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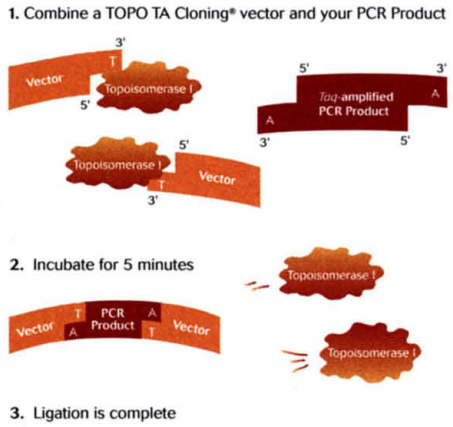

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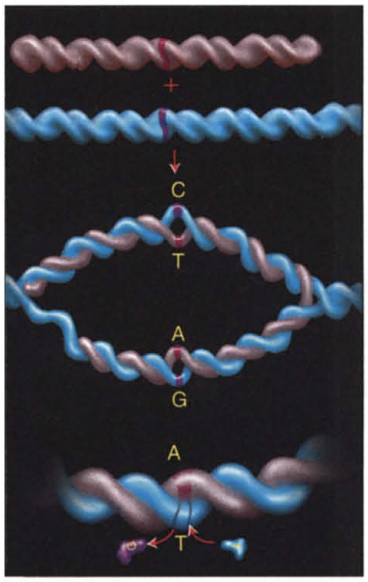

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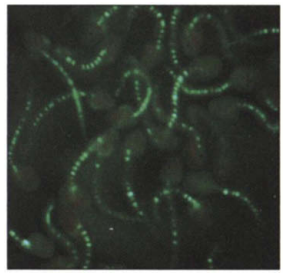
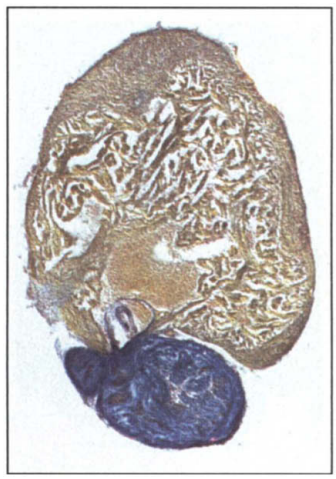


COVER 2157

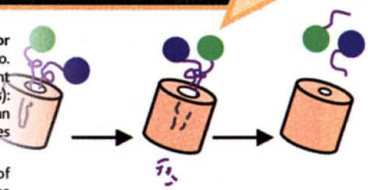
A group of about 30 tadpole-stage *Ciona intestinalis* embryos 12 to 14 hours after fertilization. The embryos were electroporated at the one-cell stage with a fusion gene containing the 5′ cis-regulatory region of the *Brachyury* gene attached to a green fluorescent protein (GFP) reporter gene. The *Brachyury* regulatory DNA directs GFP expression in the notochord cells of the tadpole tails. [Image: Mei Wang]



2188

Regenerating heart tissue

New on *Science* Express Threading from the middle



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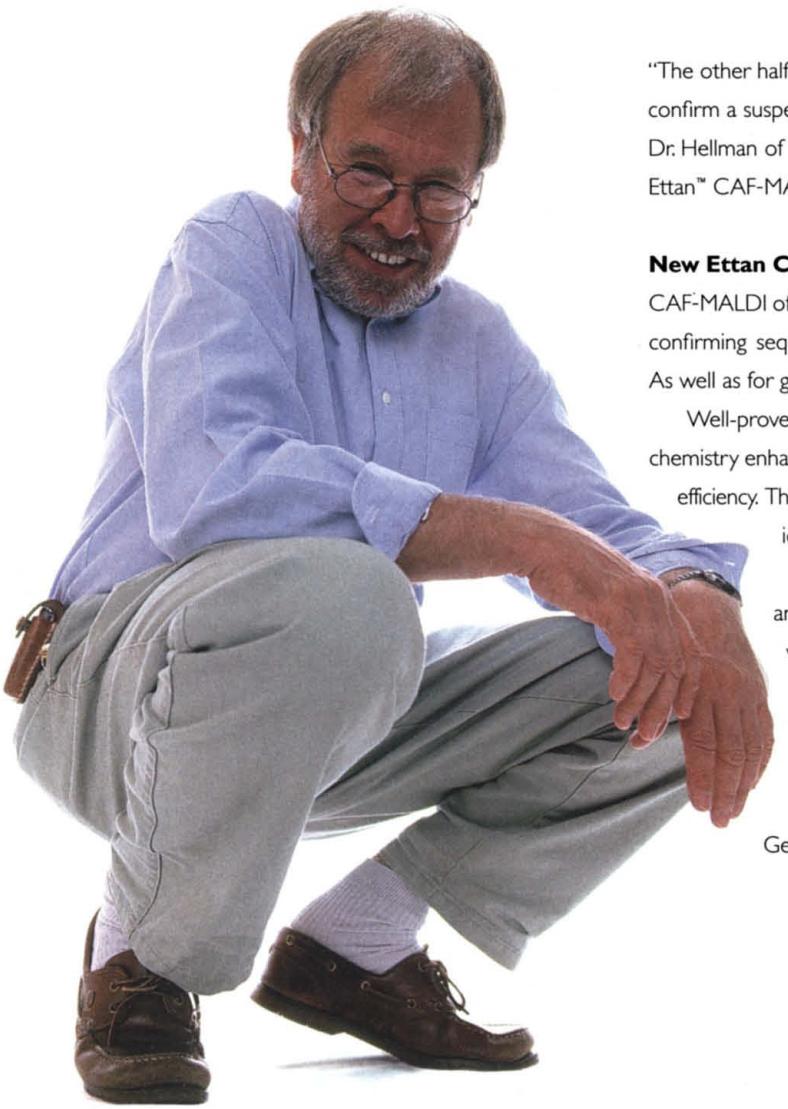

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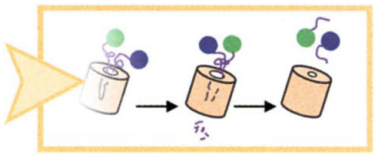
Endoproteolytic Activity of the Proteasome C. Liu, M. J. Corboy, G. N. DeMartino, P. J. Thomas

A surprising ability of the cylindrical proteasome to cleave protein substrates in the middle is revealed.



Oxygen-Mediated Diffusion of Oxygen Vacancies on the TiO_2(110) Surface R. Schaub *et al.*

Vacancies in the rows of oxygen atoms along the (110) face of TiO_2 diffuse across the rows with the help of incoming O_2 molecules.

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Largest known protein might play a role in heart function and failure.

NEWS FOCUS: One for All R. J. Davenport

Worm and fly longevity pathway controls mouse aging, too.

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Famous chromosome-protecting protein helps maintain master copy of DNA in stem cells.

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Worms gain time by cutting energy production as larvae.

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THIS WEEK IN Science

edited by Phil Szuromi

Short-Lived Solar System Tracers

Radiogenic nuclides with short half-lives that were present in the early solar system are now extinct, but their abundances can be extrapolated from decay products that remain in some mineral grains in primitive meteorites. Marhas *et al.* (p. 2182) found evidence for beryllium-10 but no evidence of aluminum-26 or calcium-41 in hibonite grains in the Murchison meteorite. The ^{10}Be could only have been produced by irradiation from the young Sun, so the absence of ^{26}Al and ^{41}Ca indicates that these two nuclides found in other meteorite grains may have come from a distinct stellar source outside of the protosolar nebula. This source might have helped to trigger solar system formation.

2185 On the Trail of an Impact

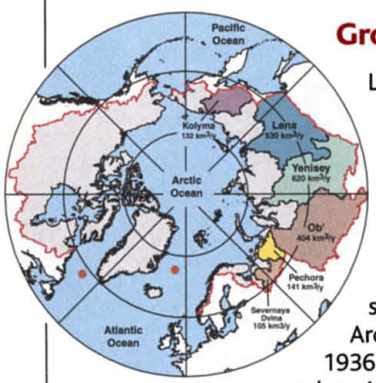
The size, composition, and energy of bolide impacts can be inferred not only from the craters that were left or filled in on Earth's surface, but also from far-flung ejecta deposits. Walkden *et al.* (p. 2185) have found an ejecta deposit of Triassic age in southwestern Britain that may have come from the Manicouagan crater in northeastern Canada (a distance of about 2000 kilometers), and hence may represent an energetic event that had global repercussions. If further work confirms the 214-million-year age of the ejecta deposit, then this event will have occurred just prior to the species extinctions recognized at the Triassic-Jurassic boundary about 202 million years ago.

And in Brevia ...

The apicoplast, an organelle of the malaria parasites and its relatives, has been shown by Funes *et al.* (p. 2155) to have originated from the secondary endosymbiosis of green algae, with subsequent lateral gene transfer to the host nucleus.

Genomic Clues into Chordate Origins

The sea squirt *Ciona intestinalis*, an invertebrate chordate that has been extensively studied in embryology, occupies a critical node on the metazoan and chordate phylogenetic trees. Dehal *et al.* (p. 2157; see the cover and the news story by Pennisi) generated a draft genome sequence and assembled the euchromatic regions of *C. intestinalis*. Because ascidians like *Ciona* apparently diverged prior to the genome-scale expansions that occurred in the vertebrate lineage, they may reflect the chordate genome prior to the emergence of vertebrates. Indeed, many of its genes show stronger similarity to invertebrate proteins than to those found in vertebrates, but nearly one-sixth of the *Ciona* genes possess a vertebrate counterpart. In addition, *Ciona*-specific genes were identified, as well as curious innovations as seen in the presence of genes involved in cellulose metabolism.



CREDIT: PETERSON *ET AL.*

Growing Flow

Large changes in the discharge of Eurasian rivers can affect the formation of North Atlantic Deep Water and could have an impact on oceanic thermohaline circulation and global climate. Peterson *et al.* (p. 2171; see the news story by Stokstad) report observations that show increased river discharge to the Arctic Ocean from Eurasia by 7% since 1936. The increase correlates with global and regional warming as well as with the North Atlantic Oscillation, a large-scale atmospheric alternation. If the increase continues to follow predicted temperature trends (such as those of the Intergovermental Panel on Climate Change), the discharge may become great enough to affect the North Atlantic thermohaline circulation by the end of this century.

Stormy Weather

Global climate models have predicted a shift toward more extreme precipitation patterns. In an effort to understand how increased storm variability would affect a grassland ecosystem, Knapp *et al.* (p. 2202) performed a 4-year field study in which they experimentally manipulated the variability in growing season rainfall without altering total precipitation. More extreme storm patterns led to enhanced plant species diversity but increased water stress in the dominant plant forms and affected overall carbon cycling by reducing productivity and soil CO_2 flux.

A Superfluid of Fermions?

The realization of a fermionic superfluid from a condensed cloud of strongly interacting atoms remains one of the major issues in ultracold gases. However, conventional routes to achieve the fermionic counterpart to that formed from bosons have not been successful. Using a mixture of spin-up and spin-down lithium-6 atoms confined to an optical trap, O'Hara *et al.* (p. 2179; see the Perspective by Pitaevskii and Stringari) observed an anisotropic expansion of the atomic cloud after release from its trap that may signal the onset of a superfluid phase.

Game Birds

In the Iterated Prisoner's Dilemma game, a "defecting" player who chooses an immediate reward does better for a single throw, but a cooperating player does better in the long run. Repetition of the game combined with reciprocity between individuals can lead to the indefinite maintenance of cooperation. However, it has been suggested that temporal discounting (the decreased value of a larger award if it is delayed) might constrain cooperation in nonhuman animals. In an experimental study, Stephens *et al.* (p. 2216; see the Perspective by Mesterton-Gibbons and Adams) offered pairs of captive blue jays immediate food rewards as well as delayed rewards that could be seen by the birds but were not "paid out" until several plays later. Stable cooperation between the birds was seen and was favored when discounting was reduced and when the opponents adopted a reciprocating strategy.

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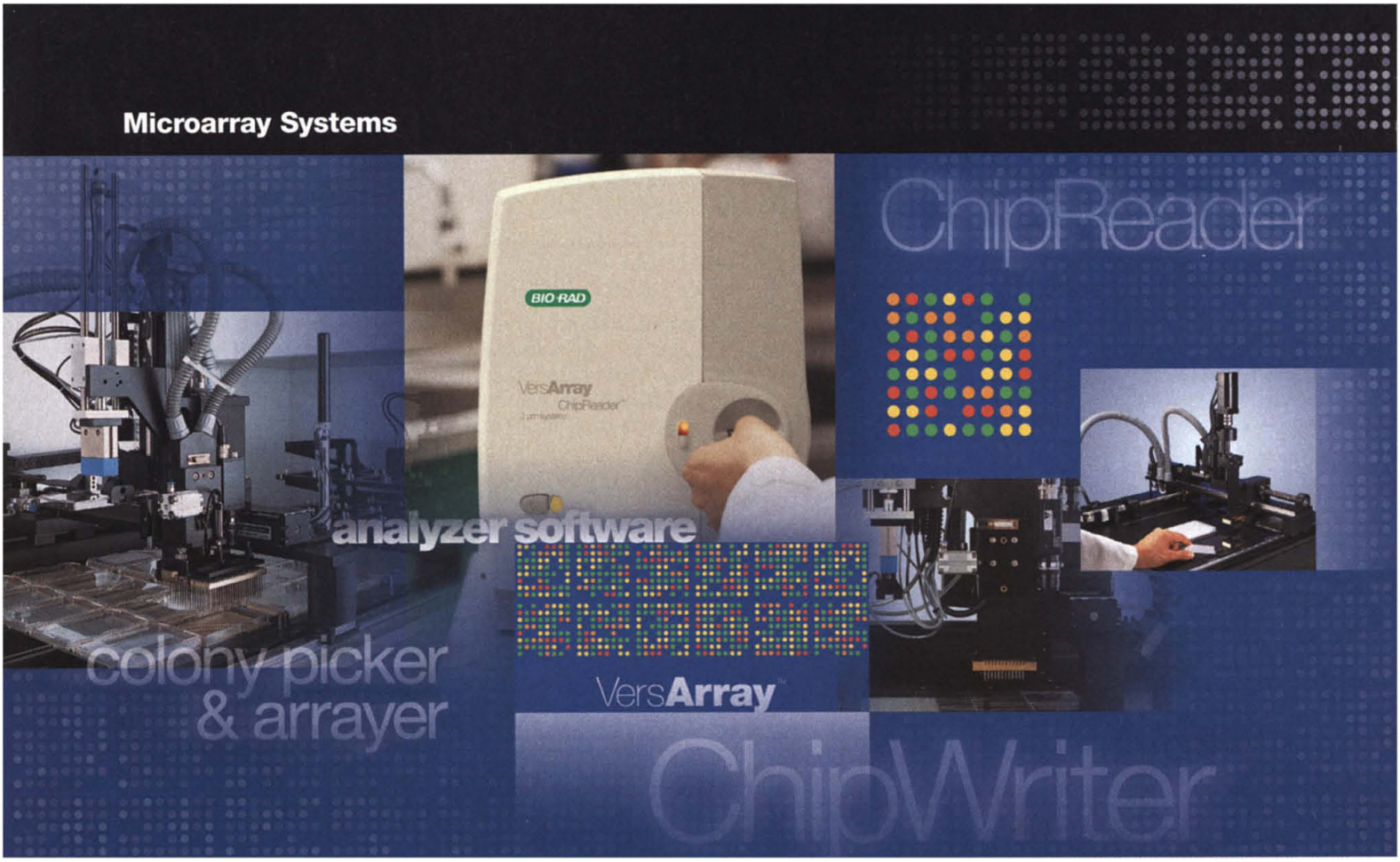
CONTINUED ON PAGE 2089



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Music in the Brain

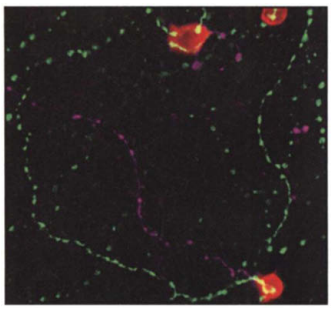
Is there a correlation between the formal geometrical representation of tonal music and the brain activity in a listener trying to detect a wrong note in a melody? In a functional magnetic resonance imaging study, Janata *et al.* (p. 2167; see the Perspective by Zatorre and Krumhansl) found consistent activity within the rostromedial area of prefrontal cortex across different listening sessions. Representations of tonality were structured within sessions with different subregions representing different parts of the tonality surface, but this structure varied across sessions and subjects. This dynamic organization might reflect the relative nature of musical structure, and its representation in the rostromedial prefrontal cortex in a given session may be influenced by interactions between short-term as well as long-term memory.

Sobering Results

How does alcohol intoxication impair human psychomotor activity beyond slowing performance and impairing sensory judgments? In a combined electroencephalography (EEG) and behavioral study, Ridderinkhof *et al.* (p. 2209) found that the anterior cingulate cortex, an area of the brain crucially involved in action monitoring, shows signs of impairment even for amounts of alcohol well below the legal driving limit in most countries. Subjects drinking alcohol showed a significantly altered EEG signal as well as a reduction of post-error adjustments in performance. Alcohol thus interferes with a critical component of cognitive control, which may explain why people under the influence of alcohol fail to recognize poor performance and persist in it.

Overcoming a Broken Heart

Injury to the mammalian heart leads to fibrotic scar formation rather than regeneration of the damaged heart muscle. Poss *et al.* (p. 2188; see the Perspective by Scott and Stainier) show that the zebrafish heart responds very differently. Two months after surgical removal of 20% of the ventricle, zebrafish exhibited complete restoration of the heart, apparently through robust division of cardiomyocytes. Thus, zebrafish may prove to be a valuable model system for genetic dissection of the molecular mechanisms underlying heart muscle regeneration.



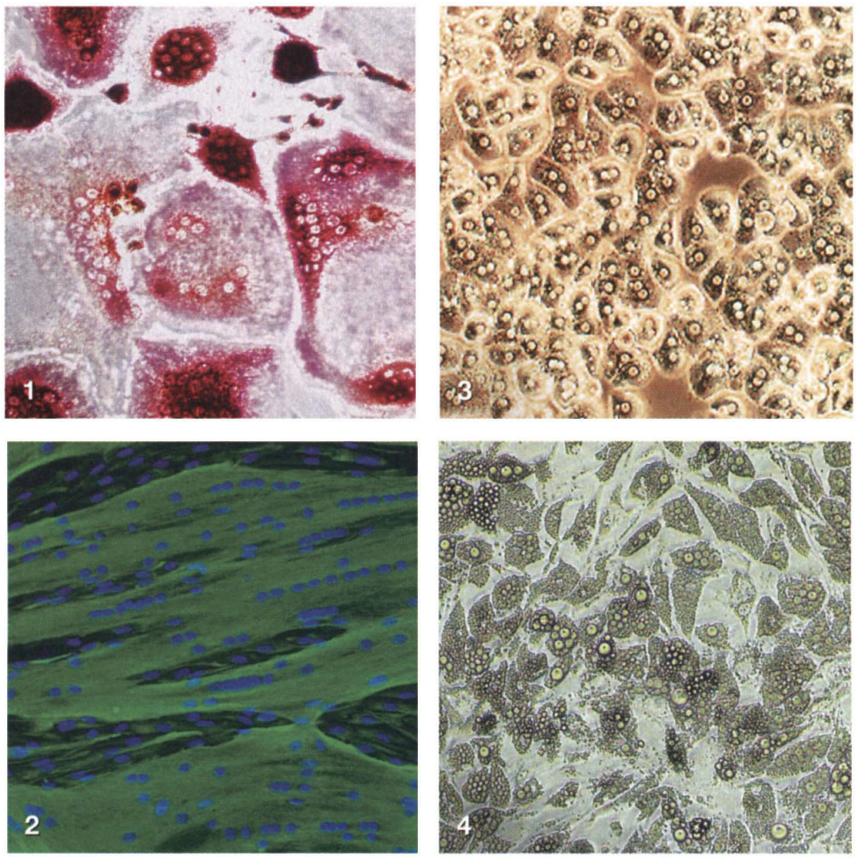
CREDIT: PANDA *ET AL.*

Waking Up on a Cloudy Morning

Several photoreceptors have been proposed to be critical for synchronizing the mammalian circadian clock, but the most promising is melanopsin, which is found in specialized retinal ganglion cells. To test melanopsin's functional relevance, Ruby *et al.* (p. 2211) and Panda *et al.* (p. 2213) examined mice in which the gene for melanopsin has been deleted and found that light was still able to entrain the clock, but not as effectively. At low light levels, however, light could not entrain the clock in the mice without melanopsin. Thus, melanopsin is not the only photoreceptor but appears to be the one specialized for ensuring entrainment at low light levels.

Aide-Mémoire for Antibody Production

What persuades a memory lymphocyte to stick around for years after an infection has been cleared? For B cells, the explanations have been that either antigens persist somehow or that some B cells develop into long-lived antibody-secreting plasma cells that need no stimulation. Bernasconi *et al.* (p. 2199) provide evidence for an intermediate mechanism in which nonspecific stimuli—not limited to antigens from any one pathogen—spur B cells into continued antibody production. In culture, human memory, but not naïve, B cells divided strongly in response to CpG sequences of DNA, which are powerful signals to innate immune cells. The T cell cytokine interleukin-15 evoked the same response and, like CpG, could induce some B cells to become plasma cells. Frequencies of antigen-specific plasma B cells and levels of circulating antibody in individuals more than a decade after vaccination agreed with predictions made from these experiments.



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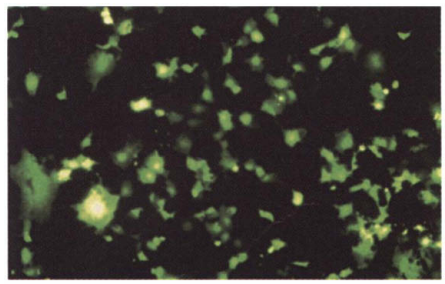

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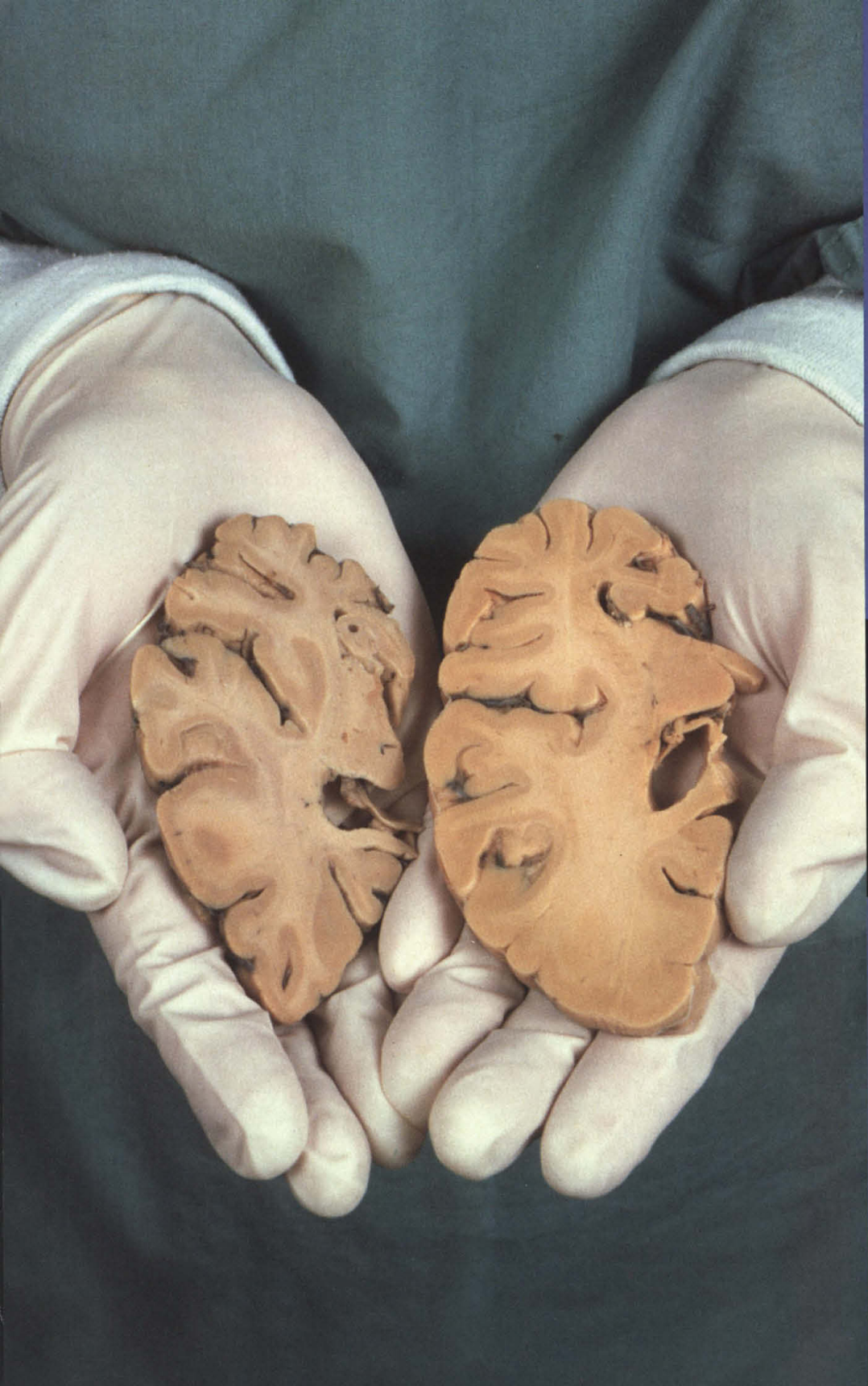
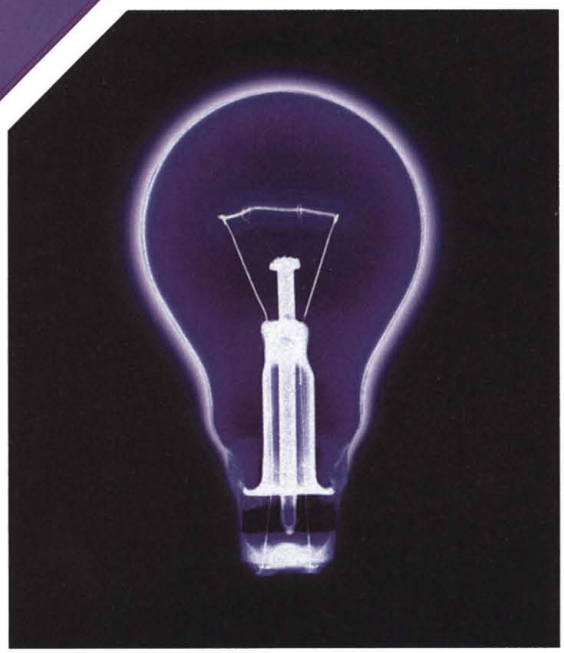


The long-term toll. Over many years, Alzheimer's disease (AD) kills so many nerve cells that the brain shrinks. Compare a slice from the brain of someone with AD (right) with a corresponding slice from a normal brain (left). [Credit: Simon Fraser / MRC Unit, Newcastle General Hospital / Science Photo Library]



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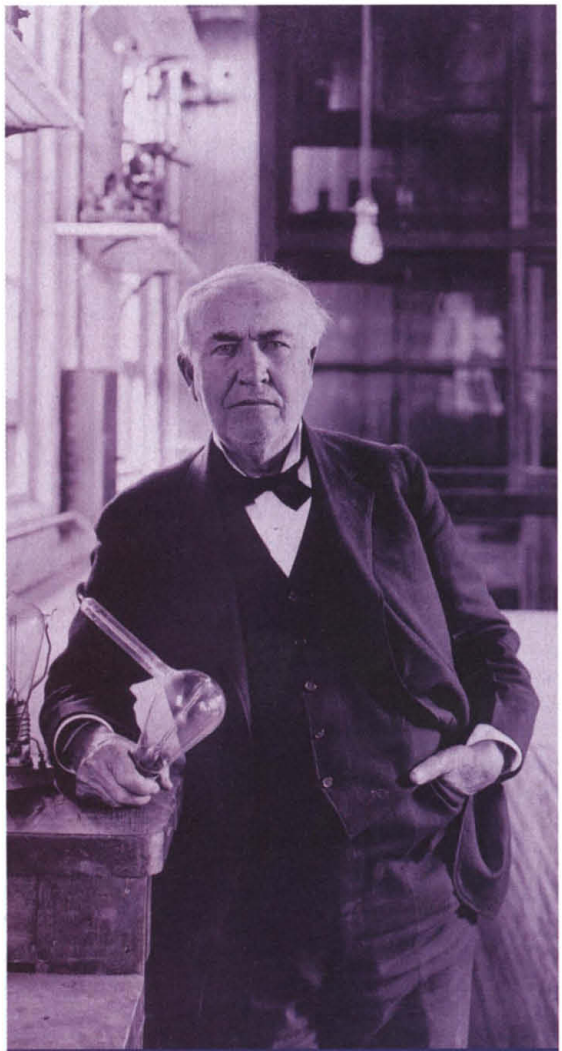

Thomas Alva Edison with the Edison effect bulb, c.1918

Photo Courtesy of the US Department of the Interior, National Park Service, Edison National Historic Site

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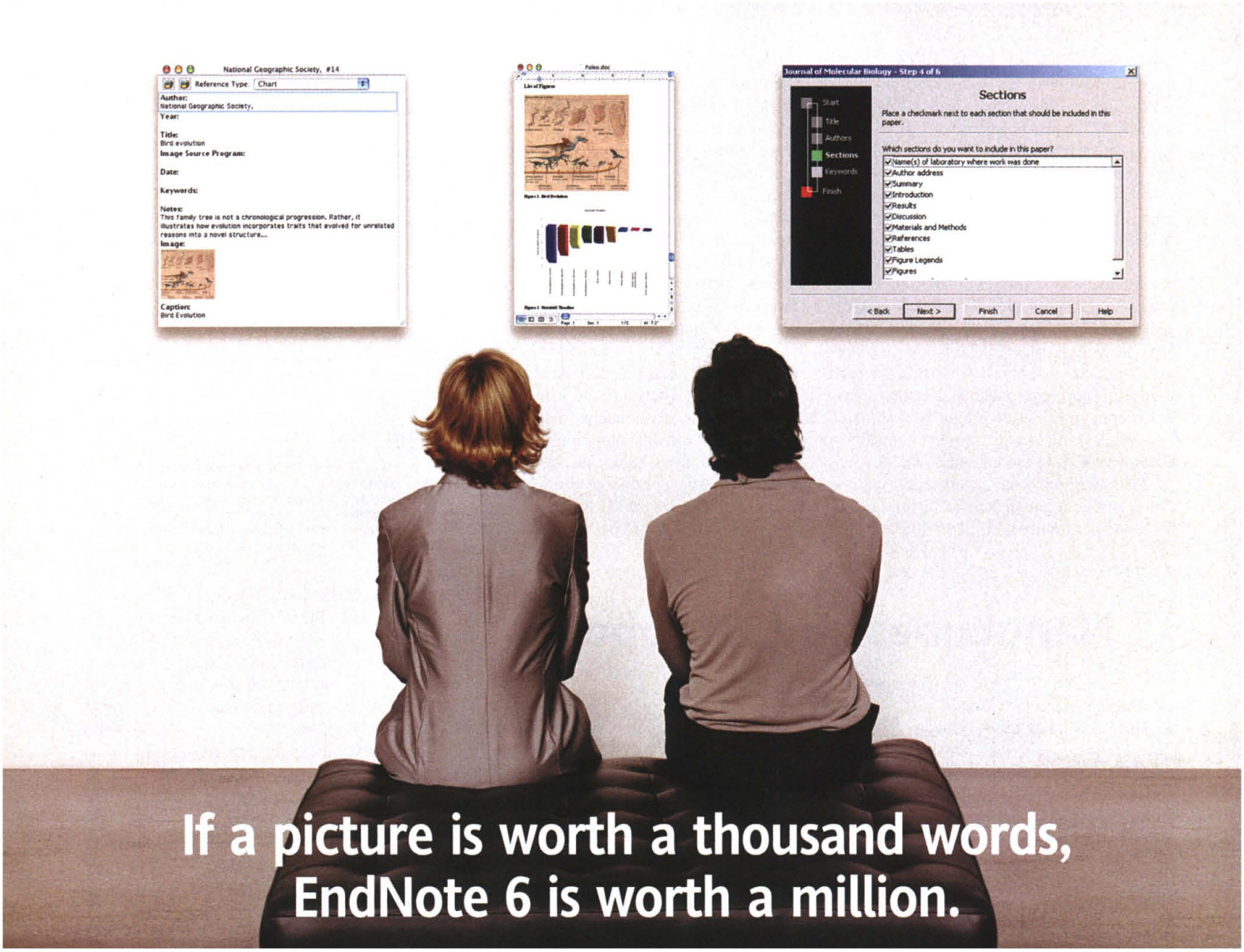

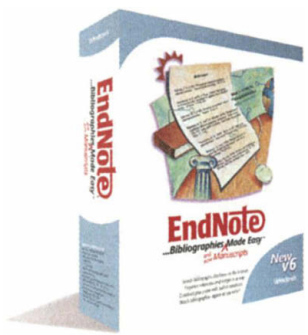

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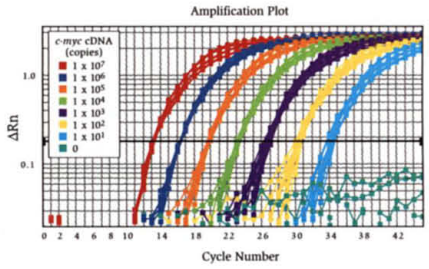

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