

a key component in the semiconductor-device toolbox.

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Palaeontology

# Chinese lantern for early primates

Robert D. Martin

A fossil skull from China, dating to 55 million years ago, provides much-needed substantial evidence of early primates in Asia. Interpretation of the creature's eye size and activity pattern will spark debate.

The first fossil evidence for 'primates of modern aspect' — the euprimates — appears abruptly in the northern continents at the beginning of the Eocene, about 55 million years ago. Eocene primates are well documented from sites in North America and Europe, but specimens from Asia have been scarce and fragmentary. That situation changes with the report by Ni *et al.* of a well-preserved partial primate skull, with lower jaws, from China (page 65

of this issue<sup>1</sup>). The authors allocate the fossil to a new species of the genus *Teilhardina*, which was originally established for fragmentary material from Belgium<sup>2</sup>.

The new skull has several euprimate characteristics, notably a bony ring around each eye-socket (orbit), forward rotation of the orbits and a relatively large braincase. But the skull is very small, with an overall length of about 25 mm, and the animal's body mass is estimated as 28 g — less than in any modern

primate species. As expected for one of the earliest known euprimates, the dentition is relatively primitive. The upper and lower jaws both contain four premolars on each side (the maximum known for any primate) and the front premolars are not as reduced as in other *Teilhardina* species. Certain dental features, and its small body size, suggest that the animal was an insectivore.

The bigger picture is outlined in Fig. 1, which reflects the widely accepted view that there is a basic dichotomy in the primate evolutionary tree — one lineage leading to modern lemurs and lorises (strepsirrhines), the other to tarsiers, monkeys, apes and humans (haplorhines)<sup>3–5</sup>. All or most Eocene primates are allocated to two major groups, lemuroids and tarsoids. These are commonly linked to modern strepsirrhines and haplorhines, respectively (although both could possibly have arisen from an independent northern radiation of primates<sup>6,7</sup>). *Teilhardina* is included among tarsoids as a potential relative of haplorhines.

As well as the new species (*T. asiatica*), and the originally described *T. belgica*<sup>2</sup>, the genus *Teilhardina* currently includes five other species from North America. On this basis, then, *Teilhardina* seemingly had a remarkably wide distribution. Using characters derived from the new skull, Ni *et al.*<sup>1</sup> repeated an earlier analysis of primate relationships<sup>5</sup>. The results confirm the basic primate dichotomy, and are striking for *Teilhardina* itself. *Teilhardina asiatica* and *T. belgica* together constitute the earliest offshoot from the haplorhine side of the tree, branching off before the split between other tarsoids and haplorhines (Fig. 1). By contrast, *T. americana* (the only American species considered) lies within the cluster containing all other tarsoids, reflecting a pronounced separation from *T. asiatica* and *T. belgica*. Inclusion of *T. americana* and other closely related North American species in the genus *Teilhardina* is therefore questionable, as is the apparent extensive distribution of the genus.

Another unusual feature of *T. asiatica* is the small size of the orbits relative to skull length. Analysis of the scaling of orbit size using a published data set<sup>8</sup> indicates that this species falls on the best-fit line for modern diurnal primates, which generally have relatively smaller orbits than nocturnal species. From this, Ni *et al.*<sup>1</sup> infer that *T. asiatica* was diurnal. They go on to interpret the evolution of nocturnal versus diurnal habits among primates, and conclude that the last common ancestor of euprimates was a diurnal, visually oriented predator.

This is an important issue, one on which I have to disagree with the authors on both statistical and biological grounds. Prediction from regression lines beyond the range of the original data is suspect, and *T. asiatica* is smaller than any modern primate. In fact, Ni and colleagues excluded all large-bodied

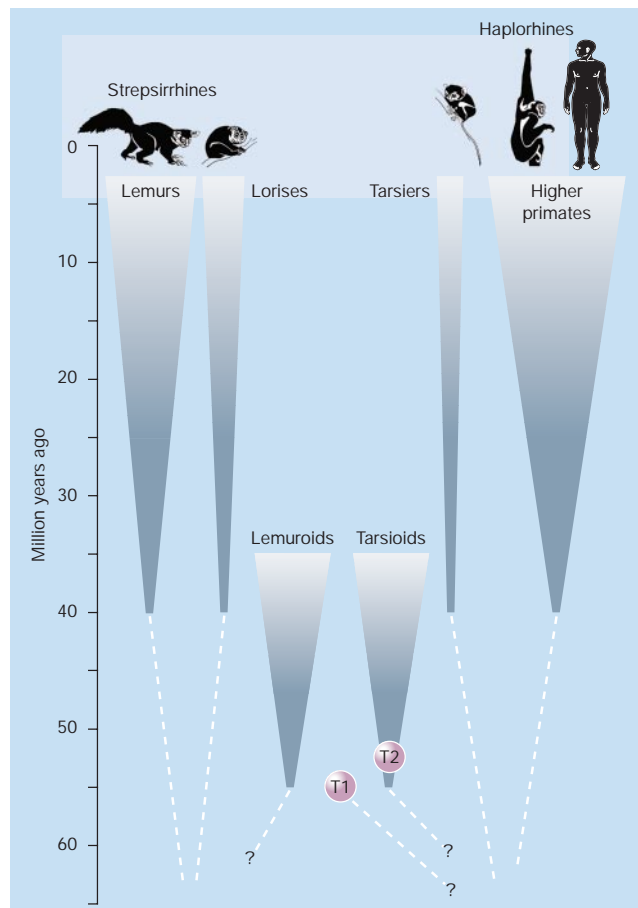


Figure 1 Primate evolution in outline. This tree incorporates the results of the analysis by Ni *et al.*<sup>1</sup> (see Fig. 3 on page 67; lemuroids are formally known as Adapiformes, and tarsoids as Omomyiformes). Along with *Teilhardina belgica*, the new species *T. asiatica* branches away first on the haplorhine side of the tree (T1). By contrast, *T. americana* (T2) is nested within the other Eocene tarsoids, calling into doubt its place in the genus *Teilhardina*. (Primate icons drawn by Lucrezia Beerli-Bieler.)

primates from the original data set, so altering the slope of the best-fit line for diurnal primates and strengthening the inference that *T. asiatica* was diurnal. Furthermore, no account was taken of the potential problem of 'phylogenetic inertia'<sup>9</sup>: closely related species may not be statistically independent, so estimates of probability may be open to doubt.

Biologically, one cannot assume that early primates (particularly if unusually small in size) showed the same functional patterns as modern primates — which themselves are very variable. Given that ancestral primates descended from ancestral mammals with smaller eyes, early primates presumably showed only moderate enlargement of their eyes, regardless of their habits. In early primates, the brain was less than half the size of the brains of their modern relatives<sup>3</sup>. So processing of visual inputs was probably more rudimentary, perhaps explaining why some Eocene lemuroids had far smaller orbits than modern diurnal lemurs.

Another source of information comes from a study by Kay and Kirk<sup>5</sup>. To increase visual sensitivity in dim light, nocturnal species show marked retinal summation of inputs from the photoreceptors, resulting in a narrower optic nerve. This is reflected by a narrower opening (foramen) for the optic nerve in the back of the orbit. For living primates, Kay and Kirk found a good match between activity pattern and relative size of the foramen. However, all Eocene primates have a small foramen, regardless of whether they have relatively small orbits (suggesting diurnal vision) or large orbits (indicating nocturnal habits). Thus, visual adaptations in early primates were clearly different from those in modern primates. Finally, a feature on the snout of *T. asiatica*, the infraorbital foramen, is markedly larger than in modern primates. The size of this foramen — large in primitive nocturnal mammals, typically

reduced in diurnal mammals — indicates the degree of development of tactile whiskers for non-visual orientation.

I believe, then, that we remain in the dark with respect to the activity pattern of *T. asiatica*. Regardless of that, however, Ni and colleagues' discovery is notable not only for its implications for primate systematics but also from a biogeographical perspective. Until recently, it was widely held that direct migration of mammals between Asia and Europe around 55 million years ago was ruled out by a transcontinental marine barrier. The landmass of Eurasia was largely or completely split down the middle by a combination of the Western Siberian Obik Sea to the north and the Turgai Straits to the south. So it was suggested that the only possibility for interchange of mammals between Asia and Europe was indirect migration across the Bering Straits, through North America and across the Greenland landbridge, or vice versa. However, the presence of closely related *Teilhardina* species in China and Belgium (but not in America) in the early Eocene adds to evidence that migration between Asia and Europe did not necessarily involve such a roundabout route<sup>10</sup>. ■

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#### 100 YEARS AGO

Under the title of "The Case for Vaccination," Mr. C. E. A. Winslow gives an admirable survey of the statistical data in favour of the efficacy of vaccination (*Science*, July 24, p. 101). It points out that a single vaccination greatly reduces the probability of an attack of small-pox, postpones it to a later period of life, and renders it less dangerous if it does ensue. To ensure absolute protection revaccination is required. During the small-pox epidemic of 1871, of 734 nurses and attendants in the Metropolitan Asylums Board Hospitals 79 were survivors from small-pox attack, and escaped infection; 645 were revaccinated on entrance, and all escaped; 10 were not revaccinated, and all took small-pox. Mr. Winslow concludes, "if statistics ever proved anything, those quoted prove the protective influence of vaccination." *From Nature* 31 December 1903.

#### 50 YEARS AGO

*Scientific centenaries in 1954.* The modern use of a surname is so well established that it is worth recalling that, as late as the fifteenth century, hereditary surnames were by no means general, it being the custom to add to the baptismal name the place of the owner's birth or residence, or his occupation or some peculiarity that would identify him. Thus we find that Hermann, an eleventh-century monk, was known as Hermann of Reichenau, after the abbey in Switzerland where he spent most of his life, or Hermann the Cripple, on account of the paralysis which had afflicted him from youth. Hermann, born in 1013, has been described as one of the most learned men of his age, and interests us particularly because he was devoted to the study of mathematics and astronomy... He died in 1054, at the castle of his father, Count Wolferad of Alshausen... The year 1954 marks the five hundredth centenary of the birth of the Italian astronomer Domenico Maria di Novara... Passing from Italy to Germany, we note the death in 1554 of Jerome Bock, the herbalist... His great herbal, "New Kreütter Büch", which appeared first in 1539, is remarkable because Bock was the first botanist to attempt descriptions, from direct observation, which would render illustrations unnecessary. To obtain his material he made long journeys on foot, dressed as a peasant, to avoid undue attention. Illness and misfortune clouded his later life, and he died when only fifty-six, predeceased by eight of his ten children. *From Nature* 2 January 1954.

#### Oceanography

## The southern supplier

Joachim Ribbe

Physical processes in the Southern Ocean largely control nutrient distribution in the global marine environment, a finding that further highlights the influence of this oceanic region on Earth's climate.

To understand how climate change comes about, and what the future may hold, we need to untangle the linkages between ocean circulation and the productivity of phytoplankton. Productivity depends on nutrient availability in the ocean and, as phytoplankton are leading players in the global carbon cycle, they partly determine levels of the greenhouse gas carbon dioxide in the ocean and atmosphere.

On page 56 of this issue, Sarmiento *et al.*<sup>1</sup>

argue that the Southern Ocean controls the distribution of nutrients in most of the upper ocean throughout the world. It does so through the formation of nutrient-rich water masses, which spread throughout the Southern Hemisphere and into the North Atlantic. A similar process occurs in the North Pacific, but makes a smaller contribution to nutrient availability.

The formation of water masses within defined geographical regions links the global