linguistic differences — certain acoustic contrasts are present in some languages but not others. It is not that children become increasingly sensitive to the distinctions made in the language that they are exposed to. Instead, they start off sensitive to every distinction that human languages make; the process of learning a particular language involves becoming insensitive to those distinctions that are irrelevant, and learning what to ignore.

Phonology and meaning differ in certain important ways, however. Another striking fact about phonological development is that the early sensitivity disappears. If the child's language does not exploit a distinction, then the child loses the ability to notice it. This is one reason why it is so difficult to learn a second language. But, as Hespos and Spelke point out, even an adult English-speaker who has never heard Korean can tell the difference between a tight fit and a loose fit. This difference between phonology and meaning makes sense. Phonology is for communicating; once a language is learned, nothing is lost by jettisoning those phonological contrasts that are irrelevant. But meaningful contrasts such as loose fit and tight fit are for making sense of the world. This is nicely demonstrated by the finding that 5-month-olds can use their sensitivity in a non-linguistic context, when predicting the motions of objects.

In addition, although all phonological distinctions made by language may be innate, this cannot be true for all distinctions of meaning. Babies might understand the contrast between tight fit and loose fit, and between support and containment, but they are unlikely to comprehend the contrasting meanings of the verbs 'leering' and 'glaring', or the nouns 'accountant' and 'lawyer'. This must be learned.

What is the nature of this learning? One compromise view is that there is a universal core of meaningful distinctions that all humans share, but other distinctions of meaning that people make are shaped by the forces of language; this is consistent with the theory of linguistic relativity. But it is also possible that the strong Augustinian view is correct: language learning might really be the act of learning to express ideas that already exist, either because they are unlearned (as is likely to be true of the domain studied by Hespos and Spelke) or because they have been learned though experience with the physical and social world.

The question of how language and thought are related is one of the deepest in psychology, and there are many variants of the claim of linguistic relativity that this current research does not address[8–10]. But the capacities of 5-month-olds do pose a serious challenge for certain strong versions of the view that language precedes thought, and show that, in some domains at least, children think before they speak. ■

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Palaeontology

Echinoderm roots

Andrew B. Smith

A bold claim about the origins of the echinoderms is based on newly discovered fossils from China. But many pieces are still missing from this part of the fragmented puzzle of life's evolutionary history.

Few marine animals are so immediately recognizable as echinoderms. The five-fold symmetry of a starfish or sea urchin is striking (Fig. 1), and this pentaradiate form sets them apart from their bilaterally symmetrical relatives. The echinoderm skeleton is equally distinctive, being made of calcite plates with a microstructure that resembles a very holey Swiss cheese. Finally there is their bizarre asymmetrical transformation from larva to adult, which involves loss of the right-hand set of paired larval body chambers. But echinoderms have not always possessed these features, and unravelling their early history remains highly controversial.

A. B. SMITH

Figure 1 **Sea-urchin symmetry: an example of the unique pentaradiate form of echinoderms.**

On page 422 of this issue Shu *et al.*[1] describe a new group of small fossils from the Lower Cambrian of Chengjiang, China. The fossils are some 520 million years old: Shu *et al.* call them vetulocystids, and interpret them as the most primitive echinoderms yet known. If correct, this links the echinoderms to an enigmatic group, the vetulicolians, remains of which are found in the same deposits of early Cambrian age.

Fossils can be made sense of only by comparison with living organisms, where the biological function of structures that become preserved can be directly observed. This is relatively easy when the fossil is rather close in structure to its extant relatives. But fossils such as the vetulocystids, whose affinity with living groups is not immediately apparent, pose a major difficulty. In the past they would have simply been hived off into their own higher taxonomic group, thereby avoiding the problem. Nowadays, palaeontologists take the harder path and strive to place such fossils into their appropriate branch in the tree of life, interpreting characters they display in the most plausible (or least implausible) way.

The vetulocystids are a fascinating but frustrating group — fascinating, because of what they may tell us about the morphology of echinoderms before they had evolved such distinctive morphology, and frustrating because of the difficulty of interpreting even their basic anatomical organization. In this they are not alone. Another group of primitive and entirely extinct echinoderms, the homalozoans, have been the source of debate amongst palaeontologists for years.

Echinoderms belong to the branch of the animal kingdom known as the deuterostomes, a group that also includes ourselves. This is a very diverse assemblage of organisms, the other members being the vertebrates (fishes and tetrapods), urochordates (tunicates and sea squirts) and hemichordates (pterobranchs and acorn worms) (Fig. 2, overleaf). Molecular data strongly support this grouping, placing vertebrates and urochordates together and echinoderms and hemichordates as a second pairing[2]. But in terms of morphology echinoderms have always stood apart because of their aberrant symmetry and lack of structures known as gill slits. Gill slits are present in hemichordates, urochordates and the more primitive vertebrates, and are openings that pierce the wall of the digestive system just behind the mouth. They appear to have evolved for venting excess water drawn into the gut during feeding and are unique to deuterostomes.

Homalozoans are important fossils because they help bridge the gap between radiate echinoderms and other

NATURE

100 YEARS AGO

The Fourth Dimension. **By C. Howard Hinton, M.A. A book bearing the present title may be reasonably expected to contain certain things. In the first place it should have a clear exposition of Descartes's applications of algebra to geometry, and conversely of geometry to algebra, the logical conclusion of which consists in the removal of all restrictions as to the conceivable number of dimensions of space. In the second place it should contain clear, concise, and exactly worded statements of the peculiar and distinctive geometrical properties which are characteristic of spaces of two, three, four, or more dimensions respectively… Now such things as these are either entirely absent from the book or else they are mixed up with such a mass of irrelevant and discursive matter as to render it often quite impossible to make out what the author is driving at… There is a certain class of individual, far too common in this country, who busies himself in pestering his mathematical friends with long and rambling letters on such questions as "What is the fourth dimension?" or "What is the ether?" Such people very rarely know anything about the three dimensions of the space they live in, but Mr. Hinton's book will, it is to be hoped, give them something to think about which will at least amuse them and keep them occupied.**

From *Nature* 21 July 1904.

50 YEARS AGO

It is firmly believed by most theoretical physicists that the antiparticle to a proton can exist… This particle should bear the same relation to a proton as does the positron to an electron. Should it be possible to create such a particle by a proton–nucleon collision, the incident proton will require a kinetic energy of at least 5.6×10^9 electron volts. At present only one particle accelerator, the Berkeley 'Bevatron', exists which is designed to reach this energy. At this energy the production of antiprotons is not expected to be very copious, and their abundance relative to other particles formed will probably be far smaller than in many cosmic ray phenomena which have already been extensively investigated. The problem of the conclusive identification of the antiproton may be a difficult one for some time to come.

From *Nature* 24 July 1954.

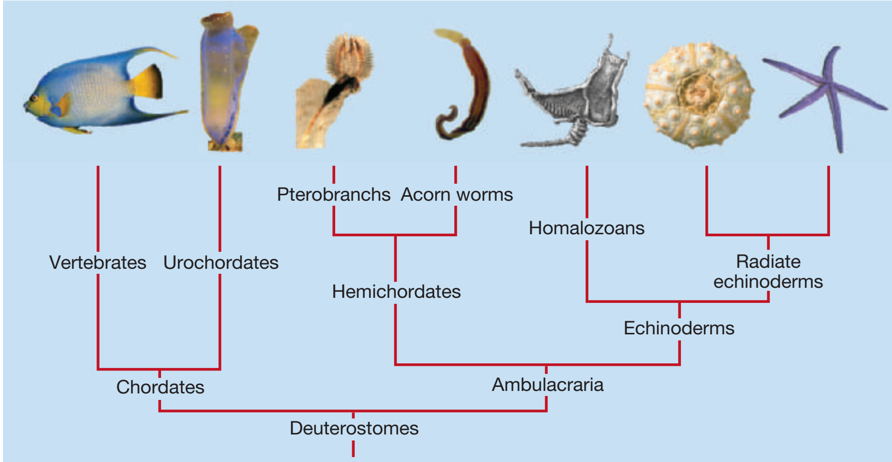

Figure 2 **The main deuterostome groups. Shu *et al.*[1] interpret their vetulocystid fossils as an offshoot of the echinoderm lineage that branched off before the division between the now-extinct homalozoans and the radiate echinoderms. According to this view, the vetulocystids have affinities with another mysterious group, the vetulicolians, which may have diverged from the deuterostome line before the division between the chordates and ambulacraria.**

deuterostomes. They have the characteristic skeleton of an echinoderm and a strongly asymmetrical development. But homalozoans never display even a hint of radiate symmetry and, more importantly, they have gill slits and a post-anal muscular appendage. These last two traits are probably primitive features common to all deuterostomes. So do the vetulocystids take us even further back towards the root of echinoderms?

Faced with such fossils, the first step is to define front and back, and identify the major body openings — mouth and anus, gill slits, and the pores involved in water circulation or reproduction (gonopores) are all possibilities that must be considered. Here the problems really start because fossils do not come ready labelled. Pictures of the fossils themselves, and the interpretations of Shu *et al.*, appear in Figs 1–3 of their paper (pages 423–425).

In the best-preserved vetulocystid material there is evidence for a straight gut running to the posterior along a possibly segmented tail-like structure, as in vetulicolians[3], and this presumably led to a terminal anus. The sack-like anterior part, or theca, has two large and more or less identical openings, both circular and taking the form of a low pleated cone. The anterior of the two circular cones is taken to be the mouth and the posterior may be the anus or gonopore. Towards the base of the theca there is a rhomboidal structure, which Shu *et al.* interpret as respiratory in function and possibly a gill. The identification of the vetulocystids as a 'basal' echinoderm group hinges on this interpretation, with the presence of a single rather than paired 'gill' implying echinoderm-like developmental asymmetry. There is no calcite plating.

But other interpretations are possible. The two circular structures could be gill openings (they are in a similar position in vetulicolians[3]), the mouth anterior and forming the elongate recessed zone, and the rhomboidal structure a folded epithelial zone for gaseous exchange (analogous to those of certain primitive stemmed echinoderms) rather than a gill. That would make the echinoderm affinities of vetulocystids much more dubious. Vetulocystids and vetulicolians share many similarities and are clearly closely related, but quite where they fit within the deuterostomes remains ambiguous because of these alternative possibilities. Such is the way with fossils.

There is now direct fossil evidence that all of the major deuterostome groups were established by about 520 million years ago. Fossil vertebrates (yunnanozoans[4]), tunicates (*Shankouclava*[5]) and both asymmetric and radiate echinoderms (homalozoans, helicoplacoids) have all now been discovered in early Cambrian deposits. *Phlogites*, a tentacle-bearing early Cambrian fossil of uncertain affinity[5], might even be a hemichordate or part of the common ancestral lineage of echinoderms and hemichordates. So, if deuterostome divergence occurred around 575 million years ago, as recent molecular-clock studies suggest[6], there is a 50-million-year gap in the fossil record between the origin of deuterostomes and their appearance in the fossil record. In the jigsaw of deuterostome evolution, vetulocystids represent another piece to be fitted into a puzzle where many of the pieces are still missing. ■

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