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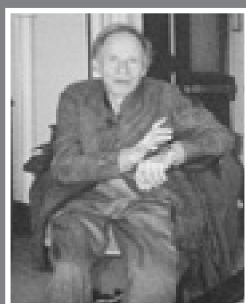
Public Interest Report

What Limits Should be Placed on Biomedical Research in Response to Security Concerns?

John Rennie addressed the following remarks to the audience gathered for the Hans Bethe Award Ceremony.



Philip Morrison receives the FAS Hans Bethe Award for Science in Public Service. See pages 5-6 for details on the event.

Thank you. It's a great pleasure to be on this panel today, grappling with the topic of security-based limitations on biomedical research. In the interest of candor, I should begin by pointing out that none of the three of us [John Rennie, Kumar Patel, Victor McElheny] is actually a biomedical researcher or security specialist. So we might be a bit like nuns commenting on the merits and difficulties of sex education—our heart is in the right place, but you may have

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The Politics of Hope and the Politics of Fear

By Henry Kelly

America's longstanding ability to inspire world efforts that direct science and technology toward addressing global problems is becoming a casualty of the Bush Administration's assault on internationalism and of soaring federal deficits. Whatever success we may have in addressing public fears through investments in national defense and homeland security, there's little doubt that we're racing headlong toward global disasters in areas ranging from environmental and

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Journal of the Federation of American Scientists

In This Issue

Located on the web at **www.fas.org**

About FAS

The Federation of American Scientists (FAS), founded October 31, 1945 as the Federation of Atomic Scientists by Manhattan Project scientists, works to ensure that advances in science are used to build a secure, rewarding, environmentally sustainable future for all people by conducting research and advocacy on science public policy issues. Current weapons nonproliferation issues range from nuclear disarmament to biological and chemical weapons control to monitoring conventional arms sales and space policy. FAS also promotes learning technologies and limits on government secrecy. FAS is a tax-exempt, tax-deductible 501(c)3 organization.

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to make allowances for some inexperience or naïveté in our views.

"Naïve"—that's a word that has come up a lot in discussions of this subject in recent years. For example, George Poste, a former head of SmithKline Beecham and the chair of a Dept. of Defense task force on terrorism, told Nature back in November 2001 that biology must "lose its innocence" about how legitimate scientific work could be perverted to malicious ends.

He made an interesting point. Physicists for more than 60 years have been inescapably aware of how their nuclear research could be coopted for evil ends. It's an awareness that security restrictions enforce and drill home at every turn. The physics community has become well-acquainted with advising the government on potential strike and counterstrike development, and with drafting regulations that try to preserve the needed priorities of both research and security. Biologists have certainly always known that their work could be misused in horrible ways—germ warfare goes back deep into history, and worries about the intentional or unintentional creation of novel disease organisms has been the stuff of laws and studies and even pop culture. But biologists have not always had to worry about the government stepping in to interfere with their research for reasons of security.

I think that several very specific events or actions frame our current view of tensions between biomedical research and security. One, of course, was the set of terrorist attacks on 9/11, about which enough has been said. Another was the mailing of weapons-grade anthrax, which took place on the heels of 9/11 and which has never been attributed to any culprit.

Aside from those acts of terrorism, we also have two acts of research. In 2001 Australian researchers were genetically modifying mousepox virus with the intention of developing a contraceptive vaccine to curtail the rodent population explosion. To their amazement and dismay, they found that inserting an interleukin gene inadvertently converted relatively mild mousepox into a mouse superpathogen. The publication of that work prompted worries that some would-be bioterrorist who couldn't obtain a sample of smallpox might create his own disease instead. Then in 2002 Eckard Wimmer of SUNY Stonybrook published a paper showing that it was possible to synthesize poliovirus from scratch, using the publicly available viral genome.

Finally and most recently, we have an act of policy on scientific communication. In mid-February 2003, the editors of more than 30 journals publishing biology research announced that they would adopt a voluntary policy of self-policing papers for information that might be useful to terrorists. Nobody likes

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New format for the Public Interest Report

We're moving to a quarterly, more substantive format, effective this issue. We hope you will continue to find the PIR interesting and informative.

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to talk about this as self-censorship, but it is in many ways a matter of semantics.

How serious or significant will this self-policing by the journals be? The great worry is that security screens might prevent valuable discoveries from becoming public, or that information essential to understanding exactly how experiments were performed will be excised, making it difficult for other researchers to replicate or scrutinize published reports. Both those results could be disastrous for science.

But in fact, it all depends on how the editors choose to exercise this policy. It is purely voluntary, and each journal will interpret it in its own way. The editors who have commented on this decision publicly say that they expect only one or two papers a year may run afoul of these restrictions. And even in those cases, the editors would probably still publish the papers' results, leaving out just enough details to mitigate the damage they might do. (I believe the editors pointedly remarked that they would still publish both the mousepox and poliovirus synthesis papers I mentioned earlier.) The editors claim a commitment to making sure that the flow of essential scientific information would not be impeded, and I think they deserve the benefit of the doubt.

A natural question to ask is, why did the editors choose to introduce this policy at all? Let's not be so cynical that we don't credit their announced desire to prevent terrorists from doing harm. But it's likely too that the editors felt it was essential for them to act as a way of heading off more ham-fisted outside review by the government.

Starting shortly after 9/11 and the anthrax attacks, rumors started to circulate that the Bush Administration was leaning on biomedical journals to censor delicate information. These rumors were denied on both sides for quite some time, but at this point it seems to be acknowledged by Ronald Atlas, the president of the American Society of Microbiology, and others. Moreover, there were reports that early drafts of the Homeland Security bill in 2002 would have established authority for that agency to limit the publication of sensitive papers; that condition was withdrawn after protests. On January 9 of this year, the National Academy of Science and the Center for Strategic and International Studies convened a meeting to discuss conflicts between open scientific publication and terrorism concerns; during those proceedings, it was suggested that Congress might feel an obligation to legislate some kind of biology research oversight for itself. In short, government limits on biology research and publication were in the air.

My own perspective on the new journal policy straddles the fence, I suppose. In practice, this is not going to interfere much with scientific communication, so even though as a journalist I'm predisposed to be a First Amendment absolutist, I'm not going to wring my hands about how this journal policy will wreck or cripple science. On balance, if the editors were really feeling heat from the government, or feared with good reason that it was about to be turned up, they were probably wise to take this on themselves. There's every good chance that if the editors are dedicated to making good research public, this self-policing will become a non-issue over time.

> ***"... it's reasonable to worry about how new biological research could be of service to terrorists, but before society cracks down too hard on open research and discovery, it should make a stronger case that new research really abets terrorism."***

On the other hand, for roughly the same reasons, I think that it's going to do almost nothing to further our national security.

After all, how much do newly published research results help terrorists, anyway? Remember, the most sophisticated approach to bioterror ever taken was the weaponized anthrax attack through the mail a year and a half ago—and my understanding is that nobody has

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ever published a paper about how to weaponize anthrax.

A lot of the information that budding bioterrorists might want to use is already out there in the public domain. Intelligence experts all fear that large numbers of underemployed researchers who had experience with making secret bioweapons in the former Soviet Union are potentially available to terrorists with cash. And of course, nature itself is full of nasty pathogens already—Ebola virus, anyone?

My feeling is that it's reasonable to worry about how new biological research could be of service to terrorists, but before society cracks down too hard on open research and discovery, it should make a stronger case that new research really abets terrorism. Moreover, before government's protective iron hand closes too tightly on research, it should do more to sensibly govern the commercial availability of actual materials that could be put to malicious ends. Controlling materials may be easier than controlling information, while doing more direct good. And such restrictions shouldn't fall more heavily on biological materials than on chemical or radiological ones, given their tremendous potential for misuse.

Back in November 2001, we at Scientific American arranged a vivid demonstration of how easy it was to obtain dangerous chemicals. At a time when the whole country was on alert against terrorists, we picked up the phone, called a chemical supply company, and conspicuously ordered all the ingredients needed to make the nerve gas sarin. These chemicals were delivered through the mail to an office in midtown Manhattan, no questions asked. Theoretically, I had enough material in my office to kill thousands of people.

It's important to realize that terrorists in the real world aren't usually going to be like the villains in James Bond movies. They aren't Dr. No, with a secret underground lab inside a volcano. They're far more likely to be fanatics working out of a garage or a cave. They aren't that sophisticated, and they don't need to be.

For all the fearful emphasis on bioweapons, chemical weapons and radiological weapons, it's still most likely that terrorist attacks will continue to employ conventional explosives and the like. Ordinary explosives are cheap and easy to make. The Oklahoma City bomber made a truckload out of fertilizer. Of course, explosives are only one of the mundane weapons potentially available. The terrorists of 9/11 killed thousands of people by hijacking and crashing airplanes. Earlier this year, the D.C. snipers spread fear across several states by killing individuals with rifles, over and over again. If I were al-Qaeda and I had secret operatives in the U.S., I would tell them to join the N.R.A., buy rifles and spread out across the country. A loose, decentralized network of snipers like that could paralyze much of the nation and would be almost impossible to stop.

Never forget that the great goal of terrorists is not to kill, but to spread terror. They want to make our society grind to a halt. They can do this by spreading fear directly, or by making us armor ourselves into a cocoon.

A problem with instituting restrictions on biomedical research, or any other kind of research, in response to this "war on terrorism" is that it's not like a conventional war. There isn't a well-defined enemy; there isn't a well-defined set of targets for us to protect or attack; there isn't a defined timeframe outside of which it's possible to think of resuming normal practices. Essentially, we're opening the door to policing research forever.

Some limits on biomedical research are prudent, appropriate, and don't infringe on liberties essential to progress. But before we adopt more severe limits, let's insist that the case be made that they are truly necessary.

Author's note: John Rennie is Editor-in-Chief of Scientific American.

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Right
Victor McElheny, John Rennie and Kumar Patel (l-r) address the audience gathered for the Hans Bethe Award ceremony.

Hans Bethe honors Philip Morrison

By Hans A. Bethe

Philip Morrison receives the FAS Hans Bethe Award for Science in Public Service.

Philip Morrison has spent a lifetime contributing his extraordinary clarity of thought and unfailing ethical compass to America's most critical decisions. I am sorry that I cannot join your celebration, but I add my voice to the many others gathered to honor Phil's many, and continuing, contributions. It's particularly fitting that the Federation of American Scientists is recognizing his work. Phil and I helped found the organization in 1945 because of our shared belief that scientists had an obligation to participate in the difficult choices that had been forced on our country by extraordinary advances in nuclear physics so vividly demonstrated by the development and use of atomic weapons. The range and complexity of issues hinging on sound scientific advice has increased since that time, even though many of the most troubling technical issues regarding the control of nuclear weapons have been solved. Phil Morrison has been able to bring insight and good sense to an astonishing number of issues. He has inspired several generations of scientists to understand how they can use their scientific training to participate effectively in public issues. And for 60 years he has helped people without technical backgrounds understand the beauty of new scientific insights and think about their consequences.
It is an honor to know him.

Author's note: Hans A. Bethe co-founded FAS and won the Nobel Prize in Physics in 1967 "for his contributions to the theory of nuclear reactions, especially his discoveries concerning the energy production in stars."

PIR

Remarks delivered by Frank von Hippel at the Presentation of the FAS Hans A. Bethe Award to Phil Morrison

This may be my last significant act as chairman of the Federation of American Scientists. It would be a great way to end.

Many of us know about Phil Morrison's contributions as an astrophysicist.

Millions know him through his book reviews in Scientific American where he has offered original and engaging perspectives on virtually every subject under the sun.

In addition to his science and public education work, however, Phil has been a leader in the effort to reduce the nuclear danger. He was one of the first to become aware of this danger as a member of the World War II nuclear-weapons development program.

Phil was one of the first Americans to walk through the rubble of Hiroshima. Only months later, he co-founded the Federation of American Scientists to institutionalize the scientists' effort to prevent nuclear war.

Thirty years later, in the 1970s and '80s, Phil was still at it when he co-founded the Boston Study Group which helped create a new generation of activist analysts who laid the basis for the Nuclear-weapons Freeze movement.

Most impressive to me, however, is the example Morrison set during the early 1950s, a period of madness when the decisions were being made to increase the numbers of nuclear weapons from hundreds to tens of thousands and their power from the equivalent of tens of thousands to millions of tons of TNT .

"Phil was one of the first Americans to walk through the rubble of Hiroshima. Only months later, he co-founded the Federation of American Scientists to institutionalize the scientists' effort to prevent nuclear war."

During this time, Phil's patriotism was sometimes impugned but he would not be silenced. I would like to quote one of his responses at the time:

"Out of my whole experience in life, and especially out of the events which culminated in my walking through the rubble of Hiroshima, I have gained the deep conviction that in the true interests of America…it is urgent that some voices speak for peace, even in times of crisis and even in the face of bitter opposition…

"It is not easy to take such a stand, particularly in a world where great-power conflict is the way of international life, without angering many who see in the insistence upon peace a surrender of national interest…

"I know moreover that not all patriotic Americans disagree with my views, though as yet they are shared by only a minority. This is both inescapable and proper; in a democracy ideas may begin with a few, but spread to a majority in time…"

Today, this statement is well worth recalling.

The FAS has taken its time about creating this award.

But Hans Bethe, the grand old man of American physics and nuclear arms control, is still alive and – when I last checked – studying the physics of supernovae in Ithaca.

And Phil Morrison is still ready to speak truth to power.

So it is my honor to present to Phil Morrison the first Hans A. Bethe award.

The inscription is:

"To Philip Morrison for his persistent and infectious conviction that decent people armed with reasoned arguments can prevail."

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resource management to demographics to disease control. And yet in pragmatic terms, the most dangerous long term threat to US security is likely to be a rapidly growing gap between the billion people benefiting from modern technology and the five billion who largely aren't.

There is real reason for hope that these neglected global threats can clearly be met with creative and continuous investment in new technology. But US leadership is essential, and not just because our economic base makes us the world's largest research enterprise. The US has an astonishing tradition of embracing technology-driven change and finding ways to combine enthusiastic private investment with massive public support. This model has driven progress in modern aviation, atomic energy and space exploration. It's pushed forward everything from automobiles and highways to the Internet. To be certain, the government has supported some really dumb projects, forcing an inappropriate design for nuclear power onto commercial markets and hyping the abortive US Synfuels project. Still, for the most part, public investment in research and infrastructure—combined with a willingness to juggle regulations in ways that encourage invention—has worked remarkably well.

Big ideas, crazy or otherwise, are much more likely to be taken seriously by US investors than by anyone else. Electricity, telephones, movies, automobiles, airplanes, rock videos and countless other American obsessions depended on science and invention from around the world. But Americans were somehow better able to meet the ideas with big money and to tolerate the social disruptions – and occasional chaos – that these products created. What other nation could embrace something like the Internet with enthusiasm so blind that a few years after dot-coms were offered, URL addresses were posted on everything from chewing gum wrappers to instruments for brain-surgery? And American tolerance for risk has been incredible: where else could enough animal spirits be found to create several trillion dollars in new wealth and then see most of it disappear overnight? Few would deny that, despite its pitfalls, this enthusiasm has changed the world—and mostly for the better.

This is no time for the US to be missing in action. Consider the following challenges:

Energy and the Environment

Finding a sustainable way to provide the 9 billion people likely to be alive at the end of this century with a reasonable level of prosperity presents an extraordinary scientific, technical and political challenge.

The average person on the planet today consumes energy at a rate of 2 kilowatts (kW), but about two billion people alive today don't use much more commercial energy each than Homer did. Americans, however, use an average of 11.5 kW, and the average Western European uses roughly 5 kW. If the world's population increases from six billion to nine billion during the coming century, and the typical person enjoys the lifestyle of a typical European today, total energy use will quadruple.

Can we possibly meet the energy requirements of nine billion people while delivering a prosperous lifestyle? There's no question that it's technically possible to solve this problem. Resource constraints need not limit growth if we're willing to keep pushing the frontier, since we're nowhere near theoretical limits in providing modern amenities. For example, we can make enormous gains in transportation by paying attention to simple things like urban design, advanced transit strategies and new technologies for vehicles and fuels. Advanced technology has scarcely touched traditional industries like housing. And biological systems – which manage to operate human brains on much less power than a Pentium III and run nanodevices that assemble systems like ears out of simple raw materials – provide clues to possible gains in manufacturing and energy efficiency.

Yet while much is possible, action has been anemic. Private investment in research has declined because incentives for invention are weak. Simply increasing the price of fuels to reflect the environmental and security costs associated with each would appear an easy solution. But US politics demands that energy prices kept low. A confusing mixture of incentives and regulations has been created in the past few decades. While automobile and appliance efficiency standards and other regulations may have helped, they are often offset by production subsidies that keep prices artificially low. Since the full cost of energy consumption is not reflected in market prices, private incentives for innovation in energy efficiency and energy supplies are well below optimum.

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The political process is stalled, with environmentalists and the Bush Administration engaged in a paralyzing ritual dance. The administration emphasizes technology as a long term fix; environmentalists argue that this is an excuse for doing nothing, and want immediate regulatory requirements forcing change. Both are only partially right. The Bush Administration is right to argue that over the long term, radical technical change is essential to any solution –after all, we're looking for 300% improvement, and the kinds of regulatory changes the environmentalists want are likely to be overwhelmed quickly by the sheer pressure of growth. Suppose, for example, automobile fuel economy standards were increased 30% over ten years: growth in energy consumption would be slowed, but thirteen years after the program started, consumption would be back to where it originally was.

At the same time, environmentalists are right to argue some changes must be forced now, as their effects will linger for decades. It can take a generation for a new automotive technology to become dominant on the road. For example, a new auto design available today would take a decade to become the dominant new vehicle sold and another decade to become the bulk of the fleet on the road. Houses built today will be around for a century. With nearly two billion people likely to move into large urban areas during the next five decades, decisions made about these communities' layouts will potentially haunt us for generations.

To maintain the flow of innovation, a large and sustained investment in research will be essential, as will programs to test concepts at a significant scale as they become practical. For example, while there's good reason to believe that US energy consumption can be cut by at least 30% with cost-effective technologies, some of these needed innovations are unlikely to be able to compete with cheap Middle Eastern petroleum and natural gas.

The Administration's plan to spend $1.2 billion on hydrogen research over 5 years is clearly a worthwhile effort. But it will scarcely let the US catch up to the level of spending in Europe and Japan in similar areas and it's hard to take seriously, since its proposed budget for renewable energy and energy efficiency (which includes most of the hydrogen research) is lower than the 2002 budget for the same field. Moreover, the budget cuts funding for energy efficiency research by nearly 15%. Not only will much critical work go unfunded, but broad cuts will block development and testing needed now on technologies like super-clean diesels for hybrids and alternative liquid fuels that may be easier to introduce than hydrogen.

Infectious Diseases

We've focused great attention on heart disease and cancer but our confidence in the miracle of 20th-century antibiotics has tempted us to underinvest in research on infectious diseases. And yet infectious diseases are not likely to remain the "orphan diseases" of the third world for the rest of the century. We've been fortunate that influenza of the kind that killed millions in 1918 hasn't reemerged – we'd be only slightly better prepared. Diseases like AIDS can move around the world with breathtaking speed, and it's only dumb luck that AIDS is not easily spread. The chances are very good that the world will face a dangerous infection from a natural mutation or from an intentionally manipulated pathogen before the century is out.

It's essential to increase resources focused on infectious diseases both to protect ourselves against naturally occurring infections that can spread rapidly through world transportation systems, and to defend ourselves against diseases intentionally created for malicious purposes. The work must be able to unravel the extraordinary methods that infections like malaria use to resist conventional therapies, and develop strategies for addressing infections able to mutate rapidly. Tools are needed for rapidly detecting and identifying new infectious agents. And it may soon be essential to be able to design vaccines and targeted therapies only hours or days after a new infection is identified.

Education

Access to information and education are essential to a world in which each person can enjoy the benefits of prosperity and free society. Education is also particularly important for empowering women in developing societies. But finding a way to provide education at an affordable price presents a heroic challenge.

Skillful use of modern information technology can help. We are so obsessed by the latest developments in computing that we easily forget that the chips that drove state of the art computers five years ago are available for pennies today. With the right kind of

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investment, it should be possible to develop a simple wireless device capable of supporting access to the world economy and intellectual resources for less than ten dollars per unit. Equally important, it should be possible to build the technological infrastructure needed to deliver high quality education to anyone with access to these devices. Well designed tools will make it much easier to build and use instructional systems tailored to the specific needs of each individual and culture. Moreover, this learning can be highly motivating, timely and provide skill assessments that make sense for both the instructors and learners.

Water

Agricultural and other human uses of water consume between a third and half of all global water runoff, and are growing rapidly. Moreover, an increasing fraction of available water is highly contaminated by human or industrial waste. And compounding this problem, the runoff is unevenly distributed. Even in the US, more than ten million acres are irrigated in areas which mine ancient water supplies from shrinking aquifers, and aquifers in Northern China and the Middle East are declining precipitously.

Unfortunately, the changes needed to make water use more efficient often face huge political hurdles. Entrenched agricultural interests have produced a gridlock in the US and in much of the world which is unlikely to be broken absent a catastrophe. The only practical paths for avoiding crisis may be in developing technologies that take advantage of improved plant genetics and irrigation methods to increase agricultural-water efficiency, and in promoting strategies for improving water-use productivity in residential, commercial and industrial applications. A low cost technique for desalinizing ocean or brackish water and for purifying contaminated water could also break through the political morass, and would surely rank as one of the century's key inventions.

Food

A related challenge involves finding ways of feeding 9-10 billion people. Again, the problem is not simply one of increased numbers, but the implication which accompanies a shift to the consumption styles of the affluent. In poor nations, per capita consumption is about 2100 Calories of which about 80% come from grain. US per capita consumption averages about 3700 Calories of which only about 20% is from grain; more than a third comes from animal products. Typically a Calorie of animal products requires an order of magnitude more land than grains. Attempting to reproduce western eating habits worldwide while supporting population growth could drive dramatic growth in food demand, and if American experience is any example, in waistlines.

While demand will surely grow, arable land per person has been declining in recent years—particularly in the most heavily populated parts of the world. Water-logging and salinity, urban sprawl and other factors are the culprits. Only modest amounts of new land may be found in sub-Saharan Africa and in South America by clearing forests and other natural regions but such a strategy introduces other problems.

It's obvious that the growth in demand can only be sustained by maintaining growth in output per acre. Low input, low-till production and other sustainable agriculture techniques are essential for reducing soil loss and use of agricultural chemicals, but it's unlikely that they can, by themselves, achieve needed increases in output per acre. Long term solutions require genetic improvements that can cut inputs and increase land productivity – the research challenge is doing this in a way that is demonstrably safe for the environment and for consumers. It's essential to develop tools for restoring degraded lands and cleaning contaminated aquifers. We might even consider looking for ingenious ways to go beyond consuming primarily the fruits of plants (e.g. grains), that have been the center of productivity research since the beginnings of agriculture, and look for chemistry that can use the glucose in cellulose and other plant constituents that are the bulk of plant biomass to synthesize attractive food products.

Reopening the Frontier

For several generations the world has been able to rely on America for the vision, passion, money and inspired recklessness needed both to imagine and to act. It's not hubris to suggest that it will be difficult for the world to fill the void left if America abandons this historic role, and instead ignores the challenges this century presents. Solutions won't be found with wishful thinking or by relying entirely on private investors—many demand thoughtful public action.

If the US envisions its role as a superpower only in military terms, the world will have lost an essential resource for maintaining hope and

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A New Executive Order on Secrecy Policy

by Steven Aftergood

A Bush Administration executive order on national security classification policy leaves much to be desired from a public policy point of view and will do nothing to curb the Administration's excessive secrecy, though it is not quite as egregious as critics had anticipated.

> "The order does not touch the roots of dysfunction in the classification system, which allow agencies to make extravagantly false classification claims."

In recent decades, whenever the Presidency shifted from one party to another, the new President has issued an executive order on secrecy policy to serve as the foundation of the classification system. Typically, and at least rhetorically, the orders issued by Democratic presidents have emphasized disclosure, while those of Republican presidents have stressed secrecy.

President Clinton's 1995 executive order 12958 dramatically accelerated declassification, inaugurating a process which has now yielded close to a billion pages of historically valuable declassified documents.

The Bush Administration's initiative to craft a new executive order, which began in August 2001, has therefore been a source of anxiety for those who feared that the Administration's predilection for official secrecy would lead to dramatic changes in classification policy.

Bush Administration Secrecy

Secrecy has become a distinguishing trait of the Bush Administration that is acknowledged even by its ideological partners. "An iron veil is descending over the executive branch," complained Rep. Dan Burton (R-IN) in 2001 after the Bush Administration rebuffed some of his inquiries regarding Justice Department oversight.

The barriers to information access are increasingly numerous and diverse. Census data, information about the role of industry in the Vice President's Energy Task Force, and budget estimates for the war on Iraq are just a few of the topics on which battles for access have lately been fought.

Of course, in many cases, there are two sides to the story, as in disputes over disclosures of inventories of toxic materials, for example. Opponents of disclosure argue that indiscriminate release of information could expose security vulnerabilities. (Environmentalists counter that disclosure is a prerequisite to correcting the vulnerability.)

But in other cases, the secrecy is mindless, arbitrary and unwarranted. For example, although the Central Intelligence Agency declassified the intelligence budget totals in 1997 and 1998 (under pressure of litigation), the Agency today says that the same information from 1947 and 1948 must remain classified and would damage national security if disclosed! This extreme case illustrates the bad faith that pervades much of the secrecy system today. (An FAS lawsuit opposing the CIA's claim is pending under the Freedom of Information Act.)

The Bush Administration's new executive order on national security classification, signed in late March, does not eliminate all constraints on official secrecy, as some had feared, but neither does it move beyond the parameters of the Cold War secrecy system into a truly twentyfirst century information policy.

The new Bush order generally affirms the single most important achievement of the 1995 Clinton executive order, which was its

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Fallout

During the lead up to the war in Iraq, several Administration leaks suggested tactical use of nuclear weapons was being contemplated. Michael Levi responded in this article.

By Michael Levi

If you watched the Super Bowl in Washington, D.C., you may have seen an ad warning that war with Iraq could end with the use of nuclear weapons. The spot, produced by the antiwar group MoveOn.org, is a remake of Lyndon Johnson's famous 1964 campaign commercial, which implied that Barry Goldwater might lead the United States into nuclear war. Like Johnson's ad, which was pulled after running only once, the spot indulges in more than a bit of hyperbole but still contains a troubling kernel of truth.

Since taking office, President George W. Bush has dangerously and unnecessarily blurred the line between conventional and nuclear weapons. Prodded by nuclear weapons scientists and a few narrow-minded ideologues—such as Wayne Allard, chair of the Senate Armed Services Strategic Forces Subcommittee, and Curt Weldon, number two on the House Armed Services Committee—the administration has been groping since early 2001 to find military missions for tactical nuclear weapons. In the past few weeks, administration officials have made not-so-veiled threats that the United States might use nuclear weapons against Iraq. These threats have alarmed the public and hurt America's image—and for no good reason: Tactical nuclear weapons have little if any military value.

For much of the cold war, American strategists planned to use nuclear weapons to repel superior Soviet conventional forces. During the Gulf war—despite possessing overwhelming conventional power—military planners considered using nuclear weapons to incinerate Iraqi stockpiles of biological weapons; they eventually settled on high explosives. Indeed, the Gulf war experience convinced many hawkish military thinkers that tactical nuclear weapons had become obsolete. Under the Clinton administration, the preemptive use of nuclear weapons was not official policy. Yet some analysts remained attached to a few niche roles for battlefield nuclear bombs. Two missions topped their lists: destroying underground bunkers and neutralizing the stockpiles of chemical and biological weapons they often contain. Last March, these activists got a boost from the Bush administration's classified Nuclear Posture Review, which argued that "nuclear weapons could be employed against targets able to withstand nonnuclear attack (for example, deep underground bunkers or bioweapon facilities)." Forced to choose between nuking Saddam Hussein and leaving him be, they asked, which would you pick?

Given the immense power of nuclear weapons, it's natural to imagine them easily obliterating underground hideouts. Saddam, for example, is believed to have several underground command centers, though the United States is unlikely to know the details of these bunkers well enough to be able to penetrate them all with explosives. Nuclear bunker-busters, though, are far less effective than most suppose. The Little Boy bomb dropped over Hiroshima—20,000 times larger than Timothy McVeigh's Oklahoma City bomb—destroyed everything within one mile of ground zero. Yet the same bomb detonated against a granite-walled bunker would be at least 30 times less effective. Even the biggest nuclear bomb in the U.S. arsenal—the nine-megaton B-53—would leave some 200-meter-deep bunkers intact.

And that's the good news. To destroy underground bunkers and chemical or biological agents, nuclear weapons must be detonated at or below the earth's surface. Their radioactive products attach to bits of earth and rock, falling back to the ground within minutes or hours, before their radioactivity has had time to decay. For all their physical destructiveness, the nuclear weapons that exploded 1,000 feet over Hiroshima and Nagasaki produced little lingering fallout; people entering the cities immediately after the attacks were unharmed. In contrast, radioactive fallout from a Hiroshima-sized bomb detonated at ground level would kill civilians as far as 30 kilometers downwind; for our nine-megaton bomb, that distance would be increased more than ten-

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fold. That bomb, if dropped in western Iraq, could contaminate cities as far away as Tel Aviv. American troops would have to avoid contaminated zones, complicating battlefield strategy and tactics.

Fortunately, the hypothetical choice presented by nuclear weapons proponents such as Weldon—nuke Saddam or leave him alone—is a false one. Since before the Gulf war, American engineers have been developing an array of techniques and technologies specially designed to attack underground bunkers. While some work has focused on bruteforce solutions—building conventional bombs with bigger blasts and high-speed missiles that penetrate deeper underground—the scientists have also made great strides in learning to disable enemy bunkers without physically destroying them. By collapsing entrance tunnels, severing power lines, bombing communications antennae, and closing ventilation ducts, American forces can "functionally" destroy underground facilities. Special forces, featured in Afghanistan, could play a critical role. In contrast with physically destroying facilities, this strategy would allow American troops to enter bunkers later and collect vital intelligence.

Biological and chemical targets present a different challenge since a U.S. attack could spread deadly agents across the countryside. Indeed, a typical bomb detonated against a facility holding a substantial amount of anthrax could, depending on the conditions, kill as many people as a small nuclear weapon. But again, the apparent choices—incinerate the anthrax with a nuclear bomb but spread radioactive fallout, or spread live anthrax but avoid nuclear fallout—are not the only ones. The United States has developed thermobaric bombs that generate high temperatures in closed spaces, neutralizing exposed spores. Air Force laboratories are also developing potent payloads that chemically neutralize agents on contact. And, if chemical or biological agents are accidentally dispersed, American troops can defend themselves with protective gear. In contrast, special clothing cannot provide complete protection against the radioactive fallout from friendly nuclear fire.

America's greatest weakness is in intelligence, not explosive power. Osama bin Laden survived in Afghanistan not because our bombs were too small but because we could not find him. Most of Saddam's bioweapons survived the Gulf war unscathed not because we feared collateral damage but because we did not yet know Saddam's stockpiles existed; even today, inspectors are unable to find Saddam's biological weapons. And, even if we choose to attack North Korea's nuclear program, we will be unable to destroy its uranium-enrichment facilities, not for lack of weaponry but because we do not know where these sites are.

Political fallout from the use, or even threat, of nuclear weapons elevates this discussion beyond mere technical quibbling. The Bush administration seems oblivious to the irony in using nuclear weapons to fight a war against nuclear proliferation. Certainly, the nuclear taboo is not a panacea—Kim Jong Il and Saddam care little about international norms—but it is still valuable. By needlessly claiming that we need nuclear weapons to fill military holes, we confirm all the worst international stereotypes about a trigger-happy Bush administration, undermine our argument that others should forego them, and weaken our coalitions. We weaken our coalitions by undermining global regimes, such as the Nuclear Nonproliferation Treaty, that our allies strongly support.

The administration's "clarifications" are only making things worse. Following a Los Angeles Times revelation of nuclear contingency-planning against Iraq, the White House sent Chief of Staff Andy Card to "Meet the Press" to explain. After bumbling through a technical discussion of Iraq's nuclear program, Card asserted unhelpfully that the United States would neither rule in nor rule out nuclear attacks. Two days later, responding to reporters in Bishkek, Kyrgyzstan, Assistant Secretary of State for European and Eurasian Affairs Elizabeth Jones—a strange choice for handling this issue—remarked, "Will the United States use limited nuclear weapons in Iraq? The answer is 'No.'" Her carelessly worded comment was promptly interpreted as ruling out limited nuclear strikes (Associated Press), all nuclear strikes (Agence France-Presse), and strikes using nuclear weapons of limited power (Russia's TASS).

Despite the administration's bungled pronouncements, some of its most hawkish backers are getting the right picture. Appearing on "Fox News Sunday" just before Andy Card's interview, Defense Policy Board Chairman Richard Perle argued, "I can't think of a target of interest in a conflict with Iraq that could not be dealt with effectively by conventional weapons, non-nuclear weapons. ... I can't see why we would wish to use a

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North Korea's Missiles – How Great is the Threat?

by Ivan Oelrich

A version of this article first appeared in the Seattle Post-Intelligencer.

CIA Director George Tenet stated that North Korea has a missile that can reach the United States, even though North Korea has not yet demonstrated this capability. Coupled with the crisis of Pyongyang's nuclear weapons, this has lead many to believe North Korea could strike the American West Coast with nuclear weapons. Yet this is not the case. Events in North Korea are indeed worrying, but the public debate is not helped by exaggerating the threat.

Most of our information about North Korean missiles comes from observing flight tests, so we know much about the shorter-range missiles that the North Koreans have flown. But Pyongyang has not tested intercontinental range missiles. Without flight tests, US intelligence analysts can only estimate the sophistication of North Korean technology and the calculated range of any large missile is extremely sensitive to these estimates.

How far a missile can deliver a payload is determined by the efficiency of the engines, the amount of fuel and the weight of the rocket structure and payload. For any long-range rocket, fuel makes up the great majority of the initial weight. The structure is the great majority of the remainder, and the payload is typically a tiny fraction of the total initial weight. Thus, small changes in the estimates of the required structural weight of the rocket or the efficiency of the engines translate into large changes in the mass left for payload. In general, as the range of the rocket increases, the calculated performance becomes ever more sensitive to these technical assumptions.

It is important to distinguish between what is known about North Korean missiles and what is extrapolation. The North Korean short-range SCUD has been exported and the US almost certainly has access to samples of the missile. The single-stage No Dong missile has been tested and thereby also revealed much of its capability. The North Koreans flight tested a three stage space launch vehicle in August of 1998. Most analysts believe that the first two stages are the equivalent of the intermediate-range Taepo-Dong 1 missile. Radar tracking of that single test revealed the performance of the first two stages and, with an estimate of the mass of the third stage, the overall performance of a hypothetical two stage version can be calculated. (The third stage apparently failed, possibly exploded, and the satellite payload did not reach orbit.) The so-called Taepo-Dong 2 is the missile that is claimed to be able to reach the US and it is even more problematic. The second stage could be the same as the first stage of the Taepo-Dong 1, sitting atop a new, bigger, and as yet publicly unknown first stage. However until the missile is flight tested, all information on its capabilities will remain speculative, and intelligence sources can only conjecture as to what the North Koreans can build with available technology.

> **"It is important to distinguish between what is known about North Korean missiles and what is extrapolation."**

A total assessment of the North Korean ballistic missile threat also requires some knowledge of the possible payloads. If the missiles are intended as nuclear weapon delivery vehicles, then advances in nuclear bomb design can have as much of an effect as advances in missile technology. Unfortunately, the US knows even less about North Korea's possible nuclear weapons than it does about its missile technology but estimates that North Korea missiles can reach the US with a nuclear warhead assume quite sophisticated nuclear weapon designs. Until the North Koreans flight test the missile, it is too early speak with any certainty about their ability to reach the Northwest of the US and government officials should be more careful to qualify their estimates of dangers facing the nation.

Author's note: Ivan Oelrich is a senior research associate for the Strategic Security Project at the Federation of American Scientists.

Nuclear Dangers Beyond Iraq

By Michael Levi

Editor's Note: Last fall, Michael Levi wrote that confronting Iraq would address only a small corner of the nuclear danger. As the war on Iraq begins, his observations and admonitions are still timely.

President Bush wisely warns of the danger posed by a nuclear-armed Iraq, but he remains unevenly engaged in other efforts that would stem the spread of nuclear weapons. Saddam Hussein's nuclear potential has been repeatedly cited by the administration as the one unassailable reason why the American people should support an invasion of Iraq. Yet ours is a dangerous stance: If we remove the threat of Saddam Hussein while leaving the rest of our nonproliferation policy unchanged, we will achieve only a marginal improvement in our security against nuclear terror. To make an invasion of Iraq worthwhile, a new investment in nuclear security is urgently needed.

Leading experts and many in the intelligence community agree that Saddam Hussein still needs several years to produce enough highly enriched uranium for a nuclear bomb. Thus, when Vice President Dick Cheney warned that Iraq could quickly obtain nuclear weapons, he could only have been referring to one thing: Iraq might acquire the crucial fissile material it needs abroad, through theft or on the black market.

How much security can we buy by merely removing one customer for this supply? Certainly, Saddam Hussein's nuclear potential is greater than that posed by terrorists working without state support. Intelligence reports suggest that Iraq has the implosion technology needed to make a bomb from 20 kilograms of highly enriched uranium. Al Qaeda, for example, probably does not have such technology and would need three times as much for the simple Hiroshima-type weapon it could master. Other sources indicate Iraq could make a bomb from plutonium; terrorist groups like Al Qaeda most likely could not. For these reasons, Iraq poses a special threat.

That said, our current effort, focused narrowly on Iraq, is woefully inadequate for reducing the nuclear threat. The same uranium Iraq seeks abroad might be bought by terrorists and fashioned into bombs. A terrorist group like Al Qaeda, if it were to obtain a nuclear weapon, would be more likely than Iraq to use it.

And yet our responsibilities in securing nuclear materials are being ignored. A month ago, Ted Turner and the Nuclear Threat Initiative had to pitch in $5 million to evacuate two bomb's worth of poorly secured uranium from Belgrade. House Republicans are pushing for a provision in next year's defense bill that would block the president from spending nonproliferation money outside the former Soviet Union.

Over a year ago, a bipartisan commission chaired by Howard H. Baker Jr. and Lloyd N. Cutler urged that we spend $30 billion over the next 10 years to secure nuclear materials in Russia; at our current spending rate of $1.1 billion per year, we will fall miserably short.

Despite inadequate funding, our programs have been very successful. We have secured the uranium that might have made thousands of bombs and we have kept numerous Russian nuclear scientists from going to work for rogue regimes.

A new investment in nonproliferation would help convince a skeptical world that we're serious about nuclear proliferation — that our obsession with Iraq is about weapons of mass destruction, not domestic politics or oil or revenge. An extra billion dollars spent on nonproliferation would be a tiny fraction of the cost of war in Iraq. If nuclear terrorism visits America, will it be any consolation that the bomb was not Saddam Hussein's?

Author's Note: Michael Levi is director of the Federation of American Scientists' Strategic Security Project

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a nuclear weapon." The Prince of Darkness isn't about to campaign to ban the bomb, but, like most others, he knows that tactical nuclear weapons aren't very useful. It's time Bush learned the same.

Author's Note: Michael Levi is director of the Federation of American Scientists' Strategic Security Project.

PIR

Progress Towards a National Initiative for Information Technology to Improve Learning and Teaching

By Kay Howell

We are making good progress in our efforts to create a major national initiative to transform education, training and lifelong learning through innovative use of advanced information technologies. FAS has joined a national coalition of public and private sector organizations to support an important new national educational research and development initiative, the Digital Promise Project. The project proposes that Congress create a major national trust fund that would be used to sponsor research in learning science and technology, help bring the contents of the nation's libraries, museums, universities and schools into the digital age, and encourage these institutions to teach the skills and disciplines needed for the information-based economy. The proposed fund, known as the Digital Opportunity Investment Trust (DO IT), would do for education in its broadest sense what the National Science Foundation does for science, the National Institutes of Health does for health, and the Defense Department's DARPA does for national defense. The fund would finance this work with revenue from auctions and fees for licenses to the publicly owned electromagnetic spectrum (the frequencies that transit radio and television signals, for example).

The national initiative proposed by DO IT would help make the Internet into an enriched tool for training, learning and public participation. Students could travel through a virtual solar system, and students studying medicine could practice surgery on a digital, anatomically correct, 3-D recreation of the human body. People of all ages could gain access to individual virtual tutors, to improve their reading, language skills, and mastery of math and science. By funding content development and research, the riches stored in our nation's museums, archives and libraries would be accessible to every school, and to the most remote homes in the nation and the world.

Recognizing the need for a national program to support creative research and forge new alliances between corporate and university teams, Congressman Ralph Regula (R-OH) led a Congressional effort that resulted in a $750,000 appropriation to FAS for the Digital Opportunity Investment Trust. Taken in combination with corporate, foundation and other government funding already committed, this will allow us to develop and communicate a detailed plan for a national program. These funds will support the Digital Promise Project's campaign to promote awareness of both the potential and the possibilities offered by educational technology and FAS' Learning Federation Project's preparation of a plan for a coherent research program.

The Learning Federation we are forming is designed to support and manage the kinds of research in learning science and technology that are called for in the national program proposed by DO IT. Our first goal is to develop a research plan, or technology roadmap, that describes the types of learning environments that are possible and outlines the types of projects that should be supported to achieve them. The roadmap is a plan with clear goals and objectives that includes a research agenda with priorities set for the near-, mid-, and long-term and a management plan that will ensure continuous evaluation and feedback of the R&D activities. The roadmap is being developed through an iterative process that includes: literature reviews; interviews with researchers and practioners; and a series of workshops that convene experts from universities, schools, government, corporate training organizations and software publishers. We are developing individual roadmaps for specific research focus areas, including: learning science and technologies, learning tools and evaluation and assessment. Three workshops have been completed: Question Generation and Answering Systems for Technology-Enabled Systems; Instructional Design

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for New Technology-Enabled Approaches to Learning; and Open Architectures and Interoperable Simulations for Exploration Based Learning. A workshop on User Modeling and Assessment is scheduled for May. A final comprehensive roadmap will be assembled from the work of these components, and is scheduled for publication September 2003.

Follow our progress via the Learning Federation link on the FAS website, www.fas.org and www.digitalpromise.org. We encourage your support for this important investment in the future of American education.

Author's Note: Kay Howell is Director of the Learning Federation Project at the Federation of American Scientists.

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A New Executive Order on Secrecy Policy— Continued from Page 10

aggressive declassification regime for historically valuable documents that are 25 years old or older. The order includes a provision for automatic declassification of 25 year old documents, of which there are many millions, but will defer its effective date from April 2003 until December 31, 2006.

The new executive order also preserves the Interagency Security Classification Appeals Panel (ISCAP), which has proven to be an exceptionally powerful tool for correcting classification abuses by subjecting them to the scrutiny of an interagency review panel. The new order will somewhat blunt the ISCAP's effectiveness, however, by permitting the Director of Central Intelligence to reject Panel rulings unless he is overridden by the President.

The order directs that "the unauthorized disclosure of foreign government information is presumed to cause damage to the national security" and such information would therefore be presumptively classified, which has not previously been the case.

It includes the new category of "infrastructure" vulnerabilities as potentially classifiable information, and it would ease the reclassification of previously declassified information.

"It could be a lot worse," several officials spontaneously agreed. "Keep in mind that this is the Bush Administration we're talking about, it's post 9/11, and we're about to go to war," said one agency official. "It could be a lot worse."

It could also be a lot better.

The order does not touch the roots of dysfunction in the classification system, which allow agencies to make extravagantly false classification claims. Strengthening and expanding the ISCAP review process, rather than curtailing it, might have been one way to improve the correction of classification errors and abuses.

More fundamentally, the order is a vestige of a Cold War information policy that is now obsolete and increasingly counterproductive. It could have been implemented without any problem thirty years ago, but is simply oblivious to the implications of the information revolution of the past decade.

Not only do the order's authors fail to acknowledge the qualitative distinction between old fashioned paper records and digital data, they do not know what Senator Richard Shelby has lately pointed out: namely, that imposing a strict "need to know" standard of information control can diminish information's utility, and must inevitably exclude many of those who could productively exploit it to the detriment of national security.

Author's Note: Steven Aftergood directs the FAS Project on Government Secrecy. A version of this article was published as an op-ed in The Forward on March 28, 2003.

PIR

Science, Public Enterprise and *Scientific American*

by Gerald Piel

The following article is an excerpt reprinted from Gerald Piel's book: *The Age of Science: What Scientists Learned in the Twentieth Century*, published by Basic Books in 2001.

Purchase of the product

Since 1945, the outlay on the promise of product from science—weapons and pharmaceuticals, in particular—has mounted to a cumulative total approaching $500 billion in 1990 dollars. In the first flush of postwar enthusiasm and rising appropriations, the granting agencies of the federal military and para-military and health departments construed their missions broadly to cover the most remotely relevant enterprises in fundamental research. Since 1970, funding from those sources has been going to ever more narrowly construed "mission-oriented" projects. It has gone to support projects, not scientists, and for the short term, not for the long term of sustained scientific inquiry.

Until the 1980s, the National Science Foundation disbursed less than 7 percent of the annual federal expenditure for science. Its budget climbed then into the billion-dollar range after it was charged to install "institutes" for the promotion of U.S. "industrial competitiveness" in the universities. The agency otherwise has managed to grant half the applications approved by peer review a quarter of the funding requested.

Public expenditure on product from science meanwhile got its money's full worth. U.S. industrial supremacy is owing, in no small respect, to the high technology purchased incidental to the country's expenditure of $18.7 trillion (1996 dollars) on its military establishment over the long course of the Cold War arms race.

In the settling of federal "science policy," the universities and the scientific community have their complicity. They did not seize the opportunity for public education in science represented by the proper argument for the outlay of $500 billion of public funding. They went along with the case for utility and its ready appeal to Congress.

Freely motivated inquiry

Federal funding has been directed, in consequence, to less than the full spectrum of freely motivated scientific enterprise. In this respect, it is notable that the plant sciences—not of interest to the defense or health department—withered in all but the few universities where botany was well and restrictedly endowed.

On the sheer volume of the funding, on the other hand, science in the U.S. has flourished. So the Nobel prize scoreboard testifies year after year. Yet, after half a century, the federal commitment to the support of science amounts to no more than a small fraction of the government's annual expenditures for the purchase of science. Presently, this funding, along with the rest of the country's investment in human and material resources, is in decline.

That decline has been in part offset, to the greater peril of freely motivated open scientific inquiry, by market-motivated industrial financing. The intrusion of the market compromises work in the life sciences especially. Whole university medical-school departments now operate as subsidiaries of pharmaceutical companies. They are generously funded under agreements that induce or compel restraint on publication and the open communication that is the life of competitive collaboration in science. Intellectual property formerly deeded to the community is now private property. The choice of question to be investigated turns on the movement of NASDAQ exchange. The ablest scientists—in particular young scientists framing their first venture—find it increasingly difficult to do what they really want to do.

SCIENTIFIC AMERICAN had much to report over those decades on the new technologies that supply public verification of the advance of science. From the first demonstration of the "transistor" at Bell Telephone Laboratories, reported in our pages in 1948, the magazine tracked the solid-state revolution in electronics and its ramifications into every economic activity. The latest editions of the computer chip put millions of transistors and equivalent circuits to

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work. Now, in accordance with predictions made in 1960 from the data placed in reach of computer analysis by Leontief interindustry tables, ever more powerful computers are downsizing the clerical and middle-management pay-roll.

The computer is only part of the story. With elegant electronic sensors on the input side and electromechanical actuators on the output side of the computer, automatic production increasingly replaces people in the "process" industries. In 1990, the petroleum refining industry employed half as many "production" or blue-collar workers as it did in 1950, while multiplying its output by three. The steel industry reduced its production payroll by half while producing the same ingot tonnage. The percentage of the U.S. labor force employed in production functions declined from more than one-third in 1950 to less than 20 percent in 1990. White-collar professional replaced them.

The flat production of steel between 1950 and 1990—in an economy that multiplied its total output four times—signified another impact of the new physics. Understanding of the structure of matter from the inside displaced and replaced materials in their traditional end uses. By 1960, organic plastics overtook steel in bulk; a decade later, in tonnage. Ceramics reinforced by microscopic carbon fibers—on the ancient model of bricks made with straw—stood up to fiercer heat in turbine blades. The optical-glass fiber—another triumph of the late Bell Telephone Laboratories—began to take over from copper in the communication systems, piping photons in place of electrons.

The habit of consensus

In 1952, a single-topic issue of SCIENTIFIC AMERICAN reported on the economic and social consequences of this impending revolution. The reconstruction of the labor force and the declining compensation paid to labor, in white as well as blue collars, now excite political concern for the well-being of the "middle-class," which now means higher-paid wage-earners. This country and the rest of the industrialized world face questions not yet articulated about purpose, value and equity in securing the blessings of the workless economy.

On the questions of the arms race and its control, so much at the center of public concern over all those years, the country is indebted to the consensus-forming habit of the scientific community. This is belied by the mass-media coverage of these issues. The media give equal time to the consensus and to the dissenting maverick and kook, often a spokesperson for an economic interest in the issue. By way of balance, we reserved the pages of SCIENTIFIC AMERICAN for the consensus.

The lay public, including its representatives in Congress, had independent counsel, therefore, on the arcane technical issues of the arms race and arms control from authorities as fully informed as the official security-cleared "defense intellectuals." Our authors made public record of the ominous transformation of our country's "nuclear deterrent" from retaliatory to first-strike weaponry during the 1960s. They exposed in hard numbers the lunatic stockpiling of tons of nuclear explosives that perpetuate, in the now-prevailing international anarchy, the peril to civilization laid by mutual assured destruction. The publication of these articles in our Russian-language edition, V MIRE NAUKI, shows the consensus-forming habit of the community to be international.

Beginning with an article on the Amazon frontier in its second issue, the new SCIENTIFIC AMERICAN kept the interlocking determinants of the world future—population, environment and development—under surveillance. I still hope to see recognition in U.S. public policy of the concept, first published in the magazine in 1955, of the "demographic transition," of the transit of the population:

a) from near-zero growth at high death rates and high birth rates and life expectancy of less than 30 years;

b) through the population explosion;

c) to near-zero growth again at low death rates and low birth rates and life expectancy exceeding 70 years.

The 1.25-billion population of the industrialized countries has already arrived at zero growth. If all goes well, every indicator says that the rest of the world population may complete the transition to bring population growth to a halt by the end of the 21st century. The population explosion sustains in public understanding, however, the Malthusian vision of population growth to self-extermination in the war of all against all. That vision continues to determine the foreign policies of nations, including our own.

International conventions now recognize what SCIENTIFIC AMERI-

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CAN authors began telling their readers 30 years ago: combustion of fossil fuels exacts the principle cost and peril laid to the environment by industrial civilization. The fourfold multiplication of energy consumption since 1950 has increased the carbon dioxide input from human activity to more than 25 percent of the planetary atmospheric turnover. The next fourfold increase in energy supply necessary to carry the rest of the world population through the demographic transition cannot conceivably be secured from fossil fuels. Alternative primary energy sources—including photovoltaic conversion of solar energy and extraction of solar energy stored in the ocean and not excluding nuclear power—were all appraised for our readers in time to have allayed the present international anxiety. In the words of the British molecular biologist P.B. Medawar, "Problems caused by technology must, by definition, be cured by technology."

Warren Weaver, in the September 1953 issue of SCIENTIFIC AMERICAN, declared the hope that "the citizens of a free democracy, understanding and prizing the work of science, will provide the support and terms of support that will cause science to prosper and bring its benefits, power and beauty to the service of all the people." As bursar for the sciences at the Rockefeller Foundation from 1932, Weaver had administered the principle fund—a few million dollars a year—that supplemented university science department budgets before the Second World War. That September issue was devoted to "Fundamental Questions in Science." Weaver's concern, shared by the editors, was with the terms on which the large and growing expenditures by the federal government were then flowing to support the work of science in the country's universities. That work, reported by the scientists engaged in it, principally filled the pages of SCIENTIFIC AMERICAN and brought readers to those pages.

Author's note: Gerard Piel is the founder and former publisher of SCIENTIFIC AMERICAN and long-time supporter of FAS. He is the author of numerous books and was the recipient of over twenty honorary doctorate degrees and a host of other honors and awards.

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The Politics of Hope and the Politics of Fear — Continued from Page 9

for creating a constructive, pragmatic vision for the future. It is plain foolishness to believe that goodwill alone can substitute for a good defense. But defense built entirely on intimidating our adversaries is surely not sufficient for building a secure long-term future. For this, the US must again be viewed as a nation willing to work closely with an international community and lead with its relentless hope in endless frontiers.

Author's note: Henry Kelly is the President of the Federation of American Scientists.

PIR

New Board Members Introduced at Annual Meeting

On December 13, 2002, FAS officially introduced six new members to its Board of Directors at the organization's annual meeting.

The following members were elected by the FAS membership in June 2002:

- Rosina Bierbaum, Dean and Professor at the School of Natural Resources and Environment, University of Michigan.
- Tara O'Toole, Director of the Center for Civilian Biodefense Strategies and member of the faculty of the School of Hygiene and Public Health at Johns Hopkins University.
- Steven Weinberg, Nobel laureate and Professor of Physics and Astronomy, University of Texas at Austin.

Additionally, three new members were appointed and confirmed at the meeting:

- Lawrence Grossman, former president of NBC news and PBS, advertising agency owner, holder of the Frank Stanton First Amendment Chair at the Kennedy School ofGovernment,, senior fellow and visiting scholar at Columbia University.
- Judith Reppy, Associate Director of the Peace Studies Program and Professor of Science & Technology Studies at Cornell University.
- Maxine Savitz, member of numerous Energy advisory boards, including the Energy Advisory Board, the Department of Energy's Laboratory Operations Board, the American Council for Energy Efficient Economy, the American Association for the Advancement of Science, the National Academyof Engineering and the National Science Board.

We welcome our new board members and look forward to their support and leadership over the next three years.

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Attention FAS Members!

In our continuing effort to provide FAS members with lively and timely articles in national security policy and other areas of science and technology policy, we are inviting members to submit proposals for articles in areas of interest to FAS members (maximum 1000 words). Selection of the articles is at the discretion of the Editor. Completed articles will be peer reviewed.

Proposals should be sent to the Editor, PIR, Federation of American Scientists, 1717 K St. NW, Suite 209, Washington, DC 20036, or to fas@fas.org. Please provide us with your full address including email in all correspondence.

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