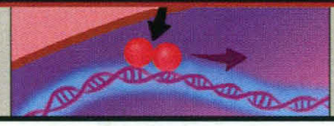
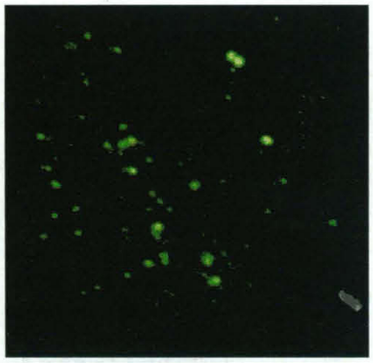


they are difficult to use in tandem, for each dye must typically be excited with photons at a different wavelength. Quantum dots are a tempting alternative. They can match dyes color for color because their electrons, like those of all semiconductors, exist at discrete energy levels, known as bands. Adding energy—say, from a photon of light—kicks an electron up from a lower "valence" band to a higher "conduction" band. When the excited electron drops back into the valence band, it can give up its excess energy as a photon with an energy equaling the gap between the bands. In quantum dots, this bandgap increases as the dots get smaller, confining the electrons into tighter spaces. Thus, smaller dots with larger bandgaps give off more energetic, or bluer, photons.

These 1- to 5-nanometer-sized particles, chemically synthesized at high temperatures, also lack many of the drawbacks of organic dyes. They are nontoxic and fluoresce up to 100 times longer. "That means that you can get better signal to noise and thus better detection," notes Taylor. And laser photons energetic enough to excite small dots can also excite fluorescence from larger dots at the same time. "They can all be excited with one laser," says A. Paul Alivisatos, a chemist at the University of California, Berkeley, who led one of the two teams. "That's important in biology," he adds, "because it allows you to do multiplexing"—watch many different colors, and therefore different biomolecules, at once.

To test this promise, Alivisatos, together with Lawrence Berkeley National Laboratory's Shimon Weiss and their colleagues, and another team led by Shuming Nie at Indiana University, Bloomington, started with what are known as core-shell quantum dots, which have an inner core made from one semiconductor surrounded by an ultrathin shell of a semiconductor with a higher bandgap. The shell, Alivisatos explains, helps confine all of the excitation energy in the dots to the core, resulting in a purer color.

After selecting their dots, both teams chemically altered their surfaces so the dots would dissolve in water, enabling them to diffuse throughout cells. The researchers then linked the light emitters to molecules that would guide them to specific cellular targets. Alivisatos and his colleagues, for example, turned to a molecule called avidin, which binds to another molecule, biotin, like a key in a lock. They linked avidin to red-light–emitting dots and, in mice fibroblast cells, used biotin to label a filament-forming protein called actin. When they added the dots to the cells, the avidin keys found their biotin locks and lit up the filaments in red. In the same experiment, described on page 2013, the group decorated green-emitting dots with negatively charged urea and acetate groups, which helped direct the dots into the cells' nuclei, turning them green.



S. NIE/INDIANA UNIVERSITY

M. BRUCHEZ JR. *ET AL.*

Technicolor. Semiconductor light emitters linked to targeting molecules highlight a cell's actin filaments (red) and nucleus (green). High magnification shows individual emitters within a cell *(top)*.

To get the quantum dots into the cells, the Berkeley group had to pretreat the cells with acetone, which eats holes in the cell membrane, killing the cells in the process. But on page 2016, Nie and his graduate student Warren Chan describe a different approach that works on live cells. They linked their dots to transferrin proteins, which help ferry compounds through a living cell's membrane.

Neither group is ready to stop there. Alivisatos says his group is developing quantum-dot probes that can light up DNA and might replace organic fluorophores in gene-sequencing machines. Nie plans to take advantage of the dots' bright fluorescence to improve the sensitivity of diagnostic tests, such as those that detect minute quantities of the AIDS virus. If either effort succeeds, biologists can expect a bright future from quantum dots. **–ROBERT F. SERVICE**

W. STONE/GAMMA LIAISON

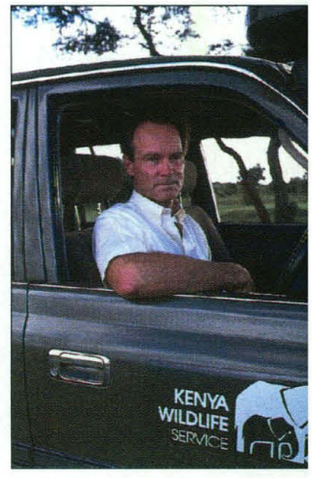
CONSERVATION

Kenya Parks Chief Ousted—Again

Kenya's fickle political winds have again blown conservation leader David Western out of office—this time permanently. Just 4 months after losing and then regaining his post as head of the Kenya Wildlife Service (KWS), which manages some of the world's best known natural areas, Western was abruptly sacked again last week by Kenyan President Daniel arap Moi.

The unexpected ouster, which came just weeks after Western had secured a $5 million grant from the Kenyan government that will allow the embattled KWS to survive a financial crisis, prompted dismay among observers in Kenya and international conservation circles. "What an end to a sad, sordid story," says David Woodruff, a University of California, San Diego, biologist who supported Western's sometimes controversial efforts to reorient the KWS (*Science*, 5 June, p. 1518). Western, however, is taking his dismissal philosophically. "Conservation is an extremely tough business—one has to accept reversals and go on," he told *Science*.

Western was appointed head of Kenya's premier conservation agency in 1994, after the resignation of Richard Leakey, a noted anthropologist who is now a leading opposition politician. Almost immediately, Western faced financial problems brought on by a decline in tourism and the end of several large grants provided by foreign donors. He also faced withering criticism from Leakey and others over his management style, his moves to cut staff, and his efforts to enlist people living on wildlife-rich lands outside the parks in conservation. The simmering controversy boiled over in May, when Moi fired Western, only to rehire him 6 days later following an international outcry from conservationists—and threats from



At ease again. Conservationist David Western.

donor agencies to withhold millions of dollars in grants. At the time, some of Western's supporters charged that Leakey was behind the ouster, but Western himself said that mining interests hoping to gain access to park lands were responsible.

This time, however, Western says he is "very puzzled" about why Moi prevented him from serving until his contract was to expire in February 1999, adding that the decision appeared almost "whimsical." Editors at *The Nation*, Kenya's leading newspaper, appear equally confused. In a 20 September editorial, they demanded that government officials explain "in fuller detail why Dr. Western was fired." Whatever the explanation, Western says he will continue to "do everything possible to support the KWS." One lesson his own tenure teaches, he says, is that the agency's governing board—rather than Kenya's president—should be given the power to hire and fire directors. "The crucial point is to keep politics out of the KWS," he says. He adds that he is "unaware of anyone waiting in the wings" to take his old job, which is being filled on an acting basis by KWS Deputy Director David Kioko.

Western plans to spend the next few years writing about his conservation experiences. He is disappointed that he won't be able to finish several tasks he started at the KWS, such as developing a long-term funding strategy and a process for identifying key areas in need of conservation. Western is proud, however, of gains he made in involving Kenyans in conservation efforts. "Conservation has filtered right down to the grassroots," he claims. "We began a process of engaging people in conservation and the role it plays in their lives." —DAVID MALAKOFF

INFRASTRUCTURE GRANTS

Canada to Draw Up Strategic Plans

OTTAWA—With $520 million to spend on refitting the nation's academic laboratories, the Canada Foundation for Innovation (CFI) has generated a lot of interest from university researchers. Too much, as it turns out.

This month, after sifting through more than 300 proposals for its first round of grants, CFI officials decided that they couldn't choose among virtually identical projects without first seeking a community consensus on priorities in a dozen or so fields for which applicants were seeking funding. That exercise will force a delay in the bulk of awards and could lead to collaborations and significant revisions among what are now competing projects. University administrators warn that it also could pose quite a challenge for a community accustomed to going its own way.

Money talks. CFI's Strangeway asks for road map before making awards.

CFI was created last year with government funds, and it instantly became the country's largest foundation. The upcoming awards are seen as a badly needed shot in the arm to the nation's sagging academic research infrastructure, and university officials had no problem generating $785 million worth of requests for an initial pot of $260 million, despite a requirement for matching funds. An initial review earlier this month eliminated about one-third of the applications, but the original goal of issuing all awards by the end of the year has been pushed back indefinitely.

The new approach involves drawing up what David Strangeway, president of CFI, calls "a coherent regional or national strategy" for several fields. Without such a strategy, he says, CFI can't be sure that its money is being put to the best use. In the area of genomics, for example, CFI received 18 applications for genetics centers, all dealing with human genomics. Strangeway says the national interest might be better served if some of these proposed centers focused on animal or plant genomics.

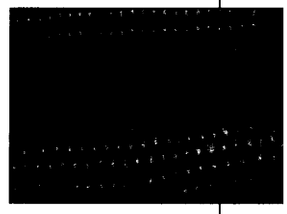
Strangeway says CFI's governing board will select the specific fields to be examined at a meeting on 13 October. He estimates the formation of 10 to 12 task forces, composed of experts drawn from around the country and the world, that would cover such areas as genomics, high-performance computing, and digital libraries. The panels would make their recommendations regarding national scientific priorities and needs. The universities, meanwhile, will be encouraged to work together to revise their proposals to address those national strategies. Both the recommendations and the revised proposals will then be fed back to CFI peer-review committees, whose advice will be incorporated into the board's funding decisions.

Such directives may encounter some resistance, however, say university administrators. "Universities spend a lot of time developing their expertise in certain areas," notes Sally Brown, executive vice president of the Association of Universities & Colleges of Canada. "If somebody puts in a human genome project as opposed to a plant one and is then told that we've got enough of those, there will be some sensitivities." Others are skeptical about Canada's capacity to develop discipline-specific strategies. "We don't even have a

ScienceScope

MAKING HAY WITH PLANT GENOME AWARDS

The University of Missouri, Columbia, learned it had snagged its largest grant ever last week—but not through the usual channels. Senator Kit Bond (R–MO) announced the $11 million National Science Foundation (NSF) award to start mapping the corn genome even before university officials in his home state were officially notified of their windfall.



The grant is just the first from a $40 million plant genome initiative added—with Bond's help—to NSF's budget. Three-quarters of the extra funds are supposed to help meet the growing demand for genomic studies of food crops and other economically important plants (*Science*, 27 June 1997, p. 1960), rather than expand studies on a laboratory workhorse, the mustard *Arabidopsis*.

In Missouri, plant geneticist Edward Coe's team will use its funds to take the initial steps needed to determine the order of some of the 2.5 billion bases that make up corn's genetic code. The 5-year project will soon be joined by other studies: NSF plans to announce about two dozen more plant genome projects by 1 October. Just who gets to break the good news to winning researchers remains to be seen.

RUSSIAN INITIATIVE WINS MAJOR SPONSOR

Despite Russia's economic turmoil, an ambitious plan to reform the nation's research and higher education establishments is moving forward. *Science* has learned that the John D. and Catherine T. MacArthur Foundation will spend $6 million over 4 years to help create elite research centers at top universities.

Run by the Russian Education Ministry and the U.S.–based Civilian Research and Development Foundation, the initiative will establish centers that can help train the next generation of scientists (*Science*, 29 May, p. 1336). The MacArthur money—and potential matching funds from other foundations and Russia—will allow the program to expand beyond a pilot project under way at the University of Nizhny Novgorod. In January 1999, organizers expect to invite proposals for a competition to award two to three new centers.