of clan chieftain—and wore a waterproof grass cape much like those used by Alpine shepherds as late as the 19th century. Tattoos on his back and legs suggest that he practiced acupuncture—some 2 millennia before the therapy is described in Chinese records (*Science*, 9 October 1998, p. 242).

Indeed, Ötzi appears to have had good reason to seek pain relief. A short man who may have lived into his 40s—a ripe old age in the Neolithic—Ötzi had arthritis and his guts were infested with eggs of the whipworm, a parasite that would have caused wrenching pain. Needle marks near acupuncture points for the bladder hint at the possibility of a urinary tract infection as well.

Scientists studied Ötzi intensively in 1991, but a bitter custody fight between Austria and Italy imposed a 9-year hiatus on invasive research. After precise measurements showed that the mummy had been discovered 93 meters south of the Austrian-Italian border, Italian officials in 1998 installed Ötzi in a refrigerated room with a peephole for viewing in the South Tyrol Museum of Archaeology in Bolzano. Austrian and Italian scientists, who had by then mended fences, began planning new lines of inquiry.

On 25 September, a team of forensic scientists from the University of Verona, Italy, and the University of Glasgow, U.K., reexamined the body for signs of trauma. Their work in the months to come is aimed at answering one major question, namely, how he died. One hypothesis is that he simply fell asleep, exhausted, and froze. But Ötzi also had a few broken ribs, hinting at an accident. Damaged tissue in Ötzi's brain suggests a third hypothesis—a stroke. An effort to test this idea could get under way next year, says anthropologist Horst Seidler of the University of Vienna, who chaired the committee that selected the current projects. He and a team at Wake Forest University in Winston-Salem, North Carolina, next year will examine the timing of Ötzi's rib injuries.

Another key project seeks to clarify Ötzi's roots. In 1994, a mitochondrial DNA study showed that his genetic stock most closely matches that of modern central and northern Europeans (*Science*, 17 June 1994, p. 1775). Two Italian groups hope to extract better DNA samples from bone and narrow Ötzi's ancestry in hopes of learning more about migration patterns in Neolithic Europe. Complementing the DNA studies is an effort to analyze the strontium and lead isotopes in Ötzi's tooth enamel. Comparing the isotopic ratio with samples from 5200-year-old geologic layers in the region can help pinpoint where Ötzi spent his childhood.

One intriguing project in the offing would look at the process of mummification by comparing Ötzi's soft tissues—particularly fatty acid content—with samples from Juanita and other mummies found in the Andes. Seidler is negotiating a joint study with the discoverer of the Peruvian mummies, Johann Reinhard, and the University of Arequipa. But he worries about the effects of Juanita's current tour of Japan, which involves stops in more than 20 cities. "I fear that all the shows and environmental changes would not be so helpful," he says.

Last week's quick analysis of Ice Man evoked no such concerns in Seidler. Monday, he says, "was a great day for my South Tyrolean friends." —RICHARD STONE

GENOMICS

Structural Biology Gets A $150 Million Boost

Structural biology got a shot in the arm this week. The U.S. National Institute of General Medical Sciences (NIGMS) selected seven centers to be the initial test-beds for structural genomics, a field that aims to work out the structures of large numbers of proteins using robotics and advanced computers. The 5-year, $150 million program is intended to speed up the determination of three-dimensional, atomic-scale maps of proteins, which in turn should accelerate discovery of new drugs by giving pharmaceutical companies a closeup look at the proteins they are trying to target.

"This is a major undertaking," says Gaetano Montelione, a structural biologist at Rutgers University in Piscataway, New Jersey, and leader of the Northeast Structural Genomics Consortium. "It's just a starting point for structural genomics. But it's a good start."

The program grew out of the widespread recognition that the Human Genome Project and similar gene-sequencing efforts are only the first step to understanding biology and disease. Although genes harbor the cell's storehouse of genetic information, proteins carry out the bulk of cellular chemistry. Genetic sequences determine the order of amino acids in the proteins they code for, but the chainlike protein molecules generally fold into 3D shapes that cannot be predicted. Fortunately, proteins tend to cluster into families that share similar overall 3D shapes, or "folds." By finding examples of each of these folds, structural genomics researchers hope to identify patterns that will enable computer models to predict the shapes of unknown proteins from their amino acid sequences.

That's a fairly safe bet, says Andrej Sali, a protein modeling expert at the Rockefeller University in New York City and member of the New York Structural Genomics Research Consortium (NYSGRC). Using the estimated 800 known separate protein folds, Sali and his colleagues have been able to create computer models for at least portions of 200,000 proteins. As such, he says the new structural genomics research effort will help modelers achieve "huge leverage" in understanding novel proteins.

STRUCTURAL GENOMICS CENTERS FUNDED BY NEW PROGRAM

Center	Lead Institute	Target
New York Struc. Gen. Research Consortium	Rockefeller Univ.	Bacteria/yeast/human
Northeast Structural Genomics Consortium	Rutgers University	Roundworm/fly/human
Southeast Collab. for Struc. Genomics	University of Georgia	Bacteria/roundworm/human
The Structural Genomic Center	Lawrence Berkeley National Laboratory	Bacteria
Joint Center for Structural Genomics	Scripps Research Institute	Roundworm/human
TB Structural Genomics Consortium	Los Alamos National Laboratory	Tuberculosis bacterium
Midwest Center for Structural Genomics	Argonne National Laboratory	Archaea/bacteria/eukarya

Officials at the National Institutes of Health (NIH) say they hope the new program will enable them to determine the structure of as many as 10,000 proteins in the next 10 years. That's just a smattering of the more than 1 million proteins thought to be present in nature. Nevertheless, it would mark a surge in the pace of discovery for structural biologists, who have collectively solved the structures for only about 2000 unique proteins in the past 4 decades. It's also expected that the coming bolus of protein structures will reveal a large fraction of the estimated 1000 to 5000 protein folds thought to exist.

The centers, each a consortium of institutions ranging from universities and national labs to companies, plan to take slightly different paths to obtaining their protein structures. The TB Structural Genomics Consortium, a center headed by Tom Terwilliger of Los Alamos National Laboratory in New Mexico, for example, is planning to focus its structural work on *Mycobacterium tuberculosis*, the organism that causes tuberculosis, in an effort to spur new treatments for the disease. The NYSGRC, meanwhile, will take a more varied approach. "We're doing proteins from bacteria to man" in an attempt to come up with new clues to conditions ranging from antibiotic resistance to cholesterol metabolism, says Rockefeller's Stephen Burley, who heads the five-institution consortium.

Each new center is slated to receive about $20 million over 5 years, a number that will vary depending on indirect costs paid to the institutions involved. But more money is in the pipeline. In July, NIGMS released another request for additional structural genomics centers to be funded next year. And when the current program is finished, NIH is expected to select two or three of the current crop of centers and ramp up their funding considerably.

–ROBERT F. SERVICE

CEPHEID VARIABLES

Astronomers Measure Size of a Giant's Sighs

To stargazers, Zeta Geminorum makes up the kneecap of one of the twins in the constellation Gemini. To astronomers, it is also one of the brightest Cepheid variables in the sky—giant yellow stars that grow dimmer and brighter over periods of days or weeks. Astronomers have long presumed that the surface layer of a Cepheid variable, called the photosphere, physically expands and contracts to cause this odd behavior. Now, they have caught Zeta Geminorum in the act of swelling and shrinking, making it the first Cepheid that astronomers have actually seen change its size.

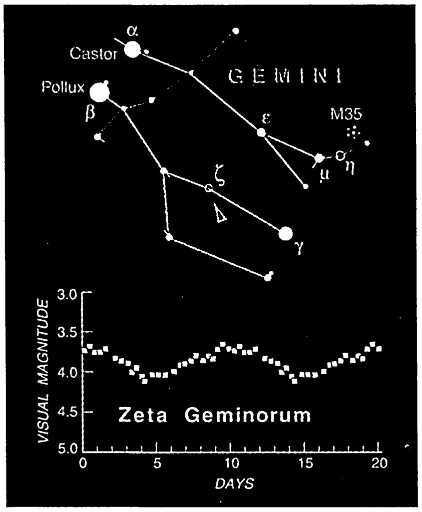
"It's been something that we've always wanted to do," says graduate student Ben Lane of the California Institute of Technology (Caltech) in Pasadena, part of the five-person team that made the observations. Earlier astronomers inferred the size of the oscillations indirectly, through the well-known phenomenon of the Doppler shift. As a Cepheid variable grows, its surface moves closer to Earth, causing its light to appear bluer; as it shrinks, the surface moves away from Earth and the light is redshifted.

Seeing the size change directly, however, has been a daunting challenge in precision astronomy. The angular diameter of Zeta Geminorum, as seen from Earth, is only about 1.5-thousandths of an arc second, or 0.0000004 degrees, and the change in its diameter over a 10-day cycle is only one-tenth of that. Picking out such a small change is equivalent to spotting a basketball on the moon—a feat beyond the ability of either the largest Earth-based telescopes or the Hubble Space Telescope.

Astronomers have now gotten around that problem by linking two telescopes into a 110-meter-wide interferometer. The Palomar Testbed Interferometer (PTI) in California has as much angular resolving power as a telescope with a mirror larger than a football field. (No such telescope exists, of course.) That makes the interferometer perfect for detecting small motions in relatively nearby objects, such as the wobble of a star with a large planet orbiting it or the pulsing of a Cepheid variable. Nevertheless, previous attempts at the PTI, as well as at two other large interferometers in Arizona and France, failed to separate the expected motion from the random jitters caused by Earth's atmosphere.

Lane attributes the Caltech astronomers' success, reported in this week's issue of *Nature*, to three factors. First, they hiked the interferometer's resolution by retuning the instrument to collect a shorter wavelength of infrared light than it had gathered in previous attempts. Second, the group filtered out atmospheric turbulence with a type of optical fiber that some of the other groups did not have. The third ingredient, Lane says, was "persistence. It took a lot of observing time," which had to be squeezed in around the higher profile search for extrasolar planets.

By last Christmas, Lane already had clear evidence of the star's growth and shrinking, and by this spring he had the most accurate estimate ever of the angular size of the oscillations. Then, by dividing the angular size of the oscillations into their absolute size (as inferred from redshift measurements), Lane calculated the distance of Zeta Geminorum as 1100 light-years from Earth.



Throbbing knee. As Zeta Geminorum changes size, it flickers on a 10-day cycle.

But the significance of the result extends far deeper into space. "In time, measurements like these will simplify and therefore strengthen astronomers' measurements of the distances of galaxies, and thus the size and age of the universe," says Jeremy Mould, an astronomer at the Australian National University in Canberra. That is because Cepheid variables are used to calibrate the distances to nearby galaxies, which in turn form a

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ScienceScope

Burning Questions The National Science Foundation (NSF) has been given some high-level advice on how to get the biggest bang for the bucks it wants to spend on environmental research. *Grand Challenges in Environmental Sciences*, released by a National Academy of Sciences panel this week, outlines the eight "most important environmental research challenges of the next generation."

Most in need of "immediate" funding are studies on biodiversity and ecosystem functioning, the consequences of changes in land use and land cover, infectious disease and the environment, and hydrological forecasting of floods and droughts. Also on the list are understanding biogeochemical cycles, climate variability, and how the world uses natural resources and recycles materials.

The report will fuel a bid by the National Science Board (NSB), NSF's overseer, to boost environmental science funding by $1 billion within 5 years; it says funding for the first four topics falls "well within the NSB's recommended increase." NSF environmental czar Margaret Leinen says the recommendations "allow us to proceed with confidence."

Deadly Embrace For the third year in a row, the U.S. Senate has endorsed the idea of doubling federal spending on civilian R&D. But opposition from Representative James Sensenbrenner (R–WI), head of the House Science Committee, will likely doom the bill—along with killing his own bid to boost information technology (IT) research.

The Federal Research Investment Act (S. 2046) passed easily last week. It calls for doubling nondefense R&D spending to more than $70 billion over the next decade. But Sensenbrenner has opposed the bill because it won't force Congress to spend the money (*Science*, 28 May 1999, p. 1452). It allows lawmakers "to champion science once, then forget about it for the next 10 years," he complained in a 19 September letter to Senator Bill Frist (R–TN), an advocate.

Frist tried to sweeten the deal this year by including Sensenbrenner's own IT research bill, already passed by the House. But joining the two bills, Sensenbrenner says, "will only ensure that neither is enacted."

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