University of Pennsylvania, Philadelphia, and colleagues. Such an extended childhood would give predators and disease ample time to pick off animals before they reproduced, says Gregory Paul, an independent dinosaur artist and paleontologist in Baltimore, Maryland. But if Curry's rapid growth rate is right, young sauropods probably weren't picked on for long.

–ERIK STOKSTAD

BIOMEDICINE

From Fat-Free Mice, The Skinny on Diabetes

When it comes to body fat, extremes can have extreme consequences. Obesity can lead to health problems such as diabetes. And now comes a dramatic illustration of the ills of having no fat at all. Two independent groups have shown that mice genetically engineered to lack fat cells also get diabetes, with symptoms even more severe than those of their obese counterparts. The animals suffer all the signatures of adult-onset diabetes in humans: high blood sugar, high insulin levels, and a ferocious thirst and appetite.

Reported in last week's issue of *Genes and Development* by Nobel laureates Michael Brown and Joseph Goldstein and their colleagues at the University of Texas Southwestern Medical Center in Dallas and by Marc Reitman and Charles Vinson's group at the National Institutes of Health in Bethesda, Maryland, the findings may yield clues to the enigma of adult-onset diabetes, also called type 2 diabetes or diabetes mellitus. Body fat plays a role in the illness, which afflicts at least 18 million Americans, but endocrinologists don't know exactly how. The mice also provide the first model ever for a rare human condition known as lipodystrophy, in which patients are born with an extreme scarcity of fat and the symptoms of adult-onset diabetes. "The insights that these models yield may provide more beneficial treatments for both diseases," says Reed Graves, a chemist at the University of Chicago who helped to pioneer the work in the current papers.

Baring all. A transgenic mouse (right) lacks the white fat seen under the skin of a control animal.

Graves worked with Susan Ross in Bruce Spiegelman's laboratory at Harvard Medical School, where the trio was trying to figure out how fat influences diabetes and related disorders. In 1993, they successfully depleted fat in mice by engineering in a toxin gene and turning it on in fat cells. The mice developed some diabetic symptoms, but the researchers could not pin down the link between a lack of fat and diabetes because these mice did not lose fat cells until they reached middle age.

The more recent experiments do a better job of eliminating fat from the animals. Both groups of researchers genetically blocked the growth of fat cells by altering transcription factors, proteins that turn genes on or off and are crucial to cell growth and maturation. Reitman and Vinson's team inactivated the genes for two families of transcription factors that normally help fat cells grow and develop, while Brown and Goldstein altered the gene for another transcription factor so that cells would get an overdose of it. Both mutations were designed to affect only fat cells.

The changes had the same effect: The mice were born with little or no white fat. The transgenic mice also failed to develop mature brown fat, which normally serves a warming function in hibernating animals. "We had to use heating pads because the fat needed for [heat production] was gone," recalls Vinson, who notes that tending to the rodents "was certainly not trivial."

Many of the animals died before reaching adulthood, but those that survived developed diabetes: Their cells no longer responded properly to insulin, which stimulates cells to metabolize glucose. As a result, insulin levels in the bloodstream skyrocketed—up to 442 times normal levels for some of Reitman and Vinson's mice—and glucose levels at least tripled. Like human diabetics, the animals also had high levels of triglycerides and other fat building blocks in their circulation, and their livers became engorged with triglycerides. "These animals are really sick," Reitman says. "But they clearly don't get diabetes in the same way as normal type 2 diabetics," where excess body fat plays a role.

Brown and Goldstein speculated that the altered transcription factor in their mice might be the key to the diabetes, and they spent a great deal of effort trying to tease apart the molecular pathways triggered by the mutation. But they could find no clear answers. Reitman and Vinson have a different hypothesis, which could explain why both obesity and a complete lack of fat can lead to diabetic symptoms. They propose that excess fatty acids and triglycerides in the circulation and liver might somehow trigger the disease. The compounds might end up in the circulation either because they spill from stuffed fat cells, in the case of obesity, or because there are no fat cells to store them, as in lipodystrophy and the fatless mice.

If the conjecture can be proven, it could open the way to new therapies for both adult-onset diabetes and lipodystrophy. Indeed, Graves's group at the University of Chicago found that a drug called troglitazone—which helps trigger fat cell maturation—could lower blood glucose levels and reduce other diabetic symptoms in his group's transgenic mouse. That drug is now available as a treatment for human diabetes, and Graves hopes the researchers will explore the effects of similar drugs in the new transgenics.

For his part, Vinson says there is a message for diabetics and nondiabetics alike: "We learned that too much fat is bad and so is not enough fat. The punch line here is that a little fat is good. As Aristotle said, 'Everything in moderation.'"

–TRISHA GURA

Trisha Gura is a science writer in Cleveland, Ohio.

SPACE SCIENCE

NASA Craft to Take the Controls in Flight

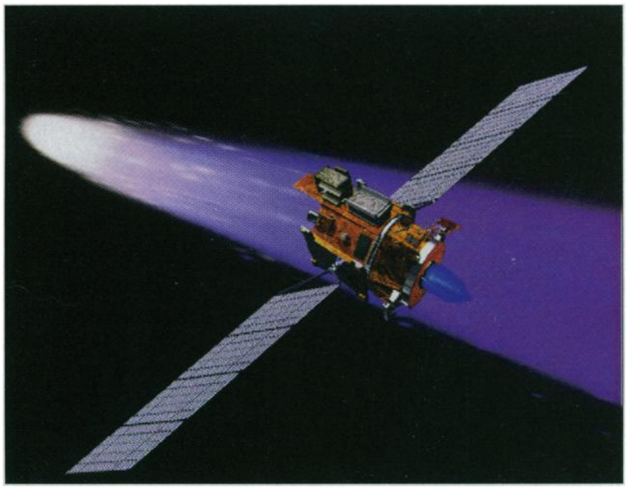
TOKYO—Both science fiction fans and scientists are eagerly anticipating tomorrow's scheduled launch of NASA's Deep Space 1 mission. But it's not the destination—a close encounter with an obscure asteroid—that excites them. What's special about the mission, which begins a series of flights testing new technologies, is the onboard software that will, for the first time, assume complete control of the spacecraft. Computer scientists say it's a step toward a real-life HAL 9000, the fictional cyber-character in Arthur C. Clarke's *2001: A Space Odyssey*. Its success, they add, would be a boon to future deep-space probes and to the field of artificial intelligence (AI).

"This experimental system is a kind of 'HAL 1000,' " quips Nils Nilsson, a computer scientist at Stanford University. "NASA's willingness to test this technology in Deep Space 1 represents a step forward for AI. If it works, it will most likely be used in future NASA missions and will attract the attention of other potential users."

Deep Space 1 is the first mission of NASA's New Millennium Program, which

CREDIT: MARC REITMAN

tests risky technologies aimed at making future missions smaller, faster, and cheaper—a mantra of NASA Administrator Daniel Goldin. "We need these technologies for the kind of science missions NASA would like to conduct," says Marc Rayman, chief mission engineer at the Jet Propulsion Laboratory in Pasadena, California, which is managing Deep Space 1 for NASA. Budgeted at $152 million, Deep Space 1 will fly by a little known asteroid called 1992 KD in July 1999, sending back information about its shape, size, surface composition, and mineralogy. Coming within 5 to 10 kilometers of the asteroid, the flyby will be the closest ever attempted of a solar system body. The mission may be extended to skirt Wilson-Harrington, an object in transition from a comet to an asteroid, as well as the comet Borrelly.



In command. Deep Space 1 will use its own software to fly itself for a week.

The autonomous control concept getting its first big test on Deep Space 1 could eventually relieve pressure on ground-based controllers, who will have to cope with a rising number of small missions in an era of restricted budgets. Greater autonomy could also lead to bigger scientific payoffs, for example, by allowing a spacecraft to modify observational plans after it spots a surprising and particularly interesting feature.

The most straightforward chore Deep Space 1 will handle is navigation. The spacecraft's autonomous navigator will determine the spacecraft's position by comparing observed patterns of asteroids and background stars with patterns stored in its memory. It will plot trajectory adjustments and fire the engines accordingly. A more ambitious experiment involves turning over responsibility for the entire spacecraft to a HAL-like autonomous agent. Given a goal, the remote agent works out the details and executes the operations needed to achieve it.

The remote agent for Deep Space 1 was jointly developed by NASA's Ames Research Center in Mountain View, California, the Jet Propulsion Lab, and Carnegie Mellon University in Pittsburgh, Pennsylvania. Its software package consists of four modules, dubbed mission manager, planner/scheduler, smart executive, and mode identification and reconfiguration. The work is carried out through operational plans that cover either a length of time or a set of tasks to be accomplished.

The mission manager begins its planning by reviewing what tasks have been completed and what lies ahead, the craft's location, and the condition of its subsystems. It then compiles a list of goals for the next plan segment—making a course correction, photographing a certain object, or transmitting data to Earth, for example—and sends them to the planner/scheduler. The planner/scheduler works out a sequence for achieving these goals and sends the information to the executive. The executive then expands the sequence of steps into detailed commands for the software controlling each of the spacecraft's subsystems. The mode identification and reconfiguration module monitors systems, identifies problems, and offers alternatives.

Martha Pollack, a computer scientist at the University of Pittsburgh, says most of these elements are established AI techniques. But Deep Space 1 "breaks new ground in showing that [such techniques] can indeed make the transition from the laboratory to the very complex application of space travel." Although the agent will control Deep Space 1 for only a week, the experiment "is a great leap for remote agents," says Barney Pell, a member of the agent design team at Ames.

Although the remote agent has captured the attention of the AI community, the flashiest of the dozen technologies onboard Deep Space 1 is probably the experimental ion thruster, which for the first time will be used as a spacecraft's primary engine. Ionized xenon atoms are accelerated out into space by charged metal grids at the rear of the engine chamber. The resulting thrust is equivalent to the pressure exerted by a sheet of paper resting in an open hand, according to NASA. But over time the ion engine can deliver almost 5 times the thrust per kilogram of traditional liquid or solid rocket fuels, making it ideal for extended space flights.

Deep Space 1 will also conduct experiments involving new low-power electronics systems and solar arrays fitted with lenses that concentrate sunlight. Although such technologies may not be the stuff of science fiction, they do add up to increased capabilities for future real space operations. "These will be the tools in the toolboxes of future mission designers," says Rayman.

—DENNIS NORMILE

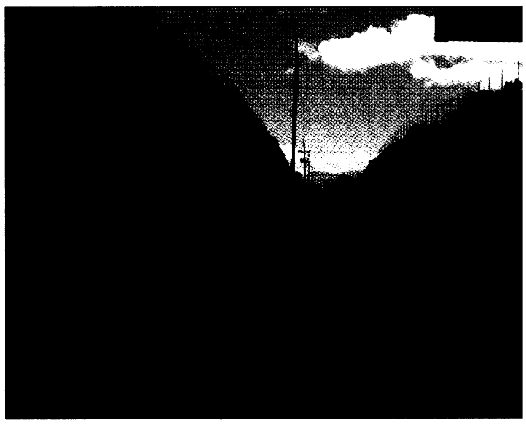
COMMUNICATIONS

Quantum Encryption Takes First Step to Orbit

For sending a secret code, nothing beats quantum mechanics—at least in the laboratory. To be useful, however, quantum messages, such as the numerical "keys" required to decode secure messages sent by other means, will have to travel long distances, for example, from the ground to a military or telecommunications satellite. Now a team of nine physicists from Los Alamos National Laboratory in New Mexico have taken a first step in that direction by transmitting a key over a distance of 1 kilometer in the chill night air of the New Mexico desert.

"What we've done is demonstrate a protocol and the physics of a system that will do that," says team member William Buttler. The system involves transmitting the key with a broad laser beam that is yet so faint that each bit of data is represented by the polarization of a single photon. "It is really something," says Nicolas Gisin of the University of Geneva. John Rarity of Britain's Defence Evaluation and Research Agency in Malvern calls the feat, described in the 12 October issue of *Physical Review Letters*, "a key step on the way to uploading keys to satellites."

Quantum mechanics has caught the eye of encryption experts because it offers a way to guarantee the security of the key—the ran-



The long view. Photon transmitter (bottom right) and receiver (center) of prototype quantum encryption system.

CREDITS: (TOP) JPL; (BOTTOM) WILLIAM BUTTLER/LOS ALAMOS NATIONAL LABORATORY