Most (but not all) nematodes are small and nondescript. For example, *Placentonema gigantissima*, which lives as a parasite in the placenta of sperm whales, grows to a length of 8 m, with a diameter of 2.5 cm. The free-living, marine *Draconema* has elongate adhesive organs on the head and along the tail, and moves like a caterpillar. But the general uniformity of most nematode species has hampered the establishment of a classification that includes both free-living and parasitic species. Two classes have been recognized (the Secernentea and Adenophorea), based on the presence or absence of a caudal sense organ, respectively. But Blaxter *et al.*[1] have concluded from the DNA sequences that the Secernentea is a natural group *within* the Adenophorea. Based on studies of free-living species, a paraphyletic nature for the Adenophorea — that is, a group comprising an ancestor but not all of its descendants — has previously been suggested (for example, by Lorenzen[2]), but the position of the various parasitic groups has always caused trouble.

One of the most interesting results of the new phylogeny is the discovery that there have been many parallel shifts of feeding strategy within the phylum. The ancestral form was obviously free-living, but the results of Blaxter *et al.* support the idea that parasitism has evolved independently many times. Of the plant parasites, for example, the order Triplonchida comprises only plant parasites, whereas Dorylaimida comprises both omnivores and plant parasites. And the sister orders Aphelenchida and Tylenchida both comprise fungivores, plant parasites — among which the eelworms (Fig. 2) parasitize many important crops, such as potato and sugar beet — and animal parasites.

The animal parasites also belong to several groups that probably evolved independently. Outside the Secernentea, the Tricocephalida comprises mammalian parasites (such as the trichina worm) which do not have an intermediate host. But the Mermithida mainly comprises species that have a juvenile stage in which they infest insects. Within the Secernentea are the Strongylida and Rhabditoidea (which are probably sister groups), Strongyloididae, Apelenchida and Tylenchida. The Strongylida comprises vertebrate parasites without an intermediate host (an example is the hook worm). The Rhabditoidea, by contrast, comprises free-living species, such as the favourite experimental model *Caenorhabditis elegans*, and insect parasites. And the Strongyloididae comprises mammalian parasites, many of which infest horses, pigs and cattle.

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Figure 2 **The bad — eelworm (root knot nematode), which forms characteristic nodules on the roots of sugar beet and rice.**

NIGEL CATTLIN/HOLT STUDIOS

Figure 1 **The good — *Steinernema bibionis*, a free-swimming parasitic nematode used for biological control of vine weevils.**

Blaxter *et al.* also identified a large parasitic group within the Secernentea, comprising three groups of vertebrate parasites (the Ascaridida, Spirurida and Oxyurida) and one group of invertebrate parasites (the Rhigonematida). Of the Ascaridida, some species (for example, *Ascaris* spp.) live in vertebrate intestines. But others, such as species of *Anisakis*, have more complex life cycles, with a crustacean as the first host, a fish as the second host and a fish-eating bird or mammal as the final host. The Spirurida live in vertebrate tissues, and they are transferred by biting or sucking insects. Well-known species include the filaria worm and the whip worm. Of the Oxyurida, the pinworm is a common but harmless human parasite. Finally, the Rhigonematida comprises parasites of terrestrial arthropods.

The establishment of a natural — that is, phylogenetic — classification for the nematodes is an absolute necessity for all aspects of nematode studies, practical as well as theoretical. Moreover, the classification described by Blaxter *et al.* will be an invaluable tool for parasitologists, who search for relationships between parasitic species. They can use this information to look for free-living relatives of important parasites that may be difficult to culture, or for ways in which to combat pests. □

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2. Lorenzen, S. in *Concepts in Nematode Systematics* (eds Stone, A. R., Platt, H. M. & Khalil, L. F.) 11–23 (Academic, New York, 1983).

Daedalus

Fibre couplings

The nail, says Daedalus, is a brilliant and versatile fastener, but with a fundamental contradiction. While being hammered in, it is a strut, loaded in compression. It must be thick enough to resist buckling. Yet once in place it is a tie, loaded in tension, and should be thin and flexible to bear its load efficiently. He is now resolving this contradiction.

An ideal nail, he says, should be driven in by a force applied, not to its head, but to its point. Its shaft would then be drawn in under tension; it could not buckle, and would form a perfect tie. But how to apply a force to the point of a nail? Well, suppose the blow on its head lasted only a microsecond. In this time, the shock would travel only a millimetre or so down the nail. The compressed region would be far too short to buckle. The pulse would travel down the nail, and would force the point into the material being fastened. Any reflected energy would travel safely back up the nail as a tension.

Now only the most rigid materials could have an impact time of a microsecond. A diamond hammer driving a diamond nail would be wonderful engineering but disastrous economics. But in electronics, microseconds are positively leisurely. A piezoelectric transducer could hit a nail thousands of times a second. Quartz is piezoelectric, and quartz fibres have amazing tensile strength. So Daedalus is now inventing the quartz-fibre piezoelectric nail.

His 'piezonail' will be a fine, flexible fibre with plated electrodes, and embedded in a plastic reinforcing jacket. You will fit it into a recess in its pulse-generator 'hammer', hold it firmly against the object to be nailed, and switch on. The burst of pulses will force it silently and instantly into the material, giving a strong, tensioned, firmly bound tie. In thick or hard materials, the piezonail will not even need a head; friction will hold it firmly enough. Many thin ties are superior to one thick one, so the hammer will also accept a 'polynail' containing many parallel piezonails in one jacket.

Construction will be transformed. The global toll of bent nails, bruised thumbs and ringing ears will plummet as the piezonail spreads through engineering, carpentry and DIY bodging. A piezonailed structure will be strong, stable, secure — and somewhat enigmatic. Its myriads of fine fixing fibres will be almost invisible, giving no clue as to what holds it together, or how to get it apart again.

David Jones