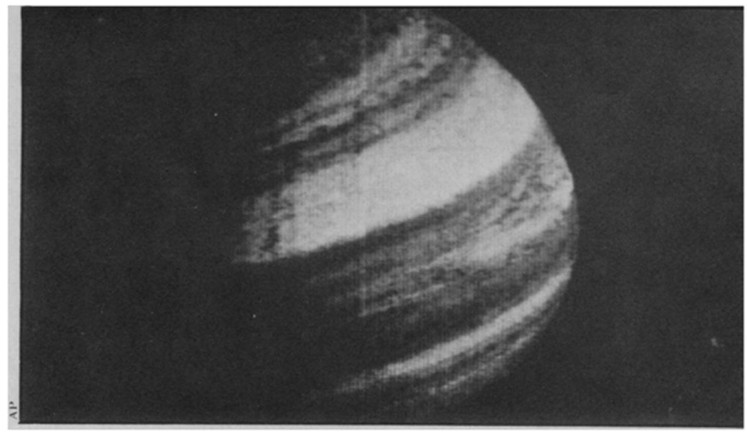


Jupiter: From pole to pole

"I like cliff-hangers," says John Wolfe, and he got one. And just as in the Hollywood versions, the hero survived a tense climactic episode—barely. Bombarded by death-dealing protons and shocked by multi-thousand-volt sparks, the Pioneer 11 spacecraft squeaked past the mighty planet Jupiter, only the second earthly emissary ever to probe the mysteries of that spectacular world.

One year ago, Pioneer 10 blazed the trail, revealing an incredible, multicolored planet seething with solar temperatures, bathed in deadly radiation and wrapped in a magnetic field spanning almost 40 times the distance from the earth to the moon. Before Pioneer 10, scientists—and spacecraft designers—know little about what to expect from the exotic Jovian environment, their estimates turned out to be about as close as they could be. Pioneer 11 pushed its luck even further.

The payoff was worth it. Pioneer 10 passed within less than 82,000 miles of the ponderous planet. Its successor flashed by at barely a third of that distance. If Pioneer 11 had followed the same route, it would almost surely have been permanently crippled, if not disabled completely, by the more intense radiation. But the scientists and engineers who guided its flight had something else in mind: the first view of the poles. Instead of repeating Pioneer 10's flight along Jupiter's lower, more equatorial latitudes (where the radiation is more intense), they directed it down under, more than halfway around to the south pole, where Jupiter's powerful gravitational attraction would swing the spacecraft up behind the planet and rush it through the radiation belts too quickly to accumulate a fatal dose. Then over the planet's shoulder, giving an even better view of the north pole, and back across the solar system to a 1979 encounter with Saturn.

Besides giving an extra planet virtually for free, this super-slingshot path (during which Pioneer 11 reached speeds greater than 107,000 m.p.h.) sent the probe around in the opposite direction from Jupiter's rotation, so that fully 360 degrees of longitude would pass beneath its inquiring sensors (only one side of the planet is ever seen from earth).

But with Jupiter, getting there is half the fun. A titan in every respect, it makes its presence known all the way to earth, a discovery made last year by Pioneer 10 when it revealed that streams of electrons detected years before by earth-orbiting satellites were in fact from Jupiter and not, as had been believed, from the depths of space. Pioneer 10 also ran into Jupiter's magnetic field while still almost 4.8 million miles from the planet, and Pioneer 11 was less than one percent closer in when the same thing happened. Just as did its predecessor, Pioneer 11 passed in and out of the field several times despite its unswerving approach, confirming last year's conclusion that the field's extremities are as limp as a half-empty hot-water bottle, sometimes compressed to as little as half their size by the varying pressure of the solar wind. Early looks at the data also hint that the solar wind may behave differently above and below the plane of the ecliptic, a question which Pioneer 11 may also be able to answer on its way to Saturn, a journey that may take it as much as 100 million miles and 17 degrees "above" the ecliptic plane.

As they guided their voyager ever-closer to its goal, Pioneer's scientists were also looking out for its four major moons, known for their discoverer as the Galilean satellites: Callisto, Ganymede, Europa and Io. On the way in, Tom Gehrels of the University of Arizona, in charge of the imaging photopolarimeter that serves as the spacecraft's camera, reported the apparent discovery of a south polar cap on Callisto, not inconsistent with earth-based spectral studies that have indicated the presence of frozen water.

Ganymede, however, may turn out to have been a more ominous presence. About half a day before Pioneer 11 reached Jupiter, ground controllers suddenly noticed that the spacecraft's radio signal had become weaker, and that temperatures in certain components had begun to rise. Checking, they found that something had apparently caused onboard heaters to turn on, and made the craft's transmitter aim itself off-center. The problems were corrected, but not before a two-hour period during which about two percent of Pioneer's scientific data were lost. The apparent cause was arcing—sparks due to the buildup of an electrical charge on the spacecraft—which Pioneer mistakenly interpreted as commands from earth. One of the instruments on board had reported a sudden upsurge in 4-keV electrons striking the craft, which was the virtual equivalent of plugging Pioneer's toe into a 4,000-volt socket, but why? The possible cause, Wolfe suggests, is that the Ganymede's passage through the region had swept away vast quantities of negatively-charged electrons, causing 4,000 volts' worth of positive protons to strike the spacecraft and build up the charge.

An even more spectacular electrical phenomenon relates Io, the inner-most Galilean satellite, with the planet itself. For some 20 years, radio astronomers have known that Jupiter gives off periodic, mighty bursts of radio noise—a natural, 100-million-watt transmitter. About 10 years ago, it was found that the signals appear even stronger when Io is near the pathway from Jupiter to earth. The ranking theory is that Io, or more likely its ionosphere, acts as a huge, direct-current generator, producing a continuous current that flows from moon to planet and back again, in a gigantic loop. Pioneer scientists hoped that their spacecraft would fly close enough to this loop to detect it by the change it would cause in the Jovian magnetic field, but an early look at the results showed not a trace. Frustratingly, this does not disprove the theory—such a study must await some future probe, such as the proposed Mariner Jupiter orbiter, which can come closer or actually pass through it.

Finally, at long, tense, last, came Jupiter itself. Besides the perils of the radiation belts, suspense was added by the fact that the spacecraft's closest approach to the planet would take place while it was out of contact with the earth, on the far side of Jupiter. Then, scarcely a minute and a half after it emerged, it would face the worst of the radiation. Because Pioneer

10 had passed farther from the planet and followed a different course, its successor's future was less than certain—but the hardy probe survived. The dread flood of protons grew until 150 million of them were hitting every square centimeter of Pioneer 11 every second; they caused false commands, erroneous readings and altered current flows, and the instrument that was mapping the planet's heat distribution by infrared lost about 40 percent of its data in the period immediately following the encounter. But most of the data were there. And oh, Jupiter.

Reds, oranges, blues, yellows, whites and the poles. In their first look at the ends of Jupiter, Gehrels and his colleagues confirmed their expectations that the strikingly regular stripes girding the planet's equatorial region are simply missing. Instead, smaller mottlings and individual convection cells form random designs, with none of the large white regions of high, cool clouds that mark the lower latitudes. In the polar regions, says Gehrels, the cloud tops are lower, giving observers a chance to see farther down into the atmosphere. Although weeks and months of careful processing are required to be more certain, it is even possible, the images suggest, that the poles include regions of "blue sky," occluded only by light concentrations of aerosols, representing virtual "windows" into the ball of hydrogen that is Jupiter. Also, says Caltech's Guido Munch, it appears on preliminary evidence that the poles are a few degrees cooler than the rest of the planet. This would hardly surprise a typical earthling, but Munch's infrared scans from Pioneer 10 showed that Jupiter's mean temperatures seem to be the same on the day and night sides of the planet, probably because more than two-thirds of its heat comes from within.

One of the major features photographed by Pioneer 10, the wide, white south tropical zone that contains the famous great red spot, has changed in the intervening year. But, said Gehrels last week, it was atypically wide when Pioneer 10 saw it and ought more to resemble the narrower feature known from any earth-based photos. Sure enough, Pioneer 11's images revealed that its northern edge is breaking up, interrupted now with large, dark blotches of lower, warmer clouds.

Such findings are intoxicating experiences for the scientists who work with them, and most of the Pioneer 11 researchers seemed as excited with their new results as they were last year with those of its predecessor. The study of Pioneer 10's data will continue for years, and the findings of Pioneer 11 are less than a week old. And there's always Saturn. . . . □

Israeli science: Push Toward Applied

Science News Editor Kendrick Frazier is on a science reporting trip to Israel. This is the first of several reports.

The room where passengers claim their luggage at the Tel Aviv airport looks like most other airports, except for the presence of a soldier standing in the middle of the room with a submachine gun. A short drive south to Rehovot takes one past more machine-gun-armed soldiers, most of them looking incongruously relaxed and unconcerned.

Once on the campus of the Weizmann Institute of Science, Israel's leading center of advanced study, the scene is quiet and peaceful, with nicely landscraped modern buildings and the sweet smell of lush vegetation. But the serenity is deceptive. Israel has always held scientists and learning in high regard. That shows no signs of changing. But two forces, one a severe economic crunch, the other a recognition of a need for more applied, as opposed to basic, research have begun to alter the course of science in Israel.

The economic pinch is hitting hard. "Quite a severe financial crisis has affected all the institutes in Israel," says physicist Gvirol Goldring, chairman of the Weizmann Institute's scientific council. The Weizmann Institute is about 20 percent short of necessary funds, for example, and it is working to find ways of employing many of its scientists in other places, such as private industry. "We've come to realize with a shock that this is our problem," says Goldring. "It's a test for us. At the moment we feel only the pain of it, the fears and the doubts. But I think we will come out of it much stronger, and wiser."

The perceived need to reorient research more to the applied end of the spectrum is more a long-term goal. It is part of a realization that although Israel has excelled in basic research, it has not done as well in applying that research to national needs. Nor has it sufficiently encouraged research and development by private industry.

Israel devotes 2.4 percent of its gross national product to research and development, the same as do the United States and Great Britain, and far higher than France, Japan, Germany and Sweden. Its numbers of scientists and engineers and numbers of students as a proportion of the population compare favorably with other countries.

Forty-five percent of all the research and development in Israel is performed by the government's defense laboratories. Thirty percent is done by universities (mainly basic research), 12 percent by industry and 10 percent by civilian-oriented government laboratories.

Eliezer Tal, director of Israel's National Council for Research and Development (NCRD), acknowledges that the amount devoted to defense research is large but, in view of the threat to Israel from the Arab countries, he considers it essential. Nevertheless, he says, "we have to look for a better way to use defense research for civil purposes."

The 30 percent figure for university research, most of it basic, catches Tal's eye. "We have to question whether it is not too big for a small country."

Israel has had a cherished tradition for intellectual inquiry. Its extensive endeavors in basic research result partly, in Tal's view, from the respectful Jewish attitude toward learning. The government's attitude in the past has been to leave the scientists alone and let them do what they want to, says Tal, a cell biologist, but now that may have to be modified.

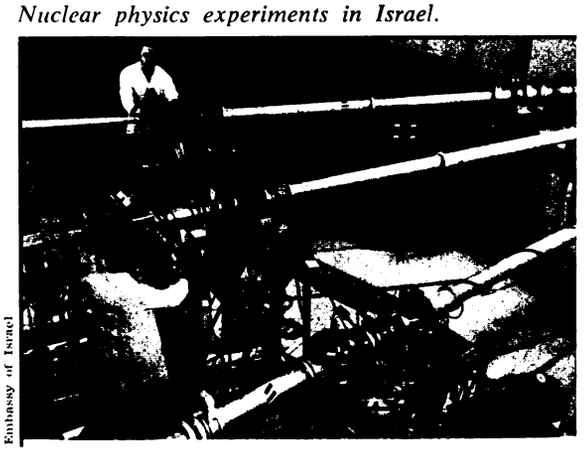
He emphasizes that he does not advocate reductions in basic research in Israel, but only that any increases go to applied research. "We should also concentrate on getting new scientists to go into applied research. Gradually, in five to eight years, we can get a better balance."

The other figure of concern, this time for being too small, is the 11 percent of R&D in Israel performed by industry.

The Israeli government has a 50-50 matching grants program for certain kinds of industrial research, and it has instituted an industrial research and development incentives program whose funding is up 40 percent since last year and which Tal hopes will not be affected by budget cuts hitting universities and government laboratories.

The president of the Weizmann Institute, Israel Dostrovsky, acknowledges that Israel has not done as good a job as it should in promoting applied research. He speaks of the phase lag be-

Nuclear physics experiments in Israel.



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