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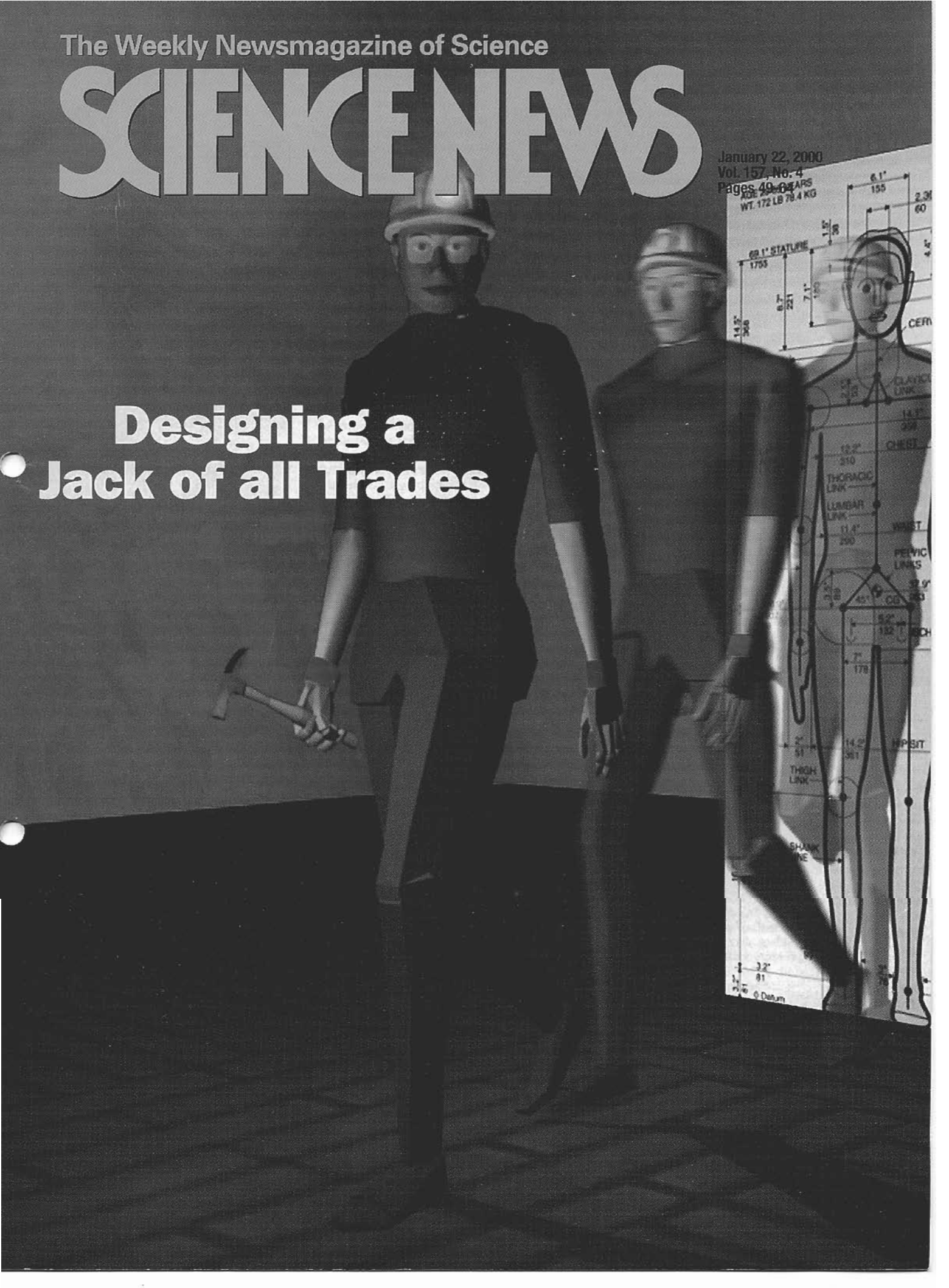
Designing a Jack of all Trades



Lasers act on cue in electron billiards

A sharp burst of laser light striking an atom can yank away an electron, ionizing the atom. If the laser pulse is extremely intense, the rapid oscillations of its electric field pull off multiple electrons, one after another. In the mid-1980s, however, amazed researchers discovered that moderately intense laser beams dislodge multiple electrons at a rate up to a million times higher than expected and, seemingly, in groups of two or more. Since then, researchers have furiously debated explanations for those findings.

This week, two German research teams independently report experimental results that favor one of three models advanced in the debate. The need to understand multiple ionizations has lately grown urgent as scientists increasingly use intense lasers in fundamental physics experiments (SN: 12/19&26/98, p. 390) and to pursue a range of applications, such as nuclear fusion (SN: 3/27/99, p. 196) and particle acceleration (SN: 12/4/99, p. 367).

In what is called the rescattering model, which the new data support, laser beams play "a type of billiard game," says Reinhard Dörner of the University of Frankfurt, leader of a team that studied laser ionization of helium atoms.

In that game, the laser beam's potent and fluctuating electric field tugs an electron some 100 atomic diameters away from its parent atom and then shoots it back at the atom like a cue ball, bashing away one or more additional electrons.

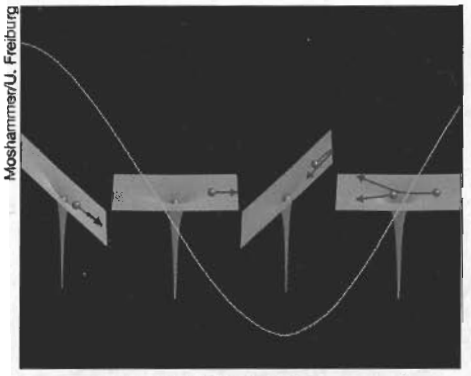
"For the first time, we really know what mechanism leads to these doubly and triply ionized ions," says Robert Moshammer of the University of Freiburg. He and his colleagues studied ionization in neon. Both groups describe their experiments in the Jan. 17 PHYSICAL REVIEW LETTERS.

The new helium experiment "really starts shutting down the controversy," comments Louis F. DiMauro of Brookhaven National Laboratory in Upton, N.Y. The neon findings are also "important," he says, but of less immediate consequence to theorists. Analysts have done more ionization calculations for the helium atom, which has only two electrons, than for 10-electron neon.

Fathoming multiple ionizations may lead to new understanding of so-called many-body interactions, researchers say. Such interactions among at least three particles—an ion and two or more electrons, for instance, in the new studies—are common but enormously difficult to analyze mathematically (SN: 1/1/00, p. 4).

In the new studies, researchers made ions by using moderately intense laser beams, several hundred trillion to a quadrillion watts per square centimeter. They fired the lasers at jets of cold atoms for up to 220 femtoseconds (10^{-15} second).

After each pulse, a weak electric field accelerates ions toward a detector that recorded ion position and time of arrival. This enabled scientists to calculate momentum. In the two alternatives to the rescattering model, the laser beam imparts no momentum to the ions. Yet both research teams found a range of momenta attributable to the strong electric fields of the beams.



In rescattering, free electrons move in a laser's electric field like balls on a tilted table. Funnel shapes portray confinement of electrons by a charged nucleus. Left to right: The maximum positive field first pulls a weakly bound electron away from the nucleus. Pushed forward and back by the oscillating field (yellow curve), this electron knocks away another.

Moshammer says the findings decisively rule out both alternatives to rescattering—two or more electrons jumping ship simultaneously by the quantum-mechanical trick called tunneling or an atom spitting out additional electrons as an adjustment to the initial loss of an electron.

Dörner argues, however, that the data are not definitive, although rescattering is probably correct. Further measurements by both teams of electron, as well as ion, momenta may soon provide a more complete picture. —*P. Weiss*

Obesity hormone tackles wound healing

In 1995, the media hailed the newly discovered protein leptin as the "obesity hormone" because it seemed to regulate the amount of fat stored by a body. While leptin remains an unproven weight-loss treatment (SN: 7/18/98, p. 43), scientists have found that the hormone may have many additional roles.

Leptin seems to play a part in immunity, puberty, reproduction, and, according to a study in the January ENDOCRINOLOGY, wound healing. Investigators at Amgen in Thousand Oaks, Calif., the company developing leptin for commercial purposes, report that injecting the hormone into mice lacking it significantly speeds the rodents' ability to mend skin wounds. Applying leptin directly to a wound also accelerates its healing, the Amgen team reports.

Mice without a functioning gene for leptin become obese and develop diabetes. While trying to correct these problems by implanting leptin-releasing pumps under the skin of the animals, the Amgen group noticed something unexpected. "The wounds that surrounded the minipumps appeared to heal faster in leptin-treated animals," recalls Dimitry M. Danilenko.

This observation raised the possibility that leptin could correct a dangerous complication of diabetes. "All aspects of wound closure are impaired or slowed in diabetic animals and in diabetic people. Lots of wounds just never heal," notes Danilenko. "It's a major problem."

The investigators quickly began testing leptin specifically for its effects on healing. They applied the hormone directly to wounds, for example, to separate its local healing effect from a general improvement of metabolism after injection.

"There does appear to be, in addition to the systemic benefit, some direct local effect. As of yet, we don't know the mechanism," says Danilenko.

The Amgen team has found that cells in wounded skin, particularly those around blood vessels, make the cell-surface proteins that bind leptin and initiate its effects. Since formation of new blood vessels is an important facet of wound healing, the researchers tested whether leptin triggered this phenomenon, known as angiogenesis. They didn't see such a response.

That result contrasts with a 1998 report by M. Rocío Sierra-Honigmann of Yale University, in which she and her colleagues describe angiogenesis triggered by leptin. They also observed, but have not yet reported, that leptin speeds healing in mice lacking the hormone.

Arguing that the Amgen scientists' assay was unorthodox, Sierra-Honigmann asserts that angiogenesis largely accounts for the hormone's healing properties. "I think angiogenesis is a central component of why they saw what they saw," she says.

Would leptin enhance wound healing in normal mice? Danilenko says that Amgen's data suggest a subtle boost but don't prove it. Sierra-Honigmann, however, hints at better results in her as-yet-unpublished studies. Leptin and wound healing will make a "fascinating story," she predicts. —*J. Travis*