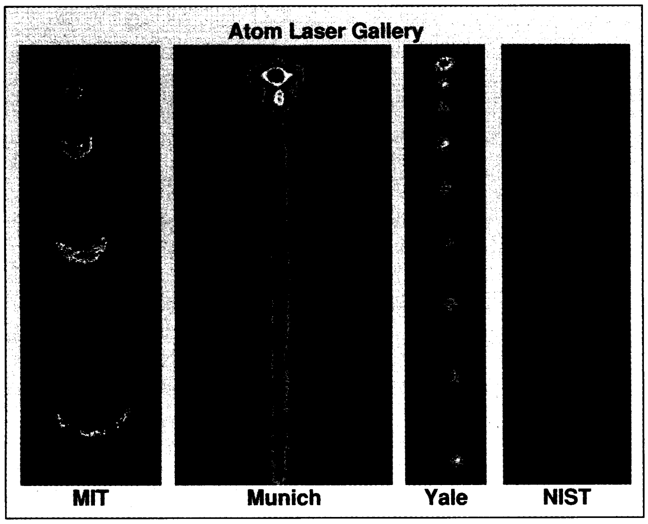
of the Massachusetts Institute of Technology (MIT): "First, it reduces the spreading of the beam, and second, it means you can point the beam in any direction." With such a beam, says Keith Burnett of Oxford University, "you'd be able to have the same control over matter that you have over light."

The active ingredient in atom lasers is a Bose-Einstein condensate (BEC), a trapped vapor of atoms cooled down to a temperature near absolute zero. Without the jostling produced by thermal energy, the atoms all condense into the single lowest quantum mechanical state. Right after making the first BEC in 1995, physicists realized that BECs could, in theory, emit a laserlike beam of atoms whose wave properties were "coherent"—identical and in step, just like the light waves in a conventional laser. Ketterle and his MIT group produced the first atom laser in 1997 by tricking part of the atom vapor into leaving the pack (*Science*, 31 January 1997, p. 637). A BEC is held together by a magnetic field, but if the atoms are slightly tweaked with a pulse of radio waves, they ignore the field, and a burst of atoms in the same coherent quantum state drops out of the trap. More recently, in work to be reported in *Physical Review Letters*, Theodore Hänsch's group at the Max Planck Institute for Quantum Optics in Munich has coaxed a more laserlike, continuous atom beam from a BEC trap. But these atom lasers could still only point downward. "The MIT result was the landmark experiment," says Phillips, "and we now have the opportunity here to make a highly directional beam."

Phillips and his co-workers, from NIST, Georgia Southern University in Statesboro, and the University of Tokyo, were able to kick the atoms out in a real beam using a technique called Raman scattering. When a photon scatters off molecules in a fluid, it sometimes exits as a photon with a slightly longer wavelength, leaving behind a tiny bit of its energy. The team used this effect to give the atoms in their cooled vapor a slight kick of momentum to get them traveling in a beam.

One potential showstopper was that the photons used to induce Raman scattering might also get absorbed and destroy the ultracold BEC by heating it. So the researchers hit their atom cloud with two laser beams. One pumps the atoms to a higher energy level, and the second stimulates them to jump back down immediately. But the photons in the second beam, which define the size of the jump, have a slightly lower energy than those in the first, so a little bit of the photon momentum is left behind. This is just enough to produce a narrow, tightly focused atomic beam, as well defined as the laser beam from a laser pointer, spreading out with an angle of only about a tenth of a degree. And although the atom laser is not fully continuous—the Raman lasers are pulsed on and off—the emitted atom pulses overlap enough to form a nearly continuous beam.



Going down. Output from early atom lasers was intermittent and propelled by gravity. The new directional NIST laser is boosted by light.

Having an atomic ray gun with laserlike precision opens up a whole host of applications. With a beam of atoms all in the same well-defined state, better atomic clocks and high-tech meter sticks can be made. Researchers typically define such fundamental standards by counting wavelengths of optical light like the ticks of a clock or the marks on a ruler, but the quantum mechanical waves from atoms are much smaller, allowing far more precise counts. The longer term dream, however, is atomic holography. Just as a conventional hologram interferes beams of photons together to create a three-dimensional image, so an atom hologram could combine beams of atoms to build a 3D solid object. Such a technique could be used to grow nanostructures for integrated circuits or biotechnology.

Researchers caution that atom lasers won't be pumping out microprocessor chips in the near future, because the number of atoms in the laser beam is so small. "We are talking about femtograms coming out of the trap," says Ketterle. But some space-age measurement applications may not be far over the horizon. "The European Space Agency has shown interest in gravitational wave measurements with atom optics," says Burnett.

—DAVID VOSS

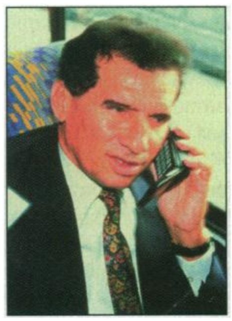
CREDITS: (TOP) W. KETTERLE/MIT; (BOTTOM) JEFF GREENBERG/VISUALS UNLIMITED

ScienceScope

Cash Crunch Studies at France's principal biomedical research agency could soon grind to a halt for lack of supplies. Researchers at INSERM have run afoul of controversial spending rules from the finance ministry, which require public labs to buy most of their supplies from companies chosen by competitive bidding at the beginning of each year. So far, however, INSERM has failed to designate its suppliers for 1999. As a consequence, researchers are exhausting limited funds set aside for purchases from "unofficial" suppliers. "I can't even buy food for my animals," says one.

INSERM researchers are protesting the buying restrictions and last week asked Prime Minister Lionel Jospin to delay proposed changes that would force scientists to make up their shopping lists a year in advance, which they say would make things even worse. A ministry adviser, however, disputed that notion, saying the changes would also widen buying choices and "take into account the special needs of researchers." Meanwhile, as an emergency measure, the ministry has doubled the amount researchers can spend with unofficial suppliers, but even these extra funds are running out fast.

Believe It or Not Newspapers in Canada and Britain are reporting that a soon-to-be-published study shows that microwave radiation from cell phone antennae messes with your short-term memory. They have even quoted British scientists who say they are limiting cell phone use based on the results. But sources familiar with the study have told *Science* that the findings are the opposite of what's been reported: that a brief, 10-minute stint on a cell phone appeared to enhance memory of a word list presented right after the call.



Researcher Alan Preece of Bristol University won't confirm either interpretation of his team's work, which is the first human trial designed to see if cell phone radiation influences brain function. The trial's results will appear in next month's *International Journal of Radiation Biology*, and Preece is planning to reveal the details at an 8 April press conference.

Pushpangadan, now head of the National Botanical Research Institute in Lucknow, disagrees, saying that he would not have fought against the odds for 12 years unless he was sure that the arrangement would benefit the Kani. And botanist Peter Raven, director of the Missouri Botanical Gardens, considers this agreement a "very good model for future" partnerships throughout the developing world. The current agreement must be renegotiated in 7 years, and the tribal community is expected to use the money for health care facilities and schools.

–PALLAVA BAGLA

DEVELOPMENTAL BIOLOGY

New Findings Reveal How Legs Take Wing

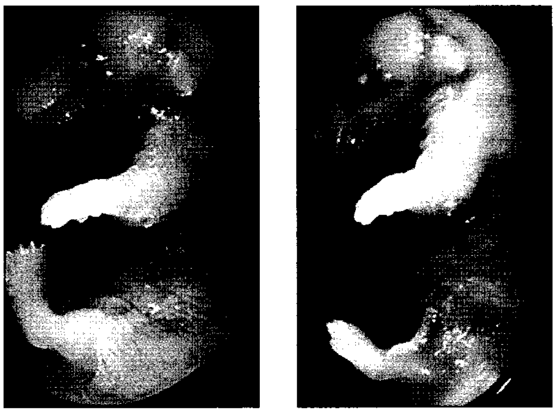
It doesn't take training at Kentucky Fried Chicken to know the difference between a chicken wing and a leg. But it's taken researchers a long time to figure out the molecular signals that tell the developing embryo which kind of limb to make. Now, work from at least four labs points to a set of proteins that appear to play a leading role in separating legs from wings.

In the past decade, developmental biologists have made impressive progress in identifying the genes that control a limb's growth from trunk to tip and from front to back. But almost all of those genes turned out to be the same in both arms and legs. That left researchers wondering just what genes control the many shape differences between the limbs. "To identify the genes that convey 'legness' is amazing," says developmental biologist Cheryll Tickle of the University of Dundee in the U.K., who has helped uncover many of the embryonic genes that structure the limbs.

The first clues came last year, when several groups reported that in a number of vertebrates, at least three genes are expressed only in either forelimbs or hindlimbs. *Pitx1* and *Tbx4* are found in the legs, while *Tbx5* is expressed in wings and arms.

Suspecting that these genes might help differentiate the limbs, several groups began to examine their effects in embryos, and results are now rolling in. Last month, developmental biologists Juan Carlos Izpisúa Belmonte of the Salk Institute for Biological Studies in La Jolla, California, and Michael Rosenfeld of the University of California, San Diego, and their colleagues reported in *Genes and Development* that in genetically engineered mice lacking the leg-specific *Pitx1*, the hindlegs have short, thin bones that resemble forelimbs. Although the animals' fore- and hindlimbs are not identical, there is "an element of armness that's come to the leg," says Rosenfeld.

The opposite experiment—expressing *Pitx1* in the wings of developing chicks—seems to bring a bit of leg to the wing, as Izpisúa Belmonte and Rosenfeld reported, and as Clifford Tabin and Malcolm Logan of Harvard Medical School in Boston now report on page 1736 of this issue. To express *Pitx1* in the forelimb, Tabin and Logan inserted the gene into a virus and then infected the chick embryonic region destined to become the wing bud. Although the wing was not completely transformed, the results were striking. Chicken wings normally bend downward at the equivalent of the wrist, but in the infected wing the bones grew straight, similar to the junction between a chicken's ankle and foot. The affected wings did not grow feathers and often sprouted claws. (Izpisúa Belmonte and Rosenfeld's experiments yielded similar results.) Logan and Tabin also found changes in the chick's muscle structure: Infected wings developed the four muscles characteristic of the chicken drumstick, but lacked the usual seven wing muscles.



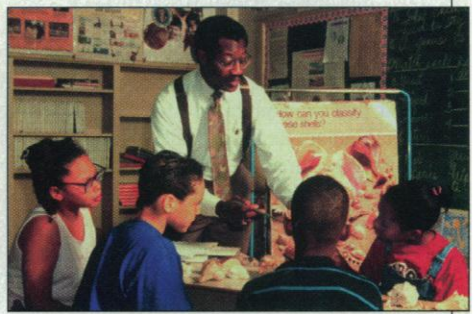
On the other hand. A mouse embryo lacking the *Pitx1* gene (*right*) forms short, slender, armlike hindlimbs.

Pitx1 apparently doesn't produce these changes alone; it seems to exert its influence by turning on another leg-specific gene, *Tbx4*. In infected wings, Logan and Tabin found the *Tbx4* gene turned on wherever the *Pitx1* gene was active. *Tbx5*, the forelimb gene, was also active, however, which may explain why neither group found complete transformations from wings to legs.

At the Nara Institute of Science and Technology in Japan, developmental biologist Toshihiko Ogura and his colleagues have found even more dramatic transformations by working with *Tbx4* and *Tbx5*. Ogura declined to discuss the as-yet-unpublished work, but those familiar with the study, such as Sumihare Noji of the University of Tokushima, who heard Ogura pre-

ScienceScope

Road Kill When students change schools often, math and science can get lost in the shuffle. That's the message from the National Science Board (NSB), which has just issued a report on improving the poor performance of U.S. students (see p. 1616). "The importance of [student] mobility hasn't been recognized" in the current push for national standards on curricula, says NSB chair Eamon Kelly, citing studies that show nearly one-third of U.S. eighth graders have changed schools two or more times. Low-income students are more likely to move frequently, he adds, a factor that could exacerbate the achievement gap between minorities and whites.



In other recommendations, the report, "Preparing Our Children" (www.nsf.gov/nsb), proposes a national campaign to improve instructional materials and teacher preparation as well as strengthen links between academic researchers, K-12 teachers, and school districts. Kelly admits that the suggestions aren't new, but says the board hopes to "raise the consciousness" of policy-makers and the public on the subject.

Trouble for IT^2? Representative James Walsh (R–NY) is making it clear that he doesn't like the politics behind IT^2, the $366 million information technology initiative trumpeted by the Clinton Administration (*Science*, 29 January, p. 613).

At a hearing last week, Walsh gave the National Science Foundation–led effort credit for being "much more focused" than NSF's previous program to make computer networks faster and more user-friendly, dubbed Knowledge and Distributed Intelligence. But he is concerned about "NSF's ability to act independently and not just follow orders from the White House" when it comes to spending its $144 million share of the six-agency initiative. The words from Walsh, who chairs the House panel that oversees NSF's budget, suggest that IT^2 could face problems if money is tight.

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