

All sabretoothed carnivores aren't sharks

SIR—Jared Diamond¹ is unwise to combine evidence associated with *Homotherium's* probable prey and functional analysis of *Smilodon*, into a hit-and-run strategy of killing large prey for both, and implicitly for all, sabretooths. In this strategy, which is considered analogous to that of the great white shark, a large piece of flesh is torn from a vulnerable area of the surprised victim and the predator retreats to await the victim's death.

Smilodon's hit-and-run strategy, proposed by Akersten², involved the mandible in the operation of the sabres. After catching a fold of skin and flesh between the upper and lower canines, and with the mandibular flanges pressed against the body of the prey to provide stability, *Smilodon* drove its sabres through the fold. As the jaws closed the incisors and lower canines penetrated the base of the fold to free it from the body.

But *Homotherium* and *Smilodon* are distinctly adapted. Unlike *Smilodon*, all *Homotherium* teeth are serrated, suggesting an adaptation to shearing flesh³. The incisors lie in a rounded, interdigitating arc which is set forward of the canines to allow the taking of a bite from fleeing prey. *Smilodon's* lower canines and incisors form a nipping transverse pincer. *Homotherium's* dorsolaterally projecting lower canines are possibly adapted for slashing. Its upper canines are sharper, completely serrated, lower crowned and more laterally compressed.

Other sabretoothed carnivores show still wider morphological diversity. In the nimravids *Hoplophoneus* and *Eusmilus* the incisors are high crowned, conical and slightly recurved. As in *Homotherium*, all teeth are serrated and the upper and lower incisors form interdigitating arcs; the hypsodont sabres resemble those of *Smilodon* but are more laterally compressed. *Barbourofelis fricki* is as large as *Smilodon* with similarly hypsodont sabres but the morphology of its sabre is more strongly compressed laterally, with lingual and buccal grooves and serrated margins. The incisors and lower canines are serrated, compressed buccolingually and form arcs that interdigitate more completely than in *Homotherium*.

The sabretoothed marsupial *Thylacosmilus* possessed a sharpened, triangular-sectioned upper canine but only one large and one small lower incisor, or canine and incisor, and no more than two upper incisors⁴. Such 'incisors' were surely less able to penetrate the skin than those of any fissipede sabretooth, or even hyaenas. Diamond did not mention that *Hyaena*, *Crocota* and *Lycaon* bite segments of flesh from prey and let it bleed to death but do not possess sabrelike canines.

Diverse dental anatomies among sabre-

tooths suggest that, despite necessary functional similarities, precise adaptations varied. The hunting adaptations of these animals were surely diverse.

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Waste disposal by plants

SIR—The provocative letter by Ford¹ notes that the abscission of leaves and leaf-like structures may function as a waste-disposal mechanism. As several times as much organic material is introduced into the soil by roots as by leaf and branch litter^{2,3}, roots provide another potential means of eliminating wastes.

The sloughing of root-cap cells is perhaps implausible for this function, because they continue to function normally by secreting lubricatory mucilage for up to three weeks after separation⁴, but root hairs have a lifetime of only a few days and the whole root cortex itself is usually shed later⁴. Five to ten per cent of the root mass may be released into the soil per day^{4,5}. Even the cortex cells die by autolysis rather than external compulsion⁴, although I have no evidence of whether their metabolism (and that of root hairs) changes before autolysis, as it does for leaves¹. Mycorrhizal death⁶ is also relevant², as 30–50 per cent of a plant's net primary production can go to the mycorrhizae⁶.

Waste disposal by roots is potentially more efficient than by leaves, because the excreted material necessarily remains within an individual plant's rhizosphere (extended to include the mycorrhizal network). The waste is then available for assimilation by suitable bacteria, and their consumption and metabolism by the soil microfauna provide a path for subsequent return to the plant⁷. There are obvious opportunities for coevolution by patch selection^{8,9} and specific mutualism.

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Body temperature and the thermodynamics of water

SIR—The suggestion by Paul¹ that the selection of mean body-temperature levels in homoiothermic animals is determined by the properties of water is a most interesting one. But his reasoning concerning the value of such an adaptation appears to be incomplete.

Paul says that because the specific heat of water is minimal at approximately 35 °C, an organism losing heat to the environment will have to do minimal work to restore its temperature to about this value. But for a given amount of heat lost by an organism, the same amount of heat will have to be generated to restore the loss, regardless of the temperature selected by the organism as its normal resting level. It is not the temperature change which is crucial to an organism but the heat lost or gained, as this heat represents energy which must be expended or dissipated by the organism in order to restore its initial level.

Furthermore, the cooling factor at around 35 °C will be greater than at any other temperature, as most of the cooling will take place as the result of water evaporation, either from the skin surface or by means of respiration. It is a case of roundabouts and swings: there is no apparent reason why this adaptation should have come about if the object is the maintenance of a given temperature level *per se*.

Although this seems to dispose of the argument that 35 °C is the optimum value for the maintenance of heat stability by the organism, it remains the optimum value for temperature lability. In other words it is easier to vary an animal's temperature at this value than at any other, because it will require least work. We might therefore seek for the reason for the selection of 35 °C in terms of the value to an organism of being able to alter its temperature easily.

There are a number of adaptive states that are either entered by animals varying their own temperatures, or are triggered by temperature changes from the environment. The induction of fever may be a powerful recovery mechanism in response to attack by hostile organisms. Hibernation is an adaptive state for some classes of mammal, and aestivation may also be beneficial. Shivering and sweating are adaptive responses to temperature change brought about from outside.

It remains to be shown, however, that these responses could not themselves have been adapted to take place at different temperatures. In other words, it is not immediately obvious that they determine the normal temperature of the organism rather than being determined by it. The explanation may lie in the fact that, because the creation and maintenance of