rays, such as ^{119}Sn, ^{151}Eu or ^{121}Sb. As for the control, in the early stages of our work we carried out one experiment with a source velocity of 0 mm s^{-1} and observed a decrease in cell proliferation (compared with the 'drug alone' group) but much less of a decrease than observed with the Doppler shift on the Mössbauer peak (+1.5 mm s^{-1}). We attribute this small effect to the presence of Fe(II)bleomycin, which would absorb at 0 mm s^{-1}, in the medium *in vivo*.

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Constraints on brain growth

SIR—In birds, adult brain size is larger in altricial species, which produce relatively undeveloped and dependent hatchlings, than in precocial species of similar adult size, which produce well-developed and functionally independent hatchlings[1]. By contrast, the relative adult brain size of placental mammals varies independently of the developmental state of the neonate[2]. Although this difference between birds and mammals is striking and may have far-reaching ecological and evolutionary implications[3], no hypothesis has yet been offered to account for its existence. We now suggest that it is a consequence of fundamental differences in the availability of substrates for metabolic processes in the embryonic brain.

Unlike most vertebrate tissues, the central nervous system (CNS) uses carbohydrates or, in part, ketone bodies as its main catabolic substrates; the direct catabolism of lipids contributes only minimally to its energy requirements[4]. Within the confines of the avian egg, however, carbohydrates are unsuitable as an energy-storage medium because of their low energy density. Instead lipids, which have an eight-fold higher energy density than carbohydrates, account for 84–98 per cent of the substrates oxidized by the avian embryo[5].

The limited stores of carbohydrates in an avian egg and the inability of CNS tissues to rely on the direct catabolism of lipids means that the metabolic demands of the CNS in avian embryos, particularly in the later stages of development, must be met by glucose derived from either glycerol or amino acids and by ketone bodies generated from fatty acids. This has its costs. First, the use of ketone bodies in lieu of glucose leads to a high concentration of blood ketone bodies, which may require additional resources to buffer the associated ionic imbalances and may inhibit proper CNS developments[6]. In addition, the relatively low energy density of amino acids, comparable to that of carbohydrates, makes them of limited use as gluconeogenic precursors in eggs, and their catabolism produces nitrogenous wastes that must be sequestered from the developing embryo.

A further problem in the egg arises from the fact that the CNS is more active metabolically than most other tissues of avian embryos and has a correspondingly higher relative rate of energy demand and oxygen consumption. Constraints on the supply of oxygen across an eggshell may, therefore, limit brain growth.

Unlike embryos in an egg, avian neonates can readily obtain carbohydrates and gluconeogenic substrates either for themselves or from their parents. They also have unlimited access to oxygen and can freely excrete nitrogenous wastes.

Altricial birds are thought to have evolved from smaller-brained precocial ancestors[7]. In extant precocial species, the ontogeny of the CNS is characterized by substantial pre-hatching differentiation and myelination of neurons[8,9], presumably because of the behavioural and metabolic demands on precocial hatchlings. One consequence of a larger adult brain may be a parallel increase in brain size at all equivalent stages of brain ontogeny[8]. In this case, the evolutionary increase in adult brain size would have required a concomitant increase in the size of the embryonic CNS, and hence in the total metabolic costs incurred to reach a functionally comparable stage of development at hatching. The relatively high costs of supporting prenatal CNS catabolism, as outlined here, might then have favoured a decrease in the proportion of brain growth and differentiation that occurred prenatally (increased altricity) with an associated increase in parental care after hatching.

Energy use by mammalian embryos is fundamentally different from the lipid-based metabolism found in the eggs of birds and all other oviparous vertebrates. The almost exclusive catabolic substrate of mammalian fetuses is maternally supplied glucose; use of lipids is rare or absent[6]. Thus, mammalian fetuses have ready access to carbohydrates during early development, which oviparous vertebrates do not have until after hatching. For most mammals there is no extended period during development in which substrates for CNS metabolism are limited. Thus, there is relatively little difference between the pre- and postnatal costs of supporting CNS metabolism relative to those for other organs, the prenatal ontogeny of the mammalian brain is not constrained by embryonic nutrition, and an inverse relationship between developmental stage at birth and adult brain size is neither required or observed.

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Biological light guides

SIR—Wells[1] suggests that the question of "whether light transmission down hairs affects skin and hair" needs investigation. In that respect, it is worth pointing out that many major vertebrate sensory systems incorporate cilia in their structure, including the hair cells of the cochlea, the oriented hair cells of the vestibular mechanism and the photo-receptor cells of the retina. The latter have been shown to have light-guiding properties (see ref. 2 for a review).

The invagination of the neural groove in the surface ectoderm of the embryo leads to the development and elaboration of the nervous system. The infolding and incorporation of surface tissue within the embryo accounts for the presence of ciliated cells within nervous tissue. Neurons, which after maturation form photoreceptors containing cilia, line the outer wall of the collapsed brain ventricle that will form the retina. A study of the evolution of the relationships between cilia and specific sensory systems would be of interest.

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