interactions among taxonomically diverse species, which are subject to variation induced by changing wildlife systems. Such changes, together with increased use of tick habitats by humans for dwellings (e.g. within woodlands of northeastern USA) and leisure activities, might explain the increased recording of cases of Lyme disease amongst those social classes that have forced this zoonosis to emerge from the shadows.

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Dinosaur fossils with soft parts

Soft tissues of long-dead organisms are preserved only in very special circumstances, and the study of such materials has caused considerable excitement. Two papers just published in *Nature*[1,2] report small theropod dinosaurs that retain a remarkable array of soft-tissue features.

Two specimens come from China and have been named *Sinosauropteryx*[1] (and were discussed in *TREE* with respect to dinosaur–bird relationships[3]). They are from a famous, probably Lower Cretaceous (about 125 million years ago), locality called Jehol in Liaoning that has produced numerous exceptionally well preserved fossils, including reptiles, birds and mammals. *Sinosauropteryx* is about 70 cm long, and is a flesh-eating theropod dinosaur, very like *Compsognathus* from the Late Jurassic (about 150 million years ago) of Germany. The described specimens of *Sinosauropteryx* are both relatively complete and undisturbed, and they have associated soft tissue traces. The internal remains in the larger specimen of *Sinosauropteryx* include her last supper – a largish lizard. Stomach contents are unusual but not unique finds, because they involve normal preservation of hard bony remains. Other internal structures are more impressive.

Low down in the visceral cavity, the larger specimen of *Sinosauropteryx* also contains two large eggs, complete with shells. These eggs had almost certainly not been eaten – they are far from the stomach (which in any case is full of lizard) and they are unbroken. They lie low in the abdomen, close to the location of the oviduct in modern birds, where the egg shell is produced before laying. Two is a low number for a reptile: indeed, dinosaur nests usually contain eight to 30 eggs, more in line with modern crocodiles, lizards and turtles. Perhaps there were two or three eggs at the other side of the abdomen of *Sinosauropteryx*. Although fossil eggs are not unique in the fossil record, eggs inside a dinosaur are. In the future, it will be interesting to try to determine whether the eggs were fertile, and whether there are any indications of foetal remains within them.

Most excitement has been aroused by the external features of the two *Sinosauropteryx* specimens: they appear to have feathers, or so the press reports stated in late 1996. Was this final proof that birds are dinosaurs, and that theropod dinosaurs, at least, were insulated and warm-blooded? The 'feathers' are now more circumspectly termed 'integumentary structures'[1]. The specimens of *Sinosauropteryx* are preserved flat on their sides, and the integumentary structures are seen as short dark-coloured tufts along the back of the neck, the back, and above and below the tail. They slope backwards, in a naturalistic pelt-like arrangement. Shorter sequences of these structures can be seen over the cheek region of the skull and on the sides of the arm. The integumentary structures are set away from the bones of the skeleton by a distance that allows for the loss of intervening muscle and skin. The structures are superficially hair-like and they are tangled in places but, in comparison with modern mammals, they are thicker than hairs would have been in such a small animal. They range in length from 4 mm behind the skull to 21 mm over the shoulder region, and then become progressively shorter down the tail.

The Chinese authors who described *Sinosauropteryx* accept that they have not found a feathered dinosaur and suggest[1] that although the integumentary structures may have some side branches they lack hooklets and barbules and other characteristics of feathers. However, they might be 'previously unidentified protofeathers which are not as complex as either down feathers or even the hair-like feathers of secondarily flightless birds'. In a commentary, David Unwin[4] is more cautious. The integumentary structures lack any specific feature of feathers – elongate frilly scales perhaps, as in many lizards today, or some

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unique kind of filamentous 'hair', as in the extinct flying pterosaurs, but not yet clear evidence of feathers, or even 'protofeathers'. However, there are now rumours of another dinosaur specimen from China that shows unequivocal feathers.

The second exceptionally preserved dinosaur find is also Early Cretaceous in age but comes from Italy. The newly named *Scipionyx*[2] is known from a single specimen from the Pietraroia locality in southern Italy, a site well known for a wide fauna of exceptionally well preserved freshwater organisms, shrimps, fishes and crocodilians. *Scipionyx* is tiny, only 25 cm long, and the unique specimen is probably a juvenile. It has no integumentary structures, feathers or other debatable structures of that kind, but its internal organs are amazingly well preserved. In the throat region is a segment of trachea, with the reinforcing rings, and there are patches of preserved muscle in the shoulder area and at the base of the tail. The most amazing feature is the preserved intestine – a broad but short irregular tube filling the abdominal cavity and showing bands of muscular tissue. The texture and colour look just like the intestine of a recently dissected animal.

Other soft-tissue traces in *Scipionyx* include a haematitic halo just anterior to the intestine, possibly representing the liver. The putative liver has given rise to a great deal of excitement because its position, well forward under the rib cage, implies that the lungs were small, in no way bird-like, and that this dinosaur, as well as *Sinosauropteryx*, might have had crocodile-like respiration[3,5]. This crocodile-like physiological system has been taken as evidence against a close relationship between birds and these highly derived theropod dinosaurs[3,5]. However, possession of a primitive character, such as a 'reptilian' respiratory system, does not indicate anything about relationships, other than that dinosaurs evolved from primitive reptiles, and that birds later evolved a specialized respiratory complex.

These two new reports are not the first notices of dinosaur soft parts. Skin impressions of many dinosaurs have been noted, generally showing impressions of the small bony scales set in the skin. Some specimens even contain organic material[6]. A specimen from the Early Cretaceous of Brazil shows muscles and other soft tissues of a theropod dinosaur preserved in apatite (calcium phosphate)[7]. Another theropod dinosaur from the Early Cretaceous of Spain, *Pelecanimimus*, has been reported with skin and muscles mineralized in the throat and neck region, the back of the head, the arm and the chest area[8]. These are preserved in an iron carbonate, and the body outline is replicated by phosphatized microbial mats. Special conditions are required for such preservation – the body is placed in gentle anoxic waters where bacteria grow over the carcass in a few days after death, before much decay or scavenging can take place. Some of the surviving soft tissues are replaced by bacteria and then mineralized in carbonate or phosphate derived either from the decaying carcass or from surrounding waters. Rapid fossilization seems to be the key, and geochemical studies of the new Chinese and Italian dinosaurs should reveal how they came to be so remarkably well preserved.

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