al options will be developed in parallel, and the decision on when to fly them will be made at a later stage in the process. Some will be put in a "mission bank" to be revived later when a launch opportunity arises. There were also calls for the world's major space agencies to coordinate missions more closely and avoid costly duplication. "With today's state of worldwide scientific budgets, we cannot afford to compete with each other," says ESA's director of science, Roger Bonnet.

ESA has requested proposals by next January for the first of these new "fleximissions." By the summer, the SPC will select two fleximissions and one backup, which "will go forward in parallel," says Bo Anderson, director of space and earth sciences at the Norwegian Space Center and newly elected SPC chair. The order in which the fleximissions will be launched will be decided later. In this way, "we have a continuously larger selection of missions which can be implemented faster," Anderson says. This should result in projects being completed sooner, allowing the agency to disband project teams more quickly. SPC vice chair Giovanni Bignami, science director of the Italian Space Agency, says ESA's contribution to the Next Generation Space Telescope is a likely first fleximission to reach fruition.

Previously, ESA's space science program, known as Horizons 2000, has adhered to a rigid timetable of launches: A major "cornerstone" mission is lofted every few years, interspersed with medium-sized missions—all chosen by the scientific community. It may take researchers some time to get used to a more flexible approach. Hans Balsiger of the University of Bern in Switzerland, a former SPC chair, points out that scientists building scientific payloads may have to live with extended delays if their payloads sit in the mission bank. Balsiger, a principal investigator for the Rosetta cometary rendezvous mission, thinks the situation is "survivable," however.

With their minds set on cost cutting, delegates at the Naples meetings also called for better coordination between the world's space agencies. Bonnet noted, for example, that the Inter-Agency Consultative Group (IACG), which brings together NASA, ESA, and the Russian and Japanese space agencies, doesn't always work very well. As an example, he points to the various programs to explore Mercury. Although a Mercury mission has long been a prospective ESA cornerstone project—and was presented to IACG representatives in Rome in 1994—"I was surprised to find out that the Japanese had included in the program a mission to Mercury without ever telling us anything," says Bonnet. And Bonnet was "even more surprised" when he recently learned that NASA also has a Mercury mission planned, called Messenger. "This isn't justifiable in today's financial climate," says Bonnet. NASA's representative in Paris, Jeffrey Hoffman, says the Messenger mission was proposed by groups of scientists and selected by NASA. "If Europe makes a decision to select a Mercury mission as their next cornerstone, then we will do everything possible to make sure that we take advantage of whatever synergy we can have between the two missions," says Hoffman.

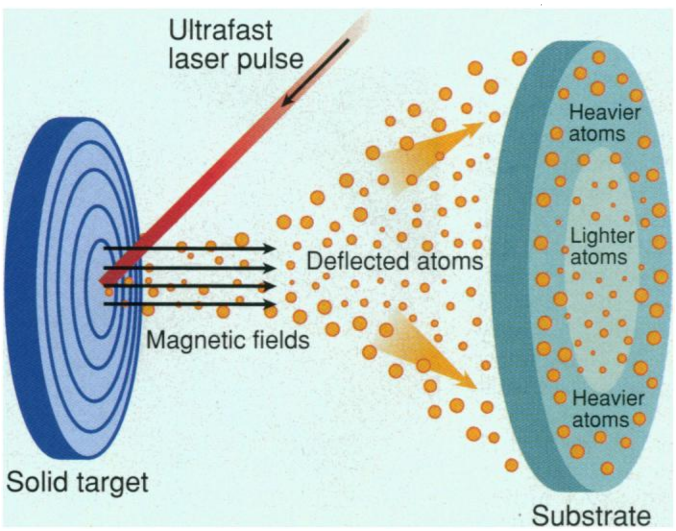
—**ALEXANDER HELLEMANS**

Alexander Hellemans writes from Naples, Italy.

CHEMISTRY

A Cheaper Way to Separate Isotopes?

For Manhattan Project scientists racing to build the first atomic bomb during World War II, one of the biggest challenges had nothing to do with learning how to set off a nuclear explosion. They also had to devise a way to separate the fuel for the reaction, uranium-235, from its slightly heavier but far more abundant cousin, U-238. Ultimately, project scientists built a stadium-sized gaseous diffusion plant to separate the isotopes, taking advantage of the lighter isotope's tendency to float farther than heavier ones in a given time. Ever since World War II, separation of all kinds of isotopes has remained an industrial-scale operation. Now, new results with a tabletop laser could change all that.



Moving out. When vaporized by an ultrafast laser, heavier isotopes tend to concentrate at the edges of the target.

CREDIT: PAUL VANROMPAY/UNIVERSITY OF MICHIGAN CENTER FOR ULTRAFAST OPTICAL SCIENCE

In this week's *Physical Review Letters*, researchers at the University of Michigan, Ann Arbor, report using a laser that fires ultrashort, power-packed pulses to separate isotopes of elements ranging from boron to zinc. The technique isn't the first to use lasers to separate isotopes. But this one doesn't require the use of complex and expensive magnets, making it potentially far easier and cheaper, if the cost of the lasers comes down and the technique can be scaled up. Indeed, Todd Ditmire, a short-pulsed laser physicist at Lawrence Livermore National Laboratory in California, describes the new method as a "potentially big deal" that could provide a cheap new isotope source for research, industry, and medicine.

The Michigan researchers, physicists Peter Pronko and John Nees and graduate students Paul VanRompay and Zhiyu Zhang, were initially trying to grow thin films of boron-nitride, a superhard material. Researchers commonly make such films, which are used for high-tech optical and electronic devices, by aiming a laser at the material, vaporizing it, and depositing it onto a surface. Pronko and his colleagues, however, were trying out an unusual laser: one that delivers up to 1 quadrillion watts of power per square centimeter in extremely short pulses lasting just 150 femtoseconds, or quadrillionths of a second. Trained on a solid block of boron nitride, the laser deposited a film on a nearby silicon disk—and did much more besides.

Boron comes in two isotopes, B-10 and B-11, which were randomly distributed in the solid target. But much to the researchers' surprise, when they used a device called an electrostatic energy analyzer to study the boron isotopes in the gas plume created by the laser pulse, they found that the two species of boron didn't remain mixed as they flew. "We thought our instrument was broken," says Pronko. "So we went back and did the experiment over again." Each time they looked, they found that most of the heavier borons landed in the outer portion of the circle, while the lighter ones stayed toward the middle. After a few tries, says Pronko, "we were convinced that what we were seeing was real."

Still, the result was puzzling. Not only did the isotopes separate, but the heavier isotope seemed to travel farther in the vapor than the lighter one—just the opposite of what happens when isotopes drift around in an uncharged gas. The answer, Pronko and his colleagues realized, lies in the electrical and magnetic storm kicked up by the potent laser burst.

First, when the light hits the target, it kicks out electrons from the surface atoms. As the electrons fly away from the target's surface, they pull the now positively charged borons and nitrogens after them. At the same time, the energy burst at the surface creates a powerful magnetic field, projecting from the surface as a series of magnetic field lines. These lines tug on the ions as they travel, causing them to spiral around the field lines. Key to separating the isotopes, the less massive ions fly in a tighter spiral, while the more massive ones take a wider trajectory, which moves them farther out on the target.

The result was that the outer region of the disc had about twice the amount of the heavy boron isotope as the inner region—enrichment that Ditmire calls surprisingly good. What's more, the Michigan team had similar results with gallium and copper, two other elements that are widely used in electronic devices. They are already planning to use their technique to make isotopically pure thin films of semiconductors, which are known to have an improved ability to conduct heat, a key requirement for today's densely packed computer chips. And Pronko says the technique may also prove useful for separating medical isotopes, such as yttrium-90, which is used to treat non-Hodgkin's lymphoma.

For now, he adds that his group has no plans to see whether the technique can be used to purify bomb-grade uranium—and that application may not be economically feasible in any event. Gérard Mourou, who directs Michigan's Center for Ultrafast Optical Science, says that—fortunately—many laser setups would be needed to collect the kilograms of enriched nuclear material needed to build a bomb. –ROBERT F. SERVICE

EVOLUTION

Handsome Finches Win a Boost for Their Offspring

Why one individual finds another attractive is, as the old song puts it, a "sweet mystery of life." For species that have evolved showy feathers or fins, the thinking has been that the ornaments might signal otherwise invisible "good genes" to a potential mate. Peacocks are a classic example: Those that thrive while sporting a magnificent—but unwieldy—tail, the theory goes, must be fit in other ways as well. New results now suggest that at least for birds, the mother's contribution to the fitness of offspring fathered by attractive mates may have been overlooked.

On page 126, evolutionary ecologists Diego Gil, currently at the Université de Paris X in Nanterre, France, Jeff Graves of the University of St. Andrews in Fife, Scotland, and their colleagues report that female zebra finches that have mated with such males deposit more of the sex hormone testosterone in their eggs than they do after a liaison with males they deem less attractive. Studies in canaries have suggested that developing chicks that receive more testosterone beg more vigorously for food and grow faster than other chicks. Therefore, Graves concludes, it is not clear whether the father's "good genes" or the mother's extra help should get the credit for any added success enjoyed by offspring of an especially attractive father.

A head start for hunks? A female zebra finch (center) includes more testosterone in eggs fertilized by males wearing attractive red leg bands (right) than in those fertilized by green-banded males (left).

CREDIT: JEFF GRAVES/UNIVERSITY OF ST. ANDREWS

Why the offspring of attractive males should be accorded such favored treatment remains a mystery. But the finding raises a caution about other experiments meant to show that attractive males really do pass good genes to their offspring, says evolutionary ecologist Doug Mock of the University of Oklahoma, Norman. "People want to believe [the good genes theory]. It is a very sexy idea, but people will have to be careful" in testing it, he says.

Graves and Gil, with St. Andrews University colleagues Neal Hazon and Alan Wells, took advantage of a peculiar taste of zebra finch females. The birds seem to find males wearing red leg bands particularly attractive, but they tend to ignore males wearing green leg bands. No one is sure exactly why red leg bands are the finch's equivalent of a sleek Rolex, while green labels a guy a geek. But because females also pursue males with especially red beaks, it's possible that the leg bands trigger the same reaction, says Nancy Burley of the University of California, Irvine, who was the first to document the attraction. Whatever the explanation, the female zebra finch's fetish allowed researchers to vary a male's attractiveness—and thus distinguish the effects of his sex appeal on the mother from those of his genes.

The team randomly gave males either a red or a green leg band, and then divided 12 females into two groups of six. The researchers allowed members of one group to mate first with a green-banded male, and then, after collecting the resulting eggs as soon as they were laid, mated each female with a red-banded male. Members of the other group mated with a red-banded male before receiving a green-banded suitor.

To see if the female's ardor had an effect on the egg content, the researchers analyzed the yolks for testosterone and its breakdown product 5α-dihydrotestosterone, which in other studies had seemed to influence a chick's eventual success. They found that the birds consistently included more of the hormone in eggs fathered by their red-banded mates than in eggs fathered by the green-banded ones. This suggests that the mothers have more influence on the fitness of the progeny of highly attractive males than scientists had thought.

The new result "certainly raises the bar for people who want to demonstrate good-gene effects from the father in birds," says evolutionary ecologist Carl Gerhardt of the University of Missouri, Columbia. It leaves several questions unanswered, however. Because the researchers had to destroy the relatively small finch eggs to determine their hormone levels, they cannot be sure that the differences they observed do in fact influence the success of zebra finch chicks. To answer that question, Gil is planning experiments in which he will inject finch eggs with an extra dose of testosterone.

Nor can the scientists explain how the females control testosterone levels in their eggs, although Gil suggests that it may be due to the attractive, red-banded males increasing the females' general arousal. Other work has shown, he notes, that a female canary's overall hormone levels affect those in her eggs, and another study suggested that testosterone levels in a bird's blood increase with high levels of social interaction. But he adds, "The problem is we don't know much about [these hormones] in females."

The team hopes their findings will prompt others to help answer such questions—and a broader question as well. "We do have females choosing particular males," says Graves. "The question remains, what do they get out of it? Good genes is a nice answer if it worked—and it may well work—but it's not as easy as it seemed" to solve the "sweet mystery."

–GRETCHEN VOGEL