patchy environment created by the leaky cow as it does to wild herbivores.

We have analysed[2] the contribution of the Maasai and their herds to ecosystem dynamics, including patch production, in relation to the part played by wild grazers. Wildebeest have come to dominate the herbivore community in the Serengeti Ecological Unit since the exclusion of the Maasai from the national park. The wildebeest seek out high nutrient concentration areas in which to feed but ruminate, defaecate and urinate in short-grass habitats different from the areas they graze[3]. However, the resulting processes of nutrient stripping and concentration are taken to far greater extremes by Maasai herds which graze in selected pastures, but ruminate, defaecate and urinate in night enclosures. The resulting high-nutrient patches revert to grazing land after a few weeks (for temporary wet season camps), years (in permanent arid zone settlements) or decades (in wetter highland zone permanent settlements)[2].

The overall structure and species diversity of these Serengeti mosaic grasslands are remarkably resilient while grazing is maintained. Belsky[4] has shown the rapid recovery of both species diversity and spatial structure following a variety of natural and experimental artificial disturbances. In contrast to other conservation areas, the Serengeti grasslands resist invasion by introduced species[2]. However, exclosure of grazers leads to loss of productivity and diversity.

Patch production by cattle can go too far. Tolsma *et al.*[5] have shown that nutrient stripping by livestock generates phosphate and other deficiencies in intensively ranched Botswana rangelands, while concentration of nutrients around livestock watering holes leads to the growth of toxic plants. However, in Maasailand, 20 years of attempts to intensify livestock production have failed to change standard measures of the ecology of livestock production[6]. It is just as well for the conservation status of one of the world's richest and most diverse grassland ecosystems that the leaky Maasai cow retains its traditional role.

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# "Surface tension" in the lungs

SIR — In a letter to *Nature* in 1955, Pattle[1] noted that the foam in cases of acute pulmonary oedema was peculiar in that the bubbles were extremely small and very stable. He used two phrases to explain the phenomenon that he had so accurately observed. First, "The surface tension of the lung bubbles is therefore zero"; and subsequently "It is thus evident that the alveoli are lined with an insoluble protein which can abolish the tension of the alveolar surface." Thus the word 'tension' carries two distinct meanings; the first (dynes per cm) as a manifestation of surface free energy (ergs per $cm^2$) giving rise to the spontaneous contraction of liquids, a consequence of the unequal pull experienced by molecules in the interface between two phases having unequal concentrations; and the second, where a solid surface is too rigid to be distorted by surface free energies.

Recent claims to have achieved zero[2,3] or near-zero[4] surface tension at air/water interfaces are reminders that a body of lung physiologists and neonatologists, following up Pattle's observations, failed to distinguish between the two, quite different, implications of the term 'tension', with the result that a custom has prevailed in which all measurements from whatever device are presumed to identify with the 'tension' of the surface free energy kind.

It is remarkable that these claims, persistent over the past 30 years and pertaining to lung surfactant(s) placed on water in a Langmuir trough or within tethered bubbles or, by implication, within the alveolar spaces of a lung, had not been challenged until recently[5]. The claims are absurd as zero surface tension is tantamount to zero surface free energy, which in turn implies absence of interface. Yet no author has ever described the spontaneous demise of (standing) water into vapour following the application of lung surfactant. The surface tension of a water/vapour interface approaches zero only at the critical temperature (374.1 °C), at which point the concentration of liquid water is equal to the concentration of water vapour and a single phase is established.

Correct interpretation of the measurements is essential if one is to draw valid conclusions relating to lung mechanics, lung microanatomy and to the mechanism of action of lung surfactant. For example, the most common method of assaying lung surfactant is to measure the weight of the meniscus of water supported by a unit length of high-energy solid (for example, a heated platinum plate). Any contamination of the plate by organic matter, whether phospholipid or protein, inevitably reduces the surface free energy of the plate to that below water and the weight of the meniscus falls. Such an event in no way reports upon the true surface tension of the sample solution and could reflect merely the affinity of a phospholipid or protein or both, whether as monomers or aggregated, to a clean metal surface[2].

Comprehension between physical and medical scientists would be resolved if the latter were to limit their reports to what they measure and not what they think they are measuring.

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# Fatal attraction to cyanobacteria?

SIR — Scavenging of shoreline deposits of neurotoxic benthic cyanobacteria by dogs has recently resulted in deaths at freshwater lochs (lakes) in Scotland. The first report in the scientific literature on animal deaths due to toxic cyanobacteria in lakes, by George Francis, appeared in *Nature* more than a century ago[1], and since then there have been many reports of cyanobacterial animal intoxications and the toxins responsible[2,3].

Until recently, the perceived circumstances of animal poisonings due to cyanobacterial toxins conformed to a general pattern. The buoyant growth habit of the widely encountered toxigenic, planktonic genera such as *Microcystis, Anabaena, Aphanizomenon, Nodularia* and some *Oscillatoria* species can result in scum formation in lakes and ponds during calm weather, so that an acutely toxic dose of cyanobacterial toxins can be presented to animals in a smaller volume than their daily water requirement. The animal deaths due to cyanobacterial toxins in Australia described by Francis[1] and elsewhere by many subsequent investigators have typically occurred after drinking from or near toxic scums[2,3].

Such poisonings have arisen under the following circumstances: if access to clear water is barred and animals are obliged to drink from regions containing toxic scum or blooms; or, as in the case of the deaths of 15 dogs and 20 sheep at Rutland Water, Leicestershire, in 1989

(ref. 3), the entire lake margin is surrounded by toxic scum and it is not possible to wade out to open water without passing through the scum. Animal poisonings due to the ingestion of toxic planktonic cyanobacterial scum, or concentrated bloom, seem to occur as unavoidable consequences of contact with toxic planktonic scums and blooms. The habit that dogs have of licking adherent material from their coats has contributed to the ingestion of lethal doses of hepatotoxic *Nodularia spumigena* after swimming in water containing scum[4]. Whether the dogs or livestock were attracted to the planktonic cyanobacteria is unknown.

We have investigated dog poisonings that have occurred rapidly after ingestion of neurotoxic benthic cyanobacteria accumulated along the margins of Scottish lochs in 1990, 1991 (ref. 5) and in May and June this year. The most recent neurotoxicoses at lochs Awe and Avich (Argyll) have included two deaths and two cases in which the animals eventually recovered. As before, we have identified benthic *Oscillatoria* spp. and the cyanobacterial neurotoxin anatoxin-a in scums and dog stomach contents. When visiting the sites where the poisonings occurred, we found that the accumulations of toxic cyanobacteria were highly localized. For example, at Loch Awe the deposits extended along the shore for about 10 m, no more being encountered for more than 100 m. Why then did the poisonings occur when the animals had ready access to clear water for drinking and swimming?

The dogs at lochs Awe and Avich were accompanied by their owners, who saw the animals eat from the shoreline deposits of toxic cyanobacteria. These deposits partly occurred as slime and wet mats in the shallows and partly as dried crusts above the waterline, which had fallen during dry weather. Scavenging by dogs is not in itself unusual, and we believe that this habit contributed to the location and ingestion of toxic doses of cyanobacterial neurotoxin. Why dogs should be attracted to toxic benthic cyanobacterial mats or crusts is unknown. Cyanobacteria, and other aquatic and terrestrial microbes such as actinomycetes, produce many taste and odour compounds which have hitherto been of interest due to their adverse impact on aquaculture and drinking water quality[6]. Perhaps these are attractive to opportunistic omnivores such as the domestic dog. The significance of cyanobacterial taste and odour compounds as (fatal) attractants to animals has yet to be investigated.

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# Dating of Nazca aqueducts

SIR — It is true that, to the best of our present knowledge, Spanish colonial documents do not settle the question of the ultimate origin of the underground aqueducts (*puquios*) of Nazca[1]. However, at least one document does refer "specifically to the Nazca galleries". This is housed in Peru's national archive, and is part of the records of the viceregal water court[2]. It establishes and confirms the water distribution of the Visambra *puquio* from 1692 to 1778, incorporating papers from the 1730s. In 1698 several haciendas, a rectory and the Indian community of Nazca had to give up flow for two hours every morning so that water could pass through the town of Nazca.

What has been dated by atomic mass spectroscopy (AMS) is not necessarily the construction of the *puquios*, or the time the two stones sampled were placed in the canals, but rather the times when the stones were last trimmed by masons. In prehispanic, colonial and republican Andean architecture, the reuse of ancient dressed stone is very common. New vertical segments of the Cantalloq *puquio* have been constructed in living memory[3] and it is worrying that Dorn *et al.* do not pinpoint the locations where their samples were taken[4].

In 1954, archaeologists observed that the Nazca to Inca site of Tambo Viejo in the nearby Acarí valley was being disassembled and its stones trucked away for use in an unidentified irrigation project[5]. Water flowed through this site, so the reuse of stones from Tambo Viejo would not be incompatible with the observation reported, but not illustrated, by Dorn *et al.*, that the morphology of *puquio* varnish indicates that it formed in moist conditions. This is only circumstantial evidence, but it is enough to caution us that, as Bray writes[1], the matter of *puquio* dating is only "partially resolved".

As yet, a complete and accurate map of the Nazca *puquios* has not been published. Furthermore, large portions of the *puquios* consist of trenches dug a few metres to the water table, roofed with wood or stone lintels supporting earthern or rubble fill to ground level. It is these stone lintels that produced the AMS dates. To the best of my knowledge, no *puquio* has ever been excavated. A careful and extensive examination of fill contents might reveal much about the sequencing of *puquio* construction, a process that could not have been accomplished in a single moment. It is strange that archaeologists have not applied their most basic and characteristic methodology to the problems presented by the underground aqueducts of Nazca.

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# Geomagnetic reversal paths

SIR — Valet *et al.*[1] concluded that there is no statistical evidence for a preferred sector of longitude in the distribution of mean virtual geomagnetic pole (VGP) paths during reversals. This contradicts the earlier suggestion that the transitional field VGPs have a tendency to follow the longitudinal band over the Americas and to a lesser extent its antipode[2], an idea which we have used to infer aspects of core–mantle dynamics[3]. We believe that the statistical analysis of Valet *et al.* has led them to an incorrect conclusion.

The criteria used by the authors of both studies[1,3] to select reliable records of reversals are basically the same: publication in refereed journals, existence of a reasonable number of transitional directions (usually 4 or 5), and sufficient description of the laboratory methods so that at least an idea of the magnetic cleaning is obtained. Thus there are only limited differences in the database of the two groups. These concern mainly the acceptance[2] or rejection[1] of four records from Argentina now published in a refereed journal[4] and, more important, of