GENOMES

Gram-Positive Bacterium Sequenced

The first genome sequence from an important group of bacteria that includes both commercially useful and pathogenic strains has been completed by an international team led by researchers in the European Union (EU) and Japan. After 5 years of work, leaders of the team of 37 laboratories announced the complete sequence of the 4.2-million-base genome of *Bacillus subtilis* at a meeting on the organism at the University of Lausanne in Switzerland last week.

R. KESSEL AND G. SHIH/VISUALS UNLIMITED

Subtleties revealed. The newly sequenced *Bacillus subtilis*.

The new sequence joins the published genomes of nine other microbes. This one, however, is an important industrial source of enzymes used in detergents, baking, and the manufacture of vitamins. It is also a member of the so-called "gram-positive" group of bacteria, which includes notorious pathogens such as *Staphylococcus aureus*, the scourge of surgical patients; *Streptococcus*, which causes middle-ear infections, pneumonia, and meningitis; and the pathogens responsible for tetanus, anthrax, and diphtheria. "The sequence information should help boost our understanding of the mechanisms of protein secretion and pathogenesis in gram-positive bacteria," says team coordinator Frank Kunst of the Pasteur Institute in Paris.

The EU spent $5.3 million to sequence 60% of the genome, with Japan sequencing a further 30%. One Korean and two U.S. laboratories helped complete the sequence. Although comprehensive analysis of the genome will take several years, researchers have already spotted features of interest. "Several genes encoding proteins with potential antibiotic properties have been identified," says Kunst.

The genome, a circular double strand of DNA, displays unusual features at the sites where DNA duplication begins and ends before cell division. The frequency of certain dinucleotides is higher than usual at the site where replication begins and lower at the end. "Compared with other bacteria already sequenced, this may help us understand how the DNA sequence is interpreted by the bacterium to initiate duplication," says Kunst.

Researchers will also be paying close attention to genomes within the genome: the integrated sequences of several bacterial viruses called bacteriophages. Under unfavorable conditions, these viruses kill the host cell and infect new ones. But some of the bacteriophages in *B. subtilis* also appear to contribute genes that aid the host bacterium by helping it resist harmful substances such as heavy metals. Others carry toxin genes, which may be responsible for some of the pathogenic properties of other gram-positive bacteria.

Now that the sequencing has been completed, the EU plans a follow-up program to study the function of each of *B. subtilis*'s estimated 4000 genes. "Comparison with genomes of other bacteria and other organisms will provide us with the most complete understanding of what is required to sustain microbial life," says Kunst.

–Nigel Williams

ASTROPHYSICS

Meteorite Grains Trace Wandering Stars

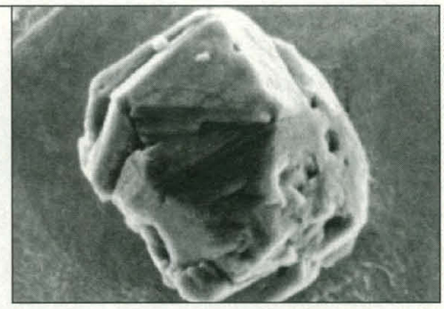
Some of the tiny dust grains found inside meteorites may be the relics of stars that migrated from distant parts of our galaxy, says astrophysicist Donald Clayton of Clemson University in South Carolina. In a report presented this week at the Meteoritical Society meeting in Hawaii and in this week's *Astrophysical Journal Letters*, Clayton presents what astrophysicist Frank Shu of the University of California, Berkeley, calls a "pioneering" theory. He argues that isotope ratios in the grains record how the stars that made them drifted long distances outward from the galactic center during their lifetimes.

Scientists have known for a decade that certain microscopic particles found in meteorites—flecks of graphite, aluminum oxide, and other materials—predate our solar system. Isotopes of common elements occur in unusual ratios in the grains, convincing researchers that the grains condensed more than 5 billion years ago in the atmospheres of other stars. The stars then shed them into interstellar space, and they ended up in the cloud of material that coalesced to form our solar system.

One particular kind of grain, made of silicon carbide, presented a special puzzle: These grains contain a higher ratio of heavy silicon isotopes to normal silicon than is found in the sun. Yet the abundance of heavy isotopes in the galaxy has been increasing over time as they are forged in the cores of massive stars. Because the meteorite grains formed before the sun did, the isotope ratio they captured should be lower than the sun's, not higher.

There is one region where heavy isotopes might have been plentiful enough to explain the dust grains: toward the galaxy's center, where large numbers of massive stars have lived and died. In Clayton's scenario, stars that formed closer to the center of the galaxy migrated outward. Their lazy orbits around the galaxy, he says, would have taken them past huge gas clouds that gave them a "gravity assist," boosting them into larger orbits just as Jupiter's gravity gave a boost to the Voyager space probes. Eventually these wandering stars ended up near the sun's future birthplace, where they exploded, depositing their remains.

This picture, says Clayton, was inspired by a recent suggestion that the sun has itself drifted outward during its 4.5 billion years of life, explaining why our solar system has more heavy elements than other stars in the region. The stars that spawned the anomalous



S. AMARI/WASHINGTON UNIV.

Dust of ages. A 4-micrometer silicon carbide grain from the Murchison meteorite.

grains, he says, were born even closer to the galactic center than the sun. He thinks his new scenario will allow researchers to treat the isotopic composition of these grains as records of these stellar wanderings. If his theory is correct, he says, meteorite grains "offer a whole new tool for exploring the structure and evolution of our galaxy."

Shu points out that such new models are often incorrect in some details, but he thinks the basic picture of stars moving radially through the galaxy is probably correct. And he praises Clayton for showing how only milligrams of dust have "tremendous stories to tell about things that [occurred] very long ago and very far away."

–David Ehrenstein