achieved by the fruit passing through different birds — could diversify the germination strategies available to the plant. For a seed travelling by bird, therefore, the long haul is by no means the only benefit available; the choice of transport and the in-flight service could be even more important. ■

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Palaeontology

On being vetulicolian

Henry Gee

Some curious fossils from the Cambrian period have been grouped into a new phylum, the Vetulicolia. All of its members are extinct, and their unusual anatomy tempts evolutionary speculation.

Researchers engaged in acts of discovery sometimes have to confront the truly strange and make sense of it. Many of the fossils from the Cambrian Period (about 543–510 million years ago) are cases in point, for they defy comparison with living creatures. In this seeming 'explosion' of life, evolution was toying with many different designs. If all living things share a common ancestor, even the strangest fossil creature must be related to something more intelligible, whether living or long-since dead. Identifying these relatives can be a daunting task.

Such is the problem faced by Shu and colleagues, who on page 419 of this issue[1] describe and discuss several fossil animals from the Chengjiang fauna of southern China. This is a remarkable assemblage of exotic forms, comparable with — and slightly older than — the fossils of the famous Burgess Shale of western Canada. Shu *et al.* describe the exquisite fossils of an unusual, partially segmented creature (see Fig. 1 on page 420) and, in an extended comparison with three other known fossils (Figs 2–5), create a new phylum — a natural group of animals united by a distinctive body plan. They suggest that this phylum, which they call the Vetulicolia, is part of the Deuterostomia, the 'superphyletic' group that includes echinoderms (starfishes, sea urchins and allies), hemichordates (the obscure acorn-worms and pterobranchs) and chordates (vertebrates, including ourselves, as well as tunicates and the amphioxus *Branchiostoma*). The relationships of these various groups are outlined in Fig. 1 overleaf.

Interpretation of any problematic fossil is a risky business. Interpreting presumably adult forms of an unusual fossil as deuterostomes is riskier still, because the defining characters of deuterostomes are conventionally embryological and will not show up in adults. However, molecular work suggests there is a close alliance between hemichordates, which have structures called pharyngeal slits, and echinoderms, which do not, at least in living forms[2]. This conclusion implies that some features seen in adult chordates and hemichordates — in particular the pharyngeal slits — might be characteristics of deuterostomes in general. Shu and colleagues present evidence that vetulicolians, like hemichordates and chordates, have pharyngeal slits; this finding, among others, aligns them with deuterostomes. If this interpretation is correct, vetulicolians represent a new, primitive deuterostome body plan that could shed light on the long-vexed question of vertebrate origins.

The vetulicolian fossils are just a few centimetres long, and are united by several characteristics, including a markedly bipartite body. The anterior half is voluminous and sac-like, with a large opening at the front — regarded as the mouth — and five pairs of lateral openings. Shu and colleagues interpret these features as pharyngeal slits. At least some vetulicolians have a trace of a groove or cleft on the inside surface of the floor of the anterior cavity, which Shu *et al.* interpret as an endostyle. The endostyle — a characteristic feature of chordates — is a gland-rich gutter in the ventral floor of the pharynx. The mucus it produces lubricates the inside of the pharynx, where it traps and concentrates food particles. It also, incidentally, concentrates iodine. The candidate endostyle of vetulicolians is similar in position to those of tunicates and the amphioxus. The filter-feeding larvae of lampreys are the only vertebrates to retain an endostyle. On metamorphosis, the endostyle becomes the adult thyroid gland. Neither echinoderms nor hemichordates are thought to have an endostyle, which appears to be a uniquely chordate feature.

The posterior half of the vetulicolians is divided into seven segments. A structure

NATURE

100 YEARS AGO

The Leonid Meteors, November, 1901. **A telegram to the daily Press through Reuter's agency announces that a considerable number of meteors have been observed in localities where the weather conditions were propitious. Advices from many stations in the United States report more or less brilliant displays of the Leonids as having been seen on Thursday and Friday nights. A steamer from New Orleans reports having seen a great shower near Cape Hatteras early on Friday morning (November 15). The only night on which the sky was at all favourable in London was Thursday, November 14, and on that occasion continual watch was kept by three observers at the Solar Physics Observatory from 11 p.m. to 4 a.m. A few meteors were seen, from twenty to thirty, but nothing in the semblance of a definite shower was presented. Many of the shooting stars seen were very brilliant, but those traced out as being Perseids or Taurids were as numerous as those decidedly radiating from the sickle of Leo, so that probably there was nothing more than is to be seen on any good night for the same interval of time.**
From *Nature* 21 November 1901.

50 YEARS AGO

In the last century, the idea of a universal and all-pervading æther was popular as a foundation on which to build the theory of electromagnetic phenomena. The situation was profoundly influenced in 1905 by Einstein's discovery of the principle of relativity, leading to the requirement of a four-dimensional formulation of all natural laws. It was soon found that the existence of an æther could not be fitted in with relativity, and since relativity was well established, the æther was abandoned. Physical knowledge has advanced very much since 1905, notably by the arrival of quantum mechanics, and the situation has again changed. If one re-examines the question in the light of present-day knowledge, one finds that the æther is no longer ruled out by relativity, and good reasons can now be advanced for postulating an æther… We can now see that we may very well have an æther, subject to quantum mechanics and conforming to relativity, provided we are willing to consider the perfect vacuum as an idealized state, not attainable in practice… It is no longer a trivial state, but needs elaborate mathematics for its description. ***P. A. M. Dirac***
From *Nature* 24 November 1951.

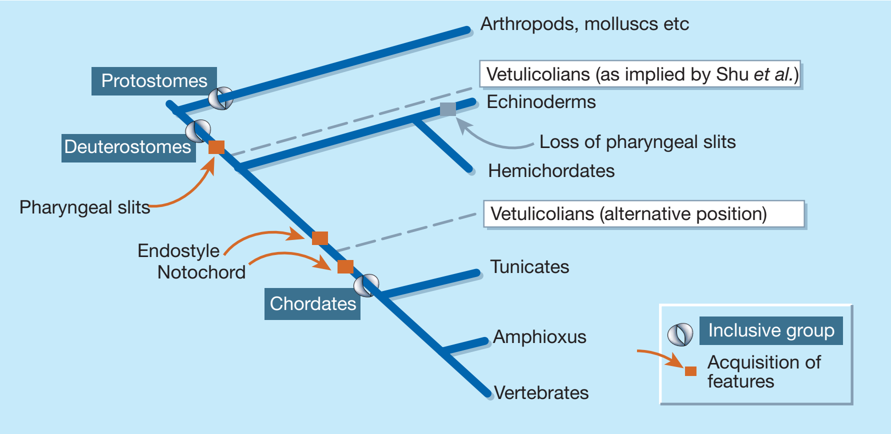

Figure 1 **The deuterostomes, and possible places for vetulicolians in the evolutionary scheme of events. Shu and colleagues[1] regard vetulicolians as 'basal' deuterostomes — phylogenetically outside all extant deuterostomes. But they also suggest that the fossils have an endostyle, a structure generally seen as characteristic of a more exclusive deuterostome group, the chordates, and implying that the vetulicolians have a more 'crownward' position in the tree of life. As interpreted by Shu and colleagues, the fossils lack a notochord and so cannot be regarded as chordates. But vetulicolians could be their immediate sister taxon.**

interpreted as a gut runs along the entire length of the posterior section, which looks remarkably arthropod-like. Indeed, the authors remark that the entire animal looks much like a small shrimp. But vetulicolians appear to have been limbless, and no arthropod exists that has traded all its limbs for pharyngeal slits.

Where do the vetulicolians fit into deuterostome evolution? The authors' assertion that these creatures were 'basal deuterostomes' — that is, deuterostomes that branched off the main lineage before the echinoderms, hemichordates and chordates became distinct — is properly cautious, given the difficulties inherent in interpreting unusual fossils. To assert that vetulicolians were more or less close to specific deuterostome groups might be asking more of the evidence than it can stand. External commentators, however, like court jesters, have licence to be more reckless.

Looking at the distribution of features in vetulicolians, and mapping them onto a deuterostome phylogeny (Fig. 1), you could make a case that these animals are akin to chordates, rather than deuterostomes in general. This would then make vetulicolians directly relevant to the question of vertebrate ancestry. In short, the latest common ancestor of chordates would have looked rather like a vetulicolian. The only real difference would be that vetulicolians lack a notochord — the axial, stiffening rod that all chordates have at some stage in their life cycle. The amphioxus has a notochord throughout life; tunicates lose it as adults, and in most vertebrates it is supplanted by the vertebral column. Shu and colleagues do not find compelling evidence for a notochord in vetulicolians.

Nonetheless, the vetulicolian body plan is close to what could be regarded as archetypal for the most primitive chordates. In the early 1970s, A. S. Romer[3] speculated that the vertebrate body was an amalgam of two separate entities: the 'visceral' and the 'somatic'. The visceral animal corresponds with the internal organs, musculature (characteristically smooth) and associated innervation; the somatic part includes the skeleton, the musculature of the body wall (generally striated), the central nervous system and the sense organs.

Romer used this 'dual-animal' model as a device to explain the course of vertebrate evolution. He argued that primitive chordates, such as tunicates, are all viscera — little more than a sac-like pharynx and gut with the most rudimentary neuronal apparatus. Vertebrates evolved by developing the somatic part, originally as the organ of locomotion in the posterior part of the animal — a beginning can be seen in the locomotory tail of tunicate tadpole larvae. In vertebrates, the somatic part has grown forwards and dorsally, covering and finally encapsulating the visceral part.

Perhaps the most striking feature of the vetulicolians is the strong division of the animal into anterior and posterior halves, just as Romer speculated. To a mind attuned to prospective vertebrate ancestors, it is easy to look at a vetulicolian and see — for example — a tunicate tadpole larva. ■

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Superconductivity

Copper oxides get charged up

Allan Hugh MacDonald

A technique for injecting electrons into the surface layers of materials has now been applied to the most mysterious of superconducting compounds — the copper oxides.

The discovery of superconductivity in copper oxide materials[1] in 1986 led to an explosion of research into these compounds. They became known as high-temperature superconductors because they have negligible resistance to electric current at temperatures up to 160 K, much higher than other materials known at the time. They continue to excite interest because many of their properties cannot be explained by the quantum theory of solids developed over the past 70 years. To many researchers it seems[2] that something fundamentally new is afoot. On page 434 of this issue Schön *et al.*[3] describe a new way of preparing these copper oxide superconductors that makes it easier to probe important aspects of their behaviour.

The superconducting properties of these materials are known to be sensitive to the density of mobile electrons in the CuO_2 planes. In particular, small changes in electron density can transform these materials from an insulating into a superconducting state, and vice versa. In the past, the electron density has been modified by adding impurities to alter the chemical structure, a process known as 'doping'. However, the impurities inevitably introduce disorder, which can change the properties of the superconductor in a way that has nothing to do with changes in their electron density. Schön *et al.* have developed a system in which an undoped copper oxide material can be made superconducting by injecting charges from a metal contact into the material. This technique makes it possible, for the first time, to investigate how the properties of a given copper oxide superconductor vary with electron density, without the complicating influence of disorder.

The simplest description of electrons in a solid-state crystal is based on an approximation in which each electron moves independently, sensitive only to the average location of other electrons. It turns out that this approximation implies that crystals with odd numbers of electrons per molecular unit