Minimalist genome. For the yeast *Schizosaccharomyces pombe*, fewer than 5000 genes is still enough to live the eukaryotic lifestyle.

Of all the eukaryotes sequenced to date, fission yeast "has the smallest number of genes," with 4944 predicted, Nurse reported at the meeting. Budding yeast has 5805 predicted genes, while humans have some 37,000, by the latest count. Even some lowly bacteria, such as *Pseudomonas*, have more than 5000 genes. That makes it clear, Nurse says, "that being a eukaryote doesn't simply depend on the number of genes, but the type and context."

Fission yeast is "a stripped-down eukaryote," says Nurse, and as such, it likely contains the bare essentials of the eukaryotic cell, along with genes that define it as a fission yeast. To check this out, Nurse and his colleagues analyzed which genes fission yeast shares with the other sequenced eukaryotes. (These include the budding yeast, human, the plant *Arabidopsis*, the fruit fly *Drosophila melanogaster*, and the nematode *Caenorhabditis elegans*.) With yeast in the six-way comparison, Nurse eliminated genes that in humans and worms, for example, support multicellularity, as well as those genes that help define each species. They then excluded all the genes that fission yeast shares with prokaryotic bacteria or archaea. Those genes that remained are "a first step toward defining the eukaryotic cell," says Nurse.

Eukaryote-only genes include, for example, those that encode proteins involved in the spatial organization of the cell. Other genes produce proteins that help move molecules around and through membranes within a cell. Some code for proteins that organize chromosomes within the nucleus or regulate cell division, while others encode proteins involved in breaking down other proteins. Eric Green, a geneticist at the National Human Genome Research Institute in Bethesda, Maryland, calls the new work an "exciting first pass" that hints at the power of comparing genome sequences to learn not only about what distinguishes eukaryotes from prokaryotes but also about what sets various eukaryotes apart. "It illustrates the exciting analytical glasses that we are going to be able to put on," he adds.

In related work, a team from the Center for Genome Research at the Whitehead Institute in Cambridge, Massachusetts, has taken a first pass at the genome of the fungus *Neurospora crassa*, another model organism. And the Department of Energy's Joint Genome Institute in Walnut Creek, California, has sequenced and assembled almost 30 million bases of the genome of the fungus *Phanerochaete chrysosporium*. These fungi have much larger genomes and, presumably, more genes than fission yeast. Comparing these fungal sequences to those of yeast and others will help define the genetic underpinnings of that branch of the eukaryotic family tree. —ELIZABETH PENNISI

VOLCANOLOGY

Oregon's Rising, an Eruption to Follow?

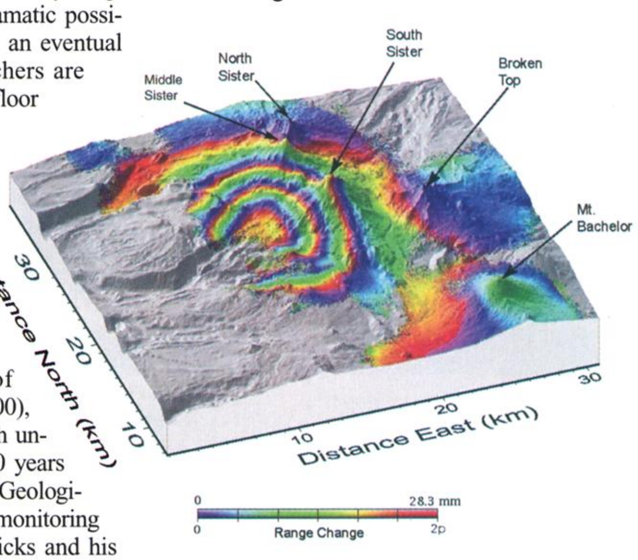
When a parcel of land including a trio of volcanoes swells upward by a tenth of a meter over 4 years, volcanologists tend to get excited. That's exactly what's happened in the U.S. Pacific Northwest. By excruciatingly precise comparison of satellite radar data, they've discovered a broad, 10-centimeter-high uplift on the flanks of the Three Sisters volcanoes in the Cascade mountain range of central Oregon. No one can say what, if anything, will happen next—the most dramatic possibility is continued doming and an eventual volcanic eruption. But researchers are thrilled to be in on the ground floor of what could become a classic case study in volcanology.

Usually, volcanologists arrive on the scene after the ground has begun to shake or, rarely, even as gas and ash are spewing out. Around the Three Sisters—North Sister, Middle Sister, and South Sister—35 kilometers west of Bend, Oregon (population 52,000), there is no geologic sign of such untoward activity in the past 1000 years or more. But as part of the U.S. Geological Survey's Cascades volcano monitoring duties, geophysicist Charles Wicks and his colleagues at the USGS office in Menlo Park, California, were using interferometric synthetic aperture radar (InSAR) to search for any change in the shape of the Cascades.

Like ordinary radar, a satellite-borne SAR measures the distance to the surface by clocking the travel time of a microwave signal bounced off the surface (*Science*, 28 June 1996, p. 1870). Taking data from overflights of European Earth Resources Satellites in 1996 and 2000, Wicks and his colleagues measured the change in the distance to the surface during the 4 years by letting the two slightly out-of-phase signals interfere with each other to form an image of interference fringes. Each rainbow fringe in an interferogram would represent a rise or fall of the surface of 28 millimeters over the 4 years, at least where snow, dense vegetation, and soil moisture variations didn't intervene.

What the InSAR analysis produced was a stunning bull's-eye of interference fringes centered 5 kilometers west of the South Sister volcano. Fifteen to 20 kilometers across and 10 centimeters high at its center, the uplift could have formed as magma oozed up into the crust within 7 kilometers of the surface; in fact, geophysicists are hard-pressed to think of any other explanation. "This came as a shock," says volcanologist C. Dan Miller of USGS's Cascades Volcano Observatory (CVO) in Vancouver, Washington. "We had no idea anything was going on in that part of the world. We may have caught an eruption in the very earliest stages."

Eruptions have certainly happened before near the Three Sisters. "Every bump around there is a volcano," says William Scott, scientist-in-charge at CVO. "It's what central Oregon is famous for." Beyond the Three Sisters, which last erupted with lots of ash about 2000 years ago, there are hundreds of volcanic vents and cones that have briefly spewed less explosive lavas as recently as 1200 years ago. If such magma reached the surface at the bull's-eye, which is in the Three Sisters Wilderness, the hazard would be largely limited to the immediate vicinity, says Scott. If the magma turned out to be the more explosive sort, ash could blow downwind toward Bend or flow down streams as searing ash clouds or muddy floods for many kilometers.



On target. A bull's-eye of a bulge falls among major Oregon volcanoes and hundreds of minor vents.

USGS researchers should have some answers by summer. They are moving equip-

CREDITS: (TOP TO BOTTOM) QUEST/PHOTO RESEARCHERS; C. WICKS/USGS ment, including a seismometer and a telemetered Global Positioning System (GPS) receiver, into the sparsely instrumented region as the winter's snow recedes. GPS should tell them within a few months whether a rapid uplift is continuing. If it is, they'll want to be ready should any of the Three Sisters or their relations awaken.

–RICHARD A. KERR

ASTROPHYSICS

Star-Cluster Census Shows Surprises

The ancient balls of stars known as globular clusters are a favorite place for astronomers to test ideas of stellar evolution. Born in the dark ages before our own sun, globular clusters contain many old, heavy stars concentrated at their cores. Those central regions are so star-rich that near-collisions abound, and heavy stars frequently grab companions to form binary star systems that can reveal crucial information about the history and destiny of the cluster.

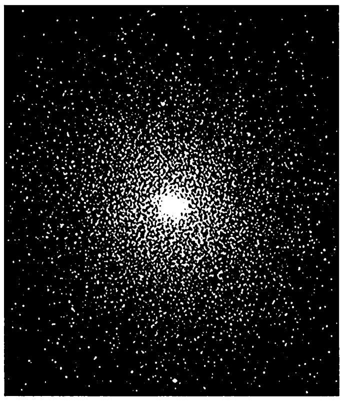
Astrophysicists trying to understand the intricacies of the globular heart have a new weapon: the Chandra X-ray Observatory, uniquely equipped to spot the x-rays emitted by many of the core's inhabitants. Past x-ray studies revealed little more than a flecked smudge compared with new results reported online by *Science* this week (www.sciencexpress.org) from a team at the Harvard-Smithsonian Center for Astrophysics (CfA), which has used Chandra to produce a sharp, color-coded x-ray map of a core.

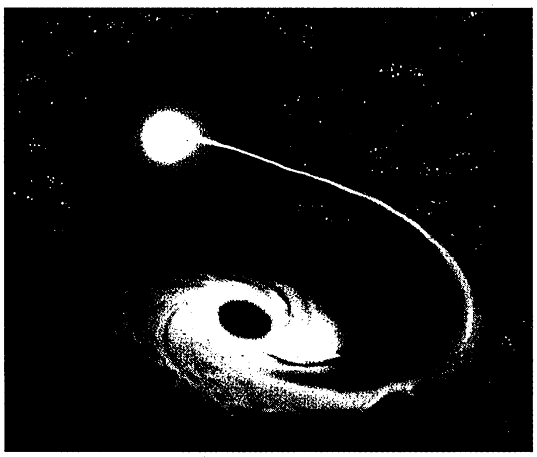
"It is a big step in x-ray astronomy to have actually resolved what is happening in the middle of a globular cluster," says Andrew Fabian of the Institute of Astronomy in Cambridge, United Kingdom. Although radio astronomers and the Hubble Space Telescope have uncovered many secrets of cluster cores, resolving individual x-ray sources and their energies is something new, Fabian says.

The cluster, known as 47 Tucanae, is one of about 150 globular clusters sprinkled through our galaxy. The million or so stars in each are made of the material from which our galaxy grew. Because stars in a cluster all formed at about the same time and are all at about the same distance from Earth, globular clusters are a perfect space lab for astrophysicists to study how stars mature as they age. Heavier stars, more than eight times the mass of our own sun, have collapsed via a cosmic firework display—a supernova—into neutron stars. Many lighter cluster residents, their fuel likewise exhausted, have crumpled under their own weight to form white dwarfs.

But stars in clusters don't merely grow old; they also learn to tango. "Clusters are so incredibly dense in their cores that stars are, in the everyday vernacular, nearly smacking into each other," says Jonathan Grindlay of CfA, who led the new study. As a result, he says, "globular clusters are binary factories," creating new double stars or swapping partners in existing binaries even today.

In a typical binary pair, a small, dense partner—a neutron star or white dwarf—sucks material from its larger but less massive companion. As this accreted material crashes into the smaller star, it heats up, emitting x-rays. Different types of x-ray emitters have distinct x-ray signatures, but only Chandra has both the crisp vision and energy discrimination to pick out and label individual sources. As a result, it can provide information about neutron stars and accreting white dwarfs that has been "sorely lacking," says astrophysicist Sterl Phinney of the California Institute of Technology in Pasadena.





Round numbers. An inventory of x-ray sources in globular cluster 47 Tucanae (*top*) casts doubt on a suspected link between x-ray binaries (*bottom*) and millisecond pulsars.

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Grindlay and his collaborators, Craig Heinke, Peter Edmonds, and Stephen Murray, set out to use Chandra to survey the relative numbers of x-ray sources in the well-studied globular cluster 47 Tucanae—"everyone's favorite globular cluster," according to Phinney. In the central core of the cluster alone, they picked out 108 distinct x-ray sources. By setting out the whole sample on an intensity-color diagram—an x-ray analog of the brightness-color diagram that optical-light astronomers use to classify stars—they claim to be able to estimate the relative numbers of four different types of x-ray sources in the cluster's core. About half are millisecond pulsars (MSPs), in which the x-ray pulse, with a period of just a few milliseconds, comes from a neutron star that spins madly after gobbling mass from its ordinary-star companion. About 30% are accreting white dwarfs, also dubbed cataclysmic variables, which are binaries comprising a white dwarf and an ordinary star. Some 15% are pairs of ordinary stars, while just two or three are what's termed quiescent low-mass x-ray binary (LMXB) stars, neutron star–ordinary star combos that accrete slowly and brighten up at intervals.

The sheer number of neutron stars "is really a bit of a surprise," Grindlay says. Those plentiful neutron stars derive from heavy stars, but astrophysicists expect that clusters should contain many more lightweight stars than heavy ones. Not only that, but neutron stars, freshly forged in a supernova inferno, travel at speeds of several hundred kilometers per second—so fast that they should just "zip out" of a cluster, Grindlay says. But Fabian thinks the problem may be an illusion. Relatively lightweight white dwarfs may well outnumber neutron stars in the cluster, he says. But because they emit few x-rays and don't form pulsars, the x-ray census may simply have undercounted them.

Another mystery is why MSPs so vastly outnumber the handful of LMXBs. Independent evidence suggests that MSPs are the children of quiescent LMXBs, and many astrophysicists believe such transformations can run backward as well. If so, the population of MSPs and LMXBs should show a delicate balance, Grindlay explains—a balance that Chandra does not see. The new results instead support alternative routes for the creation of MSPs, Grindlay says. Perhaps the pulsars result from the direct collapse of accreting white dwarfs. Or perhaps—as Fred Rasio and Saul Rappaport of the Massachusetts Institute of Technology have suggested—LMXBs made a one-way transformation into MSPs long, long ago. In any case, astrophysicists agree that puzzles, at least, are one thing 47 Tucanae is likely to keep producing in abundance.

–ANDREW WATSON

Andrew Watson writes from Norwich, U.K.