Balancing background noise

SIR—I had not known, until Huxley's comment¹ on my article², of Bárány's suggestion that the auditory ossicles could balance out background noise, although I naturally knew of his important work on bone conduction.

Because of the past history of the Mammalia, three auditory ossicles form the middle ear transformer. All other tetrapods have only one. The mammals evolved from mammal-like reptiles, which had the tympanic membrane in the lower jaw, supported by the angular bone^{3,4}. Sound was conducted from the tympanic membrane through the jaw articulation, formed by the articular and quadrate, to the stapes, which itself articulated with the quadrate.

Mammalia, by definition, have a secondary jaw articulation, between squamosal and dentary, which replaces the primary jaw articulation between quadrate and articular. With the new articulation, the ear drum moved from the lower jaw to the skull, the angular became the tympanic and the articular and quadrate the malleus and incus. So the mammals came into being with the chain of three bones in the middle ear available both to increase the transformer ratio and to function as suggested by Bárány.

The problem of background noise was much more acute in the mammal-like reptiles than in their successors, the mammals. Because the articular bone moved during mastication, it would have been essential not only to balance out unwanted noise, but to prevent damage to the organ of Corti from overstimulation by the inevitable gross movements of the stapes.

I have always been aware of the problem of unwanted noise in these reptiles, but had thought that it could be solved by some form of nerve block, rather as unwanted noise can easily be filtered out in an electronic circuit. I did not consider the question of damage to the inner ear, where some mechanism such as that suggested by Bárány could well have been important.

In present-day lizards, the tympanic membrane is held in a frame formed by the quadrate bone supplemented posteriorly by soft tissues, and in particular by a strong band of connective tissue attaching ventrally to the retroarticular process of the lower jaw. Mastication, when both the quadrate and the articular move, occasions two problems: suppressing the consequent background noise, and preventing damage to the inner ear.

In lizards, sound is conducted from the tympanic membrane to the inner ear by the stapes and a cartilagenous extra-stapes; sometimes there is a movable joint between them. Wever⁵ discusses this condition in the iguanid *Crotaphytus*, where

the lever action between stapes and extra-stapes gives a transformer ratio of two and a total transformer ratio in the middle ear of 26.6 — well up into the mammalian range (man has a transformer ratio of only 18.3). Wever does not consider the problem of background noise or damage, but I have little doubt that the mechanism postulated by Bárány could be effective. I do not know whether the mechanism would suffice in *Chameleon*, where the

Diagrammatical section of the middle ear in a mammal, showing the otic region.

stapes rocks on the rim of the fenestra vestibuli, giving the high transformer ratio of 5.6 (ref. 6).

Gekko, with the highest reptilian transformer ratio⁵ of 39.9 and a loss of acoustic energy due to reflection of only 1 dB, is in a different case. The stapes and extra-stapes are rigidly connected together, so that the transformer effect is entirely due to the ratio of the effective area of the tympanic membrane and the area of the footplate of the stapes, which supports Huxley's point that the lever action of the auditory ossicles is not necessary for a high transformer ratio. But, in *Gekko*, Bárány's mechanism would not work.

Gekko must have some other device to limit background noise and damage, which may well be that provided by the stapodial muscle, the role of which in attenuating undesirably loud sounds has recently been discussed⁷. It is significant that *Gekko* is unusual in having a stapodial muscle, found otherwise in lizards only among the Pygopodidae and the amphisbaenid *Bipes biporus*⁸. In the Pygopodidae, the stapes and extra-stapes are fused together as in *Gekko*, whereas in *Bipes* the extra-stapes is absent. In those tetrapods with a tensor tympani muscle, this could also have a protective function

similar to that of the stapodial muscle⁸.

Whatever the details, there is no doubt that more attention needs to be paid, in studies of both fossil and recent tetrapod ears, of the problems of all these animals in preventing damage to the organ of Corti from excessive movement of the stapes.

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Inositol phosphate and Ca^{2+} flow

SIR—In a recent review article¹, Berridge and Irvine discuss how the phosphoinositide messenger inositol 1,3,4,5-tetrakisphosphate ($\text{Ins}(1,3,4,5)\text{P}_4$) may act as a cellular signal by modulating intracellular calcium concentrations. In reviewing the evidence in favour of the idea that $\text{Ins}(1,3,4,5)\text{P}_4$ modulates calcium influx across the plasma membrane, however, they fail to mention that the observations on which this idea was based² cannot be reproduced by the original authors³ or by others⁴.

The original suggestion that $\text{Ins}(1,3,4,5)\text{P}_4$ may gate calcium influx was based on experiments in sea urchin eggs² and attracted considerable attention^{5,6}. Crucial to the argument was the finding that egg activation required external calcium^{5,7}. This came as something of a surprise to those who routinely work with sea urchin eggs, as it had previously been shown^{8,9} that eggs and embryos fertilize and develop normally in the absence of calcium. It was less surprising, given what is known about egg activation, that the observation could not be repeated⁴.

There may be some substance in the view that $\text{Ins}(1,3,4,5)\text{P}_4$ affects calcium influx, particularly in the light of data obtained from mouse lacrimal glands¹⁰. It nonetheless seems a little unusual to found a hypothesis on results that cannot be reproduced.

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IRVINE AND BERRIDGE REPLY—We are somewhat amazed that the phrasing in our review¹ seems to have perpetrated a misunderstanding about the possible role of $\text{Ins}(1,3,4,5)\text{P}_4$ in regulating Ca^{2+} homeostasis. We have never made any attempt to disguise or play down (to the contrary^{3,11-13}) the differences that can occur between batches of sea urchin eggs. These may be due to any number of unknown factors, and a seasonal wild-animal species shipped across an ocean is always a potential source of such problems. Furthermore, there are many examples in the

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