INDIA

Missing Generation Leaves Hole in Fabric of Research

Top fellowships go begging and outside hires stir controversy as India wrestles with a shortage of talent for leadership positions

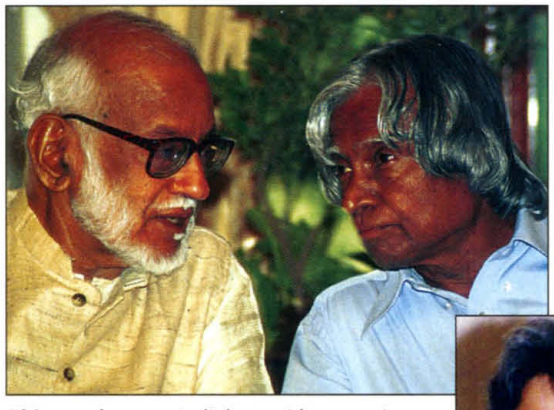
NEW DELHI—The first atmospheric neutrinos were detected nearly 4 decades ago in an Indian gold mine 3 kilometers underground. The team performing the experiment was led by physicist M. G. K. Menon, who went on to a distinguished career that included a stint as India's science minister. But this month, when the Nobel Prize in physics was awarded to a U.S. and a Japanese scientist for pioneering research in understanding these elusive particles (*Science*, 18 October, p. 527), India's contribution to the field rated barely a footnote. The experimental facility in the Kolar mine has long since been shuttered for budgetary reasons, and Indian scientists are nowhere near the forefront of this suddenly red-hot area of astrophysics.

India's slide in neutrino science is symptomatic of what Menon and others have labeled a "missing generation" of Indian scientists. "There is a lack of leaders in the age group of 45 to 55 years," says C. N. R. Rao, a former science adviser now at the Jawaharlal Nehru Centre for Advanced Scientific Research in Bangalore. The problem was triggered by a serious brain drain to the West that began in the 1970s and has been compounded in recent years by talented students bypassing science for better paying fields. The phenomenon takes many forms, from a dearth of worthy candidates for a prestigious midcareer research fellowship to consternation over the pending appointment of the first outsider to lead one of the country's flagship labs, the Tata Institute of Fundamental Research (TIFR) in Mumbai. It's also contributed to a graying at the top of the scientific hierarchy.

"Without question there is a certain crisis," says Menon, a member of the TIFR search committee that chose Shobo Bhattacharya, a 51-year-old Indian-born condensed matter physicist who has spent his entire career in the United States, most recently at the NEC Research Institute in Princeton, New Jersey. Ironically, the crisis comes as a scientist, aeronautical engineer A. P. J. Abdul Kalam, holds the largely ceremonial position of president for the first time in history and the science minister, physicist M. M. Joshi, is a member of the Cabinet of Prime Minister A. B. Vajpayee.

Menon's assessment is based on current trend lines, which point downward. India lags far behind China and most other Asian nations in the percentage of its college graduates who major in the natural sciences and engineering, according to data compiled by the U.S. National Science Foundation. In addition, the government allowed funding of university research to stagnate for much of the past decade. The result has been a decline in productivity. A recent international study of scientific publishing, for example, found that the number of Indian papers in peer-reviewed journals had dropped by 24% since 1980 and the country's global ranking had slipped from eighth to 15th, despite its status as the world's second most populous nation.

"With our scientific output on the decline, this [leadership crisis] was inevitable," says Goverdhan Mehta, director of the Indian Institute of Science in Bangalore and incoming president of the International Council of Scientific Unions. "And the problem is going to become even more acute." Some scientists see Bhattacharya's selection, which awaits final approval by the prime minister, as the final straw.



Thin at the top. India's president, engineer A. P. J. Abdul Kalam (*above*, right), and physicist M. G. K. Menon (*above*, left) are part of a shrinking corps of homegrown senior science managers; Shobo Bhattacharya (*right*) was recruited from the United States to head the Tata Institute for Fundamental Research.

One program already feeling the effects of the talent gap is the government's premier midcareer fellowship program. Begun in 1997 to mark the country's 50th anniversary, the Swarnajayanti (Golden Jubilee) Fellowship program offers research funding, salary supplements, and generous travel allowances to top scientists between the ages of 30 and 40. But only five of the 25 slots, on average, are filled each year because of a lack of qualified candidates. Demand is not the problem: This year, for example, 411 scientists applied for the lucrative fellowships.

Some scientists say that the age ceiling should be lifted to allow more experienced scientists to apply. But Valangiman Subramanian Ramamurthy, a nuclear physicist and secretary of the Department of Science and Technology, says that enlarging the pool would undermine the objective of identifying and nurturing promising talent. He also rejects the idea of settling for less than the best: "There can be no compromise on quality just to make up the numbers," he insists.

Several Asian countries, including aspiring powerhouses such as China, Taiwan, South Korea, and Singapore, have acquired world-class talent by tapping native-born researchers now working abroad. That approach, which can be a quick way to infuse new blood into tired institutions and foster international collaborations, makes sense to Raghunath Anant Mashelkar, a polymer scientist and director-general of the Council of Scientific and Industrial Research. "Ruthlessly go for best," he says about such efforts.

But the strategy is controversial in India, where many scientists see the hiring of such recruits as an implied criticism of domestic talent. "It is inconceivable that excellent scientists with adequate administrative skills working in India were not available for the job [at TIFR]," says Padmanabhan Balaram, a molecular biophysicist at the Indian Institute of Science in Bangalore and editor of the well-regarded journal *Current Science*. He and other scientists also fret that Bhattacharya's unfamiliarity with the notorious Indian bureaucracy could put him at a disadvantage in battling for resources.

Menon says that the search committee looked high and low for domestic talent, even perusing the membership lists of the country's scientific academies, before deciding upon Bhattacharya. Bhattacharya, who studies the dynamics of complex and cooperative systems, declined to discuss his plans for the institute until his appointment

CREDITS: (TOP TO BOTTOM) P. BAGLA; TIFR

has been finalized. But he suggests that he will cast a wide net, telling *Science* that "TIFR must engage the public in its vision of the future of science in India and India's role in the global science enterprise."

Whereas the TIFR appointment has generated considerable discussion, the Department of Atomic Energy caused barely a ripple last year when it chose an Indian-born U.S. citizen to lead another prominent institute within its fold, the Harish-Chandra Research Institute in Allahabad. Ravi Kulkarni, a mathematics professor at the City University of New York, says he had to demonstrate his Indian roots before being picked for the job. "I think that they wanted to make sure I was not a CIA agent," Kulkarni told an audience of Asian-American scholars this summer at a symposium in New York. In the end, he says, his extensive knowledge of Indian philosophy and the Sanskrit language won over his future employers.

The slim pickings within the domestic ranks have meant longer tenures for those at the top. With the exception of Anil Kakodkar, secretary of the Department of Atomic Energy, the secretaries of seven major scientific departments have exceeded their scheduled terms, including those at the departments of science and technology, biotechnology, space, and ocean development; the Council of Scientific and Industrial Research; the Indian Council of Medical Research; and the Defence Research and Development Organisation. When they do step down, warns Pavagada Venkata Indiresan, a former director of the Indian Institute of Technology in Chennai, their successors might be career bureaucrats, as has already happened at two ministries.

Given the magnitude and duration of the shortage of senior talent, Indian scientists are not expecting any quick fixes. But they agree that the problem can no longer be ignored. "All the government agencies should have a discussion and arrive at an action-oriented program," says Rao. "This is a matter of serious concern."

—PALLAVA BAGLA

MEETING THE INSTITUTE FOR GENOMIC RESEARCH

Gene Researchers Hunt Bargains, Fixer-Uppers

BOSTON, MASSACHUSETTS—Technology buffs, bioinformaticists, and hard-core experimentalists rubbed elbows here 2 to 5 October at TIGR's 14th International Genome Sequencing and Analysis Conference. They met to discuss better ways to gather and use genomic information, a vast array of which is now at their fingertips. Highlights included discussions of chromosome evolution and new low-cost sequencing approaches.

Do-It-Yourself Repair Kit

Men have a reputation for trying to fix things without asking for help from others. The same might soon be true of the Y chromosome, that knobby piece of the human genome that makes men men, says David Page, a geneticist at the Whitehead Institute for Biomedical Research in Cambridge, Massachusetts.

Some biologists have theorized that the Y chromosome is destined to decay because it lacks a twin to help it keep its genes intact. Other chromosomes come in pairs that intertwine during meiosis. This allows matching genes, or alleles, in one chromosome to change places with their doubles. This recombination sheds faulty DNA and keeps each chromosome pair well matched. Females carry two X chromosomes, enabling X's to recombine, but males carry an unmatched X and Y. "If a piece [of DNA] does not participate in crossing over, then its genes begin to rot," Page explains.

But now Page and his colleagues have discovered that the Y chromosome does have matching genes—within itself. These repeated genes might allow the Y chromosome to somehow fix problem DNA. It seems this chromosome has "taken out an insurance policy," says Stanley Letovsky, a bioinformaticist at Boston University.

The new find might improve the Y chromosome's reputation. "For centuries, the Y chromosome has been called a junk heap," Page points out. A few genes at its very tips are similar enough to genes at the tips of the X chromosome to successfully recombine. Researchers have proposed, though, that with no apparent way to swap out harmful mutations on most of its length, the Y chromosome has become ever more dysfunctional, full of dead or dying genes. Indeed, some geneticists have gone so far as to predict that the Y chromosome will one day self-destruct, perhaps taking males with it. A superficial view of the chromosome seems to confirm this dire warning: More than half of its 59 million bases are apparently meaningless sequence.

But when Page and his colleagues sequenced 24 million Y chromosome bases that do contain genes, they found a surprise. About one-third of that DNA consists of complex blocks that are repeated two or more times along the chromosome, Page reported at the meeting. Furthermore, the blocks tended to be arranged in eight huge palindromes. Each is composed of coding regions that are mirror images of each other, separated by small spacers.

The few Y chromosome genes that are shared with the X chromosome, in contrast, tend to exist as single copies. They are active in many types of cells, carrying out a variety of housekeeping functions. The genes in blocks thus far appear to be active only in the testes.

Page and his colleagues chopped DNA from these palindrome blocks into small segments and found that one-third of the pieces had almost perfect matches to other parts of the Y chromosome. And 18% had perfect matches that stretched as far as 2000 bases. "There are sequences on the Y chromosome that are effectively functioning as alleles," Page reported.

The researchers mapped the positions of the alleles and found that they were on opposite sides of a given palindrome, one in reverse order relative to the other. Palindromes sometimes encompassed multiple genes and even smaller palindromes. The large palindromes spanned upward of 3 million bases, Page reported. In contrast, pseudogenes—genes that had ceased to function—were outside these blocks of DNA.

Although 2 years ago Page and his colleagues suggested that

Like father like ... This male's handyman bent extends to his Y chromosome (*right*).

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