

Added 25 August 2016. I had originally intended sending this polemic to the SJUSD board, but never really finished it. One point I would modify would be to point out these days, laboratory physics really can begin in the computer, given the widespread availability of density functional software...but you still have to prove your predictions in the lab!

I'm still wondering why I felt compelled to write this letter. Perhaps it's because my seventh and last kid is now a Leland Freshman, and this is my final chance to vent pent-up frustrations I've had with the secondary school system for the past fifty years. With a few notable exceptions, I really hated high school. I guess my greatest accomplishment in high school was getting expelled. Twice. Despite these stellar achievements, I eventually wound up with advanced degrees in physics from one of those institutions that parents fantasize their children might get accepted into someday. But that's another story. My main message here is to urge that you recognize, nurture and sustain the brilliant misfits in your classes (who are most likely to be overwhelmingly male in number). It has been my life experience that it is such individuals who go on to effect real change and progress in society, and seldom the "straight-A" students, over-achievers and varsity athletes. That the former eventually get the chance to "break through" is what makes America truly different from the rest of the world – and a better place. I fear that chance may be disappearing.

I went to high school in the late 40s and early 50s followed by a marvelous and satisfying career in frontier science in technology. I'm now in my eighth decade of life – that means I've passed 70 – and retired (well, sort of!). I think I can honestly claim I've finally earned a license to pontificate, one which I will now exercise.

First of all, may I say I have the greatest respect and admiration for teachers. You could not pay me enough to do your jobs, having to deal with the kind of student I was, the new pressures brought about by the alphabet soup of standardized tests (START, SAT, etc.) and the often misguided and exaggerated expectations upper-middle class parents now place on their kids. I'm amazed that you do it at all, but hope that occasionally seeing one of my "misfits" make it is truly rewarding.

I grew up in a pluralistic, ethnically mixed neighborhood near New York City, comprised primarily of union labor and small shopkeeper families. We were the children and grandchildren of relatively recent immigrants and most of our parents (mine, for example) never finished high school. Our parents had a great appreciation of higher education, not so much in and of itself, but by possessing such, it was seen one could make a lot more money in America. I was always urged to excel in school and sometimes did. There wasn't as much homework as now, and I didn't do it anyway. I was pretty good at taking tests, though, and had an outstanding 8th grade year.

Then I went to high school and it all came apart. My principal pursuits became hot girls, fast cars, and cold beer – more or less in that order. In other words, I was a pretty normal teenage male, but a total misfit and miscreant academically. I got sick and tired of being told I wasn't "performing up to potential." I hated homework and almost never did any. In my world history class, when the topic was Metternich and the Congress of Vienna, I would be more interested whether Lois "Lushy" Mancini was returning my leering glances (she wasn't). Some years later, I had the great good fortune to audit a class on post-Napoleonic Europe by none other than Henry Kissinger, long before he became famous. By then, I was ready and receptive and totally absorbed and had my glands under control. Occasionally, in the hope of impressing some girl – this time it was Sally

– I would crank it up and ace a few algebra tests. That didn't work either. With all these distractions, I just barely graduated.

Nonetheless, there were a couple of bright spots. My track coach, Mr. Macrini, taught me how to test the limits of my physical and mental endurance, sometimes with the heel of his foot in my butt (this was well before “physical intervention” between teacher and student was outlawed). Our track team was one of the foremost at that time in New York State, and we didn't even have a track! We trained running around the neighborhood. Physical and mental toughness proved essential to whatever later success I had in college and graduate school – and career. My American History teacher, Mr. Hammond, also one of the track coaches, had been a Lt. Commander in the Navy and an executive officer of a destroyer in WW II which saw considerable action in the South Pacific. He was a rather large individual, an in-your-face type, who brooked no nonsense in his class. All us guys loved him. He had a way of making you imagine you were in front of Pickett's Charge and then scare the hell out of you with a rebel scream. It was in Mr. Hammond's class that I began to master the English language and learned how to use it. He assigned a lot of essays, all to be completed in class and quickly – very little homework that I can remember. He would break us into small debating teams and tell us which side to argue, whether you agreed with the position or not. It was great fun. Good teachers can make a difference and are remembered against the background of an otherwise dismal experience.

If you haven't noticed already, there's a great deal of difference between male and female teenagers and their relative attention span and focus. That's why most teenage misfits in my experience have been boys. It may not be politically correct these days to bring this topic up, but it's a fact that's been recognized by thoughtful observers of human behavior for centuries. A couple of thousand years ago, one of them theorized that in a perfect society, males would not undertake the study of “philosophy” until age 18 or beyond, the time till then having been spent in sports and pursuit of the military arts. His name was Socrates and he was right on. It takes some time for males to mature. I've heard a few women comment we never do (Incidentally, I just don't understand women at all. Fathering four daughters has only confused me more). When I eventually got to college, there was a fair number of Korean War vets already enrolled. Even though many were far from being “intellectually gifted,” every single one graduated. My school had a 50% attrition rate in the Freshman year, and a number of these dropouts were 17 year old hotshots from the Bronx High School of Science who melted down once away from home.

It's fashionable for one generation to claim it had life harder than the other. “I had to walk to school, and uphill both ways!” The truth is that humans evolve very slowly, even culturally as well as biologically. What is different for today's teenagers is immediate access to information and more about that later. A lot is made of the “drug problem.” But in my day, there was plenty of marijuana around if you wanted it, especially if you were a rich kid. The Puerto Ricans sold it. This was way before the cocaine craze, but heroin was occasionally available and a few lunatics actually tried it. The drug of choice was alcohol and it was incredibly easy to get, even for 14 year olds. The legal age for

alcohol in New York State at the time was 18 and by 16 most of us (males) had obtained forged draft cards (you could steal blank forms from the high school office) which was the standard ID of the day. Teenage DUI was rampant, and in my senior year, four students were killed in an auto crash, as well my Catholic “confirmation partner” of a few years previously.

What are the important subjects to master in high school today? First and foremost is the English language, whether your ambition is to become a particle physicist or chairman of Sony. During my lifetime, English has become the universal language on the planet and I believe the process is now irreversible. We Americans are fortunate in that it is our native language...well, sort of. The British might argue otherwise. Domestically, the broth in the melting pot that binds us together is not our looks but our sound. I took four years of Latin in high school and it comes in handy sometimes when deciphering prescriptions or the inscriptions on court house walls. In my day, it was claimed Latin helped build one’s English vocabulary, but since 80% of English words are “bad French” anyway, why bother? In the graduate school I attended, one of the requirements for a PhD in physics was the ability to read, write and speak the “three scientific languages” (German, French and Russian). Professionally (not culturally!), it was a monumental waste of time. I’ll give you one guess in what language are published the overwhelming majority of papers in *Compte Rendus*, *Zeitschrift fuer Physik*, *Uspehkii*, *Acta Physica Sinica* and *La Revista Mexicana de Fisica*. English is now the “official” language at several of the Max Planck Institutes in Germany. For promotion in the physics department of the National University of Mexico, one is required to have published a series of papers in one or more of seven recognized international journals – all in English. The program language at all international scientific conferences is English. Occasionally a second language is accepted honorifically – in France, for example – but a privilege not actually exercised.

I’m not saying knowledge of a foreign language is not socially or culturally desirable and even valuable. Being able to negotiate in Spanish with a traffic cop in Mexico City can save you a lot of time and money. On the other hand, I’ve been to China four times in the last 18 months and only know a few words of Mandarin or Cantonese and I continually confuse which is spoken where. As a 6-foot white man, I kind of stick out when I’m walking around in public over there and Chinese teenagers are always coming up to me, saying, “Hi, my American name is Sean, or Shelley, or Alice or whatever. Where are you from and what do you do?” with very good pronunciation. It’s astounding and one can thank the Internet and the American entertainment industry for this phenomenon.

Next in importance to English in the high school curricula is history, both world and American. History is actually equal in importance to English, except you need to know English first. Americans are abominably ignorant of their own history as well as that of the rest of the world, primarily because we’re wrapped up in doing our “American thing,” fixing the present and designing the future, very admirable pursuits. Nonetheless, as Will Shakespeare put it, “What is past is prologue,” and knowledge of previous mistakes, successes and excesses of human civilizations, even of very recent events, can teach and hopefully guide future policy decisions (Suppose as much thought and planning had gone

into the aftermath of the military campaign in Iraq as went into the postwar administration and occupation of Japan?). Studying history hones ones English skills (e.g., by reading the words of Churchill, Lincoln and Jefferson), helps us understand science (Did Galileo really recant?) and mathematics (Who thought up “zero” and why?).

From time to time, I’ve mused about how to make history more palatable to teenagers. Consider American History. What about spending some effort on finding out how our history is taught in other countries, that is, from the view of Burn’s “bug in a bonnet,” “to see ourselves as others see us?” How is the War of 1812 presented to high school students in the United Kingdom? In Ireland? And especially Canada? What view is taken in Japanese secondary schools on the Pacific War, the use of atomic weapons and the American occupation. While at the National University of Mexico, I audited a course on Mexican-American relations (it was taught in Spanish, one of the few times I had to professionally use a language other than English). You be surprised. Their attitude toward us is not as negative as you might think. What picture is painted of the slave trade with the British and American Colonies in the school system within the emerging African Republics? One can think of many other examples. Teenagers are generally obsessed by how they appear to others, and this approach could be a real attention grabber.

Teenage males are also fascinated by horror and violence. Just look at today’s video games and in my time it was comic books. World history is replete with holocausts. Focus today is primarily centered on the well-documented massacre of the European Jews by the Nazis, but the phenomenon goes much further back in time with greater uncertainty about the actual numbers involved. Some historical evidence is emerging that the later episodes of the bubonic plague may have been incidences of biological warfare. Often these holocausts were the result of purposeful neglect rather than overt action, such as the policy of the British government during the Irish famines, and the reduction of the Mexican population by disease and the military power brought about by the Spanish (By perhaps as much as 80%. We really don’t know, because the Conquistadores destroyed all records and archives kept by the Mesoamerican civilizations). In our own history, we have the example of the plains tribal cultures (there is no such thing as a Native American – we all came from somewhere else – it’s just a matter of time scale insignificant as measured by the evolution of homo sapiens). The ancestors of each of us got beaten up by the ancestors of all of us at some time in the past. In that regard, we’re all equal. The point to make is that unfortunately holocausts are still endemic in human society (viz, the Sudan today), and worthy of study to try to assure they are eliminated in the future. This subject should be much more interesting and relevant than enumerating the succession of the British Crown since 1066 or unraveling the deliberations of the Council of Trent.

You might be curious as to why I don’t consider the high school math and science curricula as critical to the education of the secondary school student as English and history. Well, I like to wise-crack that, “Everything I needed to know about mathematics and physics I learned in graduate school.” OK, in the last few years of college too. What I remember mostly from high school is that I flunked algebra and trig and got a D in

physics. I thought I knew enough to pass the tests but it turned out I didn't and I was otherwise distracted anyway as I already mentioned. Honestly, there is no subject more simple and straightforward than mathematics at any level of abstraction. Trust me on this. Accept a few axioms and postulates and the rest is just straightforward unambiguous reasoning. However, going through these steps can be extremely tedious and this is what most people really mean when they say "math is difficult and I don't see a reason to learn it anyway." Actually, I believe for the vast majority of high school students, there's a lot to ponder in that last clause. It's hard for me to justify why calculus needs to be taught in high school even as preparation for those planning a career in science and technology. I saw somewhere in the SJUSD "honors courses," there's one called "differential equations." Incredible. I suspect a lot of this "course gloss" is a result of increasingly raising the bar to college entrance to be used as a brainless filter by admissions committees for selecting who gets in and is of little predictive value of a productive lifetime career. If I'm right, the country is in trouble.

One sometimes hears, "Well, there's a lot more to learn these days because of the tremendous progress made in science and mathematics." That's just not true. What is true is that technology, the application of science and mathematics, has grown tremendously because its fruits generate so much profit. The mathematics that underpin today's encryption and compression (MP3, MPEG) algorithms were developed as part of spectral analysis theory in the late 19th century up to the 1920s refined by known numerical methods made usable by the emergence of the digital computer. All computer "software" and logic design derive from the formalism described by the Irish mathematician George Boole in the 1840s. Computer hardware and all the digital toys we (our teenagers) enjoy today are based on applications of the quantum theory of condensed matter which was pretty much completed by the late 1940s. The tremendous pressure to make things smaller, run cooler, compute faster, store more 1s and 0s, at the same time produced cheaper at high volumes thus increasing market share and at day's end yielding more dollars, has made manufacturing tools that have existed for decades much sharper and quicker. I like to point out that if you take the disk drive out of your iPod, you'll recognize it's a Lilliputian edition of the room-sized IBM Ramac 350 of the mid-1950s.

Even the determination of the crystal structure of DNA, which I believe will turn out to be the most socially significant finding of physics in the 20th century, resulted from the incremental improvement of x-ray diffraction techniques and equipment and was inevitable. The Double Helix should be required reading as part of the so-called new "linked curriculum" at Leland, a development I enthusiastically applaud. The intrigues and unbounded ambition revealed therein teach students that science is an intensely human activity and not just some abstract pursuit. Rarely does scientific discovery occur unexpectedly and at random. Having said that, I was lucky to be associated with just such an event...the discovery of a new class of superconducting materials in the mid 1980s.

We physicists for decades have felt science education in the primary and secondary school system is completely backward in sequence..."ass backwards," if you will, a term

I often heard from my Dad when I screwed up on something or otherwise misbehaved. Science is usually introduced with courses in the life or geographical/geological sciences, among the most complex and convoluted of subjects, beginning in the 6th grade. It's been known since the 1890s that all science is fundamentally based on physics. For the last decade or so, Forum on Education of the American Physical Society, on which I sit, has urged Boards of Education nationwide to teach "physics first." Much to my surprise and amazement, it appears we might be winning. Attending a meeting of the Leland Foundation this past summer, I heard about Conceptual Physics to be taught all incoming Freshmen. Unfortunately, this meeting was rather premature and unorganized and a copy of the text was not available. One can teach the basic precepts of physics and the great governing principles of the universe without the need for calculus, differential equations or vector analysis. To become an informed citizen/voter in our Republic, one only needs to know a little algebra in order to understand there's no "free energy," perpetual motion machines are impossible, and that "inexhaustible renewable energy resources" don't exist and won't lower the price of gasoline. In the spirit of "linked courses," I would put "Physics for Poets," a delightful text originally used at UC Santa Cruz, on the Leland English reading list. I would also recommend Richard Feynman's, "Surely You're Joking, Mr. Feynman," to show the human side of physicists. Dick Feynman was arguably the greatest American-born physicist of my generation, and although not exactly a "misfit" in high school, he came close. Like me, he learned getting A's in algebra did not impress girls.

At this same Leland Foundation meeting, I heard about some new computer-based laboratory "teaching programs." The meeting ran way overtime, and the opportunity to get "hands on" to these programs did not materialize. I'm uncomfortable with this trend. "Real" experiments should be performed in lab courses, so that students understand that getting the "right answer" requires patience and perseverance. With computers today, it is very easy to cheat and "manufacture" data, as witnessed by several well-publicized incidents over the past several years. The ethics of science are learned in the laboratory.

Speaking of the ethics of science, there is an active ongoing debate over the role of science in society and how this issue should be managed. This debate is healthy and should be actively encouraged. What should be separated is the practice of science, how its fruits should be applied, and what it all means. There is absolutely no doubt or argument (in my mind) over how scientific investigation should be conducted. We simply follow what Galileo and Newton taught us. If an assertion or theory is not testable by experiment, it is not science. What science "means" is a subject for theologians...rabbis, priests, immans, shamans, whatever...not physicists. We are responsible for explaining "how," and not "why." That is the reason "creationism," "intelligent design," and its derivatives, perfectly acceptable as philosophy, should not be taught along with, or in conjunction with, or as an alternative to evolution. Evolution is testable...the HIV virus evolves every few days, and gene mutation is a well established fact. The application of science to society is somewhat more dicey. Should we use our "bites from the apple of knowledge" to produce thermonuclear weapons and clones or exercise genetic selection? Wow. I would add to the "linked cinematic viewing list," the cult film, "Gataca," (What does "Gataca" mean?) where the "misfit" wins, as a great

subject for discussion and debate.. How about designer chromosomes (hopefully, no substitute will be found for “Y”)? Alternatively, you could shut down all scientific inquiry as socially dangerous. Put “Brave New World” on the Leland English reading list.

Returning to Socrates and his model for the ideal Republic, what should be the principal focus of the teenage male?