Voyager: Science and sweat

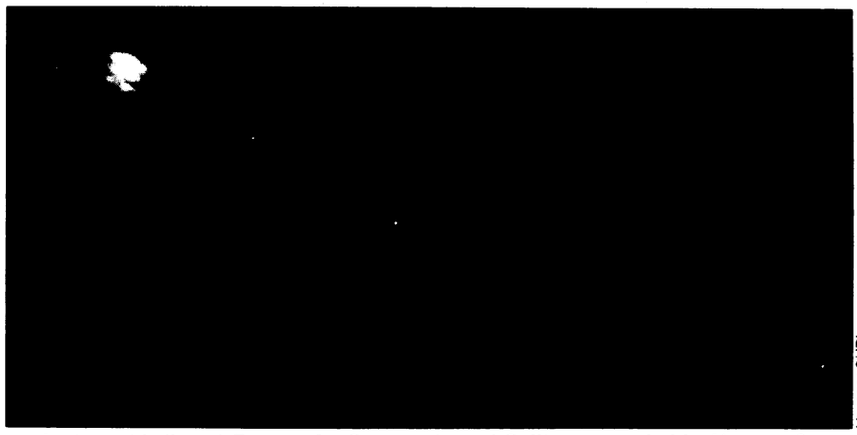
"There's nothing like having spacecraft problems to make you worry about the mission," said one Project Voyager scientist last week, "just when you're looking at data that show you how good the mission might *really* be." The comment, from a conversation at the meeting of the American Geophysical Union in Miami Beach, reflects something of the emotional quandary facing earthbound participants in the ambitious, dual-spacecraft flight to Jupiter, Saturn and perhaps beyond.

Both of the Voyager craft, launched last summer, have developed difficulties in recent weeks that, if they worsen, could significantly affect the complex scientific plans for the scheduled "flybys." Even as flight controllers at Jet Propulsion Laboratory in Pasadena were working to understand the malfunctions, however, researchers at the AGU meeting were reporting results from the early part of the mission that underscore the potential gains in store from the upcoming planetary encounters.

Voyager 1's problem stems from the fact that the movable "scan platform" carrying its cameras and some other instruments stuck during a test in February. The platform is intended to move its instruments around as the spacecraft flies its way among the moons of Jupiter and Saturn, and in subsequent tests it has successfully been moved at all four of its different "slew rates." Controllers have pointedly avoided moving it through the position in which it stuck, however, and it is not yet known whether its sequence of movements will have to be modified. An alternative would be to move the whole spacecraft, but that could affect the aiming of one or more of the instruments that are not mounted on the platform.

Voyager 2's trouble is entirely different, but at least as fundamental. A few weeks ago, flight-team engineers believe, both fuses (one the supposed emergency backup unit) blew out in one of the craft's two receivers, and the alternate receiver, now in use, has a frequency-tracking problem that apparently prevents it from compensating for the Doppler shift in transmissions from earth. An alternative transmission scheme has since allowed the compensation to take place at the transmitting end, rather than on the spacecraft, but it imposes some constraints on the transmission procedure. More to the point is that the less-than-perfect receiver is on Voyager 2, whose mission could include extensions to Uranus and even Neptune, which will require it to last until as late as 1989.

The scientific instruments, meanwhile, are already proving their abilities. S. M. Krimigis of the Johns Hopkins Applied Physics Laboratory, for example, told his AGU session audience that the low-energy charged-particle experiments on the spacecraft are yielding solar-particle compositional spectra with "better results in a single day than we have been able to get in the past 15 years."



Voyager 2/JPL

Jupiter with (l to r) Europa, Io, Ganymede and Callisto, recorded by Voyager 2.

The planetary radio astronomy experiments, designed to measure low-frequency emissions from Jupiter and Saturn, have confirmed early indications that they had recorded the first direct measurements of the polarization of earth's own kilometer-wave radio "noise." The emissions are almost entirely left-hand circularly polarized, said James Warwick of the Univerity of Colorado, head of the experiment team, compared with the near lack of polarization in, say, a solar radio burst. The measurement, says team member Anthony Riddle, also of UC, "gives us a good handle on emission mechanisms. It makes certain emission theories possible and others impossible."

One center of attention, of course, is the cameras, two of which are on each Voyager's scan platform. On Feb. 8 (admittedly before the platform stuck), the narrow-angle camera aboard Voyager 2 took a photo showing not only Jupiter — complete with stripey detail—but all four of its major (Galilean) satellites: Europa, Io, Ganymede and Callisto. And the remarkable photo was taken with Jupiter still 437 million kilometers and 13 months away. When the spacecraft gets really close, says project scientist Edward C. Stone of California Institute of Technology, the Galilean satellites will be photographed with resolution as good as that in Mariner 10's strikingly crisp photos of Mercury.

Though the giant planets and their moons are the primary goals, almost everything in between is grist for Voyager's mill. The cameras, for example, have also photographed earth and its moon. The photopolarimeters, important in studying aerosols, dust particles and other atmospheric and surface components, have already made what the University of Colorado's Charles F. Lillie says are the first whole-body polarization studies of the earth from a spacecraft, as well as the first such measurements of earth by ultraviolet light. ("It can very accurately be said," Lillie reports, "that earth is indeed a blue planet.") Mars has also been "seen" by the instruments — it is, not surprisingly, red — and there have even been preliminary observations of Jupiter and Saturn. With luck, says Lillie, future plans may also include "one or more asteroids," which have never been studied close-up at all.

The Voyagers have also been involved in what amount to cooperative studies with other spacecraft. On Oct. 26, 1977, for example, a major solar event was recorded by the Voyagers as well as by the International Sun-Earth Explorer satellites in earth orbit, thus letting the same phenomenon be observed from different positions and distances from the sun. Other multi-spacecraft studies have linked Voyager's data with that from such probes as IMP 7 and 8. Now if the Voyagers can only get to Jupiter in working order.... □

Protein clipping in lab and cell

Proteases used to be just a nuisance. Released into the fluids of homogenized cells, the protein-breaking enzymes destroy interesting activities and decrease the apparent sizes of molecules.

Recently, however, biochemists are regarding these molecular shears in a more favorable light. The researchers now have a firmer grip on the scissor handles and have come to appreciate the skill with which an intact cell snips and trims its proteins.

At the International Conference on Limited Proteolysis in Microorganisms held at the National Institutes of Health last week, biologists reported on the use and observation of protein-cleaving enzymes. Proteases can be used in cut-and-test experiments to identify what portion of a large protein binds a substrate or cofactor or hugs a membrane. The toxins produced by bacteria have at least two functional areas, says R. John Collier of the University of California in Los Angeles. By breaking tox-

ins into pieces with proteases, biochemists have discovered that one region is important for transport into a target cell and another domain is responsible for the toxin's destructive actions.

A similar approach has been used to study tryptophan synthetase, a complicated protein complex with about six binding sites. Removing pieces of the protein and determining which activities are lost gives clues to the overall organization, says Michel Goldberg of the Institut Pasteur. Protease experiments also can provide information about how proteins are folded into complexes. Edith Miles of NIH finds that in tryptophan synthetase, protease-sensitive sites available on the four subunits are unavailable within the folded structure.

An intriguing focus on proteases is their natural role in cells. Why would a cell harbor an enzyme capable of chewing up valuable material? At least three different answers to that puzzle were proposed during the meeting. The first is that cleavage by proteases can generate building blocks for growth. For example, proteins are stored in the spores of the bacterium *Bacillus megaterium*. Peter Setlow of the University of Connecticut Health Center described breakdown of those proteins to provide amino acids during germination.

Trimming proteins during production appears another use of proteases. For example, the research of Günter Blobel of Rockefeller University shows many secretory proteins are manufactured with an attached extension that is cut off before the protein is excreted (SN: 7/30/77, p. 73). Another fine honing of a cell product is reported by Michael K. Showe of the University of Basel in Switzerland. In making the virus T4, four proteins are assembled into an unstable "prehead." Cuts by a protease convert the prehead into the stable head structure. That T4 protease is far more specific than most; it acts only on the proteins when they are assembled into the prehead. Those protease molecules also nibble at each other, achieving both autoactivation and autodestruction.

Regulation of metabolism is the third natural function proposed for proteases. Many enzymes are turned off by binding inhibitory molecules. But in some cases an activity may be better halted by actually destroying the relevant enzyme. Frank H. Gaertner of Oak Ridge National Laboratory suggests proteolysis may be an override on other types of metabolic control. He reports a large number of proteases in the red bread mold *Neurospora crassa* help control cell metabolism.

And finally nipping at proteins may even affect the genes. Jeffrey W. Roberts of Cornell University reports that the gene product of the bacterial gene *rec A* is a proteolytic enzyme (or activates a proteolytic enzyme). He proposes that the protease removes a specific protein from DNA and thus allows strands of genes to recombine. □

Enkephalins: Pleasures and seizures

In 1974 two tiny brain proteins were discovered that act on nerve sites in the brain where morphine also acts. They were christened "enkephalins," for the Greek word for brain. In 1976 enkephalins extracted from the brain and injected into test animals were found to relieve pain. Thus they constitute the brain's own natural pain-relieving molecules.

But the enkephalin story is just beginning, it seems. For last year, when enkephalins were extracted from brain tissue and injected into rats, they were also able to improve learning (SN: 7/23/77, p. 59). And now injected enkephalins are showing three more talents—the ability to induce pleasure and the abilities to trigger epilepsy and to reduce memory loss.

A few months ago, Larry Stein and James. D. Belluzzi of Wyeth Laboratories in Philadelphia hypothesized that the enkephalins probably help the brain mediate pleasure as well as relieve pain. After all, morphine, an artificial pain reliever, also produces pleasure, and both it and the enkephalins act on the same nerves in the brain.

The researchers implanted cannulas (small tubes) into the brains of rats. For the next 66 hours, the animals had access, by pressing a lever, to one of the two enkephalins, morphine or Ringer's solution (a solution of chlorides that served as a control substance for the experiment).

As Stein and Belluzzi report in *Opioid Peptides* (a book soon to be published by the Macmillan Press Ltd. of London), the rates of self-administration were much higher for the enkephalins and morphine than they were for Ringer's solution. This finding shows that the enkephalins must induce pleasure, as does morphine. Otherwise the rats wouldn't have shown any more interest in imbibing the enkephalins than they did in the Ringer's solution.

The enkephalins' ability to give pleasure, in fact, may be the key to their involvement in epilepsy. Extraordinary feelings of joy and satisfaction preceded the fits of the 19th century novelist Fyodor Dostoevsky. In 1972 an epileptic underwent electrical stimulation of that part of his brain which has since turned out to be rich in enkephalins — the amygdala. In response to the stimulation, the subject reported opiate-like pleasure that lasted from minutes to hours. So Hanan Frenk of Tel Aviv University and Bradford C. McCarty and John C. Liebskind of the University of California at Los Angeles asked: Might the enkephalins actually participate in epileptic seizures?

An enkephalin was injected into either the forebrain or the midbrain of rats. As the researchers report in the April 21 SCIENCE, the molecule induced pain-relief when put in the midbrain and seizures when placed in the forebrain, not vice versa. So it looks as if enkephalin-induced pain relief and enkephalin-induced seizures are mediated by nerves in different areas of the brain. What's more, some drug might be found that inhibits the action of the enkephalins in the forebrain and thus provide a new, specific treatment for epilepsy.

The enkephalins themselves, in fact, might eventually be used to treat persons suffering amnesia. Several years ago, Henk Rigter of Organon International in Oss, the Netherlands, and his colleagues found that when a tiny stretch of the pituitary hormone ACTH was used as a drug, it had an antiamnesic effect. This protein stretch is identical to that found in the pituitary hormone Beta-lipoprotein. The enkephalins' chemical compositions also correspond to part of that found in Beta-lipoprotein. So both the ACTH stretch and the enkephalins are cousins, so to speak, all apparently deriving from the same large parent molecule — Beta-lipoprotein. This kinship prompted Rigter to speculate: Might the enkephalins also have antiamnesia activity if used as drugs?

He tested each of them on rats and, as he reports in the April 7 SCIENCE, both can reduce memory loss. Even more interesting, from a clinical standpoint, the enkephalins reduce memory loss when injected into the bloodstream in low doses, in contrast to their pain-relieving effects, which are seen only after their injection into the brain in large quantities. So, it's quite possible that the enkephalins, or some analogs thereof, might be used to treat persons who suffer amnesia from car accidents or other causes. □

Burbidge to Kitt Peak

Geoffrey Burbidge, now a professor in the Department of Physics at the University of California at San Diego, will be the new director of the Kitt Peak National Observatory at Tucson, Ariz. Last week, John M. Teem, president of the Association of Universities for Research in Astronomy, which operates the observatory for the National Science Foundation, announced Burbidge's acceptance.

Of English birth, Burbidge received his Ph.D. in theoretical physics from University College, London. He has been a professor at UCSD since 1962. His research interests include stellar evolution, nucleosynthesis, extragalactic astronomy — he has been prominent in the debate over the physics and cosmological meaning of quasars — and cosmic-ray physics. He is married to another prominent astronomer, E. Margaret Burbidge, who for some time was director of Britain's Royal Greenwich Observatory. He will take up the Kitt Peak post in the autumn. □