



ANIL KAKODKAR INTERVIEW

Breaking Up (a Nuclear Program) Is Hard to Do

India nuclear chief Anil Kakodkar has no apologies for staking out a tough line on implementation of a landmark India-U.S. nuclear pact—even if that sinks the deal

NEW DELHI—Anil Kakodkar is a legendary figure in India's rise to nuclear statehood. Now pressure is building on the self-described technocrat to prove his diplomatic mettle as well. A historic nuclear agreement between India and the United States is riding on India's plan to segregate its nuclear establishment into civilian and military components (*Science*, 20 January, p. 318). As chair of India's Atomic Energy Commission in Mumbai and secretary of the Department of Atomic Energy, an agency with 65,000 staff and a \$1.2 billion budget, Kakodkar has been asked to draw the civil-military line.

The stakes are high. The India-U.S. agreement, signed on 18 July 2005, would end a 30-year embargo on nuclear trade with India stemming from its refusal to sign the Nuclear Nonproliferation Treaty. As part of the deal, India has committed to designating which of its nuclear facilities are civilian and can be placed under international monitoring. Those labeled military would be neither under safeguards nor eligible to receive imported nuclear technologies or fuel. Before the agreement can go ahead, the U.S. Congress must amend laws; congressional action will hinge on acceptance of India's separation plan.

In negotiations since December, India has taken a hard line, tagging all nuclear R&D facilities, including its fast-breeder reactors, as military. In a sign of how fraught the talks have become, Kakodkar acknowledges that India

and the United States may fail to reach an accord: "India's nuclear program will go on with or without the cooperation," he says.

How much India compromises will depend on Kakodkar, a mild-mannered but tough negotiator who assiduously avoids the spotlight. Kakodkar, 63, trained as a mechanical engineer before joining India's premier nuclear weapons lab, the Bhabha Atomic Research Centre (BARC), in Mumbai in 1963. He says he leads a spartan life, having spent 18 hours a day over the past 4 decades "living atomic energy." He takes pride in having overseen the design of reactors, including the 100-megawatt Dhruva research reactor, which produces plutonium for the country's arsenal, and future reactors unique to India that will run on thorium.

Kakodkar spoke last week with *Science* about everything from the separation plan to India's refusal to contribute real-time seismic data to an evolving Indian Ocean tsunami warning system (*Science*, 9 December 2005, p. 1604). The following transcript was edited for clarity.

Q: What is happening with the Indo-U.S. nuclear deal? Is the separation plan the sticking point?

The determination of what is in the civilian domain ... is an Indian determination, and we think that we have done a very objective job. That is what is under debate right now.

◀ Mild-mannered but hard-nosed. The fate of a landmark India-U.S. nuclear agreement appears to rest on Anil Kakodkar's judgment of how much of India's nuclear establishment can be placed under the watchful eyes of international inspectors.

Q: You are not averse to the idea of separation?

No, not at all. But at the same time we cannot allow our strategic interest to be determined by others. We have never had any problem in getting reactors or fuel from outside and putting them under safeguard. We have done that in the past, so we can do that again. We will put some of the indigenously built reactors also under safeguard. But then I have to maintain some proportion outside safeguards, and that proportion has to be based on a good strategic calculation. Now, if somebody says, 'No no, you should put this also under safeguard,' then there is a problem. This is what is under discussion.

Q: If you need plutonium from a military reactor to fuel the fast-breeder reactors, does this linkage mean that the breeders cannot be monitored?

That is absolutely the point.

Q: So categorically the breeders will not go under safeguards?

No way, because it hurts our strategic interest.

Q: The strategic interest of security or strategic interest of energy security?

Both. It hurts both because it is linked through the fuel cycle. Putting the Fast Breeder Program on the civilian list would amount to getting shackled, and India certainly cannot compromise one security for the other.

Q: Is your strategic need for plutonium not met by CIRUS [a research reactor that India acquired from Canada in 1956] and Dhruva? Do you need additional capacity from civilian reactors?

Yes, very clearly. Not from civilian reactors, but from power reactors.

Q: But then where is a compromise likely, with the United States insisting that you put the breeders and part of your power reactors under safeguards?

We have to discuss that logic. In fact, it goes beyond the July 18 statement. It amounts to changing the goalposts.

Q: What amounts to changing the goalposts? Asking for the breeders under safeguards?

Asking for a specific thing to be put under safeguards. That amounts to changing the goalposts.

Q: If the political leadership demands it, would you be willing to accept changing the goalposts?

Where is the question of my willingness? I am a

technocrat, and I will point out all the ramifications. It is as simple as that.

Q: So what will happen to CIRUS? Why isn't it on the civilian list?

With CIRUS we have gone through a whole refurbishing, everything has been changed.

Q: Anything original left, other than its name?

Well, I think there is some concrete somewhere. But, jokes apart, it has undergone substantive refurbishing. The second point is that CIRUS is located in BARC, which is a strategic facility. We maintain that CIRUS has always been in use for peaceful purposes. At the same time, you cannot put CIRUS under safe-

guards simply because it is inside BARC.

Q: If the nuclear pact is realized, do you foresee joint reactor development with the U.S.?

Let us not speculate too much; it would be day-dreaming. India will build its own innovative reactors—that much I can tell you.

Q: What is your view on sharing seismic data?

The waveforms of earthquakes contain a lot of information, and some locations could be sensitive. What is, after all, seismic monitoring? You get information on a disturbance in the earth, measured at some location. This measurement contains both information related to the source of the dis-

turbance and information related to the path through which this disturbance travels up to the measuring point. You have to have policies that if the earthquake is more than some magnitude, data are released. Many countries do this. So we should have our own policy. That does not mean that we are against stopping everything, but it cannot be a free-for-all.

Q: You are willing to consider a change in the policy?

There is no policy. The point is, let there be some policy, and things should be done according to that policy.

—PALLAVA BAGLA



Fishing for Common Ground

Biomedical and basic researchers who study fish face challenges in combining forces to understand development and evolution

When a traditional fish biologist meets a zebrafish researcher, things don't always go swimmingly. The former cares about how fish behave in their watery world and how evolution has shaped piscine diversity. The geneticists and developmental biologists who study zebrafish generally have a biomedical bent. "We tend to think of it as a wet mouse with a transparent embryo," says John Postlethwait, a zebrafish expert at the University of Oregon, Eugene. "We tend to have very little appreciation for our organisms as fish."

But as a recent meeting in Orlando* made clear, the two camps are increasingly finding

common water. For more than a decade, the zebrafish has been one of several crucial model organisms for developmental biology (*Science*, 30 August 2002, p. 1484). Its genome is already sequenced, and there are many molecular techniques to help researchers glean this species' biological secrets, and in turn, better understand all vertebrates, including humans. Those tools are now proving seductive to biologists trying to understand the genetic basis of all fish evolution. At the same time, the zebrafish community is beginning to realize that examining different fish species can help them understand the functions of the genes they find.

Take Mark Cooper, a developmental biologist at the University of Washington, Seattle. "I need an ancient fish," he announced at a

Fish sense. Gars (*left*) can help zebrafish researchers understand the evolution of development.

roundtable session in Orlando set up to build bridges between the two fish factions. Cooper has studied how the first embryonic cells begin to establish a body axis in the zebrafish, and he is retracing the history of this key developmental step, called gastrulation, by looking at the process in other fish. "How about a gar?" Richard Mayden, a systematist at Saint Louis University in Missouri, piped up. "I've got a contact."

Cooper was ecstatic. He's been working through branches of the fish family tree looking at similarities and differences in gastrulation but has not been able to reach the lower, oldest limbs. Gar, long, narrow fish with sharp teeth whose fossil history traces back to the Permian, are a perfect complement to other species he's been examining. The ability to look at a developmental process in multiple species "opens up a huge window into the past," says Cooper.

Smoothing rough waters

Traditional fish biologists pride themselves on a great respect for their organisms, focusing on a fish's natural history and its phylogenetics. Yet they sometimes have a fear and loathing of molecular endeavors, says Jacqueline Webb, a fish biologist at Villanova University in Pennsylvania. Comparative biologists also concentrate on adult morphologies and behaviors, and their raw material is physical specimens, often from collections in natural history museums. Biologists working on zebrafish, on the other hand, tend to focus on early development and prefer to compile their data as digital images. Given such differences, until recently, "neither community has felt there is much to discuss," says Paula Mabee, an evolutionary developmental biologist at the University of South Dakota, Vermillion.

Efforts such as the Cypriniform Tree of Life Project, which Mabee helps coordinate,

* The annual meeting of the Society for Integrative and Comparative Biology was held in Orlando, Florida, 4 to 8 January.