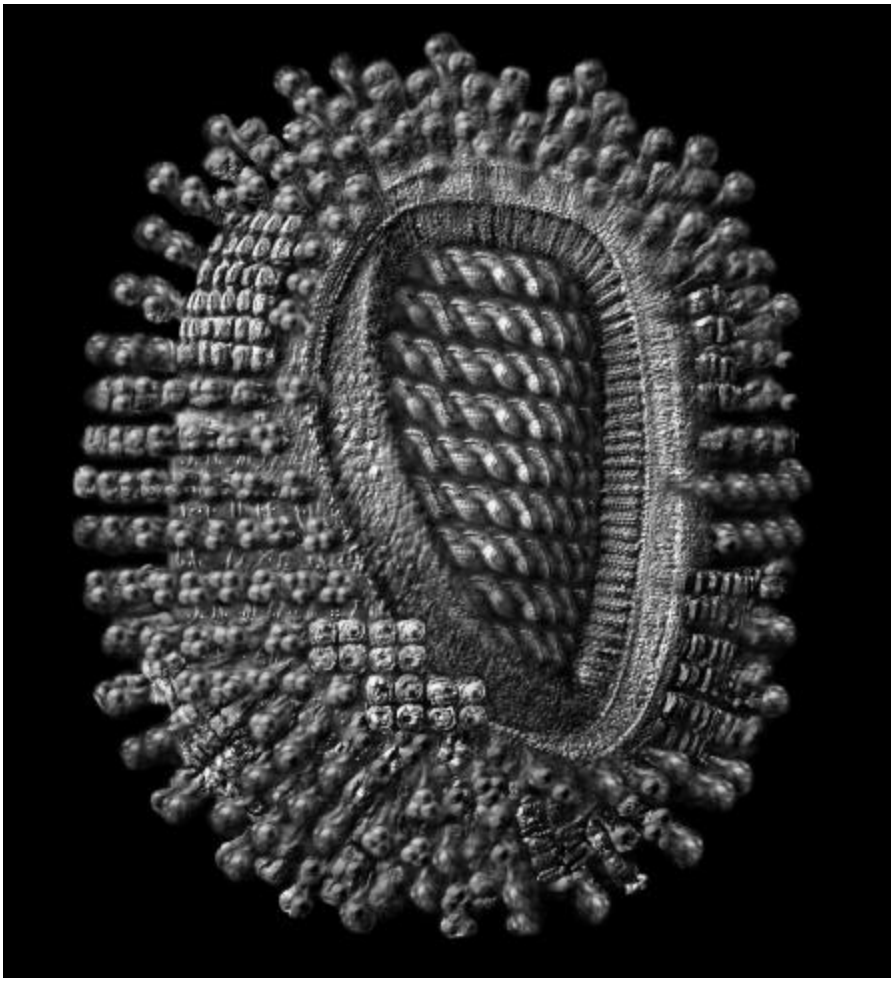

Illustration of an influenza virus partially cut away to reveal the internal structures. © Russell Kightley

# Is Science Under Siege?

*Harold Varmus*

This is an updated and edited version of a presentation given at the 1895th Stated Meeting, held at Rockefeller University on November 16, 2005.

*Harold Varmus is President of Memorial Sloan-Kettering Cancer Center. He has been a Fellow of the American Academy since 1988.*

The cardinal attributes of science – discovery, innovation, rejection of dogma, exploration of frontiers – have been emblematic of our nation's character from the outset. Many of those who founded our country thought of themselves as scientists. And when the American Academy was established in 1780, it chose to include the sciences in its title.

Science has thrived here, and we have become the nation most advanced in virtually all fields of science and technology. As a nation of immigrants, we have attracted bright people who studied and stayed here; even today, one quarter of the members of the National Academy of Sciences were born abroad. American scientists have been central to the discoveries of the twentieth century that have transformed our understanding of the world, driven our economy, and radically altered and dramatically extended our lives – atoms and genes; new vaccines, medicines, and chemicals; airplanes, televisions, cell phones, lasers, computers, and pacemakers.

Midway through the twentieth century, after science helped us win the Second World War with quinine, radar, and atomic bombs, our federal government assumed responsibility for a massive expansion of research, especially basic research; the bargain may have had Faustian aspects, but the dividends have been handsome.

At the start of this new century, science continues to be exhilarating. In my own field of cancer research, these are extraordinary times. By learning the genetic damage that drives cells to become cancerous, we can classify cancers more accurately and, for a few important conditions, treat them more effectively. Memorial Sloan-Kettering Cancer Center is not alone in showing enthusiasm for science by expanding our research facilities, building new programs, and training more people to study these diseases.

From this perspective, it may seem surprising that we are gathered here tonight to worry about the scientific enterprise in America. But – despite the successes of the past century and despite the optimism about what science can achieve in the next – science seems to be under attack on several fronts. Scientists report anxiety about their career prospects and a sense of alienation from the dominant culture and politics of our society. Anxiety and alienation are not new to science, but they are perceived as more acute and more intense now than in recent memory and driven by many things: by an underappreciation of science as an essential feature of our culture, by declining budgets for science, and by sharpened conflicts with religion in education and science policy.

I have been asked to speak to you today about these anxieties – their causes, the objective reality, and some remedies. To do this, I must talk about topics on which I must confess not to be truly expert: political science, ethics, economics, history, and even theology. But I can give you a personal account of the concerns; I can try to categorize and analyze them as a working scientist perceives them; and I can make some judgments about their seriousness and reversibility.

## Immediate targets of concern among scientists

At least four interwoven topics are prominent in conversations among scientists who are worried about the status of science in America today: the diminished role of science in the formulation of policy by the current administration; the actual policies that have been developed in the scientific arena; the diminishing resources for funding science and for the training of scientists; and the intrusion of religion into science policy and education.

Evidence that the current administration does not adequately incorporate scientific advice in the process of formulating its

*Despite the successes of the past century and despite the optimism about what science can achieve in the next, science seems to be under attack on several fronts.*

policies has been widely promulgated by the Union of Concerned Scientists since February 2004 (www.ucsusa.org/scientific_integrity/). Many experienced advisors for previous administrations, Democratic or Republican, argue that this shift away from a full review of the available facts has produced policies affecting many domains of governance that lack a strong evidentiary basis and run counter to the long-term interests of the country.

Consider the case of human embryonic stem cell research. For those of us – scientists and citizens alike – who are impressed with the prospects for discoveries and, ultimately, beneficial changes in medical practice through such research, the present rules that govern federal spending on embryonic stem cell research are troubling and unduly restrictive. They have slowed the pace of progress here, given advantage to other countries (such as the United Kingdom) with more enlightened policies, and discouraged young scientists from contemplating careers in this exciting new field.

The decision to limit federal funding of human embryonic stem cell research to cell lines derived before President Bush's speech on August 9, 2001, seemed politically calculated, rather than scientifically reasoned, even at the time. So some of the consequences have been predictable. For instance, the number of useful lines was never as large as claimed, has diminished with time, and never included lines that could be used in patients.

Other consequences would have been difficult to anticipate. The most important, in the long run, may be a fragmentation of the nation's research effort. Rather than building a unified national program to pursue this new work, we are creating a patchwork quilt of state policies that range from prohibitions of work permissible elsewhere to state financing of work ineligible for federal dollars. California illustrates the latter extreme: voters strongly endorsed stem cell research by passing a bond measure that will provide $3 billion over ten years, if the multiple legal challenges to the initiative can be resolved. A few other places, including New York City, have benefited from private philanthropy for stem cell work. These pockets of affluence will inevitably and inequitably distort the distribution of stem cell investigators across the nation, and these precedents could provide incentives to further fragment the historically successful federal oversight and funding of medical research.

Such policy issues are important, but for most scientists in the trenches the most immediate and daily concern is financial support for their disciplines and the ability to attract bright trainees to work with them. The United States still leads the nations in total support for science, and it remains among the top few when science funding is measured as a fraction of the Gross National Product. But budget projections for science agencies are flat, without even inflationary increases, at a time when the promise of science and the need for science are unprecedented. Federal support for the physical sciences has been unchanged or declining for many years, with no improvements in sight. Funding for elementary particle physics, for example, has been in steady decline for several years, and leadership of a field that we once dominated is now at least shared with European physicists, who are hosting the Large Hadron Collider in Geneva, where the next major discoveries are likely to be made after it opens in 2007.

Even the NIH, with the biggest budget among the federal science agencies, about $28 billion, is facing trouble. The Bush administration fulfilled its pledge to finish a five-year doubling of the budget that began in the Clinton era. But for the past two years – and almost certainly for the coming year as well – the NIH budget has been flat, without even an inflationary increase. With this progressive loss of purchasing power, fewer grants can be awarded at a time when the number of active investigators has grown significantly. This means that the success rates for grant applicants will be low, as low as 10 to 20 percent, even for new applicants, such as those who have finally taken faculty positions after many years of undergraduate, graduate, and postdoctoral training. Such stiff competition produces poor or arbitrary decisions and demoralizes the frustrated applicants and reviewers alike. It should also worry the public that paid for much of the training of new investigators and wants them to be working in the laboratory, not rewriting grant applications.

Although many excellent students are training in the sciences in the United States at present, the budget forecasts transmit a discouraging message to prospective trainees. For several years American undergraduates have been steering away from math and some of the physical sciences. And, as has been widely publicized, foreign students who had taken their places have been applying to our graduate schools in smaller numbers for the past few years.

There is yet another widespread and profoundly troubling phenomenon affecting the climate for science in the country: the intrusion of religion into the domains of science. No one in this audience can be oblivious to the efforts by components of the religious right to undermine the teaching of evolution in high-school science classes. Indeed, hardly a day goes by without a prominent article in our leading newspapers about one of the battlegrounds or about the resurgence of creationism masquerading under the pretentious name of "intelligent design" (ID). For anyone who has not heard, proponents of ID try to discredit Darwinism by pointing to human eyes or bacterial flagella as examples of

*For most scientists in the trenches the most immediate and daily concern is financial support for their disciplines and the ability to attract bright trainees to work with them.*

"irreducible complexity" that evolution can't fully explain, implying they must be products of a supernatural force.

Those who defend the concept that religious ideas, such as ID, have no place in science classrooms took heart, at least briefly, after November's elections. In Dover, Pennsylvania, where efforts by the local school board

*There is yet another widespread and profoundly troubling phenomenon affecting the climate for science in the country: the intrusion of religion into the domains of science.*

to present ID in biology classes were challenged in the courts, voters replaced their entire school board with new members pledged to keep science separate from religion. Then, a month later, a federal judge issued a remarkably well-reasoned ruling that supported the contentions of the new board members (www.pamd.uscourts.gov/kitzmiller/kitzmiller_342.pdf).

But these battles are far from over. New standards that weaken the teaching of evolution have been approved (but not yet implemented) in Kansas; other efforts to undermine instruction in evolution, the governing principle for all of modern biology, are ongoing in many of our states; and polls by the Pew Trust indicate that as many as 38 percent of Americans would like to see creationism *replace* evolution, not just coexist with it, in the high-school curriculum.

Still, I have been encouraged by the excellent and frequent coverage of these developments in our leading newspapers and magazines; by the bold warnings by some of our university presidents, especially Shirley Tilghman of Princeton and Hunter Rawlings of Cornell; and by the actions of many scientists, religious leaders, and other citizens concerned about the erosion of First Amendment principles, who have joined organizations formed to defend those principles.

## The underlying causes of current concerns

How do we account for the many troubling features of the landscape that I have just painted? In my view, there are at least three underlying causes of our woes: the uncertain and poorly guarded boundaries between religion and state; the failure to recognize science as a foundation of our social and economic well-being; and ambivalent attitudes toward the rest of the world.

*Limiting the influence of religion.* The boundaries between religion and state have become increasingly blurred over the past several years, to the point where the growing political force of evangelical Christians, often known as the "religious right," is affecting science (stem cell policy), the teaching of science (intelligent design), and public health (opposition to Plan B, the drug that can prevent unwanted pregnancies resulting from recent unprotected sex, and opposition to the use of condoms in HIV prevention strategies). In the category of public health, religious dogma is trumping life itself.

It is ironic that some in this country have become captive to a relatively narrow segment of the religious spectrum at a time when the breadth of that spectrum has grown dramatically, particularly with increasing immigration from Asian countries. But we as citizens have been lax in our responsibility to the First Amendment to ensure the separation of religion and state. And we as scientists have not been adequately engaged in efforts to understand and explain the relationship between religion and science.

Any first step in those efforts is to describe science and religion as largely separate spheres of activity: science asking How, religion asking Why; science invoking Reason, religion invoking Faith; science depending on objective evidence from the natural world, religion depending on subjective feelings and thoughts. Seen in this way, as many have noted, they are compatible and even complementary. Such distinctions help to explain why creationism (or ID) should not be mentioned in science classrooms: it makes no testable predictions and is supported by no evidence. It is not science.

But we also need to acknowledge that science and religion can be in conflict – and have been throughout history – depending on the scientific realms and the religious precepts. Most areas of science do not confront religious teachings as directly as reproductive biology, evolutionary sciences, or cosmology can. And some religions are much less dogmatic and prescriptive than others.

Many who turn to religion for help are seeking some sense of purpose for the bad things that happen. But one of the dominant ideas that emerges from the scientific study of the cosmos, evolution, and reproduction is that of *chance*. For many scientists, chance happenings can seem as remarkable as a god's purposes. The idea that chance, over billions of years, could lead to our universe, our galaxy, our earth, life forms, the human species, and, especially, the human brain, is, in itself, breathtaking. Jacques Monod, one of the founders of molecular biology, said it well: "... like the man who has just won a million, we still feel the strangeness of our condition." A god may be an intruder on this landscape.

Just as science and religion need to define their differences, they also need to seek common ground. It is often said that scientists need to show more tolerance of religion. Yes, but religious groups, especially those in the fundamentalist sector, need to show more tolerance of secular humanism – a creed common among scientists. As recent

*Just as science and religion need to define their differences, they also need to seek common ground.*

reports in the *New York Times* indicate, some components of the religious right are collaborating with environmental activists to protect the earth against global warming, and others are working with public-health advocates for more spending to combat disease in Africa. The world needs more such collaborations.

Current worries about the possibilities of an impending epidemic of avian influenza, one as terrible as the epidemic of 1918, may offer another platform for an enlarged understanding. During his remarks about the influenza situation last fall, President Bush referred to the idea that "from time to time, changes in the influenza virus result in a

new strain to which people have never been exposed. These new strains have the potential to sweep the globe. . . ." This is pure Darwinism: natural variation and selection. The influenza virus (pictured at the start of this article) may look like a complex machine, with its spiked globe and multiple chains of nucleic acid, but no one is arguing that it or its derivatives are the "irreducibly complex" products of intelligent design. When the stakes are high, almost everyone turns to real science for help.

*Recognizing the economic benefits of science*. Scientists have largely themselves to blame for a second problem: we have failed to keep the public adequately apprised of the crucial links between science and the social and economic benefits enjoyed in the developed world. This failure has been especially damaging in the current administration, which has allowed our budget deficits to mount and our science budgets to fall. Because the investments in science and technology are crucial to the economic health of the nation, producing well-documented returns of 130 to 150 percent, the administration may prove to be less of a friend to American business than is commonly thought.

In the long run, our attitudes and policies threaten our future productivity and competitive stature. This message is central to a report recently issued by the National Academies, *Rising above the Gathering Storm* (www.nap.edu/books/0309100399/html). The report is critical of the low status accorded to science teachers in our elementary and high schools; of the erratic and largely declining investments we are making in basic science; and of our failure to recognize that industrial productivity depends on scientific proficiency and incentives for innovation. The authors – who are themselves captains of industry, presidents of universities, and prize-winning scientists – reflect the influence of Tom Friedman's new book, *The Earth is Flat* , emphasizing the competitive challenge that we now face from India, China, and other Asian nations where students excel in science and math, where governments recognize that their futures depend on a highly skilled work force, and where high-technology businesses are growing rapidly.

In reading the report, I was reminded of an essay written several years ago by David Goodstein, a physicist at Caltech. Goodstein observed that we use the wrong metaphor to describe how we teach science to children in the United States. We don't have a pipeline that all students flow through, with a subset emerging as working scientists at the end. Instead, we have a diamond mine in which we prospect, even at very early stages, for the gems who can win Westinghouse (now Intel) Prizes and then go on to even greater glory after attending schools on scholarships. We have done well with this method, fostering innovation, making discoveries, winning Nobel Prizes, building great universities and industries, and accumulating national wealth. But at the same time we have ignored the need for that large pipeline of students with strong skills in computation and technology as well as knowledge of scientific principles. This is the method that also generates science-savvy citizens.

*We are now in danger of losing our position at the head of the global pack unless we make substantial investments to support the teaching and practice of science.*

As the report explains, we are now in danger of losing our position at the head of the global pack unless we make substantial investments to support the teaching and practice of science. But this news comes at a time when we lack the financial resources to respond to the report's expensive recommendations with anything other than a resigned shrug.

*Reestablishing beneficent internationalism*. America's status in the world has changed. We are now a feared and unequaled military power, neither faced off against the Soviets nor joined in harmonious alliances. In the eyes of many peoples around the world, we have become both a despised invader and a vulnerable target for terrorism, not the benevolent promoter of democracy we may aspire to be. And, while we remain the world's industrial leader, we are now being challenged by rising productivity in Asia and a united Europe.

We cannot afford to respond to these conditions with xenophobia or isolationism. Initially, after 9/11, immigration procedures became tougher, even for students and visiting scientists. Although the U.S. Immigration and Naturalization Service has responded to complaints from the academic community and eased visa procurement, impressions are hard to erase. While the declines in applications from abroad are not large, they are indisputable and worrisome: students, especially from Asia, are shifting their sights, mainly to other English-speaking countries with strong science programs.

This is a loss for us and a change in international reputation that we must work to restore. We may have squandered the sympathetic goodwill that we enjoyed after 9/11. But, at only modest cost, we can use our scientific skills to reestablish our good character. There are many ways to do this – by helping to coordinate international surveillance against infectious diseases, like influenza, SARS, and HIV; by increasing our investments in science done abroad, especially in poor countries and especially on topics that promise local benefit (medicine, agriculture, energy production, and environmental remediation); by promoting connectivity through the Internet and assuring that scientific reports are made readily accessible to all. The essential internationalism of science is a powerful force that we can and should harness: to defend against global epidemic diseases, to diminish threats to the world's climate and environment, and to improve the well-being of people who live in the developing world, while also reversing our declining reputation.

## Is science under siege?

So how should we answer my rhetorical title? Is science under siege? I am sorry to say: Yes and No. "Siege" is probably too strong. "Stress" or "duress" might be more appropriate words, although they might have attracted a smaller audience. And, of course, science has always been under suspicion or even attack from various quarters, sometimes even from liberal academics. So how do we judge our current position?

First, it is important to acknowledge our continued strengths. There is still considerable federal financing of science, and, unlike scientific institutions in most other coun-

tries, our academic institutions enjoy additional financing from industry and from philanthropy. The science done here is still outstanding, and the United States remains the leader in most areas. In general, the public has confidence in science and scientists, especially in moments of crisis, even though large parts of it are ill-informed about science and misguided about how we should teach it. No significant exodus of our scientists has occurred, and we continue to attract many excellent students from abroad.

But it is equally important to recognize other troubling features of the landscape: the fragility of the scientific enterprise, the importance of even subtle shifts in the research environment, and the difficulty of reversing downward trends. Furthermore, it is expensive and takes time to improve our teaching of science; politically difficult to confront the growing influence of the religious right; and hard to get the attention of a public distracted by terrorism, the war in Iraq, and many economic worries in order to explain the importance of science to the nation's future.

My own anxieties are tinged with optimism. Some university leaders, scientists, clergy, and politicians have boldly spoken up to defend the First Amendment, evolution in science curricula, the integrity of science policymaking, and many other things. In some states, the public is ahead of government leaders in appreciating the value of science, especially in controversial areas such as stem cell research and climate change. Science journalism has improved in the past few decades and generally presents our issues fairly. Portrayals of science in the arts have blossomed on the stage (*Copenhagen*, *Wit*, *Proof*, QED), occasionally in the movies, and even this year in opera (*Dr. Atomic*); the Sloan Foundation and others are encouraging more of this. New York's American Museum of Natural History has opened its new Darwin exhibit and is holding public discussions of evolution. And effective popularizers of science, like Brian Greene, a cosmologist at Columbia, are proposing International Science Festivals in our cities, simulating events that have been successful in Europe. All of us can and should become cheerleaders for science. ■



**Harold Varmus (Memorial Sloan-Kettering Cancer Center)**

**Patricia Meyer Spacks (University of Virginia) and Nannerl Overholser Keohane (Princeton University)**

Gerald Rosenfeld (Rothschild North America) and Leslie Berlowitz

John Brademas (New York University) and Frances Degen Horowitz (City University of New York)

Pierre Hohenberg (New York University), Lawrence Shepp (Rutgers University), and Elihu Abrahams (Rutgers University)