and invertebrates, not only in gene sequence but also in potential gene function, is highlighted by the homology of the netrins to *unc-6*, a gene that has been cloned in the nematode and encodes a laminin-related protein^{17,18}. Mutants for *unc-6* show guidance deficits in the circumferential growth of pioneer axons and migrations of mesodermal cells. This uncanny similarity suggests that UNC-6 protein may serve as a chemoattractant in nematode development in much the same way as netrins may control the development of circumferential commissural projections in vertebrate spinal cord.

An intriguing twist in the netrin story has developed from the discovery that genetically separable mutations of *unc-6*, which affect different domains of the protein, result in selective deficits in the nematode: for example, disrupted migration of mesodermal cells but not axons, or of ventral but not dorsal migrations or vice versa¹⁷. This latter finding in particular suggested to Tessier-Lavigne and colleagues that the netrins may have biological activities apart from chemoattraction. One possibility is that netrins may inhibit

or repulse the growth of certain axons. *In vivo*, trochlear motor neurons are located near the midline in the ventral part of the caudal midbrain, and their axons take a dorsolateral pathway to exit from the dorsal surface of the midbrain, forming the trochlear nerve. The floor plate, which expresses *netrin-1* along its entire length at the ventral midline throughout the spinal cord and into the hindbrain and midbrain², may influence the dorsolateral trajectory of trochlear axons by inhibiting or repelling their ventral growth. Indeed, preliminary findings indicate that both the floor plate¹⁹ and *netrin-1*-secreting COS cells (S. A. Colamarino and M. Tessier-Lavigne, personal communication) implanted into collagen gels inhibit neurite outgrowth from trochlear motor neurons. Thus the netrins may influence the directional growth of distinct axonal populations by two different mechanisms, chemoattraction and chemorepulsion. Only in the past year has chemorepulsion become a serious player in axon guidance, now that a diffusible activity released by the septum has been shown to repulse olfactory bulb axons in collagen gels; this

activity may act *in vivo* to steer olfactory axons away from the midline and form the laterally positioned olfactory tract^{20,21}.

The isolation and cloning of the netrins will have a considerable impact on developmental neurobiology, especially the issue of axon guidance. We await more on both general and specific mechanisms of axon guidance from analysis of netrin function and modes of action, identification of netrin receptors, and the search for other members of the *netrin/unc-6* family. Towards this end, a homologue of *netrin-1*, named *D-netrin*, has now been cloned in *Drosophila*; like its vertebrate counterpart, *D-netrin* is expressed in midline cells at a stage appropriate to influence commissure development²². Genetic analysis of *D-netrin* function in *Drosophila* should provide further insight into the role of netrins in axonal guidance, which is more than likely to be applicable to both invertebrates and vertebrates. □

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COMET SHOEMAKER-LEVY 9

A view from the far side

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BARELY a month has passed since the world was witness to perhaps the most dramatic astronomical event of the century. Over the course of a week, numerous fragments of comet Shoemaker-Levy 9 ploughed into Jupiter, leaving in their wake colossal plumes of dust and gas, and a band of dark scars in the giant planet's atmosphere. Although spectacular in their own right, Earth-bound observations were limited to the aftermath of the collisions and little is yet known about the impacts themselves.

The images above show our first glimpse of an actual collision in progress, as recorded by the Galileo spacecraft. Galileo is currently *en route* to Jupiter, scheduled to arrive in late 1995. At the time of the impacts the spacecraft was still some two billion kilometres from its destination (no doubt astronomers would have preferred it to have been closer), but it was nevertheless ideally placed to observe the collisions, on the rear side of Jupiter.

These first four images, taken 2 1/3 seconds apart, show a bright flash of light signalling the beginning of the end of the

final piece of the comet, fragment W. This event took place some seven minutes before the accompanying impact plume emerged over Jupiter's limb and came into view from the Earth. Also visible on the illuminated half of Jupiter are several dark spots, the remnants of previous impacts.

Although flashes of light accompanying the impacts were widely expected, they do not appear to have been as dramatic as many had predicted. Indeed, none was detected from Earth. That Galileo has observed such flashes is, therefore, encouraging. But the data thus far returned raise several questions. It is not, for example, clear whether we have observed a fireball resulting from the catastrophic disruption of the fragment, or simply the luminous trail of the fragment as it plunged, meteor-like, into the jovian atmosphere.

As just a tiny fraction of the images recorded by Galileo have been returned to date, we can only hope that a more coherent picture of the events will emerge when more of the data are in hand.

Karl Ziemelis