shown in figure 2. In the case of cis-to-trans isomerization, the first step is that the cis isomer sticks to six of the eight amino acids identified as binders. Next, arginine-55 catalyzes the isomerization by weakening the stiff single bond between the proline and its neighboring amino acid. With one part of the substrate still stuck to the enzyme, the other part detaches from the enzyme and rotates 180° around the weakened bond, forming the trans isomer. The rotated end sticks momentarily to the remaining two amino acid binders before the enzyme releases the isomerized substrate. The trans-to-cis isomerization works the same way, but in reverse.

Transplants, HIV

The very property that makes CypA amenable for Kern's NMR investigation—that the enzyme catalyzes a reversible isomerization—makes it hard to identify CypA's overall purpose in cellular activity because substrate and product are so similar. Indeed, when it was first discovered in 1984, CypA was named not for its enzymatic activity—which was unknown at the time—but for its ability to bind to and disable cyclosporin A, a drug that suppresses human immune systems in organ transplants.

CypA was identified as an enzyme in 1989, when two groups,[2] one from Tonen's corporate R&D lab in Saitama, Japan, and one from the Max Planck Research Unit for Enzymology of Protein Folding in Halle, Germany, proved that CypA is identical to a prolyl isomerase, which, like CypA, had been discovered in 1984. The story didn't end there. CypA and its fellow cyclophilins have turned up in all sorts of places in all sorts of organisms, including the capsid of the HIV-1 virus.

Now, evidence is emerging that CypA's fundamental role is tied to its enzymatic function—even when it appears merely to bind to other proteins. Kern and her collaborators recently used NMR to test whether CypA isomerizes HIV capsid protein.[3] It does. The finding suggests that HIV-1's deadly virulence could depend on CypA's catalytic ability.

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Recent Nearby Supernovae May Have Left Their Marks on Earth

A close encounter with a supernova two million years ago might be responsible for a widespread extinction of mollusks.

A recent paper by astrophysicists Narciso Benítez and Jesús Maíz-Apellániz at Johns Hopkins University, and biologist Matilde Cañelles at the National Institutes of Health presents evidence that the Scorpius–Centaurus association of hot young stars within just a few hundred light-years of us has produced about 20 supernova explosions within the past 10 million years.[1] That's far more than our local neighborhood's fair share, considering how very rare supernovae are. Among the 10^{11} stars in a galaxy like the Milky Way, there are only a handful of supernovae per century.

But supernovae are not always isolated, random events. They often cluster in time and space, particularly in so-called OB associations like Sco–Cen. These are loose groupings of typically a few hundred O and B stars. (O and B are spectral classifications for the two classes of the most massive, and therefore hottest and shortest-lived, stars.)

What lends the new paper more than passing interest for non-astronomers is its conclusion that parts of Sco–Cen wandered so close to us a few million years ago that a number of its supernovae may have left noticeable physical and biological traces on Earth. Benítez and company extrapolated the positions of Sco–Cen's present population of about 150 stars back in time as far as 10 million years and estimated the rate at which the association was producing supernovae during that period. Then they made the case that material ejected from about a dozen of its supernovae can account for the high levels of the unstable iron isotope ^{60}Fe discovered three years ago[2] in two layers of ocean-floor crust gradually laid down during the past 6 million years.

More speculatively, the paper suggests that, when Sco–Cen was at its closest about 2 million years ago, one of these supernovae—perhaps only 120 light-years from Earth—may have damaged Earth's ozone layer enough to cause the rather abrupt extinction of many bivalve species in tropical and temperate seas at the boundary between the Pliocene and Pleistocene epochs.

Hipparcos

Speculation about what a nearby supernova might do to the ozone layer and life on Earth goes back to a 1974 paper by Malvin Ruderman at Columbia University. But nowadays the speculators have access to a valuable resource that didn't exist before 1997: the Hipparcos catalogs (see Physics Today, June 1998, page 38). The Hipparcos astrometry satellite, launched in 1989, has provided parallax distance measurements to hundreds of thousands of stars within 500 light-years of Earth. Furthermore, when the Hipparcos data are analyzed together with ground-based observations, they yield accurate determinations of the motion and spectral classification of many of these stars.

Distance is, of course, a key determinant of the damage a supernova might do. If one wants to calculate how close a star has come to Earth in the past 10 million years, one needs to know its present position and velocity. And the spectral classification of a star reveals its approximate mass, lifespan, and ultimate fate.

Sco–Cen, the nearest of all OB associations, is in fact a loose alliance of three subgroups, ranging in age from about 14 million to 5 or 6 million years. In any one subgroup, all the stars are assumed to have been born more or less simultaneously, presumably in the same molecular cloud. The paper of Benítez and company leans heavily on a 2001 paper by co-author Maíz-Apellániz.[3] From the present positions and velocities of the individual Sco–Cen stars, Maíz-Apellániz calculated their trajectories back to the time, some 10 million years ago, when supernovae would first have appeared in the oldest subgroup of Sco–Cen.

A star's fate is determined primarily by its mass. The spectral classes O and B are subdivided into numbered subclasses by stellar mass and surface temperature. The O stars are the most massive and shortest lived. They all eventually explode as core-collapse supernovae, as do B stars heavier than about 9 solar masses. A 10-solar-mass star explodes after about 10 million years.

Availing himself of carefully vetted membership lists of the Sco–Cen subgroups derived from the Hipparcos catalogs by Tim de Zeeuw and coworkers at the Leiden Observatory,[4] Maíz-Appelániz was able to estimate the number of stars in each Sco–Cen subgroup that have already exploded, by comparing the present spectral distributions with an astrophysical model of the mass distribution with which an OB subgroup would have been born. He concluded that each subgroup, after a 4-million-year gestation period, produced roughly one supernova every million years.

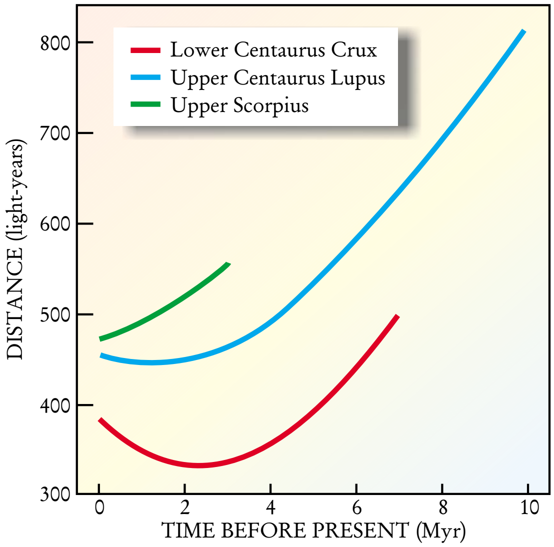

FIGURE 1. VARYING DISTANCE between the Sun and the centers of the three Sco–Cen subgroups of hot young stars, calculated back to the time when each subgroup began producing supernovae. The closest approach, by Lower Centaurus Crux, occurred about 2.5 million years ago. (Adapted from ref. 1.)

The Local Bubble

The Solar System sits inside an interstellar cavity of hot, low-density gas, some 400 light-years wide, called the Local Bubble. The principal result of Maíz-Apellániz's Sco–Cen paper was to strengthen the recent argument, by Randall Smith (Harvard University) and Don Cox (University of Wisconsin),[5] that the Local Bubble was excavated by a number of nearby supernovae over the past 10 million years.

Figure 1 shows the migration of the centers of the three Sco–Cen subgroups since they first began producing supernovae.[1] Our closest encounter, according to Maíz-Apellániz's calculation, was with the subgroup Lower Centaurus Crux (LCC), about 2.5 million years ago. The mean radius of LCC is about 90 light-years. So when the center of LCC was barely 300 light-years from us, a star two standard deviations from its center could have exploded within 120 light-years of Earth.

Iron-60, with a half-life of 1.5×10^{6} years, is expected in the ejecta of core-collapse supernovae. The strongest direct evidence for Maíz-Appelániz's estimate of a steady diet of supernovae from Sco–Cen comes from the radiological analysis of several layers of ferromanganese crust on the floor of the South Pacific by Klaus Knie (Technical University of Munich) and coworkers in Germany. They interpreted the unusually high concentrations of ^{60}Fe they found in a layer gradually deposited over 2 million years, starting 6 million years ago, to be evidence of a nearby supernova.[2] For the youngest layer, however, laid down over the past 2.8 million years, Knie's group tentatively attributed the measured ^{60}Fe excess to radioactive iron from the solar neighborhood.

Armed with Maíz-Apellániz's calculation of Sco–Cen's wanderings and its supernova output, Benítez and company come to a different conclusion for the youngest layer, which started forming when LCC was approaching its close encounter. Figure 2 compares the measured ^{60}Fe abundances for that layer with their estimate of deposition from the ejecta of Sco–Cen supernovae over the last 2.8 million years. The calculated supernova contribution assumes that the three Sco–Cen subgroups have produced a total of about eight supernovae during that period, at a mean distance of 400 light-years. Looking back over the entire 10 million years during which Sco–Cen has been active, Benítez and company conclude that supernovae from the association have ejected enough ^{60}Fe to account for the concentrations found by the German group in all the crustal layers it measured.

The ozone layer

To examine the intriguing possibility that a supernova might have caused the bivalve extinction 2 million years ago, Benítez and coauthors concentrated on LCC and considered the effect on Earth's protective ozone layer of a supernova as close as 120 million light-years. Examining such scenarios in 1995, John Ellis (CERN) and David Schramm (University of Chicago) pointed out that charged cosmic rays are the only emissions from a supernova more than about 10 light-years away that could do serious damage to the biosphere.[6] An increased flux of cosmic rays in the upper atmosphere, they noted, would have sped up the production of nitrogen oxides that catalytically destroy ozone and thus could have endangered sea-surface plankton and those that feed on it. It was they who suggesting looking for ^{60}Fe as evidence of nearby supernovae.

Benítez and company estimate that the rate of energy deposition in the upper atmosphere over a 10-year period by cosmic rays from a supernova 120 light-years away might be as much as half a milliwatt per square meter. That would be enough, they argue, to temporarily deplete the ozone layer in the tropics by about 20% and by as much as 60% at high latitudes. Ellis and Schramm's estimate of the cosmic-ray flux from a supernova 30 light-years away was only twice as big as that of Benítez and company for a supernova four times as distant.

Why only twice as big and not 16 times? Whereas Ellis and Schramm had assumed that the charged cosmic rays are dispersed on the way here by a typically random interstellar magnetic field, the Benítez calculation invokes the much weaker and more coherent magnetic field one would expect for the Local Bubble, if it was indeed swept out by supernovae. Neil Gehrels (NASA's Goddard Space Flight Center) tells us that a new model calculation, soon to be reported by his group, concludes that a supernova much farther away than 30 light-years is unlikely to have done much damage to the ozone layer. But like Ellis and Schramm, the Goddard calculation makes no special assumption about the local magnetic field.

A minor extinction

"The increased solar ultraviolet from our estimate of the damage to the ozone layer," Cañelles told us, "would have caused, at most, a minor extinction," nothing like the worldwide mass extinction in which the dinosaurs vanished. Because ultraviolet radiation doesn't penetrate very deep into water, the primary damage would probably have been to photosynthesizing phytoplankton near the surface. A significant reduction of phytoplankton abundance, Cañelles and coathors argue, might well have worked its way up the food chain to the filter-feeding

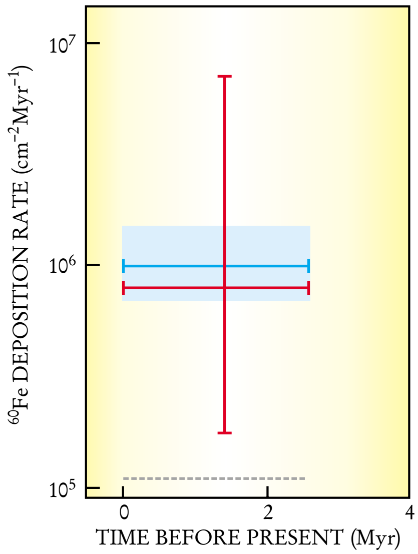

FIGURE 2. AVERAGE DEPOSITION rate of iron-60, measured (blue) in a layer of ocean-floor crust that began forming 2.8 million years ago, is compared with a calculation (red) of what one would expect from the ejecta of supernovae in the nearby Sco–Cen association of hot, young stars over that same period. The dashed line is the estimated background from nonsupernova sources. (Adapted from ref. 1.)

bivalves whose extinction in the Western Atlantic around the time of the Pliocene–Pleistocene boundary roughly 2 million years ago is well documented in the fossil record.

When this regional extinction was first documented in the 1980s, the most widely discussed explanation was the cooling associated with the onset of glaciation that marked the start of the Pleistocene. "But in recent years it has become rather clear that cooling doesn't suffice to explain the decrease in planktonic productivity that appears to have been the proximate cause," says Warren Allmon (Cornell University and the Paleontological Research Institution). "By contrast, the abrupt increase of ultraviolet in the supernova hypothesis is quite consistent with what we know about this regional extinction."

In the supernova scenario, the greatest damage to the ozone layer occurs at high latitudes. Nonetheless, it's the tropical species that would have suffered worst, because solar radiation is so much more direct in the tropics. To test their admittedly speculative extinction hypothesis, Benítez and coauthors look forward to a more finely time-resolved examination of crustal ^{60}Fe soon to be reported by Knie's group, in hopes of pinning down the times and distances of individual nearby supernovae.

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Quantum Point Contact Mysteries Reexamined

The Kondo effect is well established in metals and in quantum dots. Could something similar be occurring in quantum point contacts?

Quantum point contacts represent, in many regards, the simplest system in mesoscopic physics. By applying a voltage to a gate electrode (see the inset of figure 1), researchers can control the width of a constriction between two reservoirs of electrons in a two-dimensional electron gas (2DEG). For sufficiently large negative gate voltages, the constriction is completely closed off, and electrons must tunnel between the reservoirs. But when the voltage is made less negative, the constriction begins to open up, and the conductance through the quantum point contact increases in steps of $2e^2/h$ (see the article by Henk van Houten and Carlo Beenakker in PHYSICS TODAY, July 1996, page 22).

The origin of this quantized conductance is neatly explained using a model of noninteracting electrons. The constriction lets through an integer number of transverse modes, each contributing the unit quantum of conductance, e^2/h; an additional factor of two arises from the spin degeneracy. This system thus provides a clear demonstration of ballistic transport in quantum systems.

But the quantum point contact system has turned out to be more complicated than what this simple picture describes. In 1996, Michael Pepper's group at the University of Cambridge[1] drew attention to the presence—even in the earliest point contact data—of an additional conductance feature (see figure 1) in the vicinity of 0.7 $(2e^2/h)$.

The nature of this "0.7 structure" has proved elusive. "It's the single most important open problem in the field of quantum ballistic transport," claims Beenakker (University of Leiden). Various experimental observations clearly suggest that spin plays a significant role in the origin of the structure, but most current models are based on phenomenology and not on a detailed microscopic theory. A new suggestion—that the low-conductance behavior has its origins in the Kondo effect—is still largely phenomenological, but is attracting much attention. This conjecture has been proffered by Charles Marcus and his colleagues Sara Cronenwett and Heather Lynch at Harvard University, working with David Goldhaber-Gordon (Stanford University), Leo Kouwenhoven (Delft University of Technology), Kenji Hirose and Ned Wingreen (NEC Corp), and Vladimir Umansky (Weizmann Institute of Science).[2]

The evidence

Pepper and coworkers have made extensive studies of the 0.7 structure, looking at the effects of temperature, magnetic field, electron density, point contact geometry, and other factors.[3] From their results, along with experiments by Anders Kristensen and colleagues[4] (University of Copenhagen), Robert Clark's group[5] (University of New South Wales in Australia), and others, a fairly consistent body of experimental data concerning the behavior of the 0.7 structure has emerged.

The 0.7 structure appears even in the cleanest of samples. Although the actual position can vary between 0.6 and 0.8, the feature appears insensitive to the details of the point contact and is never seen below 0.5 $(2e^2/h)$, indicating that the feature is intrinsic and does not arise from impurities or imperfections in the point contact.

The 0.7 structure behaves differently from the conductance plateaus. As the temperature is lowered, the plateaus become sharper but the shoulder at 0.7 disappears, rising to merge with the first conductance step (see figure 1). The conductance in the vicinity of the 0.7 structure also decreases as the bias across the point