Funding is tight. Grants are rejected. Research equipment is too expensive. And these are complaints heard in well-heeled laboratories in the US and UK. In the following pages, we present inspiring examples of scientists who, using materials as simple as litmus paper, bamboo and blenders, prove that science on a shoestring is possible—and sometimes even better than the alternative.

Microscopes made from bamboo bring biology into focus

In a remote village in eastern India, dozens of underprivileged children are for the first time marveling at the elaborate details of flower petals with the help of a microscope—made out of bamboo.

Fitted with a ×20 lens, the light, compact and ecofriendly microscope is proving a boon for dozens of cash-strapped schools, granting students firsthand access to an otherwise unaffordable scientific tool.

This nifty device is a product of the creative minds at Jodo Gyan, a small nonprofit in New Delhi. "Indian children are not getting to experience all the joy and wonder of science because there is too much emphasis on the memorization and repetition of concepts," says Usha Menon, a government researcher who founded Jodo Gyan in 1999. "Hundreds of thousands of children are learning without understanding anything."

Priced at 150 rupees (roughly $4), the microscope is just one of the educational tools created by Jodo Gyan, literally translated as 'linking knowledge'. Other tools include mathematical card and board games and sticky geometric shapes in a variety of colors. The 30-member group has also led more than 700 teacher-training workshops and runs an alternative primary school that enrolls 54 underprivileged students.

Clear vision: Members of the Delhi-based nonprofit Jodo Gyan have made about 2,500 microscopes from bamboo.

But the microscope remains the star attraction. Jodo Gyan has supplied the instrument to several organizations such as Chennai's Goodbooks Teacher's Center and New Delhi's Pragya, a nonprofit that provides services to neglected, high-altitude areas. These organizations then distribute the microscopes to schools in their localities. Jodo Gyan has also secured two big orders in the last few years from the UN Children's Fund for use in alternative learning centers in India.

But with no external funding, Jodo Gyan is run on a shoestring budget, particularly because the group sells its learning aids for not much more than it costs to produce them, says Menon. The group's base of operations is a ramshackle building in Delhi's impoverished Shakurpur area that also doubles as Menon's home.

To meet the demand for its popular microscope, Jodo Gyan has fashioned a makeshift microscope factory right on the building's roof. Sitting up there amidst bamboo shards, members have so far chopped and carved about 2,500 microscopes for use in schools, educational nonprofits and, in at least one case, research.

Debal Deb, an ecologist who has set up a rural seed exchange to conserve dozens of endangered folk rice species in West Bengal, routinely uses Jodo Gyan's microscopes to study the surfaces of rice grains. More important, Deb's microscope has caught the attention of dozens of curious children from nearby villages, who stop by after school to peer through its lens.

"The microscope has opened up a whole new world for these children," says Deb. "They could never have imagined that an ant could have tiny antennae or that dragonfly wings could have such beautiful and intricate patterns."

Paroma Basu, New Delhi

pH paper trumps expensive kits in measuring acidity

Scientists in Uganda have devised a tool to test for vaginal infections that is so simple, even a child could—and did—make one.

In 2000, scientists at the Rakai Health Sciences Program in Kalisizo began studying the natural history of bacterial vaginosis, a common condition that lowers the acidity of the vagina. Using just a strip of pH paper, a bit of tape and a pediatric tongue depressor, they devised a 'swab' to measure vaginal pH.

Although the test itself was simple, coming up with a working design wasn't easy. "At that time we had never measured pH," says Mary Sullivan, a former Rakai lab manager who now coordinates hepatitis research at Johns Hopkins University.

For a previous study of sexually transmitted diseases, the researchers had shown women in nearby villages how to use cotton swabs to collect their vaginal secretions. Although fluid from a cotton swab can be smeared onto pH paper, the swabs are not ideal for measuring pH because they may not release enough fluid for an accurate reading.

Swabs can also easily become contaminated. "If the swab stayed in the air too long, if it was put on a surface or dropped, that would affect the reading." Sullivan says.

The researchers instead attached a four-inch strip of pH paper to a pediatric tongue depressor so that the measuring pad, which changes colors in response to the acidity of the environment, is at the tip. On either side is a color-coded pH key. "[The method] turned out to be very, very feasible," says Noah Kiwanuka, an investigator at the Rakai Health Sciences Program who oversaw the field work.

Once the researchers had proved that the swab worked, they set up an assembly line in Sullivan's dining room and convinced her three daughters, then between the ages of six and ten, to help. "One of them would open the tongue depressor package and pass it to the next, who would put the strip over the top, and then the third one would put the tape around and put it back in the bag," Sullivan says.

Teachers' group brings genomics revolution to minority colleges

When the human genome sequence was released in 1999, it meant two things to Edison Fowlks, a biology professor at Hampton University in Virginia.

First, genomics technologies were about to revolutionize science. And second, students and faculty of so-called minority-serving institutions such as Hampton, a historically black college, needed to be part of the revolution.

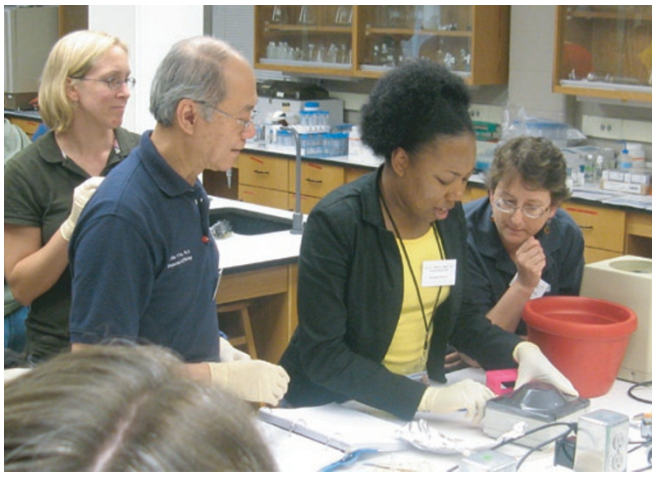
But where were such institutions going to come up with the funds to train faculty in the new technologies—much less buy microarrays and the scanners needed to read them?

In 2004, Fowlks found an answer when he met fellow biologist A. Malcolm Campbell, who since 2000 had been organizing a program called Genome Consortium for Active Teaching (GCAT) for faculty at small undergraduate institutions. Campbell is himself a researcher at Davidson College in North Carolina, a liberal arts college with 1,700 students.

Campbell had convinced genomics pioneer Pat Brown of Stanford University to donate microarrays, which Campbell then mailed to dozens of other professors. These professors taught students how to do experiments with the chips and then mailed them back to him. Campbell then read data from the chips using a single scanner and sent it back to the professors, who analyzed it with free software written by one of Campbell's colleagues. The only charges for chip users were shipping fees and the cost of the reagents for their experiments—no more than $500.

Fowlks saw the power of the model immediately. "GCAT essentially democratizes genomics," he says. "It allows a consortium of small colleges and universities to do informatics and genomics without all the powerful equipment that major universities have."

Fowlks joined forces with Campbell to expand GCAT's reach. The pair wrote a grant, awarded by the US National Science Foundation, to support a GCAT workshop at Morehouse College in Atlanta in 2005. The agency has committed to funding yearly workshops through 2009; the most recent of these, held this July, trained 40 teachers.



Genome Consortium for Active Teaching

Bring on the revolution: Using donated microarrays and a single scanner, minority faculty and students are jumping into genomics research.

The workshops are open to anyone who teaches undergraduates, with an emphasis on faculty teaching minority students. Since 2003, the Howard Hughes Medical Institute has spent $100,000 each year to buy microchips for the program. This year, GCAT distributed 1,200 chips to 72 teachers at institutions across the nation, from Alaska to Hawaii and Puerto Rico.

This fulfills not only Fowlks's and Campbell's goals, but also those set out by numerous reports on American competitiveness, such as a 2005 National Academies manifesto that calls for the nation to train more minority scientists and engineers.

"The National Academies and so many other groups have said we need to increase diversity in science, and I don't know how that's supposed to happen if we don't reach out to schools that serve large numbers of minorities," Campbell says.

GCAT is already showing results. Scientists such as Consuelo Alvarez at Longwood University in Farmville, Virginia, are publishing genomics research, and students such as Hampton University senior Sabriya Rosemond are getting swept into the genomics revolution.

Rosemond, one of Fowlks's former students, has worked in biology labs for the past two summers and is determined to go into science after she graduates next year. "I want to make science a little browner, like Dr. Campbell and Dr. Fowlks are doing," she says. For the GCAT leaders, that's an even more satisfying benchmark than the growing list of grants and papers that they are helping to produce every year.

Erika Check, San Francisco

Rakai Health Sciences Program

Simple solution: Women and children made swabs needed to test vaginal pH for a clinical study in Uganda.

The kids received their wages in gourmet gummy bears and M&Ms. On a good night, the team would make 200 swabs.

The researchers used the swabs to follow weekly changes in vaginal pH in 311 women over two years. "It's a poor woman's way of doing it," says John Thorp, a gynecologist at the University of North Carolina, who was not involved in the project. "I think that taking the [vaginal] speculum out of it greatly diminishes the cost."

Sullivan and her colleagues used to joke about patenting the swab. But it's too late. In July, New York–based company Vagisil launched its own over-the-counter version, a spatula-shaped 'wand' that measures pH.

The study ended in 2003, and the handmade pH swabs are no longer being used. But the researchers plan to revive their approach if necessary: a tube of pH strips and a box of tongue depressors are still cheaper than the $15 tab for a Vagisil kit.

Cassandra Willyard, New York