EVOLUTION

Two-layered awakening

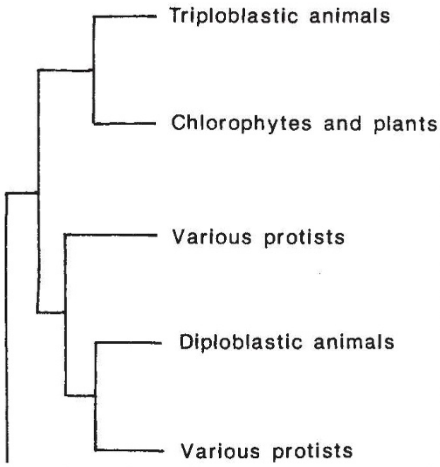
R.S.K. Barnes

CLUE is a who-done-it with three different endings, all consistent with the evidence presented during the film. This scenario bears a remarkable resemblance to attempts to unravel the relationships of animals, on which new, molecular leads are reported by R. Christen and co-workers in *The EMBO Journal*[1].

There are (it is generally agreed) three basic animal body plans: the sponges with their two cell layers, cellular grade of organization and lack of a nervous system and symmetry; the radially symmetrical cnidarians, also basically with two layers of cells, but with a net of unsheathed nerve cells and tissue-level organization; and the bilaterally symmetrical others, with sheathed nerve cords, organ systems and, embryologically, three germ layers. But views on the interrelationships of the three types cover almost all possible combinations, from each being independently derived from the protists[2,3] to all being descendants of an organism that was itself already an animal[4], by way of any two groups (often the cnidarians and the bilateral phyla) being related to each other but not to the third line (in this case the sponges)[5]. Two enigmatic but simple smaller groups, placozoans and mesozoans, may then boost the number of times that animals have evolved from protists up to five (or more) or may be allied with one or other of the three major lines[3]. You pays your money and you takes your choice.

Part of this regrettable state of affairs results from the lack of features shared by all animals but not with the heterotrophic flagellates from which they presumably sprang. All animals are, by definition, multicellular, but the dividing line between colonial protists and multicellular organisms is somewhat vague and many protist groups have colonial members whilst several include multicellular forms. Also, in all animal lines, at least ancestrally, adults are diploid and produce gametes by meiosis; but the same state occurs in some protists. The only feature unique to animals is that they develop from an embryonic blastula. Even here some protists have blastula form, although as adults, never as an embryo. Altogether this is hardly such a suite of uniquely shared characters as to inspire confidence that the animal condition could only have arisen once, particularly when multicellularity has arisen several times elsewhere.

Part of the problem is that there are no fossils that shed light on the interrelationships of early animals, and zoologists must therefore argue solely from the structure of surviving organisms. Hitherto most such argument has relied on gross or cytological anatomy, but Christen *et al.* have added fresh molecular evidence to the debate by sequencing part of the 28S ribosomal RNA molecule from three sponges, three cnidarians, three ctenophores and a placozoan (groups which they unite as the 'diploblastic' animals and for which little molecular data is available), and then comparing their findings with earlier ones of members of the same team on the bilateral



The interrelationships of diplo- and triploblastic animals as deduced from 28S rRNA sequence data by Christen *et al.*[1]. On this analysis, the triploblasts orginated relatively early and are closer to the plants in ancestry than are the diploblasts.

animals (or as they term them, the 'triploblasts'), various protists, fungi and higher plants[6,7].

Several points emerge from their comparisons of nucleotide sequences. First, although plants as expected were closely associated with chlorophyte algae, no protists emerged as potential animal ancestors (although it is unfortunate that choanoflagellates were absent from their data because many would regard them as close to the origin of at least some animals[8]). Second, in the analysis diploblasts and triploblasts appeared to be well separated (see figure) with the triploblasts originating relatively early and being closer to the ancestry of plants than to that of the diploblasts. The sponges, cnidarians, ctenophores and Placozoa were clustered as a unitary group, all potentially descended from a single ancestor.

This raises a third point of interest. Classically, ctenophores were regarded as related to the cnidarians[9], and were often united with them as 'coelenterates', although there have since been many suggestions of affinity with flatworms instead[10]. These sequence data place ctenophores firmly with the cnidarians and not with the bilateral flatworms. Finally, Christen *et al.* found no evidence linking ciliates with flatworms.

These analyses support notions that the animal condition has evolved more than once from a protist ancestry. They are unlikely, however, to be the last word on the subject, for not only are certain critical groups (such as the choanoflagellates) missing from the materials sequenced, but the information in 28S rRNA is only one of many disparate clues that have to be accommodated in this real-life detective story. □

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SEMICONDUCTORS

Dawn of the diamond chip

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THE development, by a team at Tokai University, of an all-diamond p–n junction diode may be the crucial step towards realizing the dream of diamond-based semiconductor electronics. This would be equivalent to the electronics based on silicon and III–V compounds such as GaAs. Because of its electronic properties and strong bonding, diamond offers advantages in many applications. Diamond-based chips could operate at 1,000 °C, handle very high power, and operate in highly radioactive environments (for example, as radiation monitors inside nuclear reactors). And blue light-emitting diodes, not possible with conventional materials, could be made from diamond semiconductors. The new diode was made possible by the development of a technique for doping diamond films with phosphorus to make the elusive n-type material.

Since the discovery of natural p-type semiconducting diamonds (the p indicates that they include elements that make one fewer bonds than carbon, making 'hole-type' conductivity possible), there has been much speculation that electronic devices might be constructed. Many devices based solely on p-type material have been made. These have largely relied on the 'Schottky barrier' formed when a metal such as aluminium is brought into contact with a semiconductor.

Although n-type diamond (containing five-valent elements that donate an extra electron to the diamond lattice) might be