ONE

Harmful Politicization of Science

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Politicization is inevitable when governments provide funding for science. The public expects to get something back from the science they support—for example, better health, national security, jobs. This normal politicization does no harm and may even be good for science and society. But politicization taken to the extreme can be very harmful. In extreme politicization, governments or powerful advocacy groups use science and scientists who share or benefit from the politicization to drive science out of technical decisions and to promote a nonscientific agenda.

My discussion of politicization of science begins with what must be its most extreme manifestation, when the Soviet Union used denial of income, imprisonment, and execution to impose its political will on the science of biology. The same desires for wealth, recognition, and power that propelled the politicization

of Soviet biology exist in our democracy, but tyranny is absent. In its place, those who seek to politicize science here attempt to divert federal research funds to their ends and to stifle dissenting opinions, using the power of the press, congressional hearings, and appeals to patriotism.

The proponents of cold fusion in the United States used all those means in their quest for money and fame and standing. In the end, they failed because their claims were shown to be based on corrupt or misinterpreted experiments. While the debate was going on, at least one politician testified that scientists who expressed skepticism about cold fusion were unpatriotically inhibiting pursuit of the most important scientific breakthrough since the invention of fire. Worse, those who stood in the way of cold fusion were delaying development of a scientific breakthrough that would reverse many of the world's environmental problems because it would provide pollution-free energy.

Protection and improvement of the environment are now the siren song of politicians, businessmen, and scientists who claim that their conclusions about global climate change and their proposals to stave off catastrophic change are the only thing standing between mankind and a bleak, blasted planet in the future. They have, to some degree, succeeded in strangling the flow of research money to scientists who question their conclusions and prescriptions.

In my own case, I lost a federal position because of citing scientific research findings that undermined a politician's rhetoric. I did not suffer for my actions as did the Soviet biologists, but my dismissal surely serves as a warning to other government scientists and, perhaps more importantly, to nongovernment scientists who act as advisers to the government, that politics can trump science even in purely technical topics.

The politicization of science is impossible without the participation of some scientists in it. Politicians in both tyrannies and

democracies are susceptible to scientists who say that they can show the way to manage nature without all the complicated baggage of ordinary science. How attractive the bright, adventurous, and brave individuals are who cast off the burdensome limitations of facts and theory that constrain the scientists who disagree with them. But politicians and citizens alike should question scientists who are unwilling to subject their observations and theories to independent tests, and their ideas and conclusions to discussion among technically qualified peers. Unhappily for society, such scientists, with sufficient political backing, can subvert the funding process so that information critical to their claims cannot be developed. At the present time, it is very difficult to obtain funding, either from U.S. governmental sources or from private foundations, for research that does not presuppose impending environmental doom. Suggestions that moderate global warming may actually be a good thing for humanity are treated with ridicule and hostility.

Lysenko's Destruction of Biology in the Soviet Union

Some of the worst consequences of politicized science have come from the seemingly noble aim of improving human well-being. Those who promise to circumvent the limitations that scientific laws place on human existence can always count on adulation, power, and wealth. A particularly egregious and well-documented example of this was Trofim Lysenko's destruction of biology in the Soviet Union. From the time he burst into public view in 1928 until the downfall of Khrushchev in 1964, Lysenko replaced real biology in the Soviet Union with falsehoods, prisons, and executions. Many details about Lysenko's career can be found in the excellent books by Valery N. Soyfer, *Power and Science* (in Russian), and *Lysenko and the Tragedy of Soviet Science* (in En-

glish).[1] A "people's academic," Trofim Lysenko promised to revolutionize the laws of agriculture, just as his Communist masters were trying to revolutionize human society.

The Soviet Union forcibly collectivized agriculture in 1928 and forced peasants to surrender their land, livestock, and machinery and to join collective farms. All grain was confiscated from the peasants, even grain needed for planting the following year's crops. Massive famines followed in 1929 and the early 1930s. Several million peasants starved to death in the Ukraine, and the Red Army was used to collect the grain harvest, such as it was, because whole villages had perished from hunger.

Hard-working and successful small farmers remained productive and were an affront to Soviet collectivism. Referring to these enterprising farmers as *kulaks* (clenched fist in Russian), Stalin orchestrated the "liquidation of kulaks as a class." Thousands were executed, and millions were deported to Siberia or Central Asia.

To try to cope with the disastrous effects of collectivization, the Communist Party ordered the rapid development of more productive varieties of wheat and other important crops. It imposed impossible demands on agricultural research institutions to improve (within one year) crop yields, resistance to diseases and pests, ease of harvest, food value, and so on.

The plant breeders and geneticists of the Soviet Union were some of the best in the world. Moreover, they had some of the finest genetic pools of wheat to start with; indeed, wheat varieties of Russian ancestry were the sources of the most productive wheat strains grown in the United States and Canada.

With the best of planning and luck, the time scale for intro-

1. V. N. Soyfer, *Vlast' i Nauka* (Power and Science) (Tenafly, N.J.: Hermitage Press, 1988); V. N. Soyfer, *Lysenko and the Tragedy of Soviet Science* (New Brunswick, N.J.: Rutgers University Press, 1994).

ducing effective new varieties is much longer than one year. Several years are needed to evaluate hybrids or to select varieties with desirable properties. More years are needed to produce sufficient seed for massive plantings. Lenin himself, responding to a complaint by the Russian author Gorky about the arrest of intellectuals, replied, "In fact, they are not the brain of the nation, but shit."[2] So it was not surprising that both the popular and the scientific press labeled those hapless Russian agronomists who pointed out the impossibility of producing effective new plant varieties in one year as "enemies of the Soviet people."

No wonder the Communists paid attention when young Trofim Lysenko declared that the genetics of Mendel's peas and Morgan's fruit flies was incorrect and simply a capitalist plot to exploit the peasants and working class. Lysenko believed that environmental factors determined the performance of plants and that acquired characteristics could be inherited. Having unmasked the evil Western myth of gene-based inheritance, Lysenko promised almost instant improvements in agricultural production.

Lysenko's origins—a peasant background, and little education—helped him avoid the hatred of the Soviet authorities for the intelligentsia. He first became famous in 1928 by claiming that a series of simple steps, within reach of any farmer, produced markedly improved yields of wheat. All that was necessary was "vernalization"—soaking winter-wheat seed in the fall, burying it in sacks under the snow, and planting it in the spring like ordinary spring wheat. This was all a fraud, supported by corrupted experiments and falsified statistics.

Stalin himself joined the fray, praising Lysenko and his people's scientists, and dismissing as old-fashioned and counterrevolutionary those who believed in genes. Many opportunistic biologists hopped on the Lysenko bandwagon, and he and his

2. Soyfer, *Vlast' i Nauka*, p. 6.

supporters founded Scientific Institutes of Vernalization, while his disciples took over existing institutions. Some brave Soviet biologists opposed Lysenko and many paid for this with their jobs or even their lives. N. I. Vavilov, a plant breeder of international renown, died in prison. Others were simply shot.

Honest scientists from other disciplines were alarmed about what was happening, but for many years they did little to interfere. By the outbreak of World War II, Lysenko and his henchmen were in full control of biology in the Soviet Academy of Sciences.

During the war, Lysenko's younger brother Pavel, a scientific worker in Kharkov, defected to the Germans when they overran the city. The younger Lysenko so impressed the German occupation forces that they named him mayor of occupied Kharkov. After the defeat of the Germans, Pavel managed to escape to the West and he made unflattering comments about the Soviet Union in Voice of America broadcasts. This made Trofim "a family member of an enemy of the people," a criminal offense in the Soviet Union. At about this same time, many in the top levels of the Soviet government were beginning to realize that Lysenko was a fraud who had done much damage to the Soviet Union. Lysenko's hold on Soviet biology weakened as articles in both the popular and scientific press began to assert that chromosomes and genes really did have something to do with inheritance and were important factors in practical agricultural science.

But Lysenko was not so easily defeated. By great good luck he was saved by Stalin himself. Someone had sent Stalin samples of branched wheat from his home republic of Georgia. Up to seven ears would grow on each stalk of this wheat, and Stalin was convinced that widespread planting of branched wheat would be the solution to the periodic crop failures and famines that still plagued the Soviet Union. Stalin invited Lysenko to visit him in his office, gave Lysenko a handful of seeds of the branched wheat, and ordered him to improve the wheat and make enough seed for the

entire country. This Lysenko cheerfully promised to do, and as part of the bargain, he gained permission to deal once and for all with his remaining scientific enemies.

With Stalin's support Lysenko carefully orchestrated a trap for his opponents during the meeting of the All-Union Academy of Agricultural Sciences in August 1948. Lysenko's agents encouraged the few remaining honest geneticists to speak up in favor of genes and chromosomes. On the last day of the conference Lysenko stunned the conference by announcing that Stalin himself had decreed that henceforth there would be only one approved biology in the Soviet union, that of Lysenko. From then on, taking genes and chromosomes seriously was tantamount to treason.

In the aftermath of the 1948 conference, most of the remaining honest geneticists in the Soviet Union were fired from their jobs and replaced by Lysenko's protégés. The famous branched wheat that gained Stalin's support for Lysenko turned out to give much poorer yields than ordinary, unbranched wheat, but with Stalin's support, this was no problem for Lysenko. After Stalin's death, it was not long before Lysenko hypnotized his successor, Nikita Khrushchev, who provided the same top-level political support to which Lysenko had become accustomed.

In spite of Lysenko's complete triumph over his scientific enemies in 1948, it was increasingly clear to objective observers in the Soviet Union and abroad that Lysenko's bizarre agricultural practices, together with the disincentives of Soviet economic policies, were ruining Soviet food production. Nevertheless, Lysenko continued to enjoy the full support of the leadership of the Communist Party, and no biologists who disagreed with him remained in any position to challenge or question him. The only effective scientific opposition came from outside biology.

The physicists Peter Kapitza, who later won a Nobel Prize for his work on low-temperature physics, Igor Tamm, and Andrei

Sakharov were some of the most fearless defenders of honest genetics. Lysenko hated them all, but Tamm and Sakharov were credited with the invention of the Soviet hydrogen bomb, and Lysenko did not have sufficient political power to have them jailed or shot, as he had done with his opponents in the field of biology. In 1964, Tamm and Sakharov led a successful campaign to thwart Lysenko's attempt to pack the Soviet Academy of Sciences with his cronies. This so infuriated Khrushchev that he decided to dissolve the Academy of Sciences. Luckily for Soviet science, Khrushchev was so confident of success that he took a vacation before completing his dismantlement of the Academy. On October 14, 1964, Anastas I. Mikoyan and an impressive contingent of Red Army generals showed up at Khrushchev's vacation spot and announced that he, Khrushchev, had just retired and would be drawing his pension from now on. So the "Little October Revolution," as the Russians like to call this episode, saved Soviet science from Lysenko.

The Lysenko episode shows that an entire scientific discipline can be destroyed if the attractions of false science are great enough and if its proponents are ruthless enough. The great Russian poetess Anna Axmatova, who lost her husband and nearly lost her son, a distinguished historian, to Stalin's executioners, in a few lines of verse summarizes the tragedies Lysenko and other opportunists brought to Russia:

TO THE DEFENDERS OF STALIN

Those are the ones who shouted,
"release Barrabas to us for our holiday,"
those who commanded Socrates to drink the hemlock
in the dim confines of the dungeon.
We should pour out the same drink for them,
in their innocent, slandering mouths,

these amiable lovers of tortures,
these experts in the production of orphans.[3]

The Lysenko affair is one of the most thoroughly documented and horrifying examples of the politicization of science, but no country or age is immune. In totalitarian societies politicized science often leads to tragedy; in democratic societies politicized science often ends in wasted time and effort and sometimes in farce.

To illustrate the different histories of politicized science in totalitarian societies and democracies, I will compare Lysenko's biology in the Soviet Union with the history of "cold fusion" in the United States. Most of my discussion of cold fusion has been taken from the excellent book by John Huizenga, *Cold Fusion: The Scientific Fiasco of the Century*.[4]

Cold Fusion

What can be more annoying than the difficulty of getting controlled fusion energy on earth? If we could only figure out how to do it, we could provide the world's energy needs indefinitely with the practically inexhaustible supplies of deuterium and lithium available in the oceans. We know how to get large amounts of energy from fusing deuterium and tritium nuclei in a thermonuclear weapon. But after nearly fifty years of hard work and large expenditures of research funds, the world has yet to harness fusion energy to generate electrical power. Magnetic fusion devices are large, costly, and still far from practical; imploding small sam-

3. A. Axmatova, *Stikhov Moikh Belaya Staya* (The White Flock of My Verses) (Moscow: Exmo Press, 2000).

4. John R. Huizenga, *Cold Fusion: The Scientific Fiasco of the Century* (Rochester, N.Y.: University of Rochester Press, 1992).

ples of deuterium and tritium gas with large lasers also still has a long way to go before it can be a practical energy source.[5]

In light of the great effort and limited results, Professor B. Stanley Pons and his colleague, Dr. Martin Fleischman, surprised the whole world on March 23, 1989. Pons, chairman of the Chemistry Department at the University of Utah, and Fleischman, a distinguished electrochemist from England, announced that they had observed the generation of substantial heat from deuterium nuclei fusing in the palladium electrodes of electrochemical cells under the benign conditions of temperature and pressure found in an ordinary room. Television and newspapers trumpeted "controlled fusion in a fruit jar," in glowing terms all over the world.

Pons and Fleischman had not submitted a scientific paper about their discovery at the time of their press conference, so it was very hard for other scientists to judge the claims, but as details began to leak out, there was skepticism in the nuclear physics community, even as many other scientists and the public at large were greatly enthusiastic.

There were many parallels to Lysenko's vernalization announcements in 1928. The simplicity and importance of the cold fusion process intoxicated the press. Eager scientific imitators hurried to join the bandwagon. And there was soon high-level political attention. President George Bush asked for advice from Glen Seaborg, the great nuclear chemist who discovered plutonium. Seaborg gave a sober briefing to President Bush, and he stressed the inconsistency of the claimed results with fifty years of painstaking work in nuclear physics.

Whatever his opinion of Seaborg's analysis, President Bush realized that cold fusion, if true, would be a revolution of great importance to the United States and to the world. Unlike Stalin, who immediately embraced Lysenko, Bush directed that a panel

5. H. Furth, "Fusion," *Scientific American*, September 1996.

of scientific experts be established to investigate the claims. The nuclear chemist John Huizenga and the physicist Norman Ramsey chaired the panel, and I was a member of it.

The potential for commercialization of cold fusion was an important consideration from the very start of the cold fusion episode, and patent considerations may have influenced the timing of the first press conference. Many people—Pons and Fleischman, the University of Utah, and various imitators—hoped to get fabulously wealthy from this wonderful new energy source. Much as Lysenko had managed to get a hearing at the highest levels of the Soviet Union, Pons and Fleischman were granted a hearing by the Committee on Science, Space, and Technology of the U.S. Congress on April 26, 1989, barely a month after their cold fusion press conference.[6] Opening the hearing, the committee chairman, Congressman Robert A. Roe of New Jersey, said, "The potential implications of a scientific breakthrough that can produce cold fusion are, at the least, spectacular." Many other committee members, both Democrats and Republicans, made similar enthusiastic comments.

Dr. Chase N. Peterson, the president of the University of Utah, made a point very similar to some made by Lysenko about why radically new discoveries were prone to happen far from the deadening restraints of establishment science:

> A capacity to see an old problem from new perspectives was required. Chemists, electrochemists, looked at a problem traditionally reserved to physicists. In fact therein lies some of the humor and bite of the scientific controversy that is raging. I would like to think that it may not be by chance that it happened in Utah, at a university which has encouraged unorthodox thinking while being viewed by the world as a

6. "Recent Developments in Fusion Energy Research," 101st Cong., 1st sess., April 26, 1989; no. 46.

> conservative, even socially orthodox place. There in fact may be something valuable in isolation from more traditional centers. America has prospered and innovated at the frontier and the University of Utah is still a frontier that attracts faculty who highly value their intellectual freedom.[7]

One of the most interesting witnesses was Ira C. Magaziner, who later gained fame as the architect of President William Clinton's ill-fated health care plan. At the time of the congressional hearings on cold fusion, Mr. Magaziner was president of the management consulting firm TELESIS, USA, Inc. In introducing his consultant Magaziner to the committee, Peterson described him as "one of the world's renowned business consultants on issues of world competition." After a rousing sales pitch to convince Congress to send $25 million immediately to the University of Utah, Magaziner summarized with an appeal to patriotism:

> So now I hope you can understand why I came here today, even though I am not from Utah and have no interest in palladium. I have an interest in America's future. I see this as an opportunity for America both to develop this science into future American prosperity and also to develop a model for how America can regain preeminence in commercializing other new sciences in the coming decade.
>
> I have come here today to ask you to prevent another TV or VCR or computerized machine tool or solar cell or superconductor story. I have come to ask you to lead so that we will not be the first of our nation's ten generations to leave its children a country less prosperous than the one it inherited. I have come here to ask you, for the sake of my children and all of America's next generation to have America do it right this time.[8]

In spite of Magaziner's testimony and a well-orchestrated

7. Ibid.
8. Huizenga, *Cold Fusion*, p. 51.

campaign to begin a crash program in cold fusion, sober skeptics convinced the U.S. Congress to resist appropriating massive new funds. The furor died down and the enthusiasm for supporting the research ebbed as weeks and months went by and many laboratories reported that they could not reproduce the results of Pons and Fleischman and other embarrassed laboratories withdrew hasty but mistaken confirmations of their results.

A few loyalists still maintain that a sinister conspiracy by big government and industry killed cold fusion, but cold fusion was thoroughly discredited in society at large. Unlike the Lysenko affair, there was no all-powerful political establishment that could declare cold fusion to be politically correct or incorrect and its opponents enemies of the people.

Before ending the discussion of cold fusion, let me cite Representative Wayne Owens, representing Utah's Second District, who also testified at congressional hearing:

> Some say solid-state fusion may be man's greatest discovery since fire. Others say, as I do, that it may also be the innovation to protect and perpetuate the Earth's dying life support system, more important than the possible salvation of the dying industrial superiority of America. Man cannot stand another century like the last. In those 100 years, we have consumed more of the nonrenewable richness of the Earth than was used during all of man's previous history. We polluted and poisoned our environment with its use, and it literally threatens our continued existence. The revolutionary discovery, solid state fusion, arrives simultaneously with our entry into the age of true environmental alarm. So, bursting with pride, Utah's Congressional Delegation brings to the committee the prospect of a second economic chance and a second environmental opportunity. This morning we tell you not only of the discovery which may revolutionize the world's energy system, but more importantly, it may be the answer to the preservation of our home, Planet Earth. Within

> the next two weeks, the United Utah Congressional Delegation will present you with an innovative legislative plan, one which will precipitate a whole new concept for national partnership for action. It will combine private and public investment and the opportunity for America to develop, engineer and champion the most far-reaching innovation of our time.[9]

Samuel Johnson once commented that "patriotism is the last refuge of a scoundrel." In their enthusiastic testimony, the supporters of cold fusion made ample use of patriotism, but as Representative Owens's statements show, "preservation of our home, Planet Earth" was also a favored theme. What might Samuel Johnson have said about extreme environmentalism, which is my final example of politicized science?

Extreme Environmentalism

Most Americans want to protect the environment and think of themselves as moderate environmentalists. As a country, we have made much progress in protecting and restoring the environment. Our rivers and air are cleaner than they have been for over a hundred years. Increasingly large areas of land are being set aside as wilderness. Our forests are growing back. But even as we clean up and protect the environment, "environmentalism" has attracted some whose motives—fame, power, wealth—are hard to distinguish from those of Lysenko or the cold fusion enthusiasts.

Unlike Lysenko's vernalized wheat, or cold fusion in a fruit jar, environmental issues are harder to dismiss as patent nonsense. Anyone can see that dumping raw sewage into a river degrades the downstream water quality. But how is one to respond to much subtler claims—that magnetic fields from electrical power lines cause childhood leukemia, that freon will destroy the

9. "Recent Developments in Fusion Energy Research."

ozone layer and ultimately life on earth, that pestilence, famine, rising sea levels, or worse will come from increasing atmospheric carbon dioxide and global warming? These are only some of exaggerated environmental fears promoted by one group or another.

Changes in environmental conditions are not easy to detect, as demonstrated by the massive outlays of research money to develop and maintain devices to measure them. Even with the best instruments, the great natural variability in what can be measured can mask the smaller changes that are of interest to those studying possible human-caused effects. In light of these difficulties, the average citizen must hope that scientific specialists give correct advice on important policy issues. But scientists make mistakes. If they don't make mistakes, they are not trying hard enough. Mistakes get corrected in the normal course of science as attempts are made to repeat the experiments, and conclusions are corrected or reinterpreted if appropriate.

Even without political malice, such as Lysenko's, which crippled Soviet biology, correction of a scientific mistake can take many years. A good example is the nineteenth-century dispute about the age of the earth and the sun. On one side were physicists, and on the other, geologists and evolutionists. The Scottish physicist William Thomson, later to become Lord Kelvin, had first articulated the second law of thermodynamics, which says that the entropy of the universe cannot decrease. So it was natural for him to use thermodynamic considerations for age estimates. From measurements in mine shafts, he knew that the temperature of the earth increased by 2 or 3 degrees C per 100 meters of increasing depth. So heat had to be flowing to the surface of the earth from the hot interior, since heat naturally flows from warmer to cooler regions, or the second law of thermodynamics would be violated. Assuming that the earth had cooled by conduction of heat, and that there were no sources of heat inside the

earth, Kelvin was able to estimate that the earth must have been molten no more than 98 million years ago.

Kelvin also used thermodynamics arguments to estimate the age of the sun. Supposedly, the sun was formed from accumulating "meteors," and Kelvin therefore called his theory of the sun's energy "the meteoric theory." As the meteors that formed the sun gradually collapsed to smaller and smaller volumes under the influence of their gravitational attraction for each other, they became hotter and hotter and this provided the heat for the sunlight. Kelvin's theory, published in 1900, reflected forty years of study:

> That some form of the meteoric theory is certainly the true and complete explanation of solar heat can scarcely be doubted, when the following reasons are considered: (1) No other natural explanation, except by chemical action, can be conceived. (2) The chemical theory is quite insufficient, because the most energetic chemical action we know, taking place between substances amounting to the whole sun's mass, would only generate about 3,000 years' heat. (3) There is no difficulty in accounting for 20,000,000 years' heat by the meteoric theory.[10]

While 20 million years seems like a long time, Charles Darwin, supported by geologists, had estimated that some 300 million years were required to account for geological processes, like the erosional formation of the "Weald," a large valley across the south of England.[11] Even longer times seemed to be needed to explain other geological observations. And the theory of evolution also required times much longer than Kelvin's estimates.

In the end, Kelvin, the great mathematical physicist and president of the Royal Society, was wrong, and Darwin and the geol-

10. Sir William Thomson, Lord Kelvin, "The Age of the Sun's Heat," in *Essays in Astronomy*, ed. Edward Singleton Holden (New York: D. Appleton and Co., 1900), p. 51.

11. Ibid.

ogists were right. The earth is around 4.5 billion years old. Unlike Darwin and his geologist friends, who based their estimates of the earth's age on observed erosion rates and other empirical evidence, Kelvin relied on models, for which the mathematics was impeccable, but some of the fundamental physics was incomplete. Commenting on Darwin's age estimates, Kelvin says:

> What, then are we to think of such geological estimates as 300,000,000 years for the "denudation of the Weald"? Whether is it more probable that the physical conditions of the sun's matter differ 1,000 times more than dynamics compel us to suppose they differ from those of matter in our laboratories; or that a stormy sea, with possibly Channel tides of extreme violence, should encroach on a chalk cliff 1,000 times more rapidly than Mr. Darwin's estimate of one inch per century.[12]

Contrary to Kelvin's confidence that matter in the sun behaved like matter in his laboratory, the matter in the sun is subject to nuclear interactions, which do not occur at the low temperatures and pressures of the earth. Neither Kelvin nor anyone else knew anything about the atomic nucleus. The first inklings of nuclear physics had shown up only four years before Kelvin's rather pompous dismissal of the geological evidence for the antiquity of the earth. In 1896 Becquerel discovered that uranium and a few other elements are radioactive. Although not recognized until Rutherford's brilliant discovery of the atomic nucleus in 1909, radioactivity was due to nuclear interactions with energies not just 1,000 times larger than any Kelvin had ever observed in his laboratory but 1,000,000 times larger. This was completely new physics that had not been included in Kelvin's models of the age of the sun or the age of the earth, and it was responsible for the spectacularly wrong estimates he made of both ages.

12. Ibid., p. 49.

Kelvin did not realize that heat is continuously generated inside the earth by the radioactive decay of uranium and other naturally radioactive elements. Nor did he realize that enormous amounts of heat are being continuously produced in the core of the sun by the fusion of light elements like hydrogen nuclei, ultimately yielding helium nuclei. There is enough hydrogen in the sun to keep it shining at about the same level as now for billions of years. This is "hot fusion," and unlike cold fusion, it really works and we owe our lives to it.

Lord Kelvin's understanding of the earth's age was limited by his ignorance of nuclear interactions. The current debates about global climate change are complicated by our not understanding the physics of the sun or of the earth's atmosphere and oceans well enough to dismiss them as major causes of climate change on the earth. Dramatic climate changes like the medieval warm period at the time of the Viking settlements of Iceland and Greenland from about A.D. 900 to 1250, and the subsequent "little ice age," from about 1250 to 1700, which led to extinction of the Greenland settlements, were certainly not caused by manmade changes in the concentration of carbon dioxide in the atmosphere. Subtle changes of the sun's output and perhaps other poorly understood factors must have been much more important in causing those large climate changes than changing levels of atmospheric carbon dioxide.

Global warming pressure groups would have the world believe that catastrophic changes in the earth's climate will occur without drastic limitations of carbon dioxide emissions—this in spite of the fact that the carbon dioxide levels in the earth's atmosphere have been much higher than today's for much of geological history. For example, as documented by the work of Berner,[13] atmospheric carbon dioxide concentrations were some five

13. R. Berner, "The Rise of Plants and Their Effect on Weathering and Atmospheric CO_2," *Science* 276 (1997): 544–46.

times higher than those now from about 300 million years to 30 million years ago, a geological period of flourishing life on earth. For most of the time since the first fossils of advanced forms of life appeared in the Cambrian era, some 600 million years ago, the earth's climate has been somewhat warmer than at present, and the poles have had little or no ice cover. The exceptions were two ice ages, similar to the present one, the Gondwanian, about 280 million years ago, and the Ordovician, about 430 million years ago. Both ice ages coincided with unusually low levels of carbon dioxide in the atmosphere, much as we have experienced at present. It is hard to understand hysteria over manmade increases in carbon dioxide levels that will not even bring atmospheric carbon dioxide levels up to their norm for most of geological history, and which will probably help to prevent the next advance of ice sheets. So we should be very careful about taking actions that will certainly cause great economic harm.

False biology prevailed for forty years in the Soviet Union because Lysenko gained dictatorial control. His type of control —dependent upon prison, exile, and bullet—is not possible in democratic societies, but the control of research funding enables those in political favor to restrict research that might undermine political opinions and positions. For instance, when I was the Director of Energy Research of the Department of Energy in the early 1990s I was amazed that the great bulk of federal funds for environmental studies from the DOE, NASA, EPA, and other federal agencies flowed into research programs that reinforced a message of imminent doom: humanity and planet earth devastated by global warming, pestilence, famine, and flood. I was particularly disturbed by the ridiculous claims by then-Senator Al Gore that recent NASA studies had shown that there was an "ozone hole over Kennebunkport." I remember reacting angrily to a briefing by Mr. Gore's political ally, Bob Watson of NASA, when he used the same words, an "ozone hole over Kennebunk-

port," to brief high-level members of the Bush administration in the West Wing of the White House.

After the election of Bill Clinton and Al Gore in the fall of 1992, I was soon the only "holdover" from the previous Bush administration in the Department of Energy. There I worked with the new Secretary of Energy, Hazel O'Leary, to defend basic science in the Department of Energy. Although most political appointees are replaced after the White House changes hands in a presidential election, it is not unusual for those occupying scientific posts to remain for some time in a new administration. However, after a few months, Secretary O'Leary called me in to say that I was unacceptable to Al Gore and his environmental advisers, and that I would have to be replaced. She was apologetic and gracious during this discussion, and she did not elaborate on the exact reasons for Gore's instructions.

The modern Greek poet Constantine Cavafy wrote a poem, "Things Ended," which is worth remembering as we contemplate our supposedly dying planet:

> Possessed by fear and suspicion,
> mind agitated, eyes alarmed,
> we desperately invent ways out,
> plan how to avoid the inevitable
> danger that threatens us so terribly.
> Yet we're mistaken, that's not the danger ahead:
> the information was false
> (or we didn't hear it, or didn't get it right).
> Another disaster, one we never imagined,
> suddenly, violently, descends upon us,
> and finding us unprepared—there's no time left—
> sweeps us away.[14]

14. C. P. Cavafy, *Collected Poems*, edited by George Savidis (Princeton, N.J.: Princeton University Press, 1992).

Summary

Politicized science is an inevitable part of the human condition, but society must strive to control it. Although history shows that politicized science does much more damage in totalitarian societies than in democracies, even democracies are sometimes stampeded into doing very foolish and damaging things.

The Kyoto Treaty, based on assertions that mankind's generation of carbon dioxide will cause global warming, is an example of such a foolish and damaging thing. The effects of the Kyoto Treaty, if the treaty is enacted, are likely to be more like those of Prohibition, than Lysenko's biology. The demonizations of rum and carbon dioxide have much in common. In 1920, the U.S. Congress passed the Eighteenth Amendment to the Constitution of the United States. This amendment, which prohibited the manufacture, sale, or transport of alcoholic beverages, was intended to rid the country of the accidents, disease, and violence associated with those beverages. It didn't. It began a disastrous era that helped organized crime to flourish as never before and nourished contempt for the law that has not entirely dissipated today. In 1933, the Twenty-first Amendment repealed the Eighteenth Amendment, the only time in history that an amendment to the U.S. Constitution has been repealed. Demonization of anything is hard to combat, since it is so easy to join the supposed high ground of virtue, while scorning those who go through the painstaking effort of looking at the facts for themselves. This was why it was so hard to stop the bandwagon of prohibition or Lysenko's biology.

The same human motives that cause other problems in our lives also drive extreme politicized science. As the examples here show, a common motive is the love of power and domination. This was clearly one of the most important motives for Lysenko. There is no surer way to build a powerful bureaucratic empire in

a democracy than to promote a supposed peril and then staff up a huge organization to combat it.

The intoxication of fame and glory is an important motive, especially for the scientists themselves. What bliss to be a sainted savior of the planet, to be the provider of agricultural abundance as communism dumps capitalism into the dustbin of history, or to be a new Prometheus, bringing the fire of cold fusion to desperate humanity!

Greed is often a motive. The University of Utah was transfixed by the untold dollars they thought would flow to the inventors of cold fusion. The Enron Corporation, a politically correct darling of many environmental advocacy groups, was a stalwart supporter of the Kyoto Treaty to limit carbon dioxide emissions. Enron envisaged huge profits from the trading of emission rights. Moreover, Enron's holdings of natural gas, the fossil fuel that emits the least carbon dioxide per BTU of combustion energy, would also greatly increase in value as the constraints of the Kyoto Treaty began to hurt the coal industry.

One can go down the list of deadly sins of almost any religion, and most can be found in politicized science. This should come as no surprise, since scientists are as fallible as anyone else in their personal lives. We recall that the first biblical mention of science (from "knowing" in Latin) occurs in the story of Eve's temptation by the Serpent, "*Eritis sicut Deus*, scientes *bonum et malum;* Thou shalt be as God, knowing good and evil." Science has always been associated with good and evil, and it will always be a struggle to be sure that the good prevails.