

substantially in preindustrial times.^{2,4} The variability suggests that climate is strongly sensitive to solar change and more weakly sensitive to anthropogenic emissions than presently estimated. Thus our research and several new findings appear to indicate that the IPCC's conclusions need significant revision.

References

1. A. Moberg et al., *Nature* **433**, 613 (2005).
2. M. E. Mann, R. S. Bradley, M. K. Hughes, *Nature* **392**, 779 (1998); *Geo. Res. Lett.* **26**, 759 (1999).
3. T. J. Crowley, *Science* **289**, 270 (2000).
4. C. Loehle, *Energy Environ.* **18**, 1049 (2007).

Nicola Scafetta
(ns2002@duke.edu)

Duke University
Durham, North Carolina

Bruce J. West
(bruce.j.west@us.army.mil)

US Army Research Office
Research Triangle Park, North Carolina

Constraining potential bomb builders

According to Alisa Carrigan's Opinion piece, "Learning to Build the Bomb" (PHYSICS TODAY, December 2007, page 54), to prevent proliferation of nuclear weapons, knowledge of nuclear power should be kept from scientists and engineers of potentially rogue countries. I would like to comment on her line of reasoning.

First, nuclear weapons are not the only threats to world peace. Chemical and biological weapons are as dangerous as nuclear weapons. So the restriction should not be limited to nuclear physics and related areas of knowledge; various fields in chemistry, chemical engineering, pharmaceutical and biological sciences, physics, and mechanics must also be off limits. After that come certain fields of mathematics—for example, number theory—and software engineering because they have applications in cryptography. Just imagine some terrorist hacking into a computer that is controlling, for instance, airplane traffic. Even quantum computation is dangerous because it has applications in deciphering. Where should one stop?

Carrigan distinguishes between explicit and tacit knowledge. But there is no permanent sharp line between the two. For example, Carrigan mentions the need to use fabric gloves to assemble centrifuges; since that information

has now been published, it has been transformed from tacit to explicit. Since people have access to explicit knowledge through books and journals, it is not sufficient to monitor the sources of tacit knowledge. To prevent proliferation of the required knowledge, the flow of explicit knowledge must be controlled as well. That requires establishing a system of censorship.

I think the logical consequence of accepting Carrigan's idea is a kind of "knowledge nonproliferation treaty." Such a system, if implemented, simply means that people are divided into two categories: those who have the knowledge of making nuclear, chemical, and biological weapons and those who do not. The first category, by this system, has the right and responsibility to block the second group's access to the required knowledge and technology. I think that is simply a variant of apartheid. It would force people in the second category—the "have-nots"—to invoke dirty tricks to get that knowledge. Scientific apartheid doesn't work and is not a suitable means to establish a sustainable peace.

Today, contrary to, say, 100 years ago, even people in developing countries have access to the basics of the scientific method and the fundamentals of science. From those foundations it is, in principle, possible to produce the forbidden knowledge, just as scientists in the developed countries have done. So a knowledge nonproliferation treaty does not help. Because knowledge is not only transported but also produced, it is now almost impossible to impose a knowledge blockade.

Let us consider that problem from another point of view. The case of South Africa's nuclear program is worth discussing. Why did South Africa make weapons and then destroy them? I think the answer is that four decades ago South Africa was having trouble with its neighbors—and with its own people as well. After the apartheid era, the troubles being greatly diminished, South African officials no longer saw the need for nuclear weapons.

Which other countries have made nuclear weapons? North Korea, because of its standoff with South Korea; Israel, because of trouble with all its neighbors; Pakistan and India, because of their long-standing animosity. Carrigan points out that all those nations were able to obtain the required knowledge, and from nonmilitary activities. My conclusion is that if some nation has enough motivation to build a dangerous weapon, it probably can obtain the

knowledge to do so. If we want to build a sustainable peace, why not try to reduce the nations' motivation to have weapons?

Ahmad Shariati
(shariati@mailaps.org)
Alzahra University
Tehran, Iran

Carrigan replies: Ahmad Shariati makes several valid points in his letter, but most of them are not logical extrapolations from my argument.

For example, he writes that any branch of science or mathematics could be implicated in the process of building nuclear, biological, chemical, or conventional weapons or of hacking into computer systems. That is true: Whatever can be used can be misused, and every branch of science is therefore potentially at risk of being hijacked for malevolent purposes.

Shariati thinks that condition must necessarily lead to a "knowledge nonproliferation treaty" to keep the people that do not possess knowledge to create nuclear, biological, or chemical weapons from obtaining it. But that is in direct contrast to my own conclusions. I wrote, and still believe, that "it is unlikely that the international community can stop the dissemination of nuclear weapons knowledge altogether," or stop the spread of any other type of scientific knowledge. My research indicated that a driven state will find ways to acquire the tacit and explicit knowledge it needs. For precisely that reason I proposed not a knowledge nonproliferation treaty but several steps that might help the international community better track the spread of nuclear weapons knowledge and thereby have a better understanding of who is working on what.

On Shariati's final question, I agree most completely. Attempting to stop proliferation is simply treating a symptom; the disease itself—the political and security drivers motivating states to acquire nuclear weapons—must also be addressed. But I think it is wise to treat both the symptom and the disease simultaneously, especially in this case. I am well aware that nonproliferation policies do not present a final solution to the problem of nuclear weapons, but I also believe it would be negligent to ignore proliferation entirely to focus on quelling states' desires for nuclear weapons.

Alisa L. Carrigan
(alisa.carrigan@gmail.com)
International Atomic Energy Agency
Vienna, Austria ■