

THE CAUSES OF THE POPULAR DISTRUST OF SCIENCE

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Many of you will remember DuPont's advertising slogan "Better things for better living through chemistry." DuPont used this from 1935 to 1982 – and then they dropped the "through chemistry" in 1982, perhaps about the time that the American public was beginning to doubt that chemistry was associated with better living.

General Electric's old slogan, "We Bring Good Things To Life," was more subtle, but also implied that GE created new things, things that would not exist but for GE's scientific and technical prowess.

Remember the sense of national shame in 1957 when the Russians put the first man into space – and the sense of pride when we put the first man on the Moon and the awe with which we viewed pictures of Earth taken from space.

Remember the green revolution – the enormous world wide increase in food productivity, particularly in struggling Third World countries, made possible by genetic engineering using traditional hybridization methods resulting in high yield crops such as rice and corn, and the cultivation by modern farming methods such as the use of chemical fertilizers, pesticides, and herbicides. These developments (which occurred from the 1940's to the 1960's but most importantly in the 1960's) are credited with saving millions of people from starvation and misery – and these developments which truly looked like "better things for better living" through science and technology were hailed at the time by an admiring public.

We are in the middle of a period of enormous advances in science and technology, especially in the biological sciences such as genetics, medicine and biomedical engineering. These advances have greatly deepened our understanding of living things, of evolution, of the nature of our universe, and have promise of resulting in "better things for better living." I had lived half of my life before I saw a computer, but in my second half – I of course expect there to be a third half – I have owned and used dozens of computers. Few of us could function today without access to a computer, I certainly couldn't. We have been able to see atoms, see into the distance when the universe was created, we have a profound, if incomplete understanding of DNA, RNA, mitochondria, life itself.

And yet, I contend, the peoples of the world, at least the modern western world of the US and Europe, have grown skeptical of science, have become distrustful of technology, have come to doubt that we are really seeing "better things for better living." I will give a few examples of the manifestation of this skepticism and distrust, and then I will try to explain the causes. As I will argue, most of the

distrust is ill founded. But that does not make it any less real – furthermore, there is no way that we, the wise and rational ones, can eliminate some of the most troubling of the causes of distrust. And I will close with an argument that we, the wise and rational ones, should be skeptical, if not exactly distrust science and technology for reasons that I believe are not widely understood or appreciated. It is actually this last issue that led me to this topic, and I want to give it some emphasis.

I should exclude from my topic, the views of the modern luddites. The term luddites comes from Ned Lud, who in legend or fact, resisted technological advancements in the form of mechanically assisted weaving by destroying the machinery – the luddites resist technology that displaces jobs, and the phenomena is present today. I just read an article in the NY Times that said that cloud computing would make a the jobs of a lot of middle managers unnecessary. I also exclude the Amish and others who for reasons of religion, tradition or taste prefer to live in a pre-industrial world of their own. I am concerned here with ordinary Americans or Europeans who think they know more than the scientist when it relates to matters of importance to them, matters that hit home.

EXAMPLES OF DISTRUST:

1. Vaccines. There always have been people who resisted having their children vaccinated, some for reasons of their peculiar understanding of their religious commands, and some for reasons of their distrust of government. The distrust of government continues, and maybe is greater than our recent past, but I contend that there is a new source of this anti-vaccination movement, if it can be called a movement. There is a belief by many parents that vaccines are made with dangerous levels of mercury or some other toxic substance, and that vaccines cause autism. This is true even though the scientific studies establish clearly that there is no association between those children who are vaccinated and those children who are autistic.

This is a dangerous matter, for it is common knowledge that vaccination of a population is much less effective where there are significant numbers in the population who are not vaccinated. A part of this problem was caused by a single scientist who wrote a single paper, published in a respectable journal, that claimed to show an association between vaccines and autism. This paper was fraudulent and was later withdrawn and its author discredited. There are those non scientific folk, however, who believe that the original paper was correct and was withdrawn only because of pressure from the pharmaceutical industry.

This is an example of the harm caused by distrust of science – the kids who are not vaccinated are exposed unnecessarily to disease, but the risk is to all of the others as well.

2. Climate Change. We all know about the controversy about climate change or global warming as it is sometimes labeled, and I don't want to spend much time on this. But the fact is that the scientific consensus is that changes in atmospheric gases, primary CO₂, are causing a global warming, and that global warming is causing changes that will be generally detrimental. There is somewhat less of a consensus concerning the causes of the atmospheric changes – but that seems to me to be irrelevant, the relevant questions are whether it is within our control to stop it or slow it and how much will that cost, and how to respond to the consequences of the change – e.g. what do we do about Bangladesh and the low lying islands of the world and the coastal cities of the world.

In any event, I contend that the almost violent, and certainly passionate, quality of the debate has to do with distrust of science and scientists. I think a part of the intractability of this dispute comes from scientists becoming politically active, at which time they come to lose their credibility as scientists. When some scientists were discovered to have tried to strengthen their case for political action by fudging their data, it gave the doubters a basis to distrust all of science.

Whether you agree with the consensus, or like Nick Zakov, disagree, you have to admit that this dispute is evidence of wide spread distrust of science and scientists.

In any event, climate change has become a political issue, not a scientific issue, and this is unfortunate as well as strange. It is more like the two political parties have chosen sides so they can argue, without regard to science or anything else, other than the generalized distrust of government which is admittedly a legitimate basis for political judgment. At least it is not about religion. I will say no more about the subject unless it comes up in Q and A.

3. Evolution & Age of the Universe

In the beginning God created....well you know the rest of the line. The Bible says that God took a six day work week to make the universe, that he made it in a certain order, that he made human kind on the sixth day – there actually are two versions but that is not an issue here. To some Christians and Jews and assorted others, that is the end of analysis or interpretation. If science tells

a different story, then the science is untrue, and therefore not really sound science. That this is not the only way to view the biblical account, even among those who believe in the Bible, is evidenced by the fact that the majority of Christians and Jews find no conflict between the bible, properly read, and the science. This is an instance of irreconcilable conflict between religious belief and science. This is not a case of distrust or skepticism toward science – however, those who reject science when it conflicts with their religious beliefs may be more apt to distrust science in other spheres, but this is not necessarily so. The point is the problem here is religion, not the distrust of science that interests me here.

4. Efficiency of Dietary Supplements and Food Additives

Dietary supplements and food additives are two classes of things that people eat or consume that are not deemed drugs subject to full scale regulation by the FDA or the DOA.

Most people consume them because they believe they will cure them of physical ailments, prevent disease or more generally improve their physical or mental health. They are not supposed to be marketed as solving medical conditions like drugs do. Vitamins and fish oil are two examples. Most Americans take one or more – I take two.

There are a number of problems with with the public taking these substances:

There are no controls for standard dosages, and recent studies have shown that many labeled X contain little or no X.

Some are indeed powerful and can cause serious harm on their own.

Some can interact in bad ways with other prescription or over-the-counter drugs.

Under the current law, these two categories of products can be marketed and sold to anyone in any dosage without prior testing for efficiency or safety. If there are harmful effects by the use of one or the other, the FDA can try to prove this harm, and if it succeeds the product can be banned or regulated. The only thing the sellers of these products have to do is not promote them as drugs – which of course they try to do subtly.

When some in Congress and the FDA have tried to step in and require these product to be subject to pre-marketing testing for safety and efficiency, there has been public outcry by those – probably in the majority – who fear they will not be able to get

their fish oil or whatnot. Congress as a whole has responded by going with the public outcry.

I contend that this is a good example of the popular distrust of science, plus a bit of the public distrust of government. I may comment a bit more about this example when I talk about the causes for distrust of science.

5. GM Crops

Most – more than 80% - of the corn and soybeans grown in the US are from seeds that have been the product of genetic modification of the modern type. All of the crops grown in the US and most of the world are genetically modified – they are the result of years and years of selective breeding. But I am talking here of where scientist have replaced one or more genes in a plant with a gene from a totally different plant, or even an animal.

In Europe there is very little use of modern genetic modification in crops. The Europeans as a group are spooked by the thought of a gene from a weed being put into a corn seed so as to make the corn resistant to a pest. Until recently, there was little opposition to use of GMOs in US agriculture, but currently there is a movement by those who fear the fruits of science. Some want rigid segregation of GMO's and non-GMO's. Others call for labeling of food containing GMO ingredients. This is a growing issue, one driven not by primarily by distrust of government, or by religion, but by pure distrust of science.

6. Research using fetal cells

Here we have a reverse of US and Europe. The Europeans seldom have any problems with medical research using fetal cells. Many in the US are spooked or appalled by the thought of using fetal cells for research purposes. This may an example somewhat like evolution – a conflict between religious beliefs and the advancement of science, but at least a part of the American distaste for using fetal cells comes from, I contend, a distrust of science.

7. Silicone Breast implants

This one may not be familiar to you, and this example unfortunately does not cast a good light on our legal system but it is one that helped me come to this topic.

Many women – and an occasional man - want larger breasts, and many desire to have their bodies restored after surgery. The solution is the breast implant. No doubt many substances have

been tried over the years, but mostly the surgeons used a saline solution or silicone, either solid, semi-solid or fluid form.

Suits were brought against Dow Corning (and a few other manufacturers), the maker of the silicone implants, by women who claimed to have been injured by the implants. In some of the cases where the implants were liquid silicone in a silicone sack and the sack broke, the women might have had a legitimate claim against Dow Corning for minor harms. However, the largest number of claimants were women who claimed the silicone caused some sort of autoimmune disease or a connective tissue disorder of a more serious sort. When the first suits were being tried the science was little developed and there might have been legitimate questions about the causes of the women's symptoms. But in June of 1994 an article published in the New England Journal of Medicine discredited the Plaintiffs' theories, and in 1999 the prestigious Institute of Medicine (with Bernadette Healey, who some of you may know from her time in Cleveland, as lead investigator) published a 400 page report pointing out dangers with breast implants but totally discrediting the supposed science behind the plaintiffs' law suits.

However, the suits went on and on. The plaintiffs lost lots of the cases, but the danger of losing was enough that Dow Corning felt it had to file for bankruptcy – because the public, i.e. the juries, did not trust the main stream scientists.

8. Atomic power. This one I will skip for now – it too involve a public which trusts their fears of disaster more than their faith in the scientists – and their experience – and have effectively stopped the building in the US of nuclear power plants.

REASONS FOR DISTRUST OF SCIENCE

1. Ignorance of Science.

Repeated surveys establish that the average citizen, including the above average educated citizen, in the US knows very little about science, other than that gleaned from science fiction films or books. Some of this may reflect the fact that the average citizen may not know much about anything – including the location of Iraq or the capital of Spain or the three branches of government. But even the highly educated, the ones who know the location of Iraq and the three branches of government – often know little about science.

This is probably what could be called the Two Cultures phenomenon, after a famous speech by CP Snow with that title. As Snow pointed out in his 1959 speech – later published and widely read – the “educated” humanities folk feel little need or desire to understand science – they have the profundities and beauty of language of Shakespeare. And those trained in the sciences seem, in general, to prefer the precision and beauty of mathematical proofs and DNA, and find it difficult to see the relevance of literature or the arts. Music and maybe computer games are perhaps one place where the two cultures might engage. But computer games did not exist in 1959. Music may be inherently mathematical, but that is no help to the history major needing to know something about the mathematics of probabilities.

I think that the willingness of juries and the general public to ignore science in the breast implant cases, is in part caused by the two culture phenomenon. The scientifically sophisticated is a too small of a minority in the US to allow rational public decisions in areas which should be decided on scientific basis.

2. Failure to understand probabilities and failure to understand inevitability of risk.

Much of modern science – medicine and the biological sciences but also modern physics – requires some understanding of statistics and probability, neither of which is obvious or intuitive to the average person, regardless of their cultural inclinations. Furthermore, everything involves risks – crossing the street involves risks, perhaps more risk than flying in a commercial airplane. Furthermore, as Twersky and Kahneman and others have established by scientific experiments, even scientifically sophisticated people make cognitive errors when applying probability to ordinary life situations.

As a result, we – including we sane and rational people – commonly give much greater weight to the unlikely but horrendous result of a melt down of an atomic reactor than the less horrendous but much more likely result of a tornado, or of a more natural seeming, and more gradual climate change that kills more than the hypothetical melt down. This is a major problem with getting public acceptance of nuclear power.

3. Religion, the comfort of certainty and the persuasive power of the true believer.

Lots of religious people believe in very unscientific things – like how and when the earth was formed. Most religious people and most religions find a way to reconcile science with their beliefs without any strain. I am not about to argue with those that cannot do so. In any event, the present day conflict between science and religion and the distrust between the true believers and the people of science, while interesting in its own right, is not really the focus of my talk – if my talk at this point has a focus.

4. Scientists becoming politically active and scientists becoming entrepreneurs.

I believe that scientists should speak as citizens when they are part of the political process. The general acceptance of the scientific consensus on climate change has been hindered by scientists taking it upon themselves to convince the world that they are right. I think that many people become skeptical of those who insist that that they are right and that you damn well better do something about it. People also become skeptical when they learn that the scientist trying to convince them of something have an economic or other stake in the matter.

5. The burned before and will not be burned again phenomenon.

I had an ulcer when I was at Harvard. The finest doctors at Harvard told me what I must do to solve the problem. This was in the 1960's. We know now, or think we know that my ulcer was probably the result of a bacteria, and that nearly all of the advice I was given was mistaken.

And there is the matter about eggs and cholesterol. How many times have we been told eggs were bad, and then good, that cholesterol was bad, and then just some kinds of cholesterol.

We were taught in school that one cannot inherit acquired characteristics. We know now – and have a name for it “epigenetics” – that this is not true.

When I studied physics, the atom was composed of neutrons, positrons, and electrons. Now we have a whole menagerie of sub-atomic particles.

This constant revision of what we know as true is troubling to most people, and yet it is the nature of science and the scientific enterprise. All that we know is tentative, provisional, until we find some deeper or different truth. This is clearly the case, but it is hard for most people – myself included – to not be skeptical when we know that what we know today may have to be reconsidered or at least qualified by something tomorrow. It means that skepticism is healthy – it is cynicism that is wrong – we must learn to live with uncertainty and we must make decisions based on what is likely the best course, not what is certainly the best course.

6. Distrust based on distrust of the
7. motives of large corporations and the scientists in their pay, or the universities that employ them. Or the governments that regulate them.

This is something that we all experience, and I will not say more about. It surely is one aspect of the reason some doubt the reality of climate change. It is not just a distrust of those who have financial and other interests in the issue, but a more general distrust of authority – a classical American characteristic.

WHY WE NEED TO BE MORE DISTRUSTFUL OF SCIENCE THAN WE MIGHT REALIZE:

1. Scientists are humans – they have human tendencies such as greed, pride, desire to be loved, to be admired, to be employed.
2. These are difficult times for American scientists – there are more Ph D's than we can employ in the traditional positions in the Universities. Many live a career as post-docs, earning little and with little job security. Grant money limited and competition is great.
3. Science is international. Scientists outside of the US, especially those in Asia, fight hard to get recognition and appointments in the US, where there is more money, better equipment, more prestige etc.
4. There is a remarkable amount of cheating – research fraud – only some of which is caught.

HOWEVER, THE PUBLIC FACE OF SCIENCE IS THAT:

5. Scientists often claim that they have a self-governing system that insures ultimate truth and that dishonest results are uncovered.
 - a. They have peer-reviewed journals, and only peer-reviewed publication is given much weight.
 - b. Experiments are recreated in other labs and those that cannot be replicated are cast aside.
 - c. The anonymous peer-review before publication, or before the award of grants assures that there is no favoritism and only the best are awarded grants and have their papers published.

I believe that none of the above is really true. I subscribe to an email newsletter called "TheScientist" - it's intended audience is the community of biological scientists, primarily American. Here are a few of the many troubling things I have read in recently years in the newsletter:

1. November 26, 2014: About 50 manuscripts in the open access publisher BioMed Central's systems may not have been peer reviewed. Many appeared to have been manipulated reviews. Earlier, SAGE Publishers retracted 60 papers as a result of rigged reviews, by an organized peer review and citation ring.
2. November 3, 2014: "A recent metaanalysis of plagiarism survey data authorized by two professors, one at Montreal and one in Croatia, estimates that 30% of scientists have witnessed plagiarism, and 2% have admitted to having done so themselves.
3. March 11, 2014 (NYT); The principle authors of a earth shattering paper describing a new and simple method of forcing ordinary cells into multipurpose stem cells, have retracted the paper. No one could duplicate the results – and the original research was supposedly from the prestigious Riken Center for Developmental Biology in Kobe Japan and Harvard Medical School.
4. Dec. 30, 2013, The Scientist published their list of the top10 ten retractions of 2013 – "it was difficult to keep up with all of the retractions in the scientific literature this year..." And 2014 will be worse and most cases of scientific fraud are probably never discovered because they are not high profile enough to bother following up.

This situation may improve with the advent of PubPeer which allows researchers to comment on one another's published work anonymously. However, in the past couple of months PubPeer has been sued for libel by a scientist whose work was questioned.

5. More shocking is the title of an article by professor at Tufts: "Why Most Published Research Findings are False". As best I can understand, his point is that the researchers are making claims based on false understandings of statistics. I recall another paper I read written by a statistics professor who assigned his students to discover the statistical errors in published research. The students were able to find errors in the use of statistics in a high percentage of published articles.

6. Most scientific experiments are not replicated, and most attempts to replicated experiments are unsuccessful. Scientists find it less interesting to replicate someone else's work – and in any event have difficulty in finding funding to do so or places that want to publish results that merely duplicate what has already been published. So the checks that are said to keep science honest do not and cannot be expected to work in the real world.

I have files full of examples of the above, and also of some problems not listed above. However, I still love science and technology, and I still have faith in its ability to improve our lives and save us from ourselves. Perhaps it is just as well that the general public is not aware of the limitations on the system of science in this country and the world. But I believe that it is important that educated and thoughtful people be aware of the imperfect nature of enterprise of science. As President Kennedy said just a month before he died:

“Science is the most powerful means we have for the unification of knowledge.” In any event, it is all we really have in common throughout the world.

While I believe we must be careful and skeptical, there is no alternative to relying upon the power of science, if not to make us free, to make us better.