Attorney Ardyth had to visit Order-ville seeking "Law and Order". And she wanted her Diet Coke as a travel companion. Of course, Diet Coke was hardly to be found in Orderville, because the law and order of a mostly Mormon town has nearly banned it, as a dangerous stimulant, along with coffee, tea and caffeine containing soft drinks.

Orderville in fact is not just another beautiful Utah town. It has an extraordinary history as a communal order of the Church of Latter-Day Saints, set up by Joseph Smith himself, the first of those Saints, if I have my theology right.

Joseph Smith's Communal "United Order of Latter-Day Saints" was housed in Orderville. The United Order shared their lives and wives as legal polygamists, as long as they stayed in the Utah Territory, until the Edmunds Anti-Polygamy Act of 1882 broke up families and sent many men to jail, as Utah moved to becoming a state.

In case this Americana is new to you, my source for information is the extensive and wonderful Wikipedia article https://en.wikipedia.org/wiki/Orderville,_Utah. What a glimpse of an extraordinary part of American history in that article.

I recommend further reading in Thomas G. Alexander "Utah, The Right Place, a Utah Statehood Centennial Project of the Utah State Historical Society" where you will read of the near wars between Utah and the United States, from roughly 1848 to 1891.

Communal living was well known and common throughout America of the 1800s. Utopian settlements were **found throughout America** in the 1800s and often carry their exotic names to this day (Urbana of the University of Illinois, for example). Karl Marx

studied the people who lived in American communes—he might have called them commune-ists—as examples of 'socialist' societies that shared everything material and spiritual and even families, as in Orderville. Communes did not survive in the USA. People seem to prefer to compete for resources than to be forced to share them. Communists became unpopular in the USA as their atheism became well known.

Next Year and Beyond

I look forward to next year and a few years ahead when we can share Zion/Mr. Carmel Junction/Orderville with James, Catherine, and the great grandchild they will bring along!

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