

taminated food<sup>4</sup> and which do not share the codon 146(C) and 158(C) amino acids with cattle: oryx<sup>5</sup> and domestic cat (W. G., unpublished data). Many amino-acid changes in PrP change the phenotype of prion diseases; it is intriguing to speculate about evolutionary adaptation against these diseases operating via sequence changes in PrP protein. It may therefore be the case that codons 143, 155 and, as suggested above, 168 of the human PrP gene are key amino-acid positions in the interaction with components of the infective agent. However, a correlation between a particular feature of a PrP protein sequence and predisposition to a certain strain of agent can only be demonstrated experimentally.

In addition, Krakauer *et al.* based their analysis on only 56 variant codon positions. In fact, there are at least 80 positions in the full open reading frame which show a minimum of one amino-acid replacement, leading to 3,160 possible different pairs of amino-acid replacements. There are, for example, eight sheep PrP protein variants and not the single sheep sequence shown in the phylogeny<sup>6</sup>. We suggest that a calculation on the basis of all prion protein sequences (including all known polymorphisms) would not only change the phylogenetic tree but would result in a higher probability for the occurrence by chance of the convergence observed. Serine and asparagine are highly variable in many codon positions of PrP. In addition to hominoids and cattle, the codon 143 asparagine-to-serine replacement occurs twice as a single replacement: in pig<sup>7</sup>, omitted by Krakauer *et al.*<sup>1</sup>, PrP analysis also shows that codon 155 is one of the few positions which have two possible amino-acid replacements (asparagine in hamster), perhaps indicating a tolerance for differences in this region.

*A priori* prediction of the incidence or cross-species transmissibility of a spongiform encephalopathy requires a more adequate three-dimensional structural model for PrP protein and its molecular interactions than is available, and a much better understanding of the molecular basis of the strains of these unconventional disease agents.

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## Vertebrate with protrusible eyes

SIR — Caecilians are among the most divergent and least-known major vertebrate groups. Found throughout the humid tropics (with the exception of Madagascar), these limbless, fossorial

African family Scolecomorphidae, the eye is not under bone or in a socket. Instead, it is attached laterally to the base of the tentacle<sup>7–9</sup>. In most caecilians, this would prevent the eye from being exposed to light, as it would be under heavily pigmented skin. But in scolecomorphids, the tentacular groove is covered by pigmented skin. Thus, as the tentacle is protracted and retracted, the eye moves with it along a translucent track and remains exposed to ambient light regardless of position (*a* in the figure).



*a*, Living specimen of *S. kirkii* with the tentacle retracted. Note that the eye is still visible in the tentacular groove under a layer of unpigmented skin. *b*, Another specimen with the tentacle completely protracted, clearly showing the eye beyond the roofing bones of the skull.

amphibians possess many unique and often strange characteristics, not the least being their tentacles. These protrusible organs, one on each side of the snout, are derived from the tear duct, certain extrinsic eye muscles and other parts of the eye<sup>1,2</sup>. The tentacle can be protracted a considerable distance out of the head in many species. Anatomically, it is directly connected to the vomeronasal organ<sup>3</sup>, and behavioural experiments suggest that it is involved in chemoreception<sup>4</sup>. We now show for the first time that the east African caecilian *Scolecomorphus kirkii* can protrude its eyes beyond the skull by means of the tentacle.

In all caecilians, the eyes are lidless and reduced, and at best function to detect changes in light intensity<sup>5,6</sup>. In many species the eyes are fixed in bony sockets, in others they are completely covered by the roofing bones of the skull, while yet others apparently lack eyes entirely. In most caecilians that have eyes, the eye and tentacle are morphologically distinct, the tentacle residing in a separate opening in the skull called the tentacular groove. However, among the species of the

The anatomy of preserved museum specimens of scolecomorphids suggested that their eyes might be protrusible<sup>9</sup>. That is, these animals might be able to protract the tentacle far enough to move the eye beyond the roofing bones of the skull, out through the tentacular aperture and into the external environment. Several living specimens of *S. kirkii* became available recently, giving us the opportunity to test this hypothesis. Using a 35-mm camera and a synchronized strobe, we captured images (*b* in the figure) which demonstrate that *Scolecomorphus* can indeed protrude its eyes beyond the skull. Some ver-

tebrates (for example, mudskippers and frogs) have eyes that are retractable within their sockets, but this is the only known vertebrate with highly mobile, protrusible eyes.

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