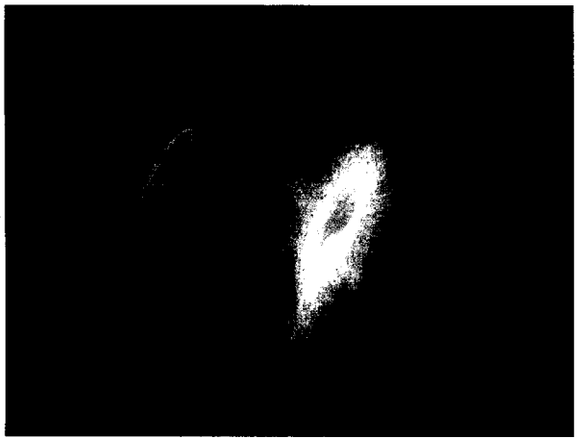
which were announced last month at the Origin of the Earth and Moon conference in Monterey, also tracked for the first time how smaller collisions following the giant impact could have tweaked Earth's rotation rate and the tilt of its axis to match what is seen today.

Don Davis and William Hartmann, now of the Planetary Science Institute in Tucson, Arizona, proposed the giant impact theory in 1975. By the mid-1980s, it had emerged as the leading explanation for the moon, largely because every other theory appeared to have fatal flaws. For example, "co-accretion," in which the Earth and moon grew up together, failed to explain why the moon has a much smaller iron core than Earth. The "fission" model, in which the moon spun off from the outer layers of Earth, failed to explain why the moon has an iron core at all. But planetary scientists embraced the impact scenario reluctantly, says Hartmann.



Big crash. Artist's conception of a Mars-sized body smashing into the infant Earth, a likely event in the early solar system.

"The big objection in those days was that a giant catastrophic collision seemed ad hoc to all the other workers."

Testing the idea by simulating the motion of the dozens of "protoplanets"—the building blocks of the planets—in the early solar system was impossible until recently. Computers weren't up to the task, and existing mathematical methods limited the length of time that could be modeled. After 100,000 orbits or so, the accumulated errors in the computations would cause the planets to fly away to infinity or spiral into the sun. Canup, Craig Agnor of the University of Colorado, Boulder, and Harold Levison of SWRI, however, use a new method called "symplectic integration," which prevents the energy of the virtual solar system from increasing, enabling researchers to model tens of millions of orbits.

Canup's simulations begin about 10 million years after the birth of the solar system, when gas and dust would have coalesced into about two dozen protoplanets, and continue until the full-fledged planets have settled into stable orbits, typically after about 100 million years. At this point, the inner solar system nearly always contains only four or five planets that have swept up all the rest. Usually, one or two of these planets have experienced impacts large enough to form a moon, Canup found. Two other research groups, relying on symplectic modeling techniques, have gotten similar results.

Planetary scientists agree that the new simulations are not the last word. "The problem with the simulations is that they are all primitive in one way or another," says Jack Lissauer of NASA's Ames Research Center in Mountain View, California, a member of one of the other modeling groups. In particular, all three models assume that colliding objects stick together like lumps of clay; in reality, many of the collisions probably threw out debris, affecting the size and orbit of the resulting body. (The new models don't actually show debris flying off to form the moon; they simply show impacts big enough to do the job.)

Still, Canup's simulation may resolve an inconsistency in the giant impact scenario: the difficulty of producing a collision large enough to get a moon-sized body into orbit, but with low enough angular momentum to produce the orbit seen today. Most plausible impacts would have resulted in a lunar orbit much farther out.

Earlier this year, Alastair Cameron of Harvard University proposed one solution. His model assumes the Earth was only two-thirds its present size when the impact occurred, allowing the impactor to be small and eliminating the angular momentum problem. If the collision took place early enough in planetary history, plenty of debris would have remained to feed the growth of Earth to its present size. But there's a snag: comparisons of the chemical compositions of the Earth and moon imply that the Earth was fully formed, or nearly so, when it spawned the moon.

Canup's simulations provide a different way out. They show that before or after the giant impact, Earth could have experienced a shower of small impacts, which could have slowed the rotation of the Earth-moon system. "Smaller impacts are very effective at tweaking the spin of a planet, even though they add very little mass," Canup says. Lissauer, however, is not convinced that Canup's solution escapes the problem of the similarity in Earth-moon composition, noting that his "back-of-the-envelope" calculation shows that the impactors would have added at least 4% of Earth's present mass after the moon had been born.

The new impact simulations also give astronomers who are searching other stars for planets like our own an extra tool. By making giant impacts a likelihood and smaller impacts a near certainty, the simulations suggest that the birth throes of moons like our own might be visible in other solar systems. Alan Stern of SWRI, who has calculated that a moon-forming impact should be detectable from a distance of 400 light-years, says the glow of such a cataclysm "would be the only way of detecting an Earth-sized planet in another solar system directly."

–DANA MACKENZIE

Dana Mackenzie is a writer in Santa Cruz, California.

CREDIT: WILLIAM HARTMANN

HUMAN CLONING

Korean Report Sparks Anger and Inquiry

SEOUL, KOREA—Last month's report by doctors at a Seoul fertility clinic that they had cloned a human embryo has set off a storm of scientific doubts and public anger here. Announced on 14 December by a team from Kyunghee University Hospital, the procedure has also sent Korean politicians scrambling to fill a hole in rules adopted last year by the Ministry of Health and Social Welfare that cover genetic research but not human cloning.

A press release from the Kyunghee doctors described a procedure using cells donated by a patient, a woman in her 30's, for unspecified experimental purposes. The researchers say they removed the nucleus of an egg cell and inserted the nucleus of an adult cumulus cell—a kind of cell that surrounds the ovary—before chemically activating the new cell. The reconstituted egg cell then divided twice in vitro before the researchers ended the experiment.

Fertility specialists Kim Bo Sung and Lee Bo Yun, two members of the Kyunghee team, say they closely followed a technique used by University of Hawaii researchers to clone mice (*Nature*, 23 July 1998, p. 369). But they have declined to provide details and say that no results will be published until further work is done. Lee says he thought that pre-implantation stage research might be helpful in treating infertile couples, but that the team aborted the embryo after four cells because of ethical concerns.

Other scientists here have joined a global chorus of skepticism about these claims. They point out that it is common for ordinary unfertilized eggs to divide twice if stimulated and have derided the Kyunghee team for grandstanding. Seo Jung Sun, head of a four-man committee appointed by the Korean Medical Association to investigate

the Kyunghee results, says he has "lots of questions" for the researchers, including whether the introduced genes were actually in charge of cell division.

An expert at one of Seoul's biggest in vitro fertilization clinic, who asked not to be identified, says the Kyunghee doctors "are not experts" on cloning and have few published papers. He sees the experiment as a response to heavy competition among what he calls "test tube baby centers" (there are up to 30 in Seoul, and 80 nationwide), noting that such publicity might be expected to drum up more business.

The announcement nevertheless produced a strong public outcry, with newspaper editorials evoking the specter of "large numbers of Adolf Hitlers." In a brief telephone interview, Lee professed "surprise" at the strong reaction. Ethical oversight of research is sparse in Korea, and many university programs have no ethics committees to judge experiments. The Korean Fertility Society visits fertilization centers, but offers no certification or regulation.

Responding quickly to the outcry, several legislators say that they want to ban all human cloning experiments except those that relate to disease research. One proposal already before the National Assembly would give the job of reviewing such experiments to a committee of representatives from government, religious groups, research, and industry. Seo says he hopes any legislation would still permit in vitro research with embryos up to 14 days old, but that it may be difficult to find support for such an approach. "Before [the experiment], congressmen were cooperative," he says. "But now they are really anxious."

–MICHAEL BAKER

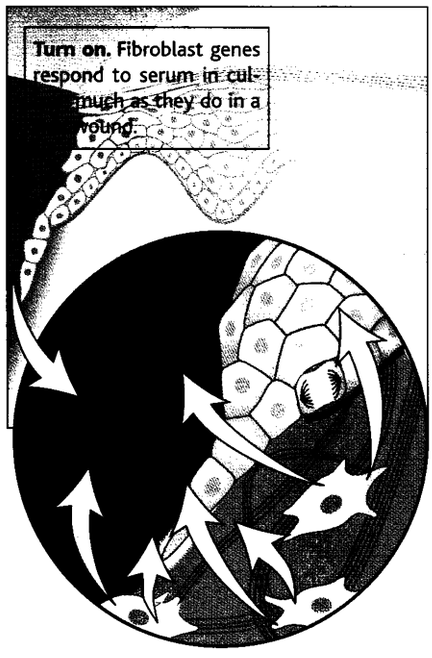
Michael Baker writes from Seoul.

MOLECULAR BIOLOGY

DNA Chips Give New View of Classic Test

It's a simple experiment, one that cell biologists have been doing for at least a quarter-century. Take a culture of connective tissue cells called fibroblasts, deprive them of nourishing serum for 2 days, then add back the serum and watch the genes that turn on as the fibroblasts grow. By now, you might think that biologists would have the cells' responses pretty well figured out. You'd be mistaken.

The standard view has been the serum's growth factors and other nutrients switch on the fibroblasts' cell proliferation program, stimulating them to divide. But on page 83, molecular biologists Patrick Brown and Vishwanath Iyer of Stanford University and their colleagues report a very different picture. Using a DNA chip that allowed them to monitor more than 8600 genes at once, the Stanford team found that the serum not only stimulates cell division, it also turns on genes needed for wound healing.



Turn on. Fibroblast genes respond to serum in cul- much as they do in a wound.

CREDIT: K. SUTLIFF

The work demonstrates the power of DNA chips for looking at how entire batteries of genes coordinate their activity. It also shows that even isolated cells can react as if they were still in intact tissue, initiating gene changes that would bring about the cell-to-cell interactions needed for wound healing. With this new approach, says Jennifer Lippincott-Schwartz, a cell biologist at the National Institute of Child Health and Human Development in Bethesda, Maryland, "Pat Brown is offering us a whole new way of looking at cellular connections."

Brown and his colleagues have been perfecting the DNA microarrays that were crucial to this experiment for the past several years. With a customized machine, they cover glass slides with microscopic dots of immobilized DNAs, each representing a different gene. Exposed to fluorescently labeled DNA copied from the mRNA made by the corresponding gene, a spot will light up—a sign that that gene is active. To date, the researchers have shown they can use these arrays to monitor gene expression in a variety of organisms, including yeast and the plant *Arabidopsis* (*Science*, 23 October 1998, p. 699). When they were ready to try it using human DNA, they turned to the serum response system because the genes involved had supposedly been so well characterized. "It was a way to check out the [microarray] system and to learn new things," Brown says.

After the team made an array representing about 8600 human genes, Iyer withdrew the serum supply that nourished his cultures

ScienceScope

Downsized Will Japan's Science and Technology Agency lose its Cabinet seat on 1 April, when the government plans to demote two VIPs from the 20-member body? The agency is vulnerable to an April Fool's Day massacre because it is supposed to merge in 2001 with the larger Ministry of Education, Science, Sports, and Culture, which will likely retain its Cabinet status.

Immune to Criticism? A White House advisory panel slammed President Bill Clinton a few weeks ago for not aggressively following up on the goal he announced in May 1997 to develop an AIDS vaccine within 10 years. But Clinton assured the panel that NIH is about to address one criticism by finally naming a director for a new NIH vaccine institute. Insiders say the leading contender is University of Michigan, Ann Arbor, molecular biologist Gary Nabel, who won't comment. His selection could rub some researchers the wrong way: Though he is a respected authority on HIV gene therapy, Nabel has published little, if any, AIDS vaccine research.

Burial Rights? Will Kennewick Man, the 9000-year-old skeleton found on the banks of Washington's Columbia River in 1996, go under the microscope—or back underground? A federal judge may answer that question this year. Scientists want to analyze the bones to learn more about early Americans, but a Native American tribe wants the remains reinterred.

Tale From the Crypt In March, code breakers at a Rome conference will help the National Institute of Standards and Technology pick five finalists for a new Advanced Encryption Algorithm—the mathematical tool used to keep electronic financial transactions secure. Cryptologists recently broke the current code, which has lasted more than a decade. The eventual winner, to be chosen next year, should instantly become the world's most popular security algorithm.

Techno-Tension Tamer Technology-transfer folks are keeping an eye out for long-awaited guidelines and standard contracts for governing the exchange of new technologies, due out in draft form next month from NIH. Rising tensions over how to share and protect potential money-making inventions prompted a committee to urge NIH to come up with the new rules. Their report can be found at www.nih.gov/news/researchtools/index.htm

Contributors: the *Science* news staff.