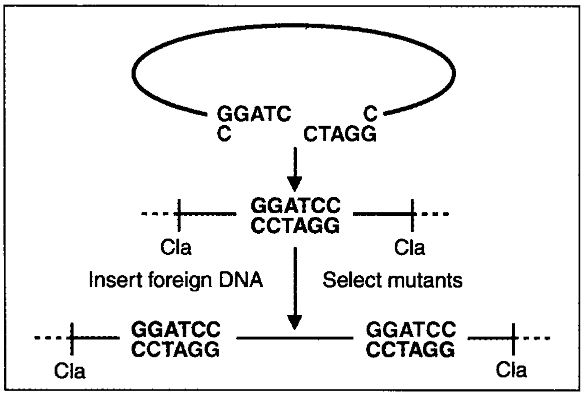
scribe the method in the 15 September 1992 issue of *Proceedings*.)

Not only did the *Dictyostelium* cells not die, but the foreign DNA was apparently inserted into the sites cut by the restriction enzyme when they were repaired by the cell's normal DNA-repair machinery. The result: the frequency of integration of the foreign DNA was between 20 and 50 times higher than it was without the enzyme. The main requirement, Loomis says, is that the piece of foreign DNA be prepared so that the sequences at the ends match up with those at the ends of the cuts made by the restriction enzyme used.



Tagging a gene. A restriction enzyme such as *Bam*HI can aid gene tagging by cutting the *Dictyostelium* DNA so that a piece of foreign DNA *(red)* can insert. The tag with flanking cellular sequences can then be cut out with a different enzyme (here *Cla*) and cloned.

Since the *Dictyostelium* genome is small, about 40 megabases of DNA, with relatively little of the noncoding "junk" DNA that clutters up larger genomes, the high integration frequency means that the foreign DNA has a good chance of inserting itself into a developmental gene. When it does, the insertion both disrupts the gene's function, creating a mutant, and tags the affected gene. Using just one restriction enzyme (designated *Bam*HI), Loomis and Kuspa have already produced 50 developmental mutants of *Dictyostelium*, and isolated 16 of the corresponding genes.

Since there are several hundred restriction enzymes, each of which cuts at its own specific DNA sequences, it should be possible, Loomis says, to saturate the *Dictyostelium* genome with insertional mutations very quickly—and pick up the organism's entire repertoire of developmental genes. "Expect an explosion of papers in the next few years," predicts Segall. Indeed, some 15 other groups have already begun to apply the method, which Kuspa and Loomis have named REMI for "restriction enzyme mediated integration," to *Dictyostelium*.

Most of the 40 or so genes already implicated in *Dictyostelium* development were identified because the researchers had biochemical evidence that pointed to the genes' involvement. But with REMI, no prior knowledge is needed to identify genes, and that means, says Firtel, that "you can now get genes that you had no idea existed before." In fact, Loomis says that his group is already recovering genes that "we knew nothing about and wouldn't have predicted." The identification of all those genes should provide a detailed picture of the biochemical pathways that control migration and the various other aspects of *Dictyostelium* development—and perhaps provide clues to the comparable pathways in higher organisms.

And as a bonus, the identification of new *Dictyostelium* genes could be important for the Human Genome Project. As Williams points out, project participants "will sequence a lot of DNA never seen before." To find clues to the function of the newly discovered human genes, the sequencers will need to look for matching genes in databases compiled from other species.

The growing enthusiasm for REMI doesn't mean that the technique is perfect, however. It can't be used to identify genes that are essential for life, since any cell in which such a gene is knocked out will simply die. And it's not clear that it will be applicable to many other species beside *Dictyostelium*. It may be less effective, Loomis cautions, for organisms whose genomes contain a lot of junk DNA, decreasing the likelihood that an insertion will hit a coding region and cause an interesting mutation.

But for *Dictyostelium* fanciers, REMI seems ideal. And to increase the efficiency of their gene search—and avoid unnecessary competition—the researchers plan to coordinate their efforts. Loomis and Kuspa, who run what amounts to the *Dictyostelium* genome project and are physically mapping the organism's genome, will serve as a clearing house where researchers can send the genes they find. By comparing the genes' locations on the map, it will be possible to tell whether they are new or have been previously isolated and whether two researchers have come up with the same gene. If they have, Loomis says, "we'll tell them that they ought to talk to each other." That way the researchers could work together, or one might agree to back off in favor of the other. As Loomis says, "There are more than enough genes for all of us. For a period of 4 or 5 years, we can all be generous."

–Jean Marx

PLANETARY SCIENCE

Earth Gains a Retinue of Mini-Asteroids

Talk about rush hour traffic. Astronomers conducting the most powerful search ever for tiny objects passing near Earth have discovered a slew of house-sized asteroids whizzing along in our neighborhood. Indeed, astronomers David Rabinowitz, Tom Gehrels, and their colleagues at the University of Arizona reported at last week's Division of Planetary Science meeting in Munich that as many as 50 of the mini-asteroids must pass between Earth and the moon each day. That's 100 times more of these nearby asteroids than observations of larger bodies had implied—which leaves astronomers puzzling over their origins and wondering how often they wreak havoc on the ground.

The objects weren't detected before because they're too faint to show up on the photographic plates used in previous searches, leaving extrapolation from counts of larger, less numerous objects as the only means of estimating their abundance. But 2 years ago, Gehrels and his Arizona colleagues in the Spacewatch program, a vigil for asteroids passing near Earth, installed a sensitive charge-coupled-device camera on a 72-year-old telescope on Kitt Peak. Since then, the camera has revealed eight new asteroids between 5 and 100 meters in size passing nearby. Given that Gehrels and his colleagues had only imaged a tiny fraction of the sky for a small part of the time, they inferred that the skies near Earth must be teeming with asteroids.

The big question now is, where do they come from? One clue, says Rabinowitz, comes from the shapes of their orbits, which are unexpectedly similar to Earth's. Of the eight asteroids, two have orbits more like Earth's than any other known asteroid, another two never stray too far from Earth's orbit, and two more pass near Earth's orbit at their closest approach to the sun.

At first, the near-identity of some asteroid orbits with Earth's raised the possibility—ruled out as more discoveries came in—that some of these objects were actually the spent upper stages of rockets launched from Earth. But several speculative possibilities remain, says Rabinowitz. Earth's gravity might have captured the mini-asteroids as they swung in from the main asteroid belt. They might have been blasted off the moon by large impacts. Or, they may be the debris from the breakup of a larger object in an Earth-like orbit.

Wherever they come from, they are unsettlingly abundant. A meteor 40 meters or so in diameter exploded over Siberia in 1908, releasing energy equivalent to that of a 15-megaton nuclear bomb and leveling 1600 square kilometers of forest. Astronomers had previously calculated that a hit like that occurs every 200 to 300 years, on average. In light of the Spacewatch discoveries, researchers are now recalculating the odds. Celestial traffic accidents, it seems, could be all too frequent.

–Richard A. Kerr