

## Cortical maps

## Upside-down world in bat's brain

from Edward Jones

ON PAGE 477 of this issue, M.B. Calford and co-workers report that significant parts of the body-surface map formed in the somatic sensory areas of the cerebral cortex of a flying mammal, the fruit-eating bat *Pteropus poliocephalus*, is reversed in comparison with that in other mammals<sup>1</sup>. This correlates with the upside-down posture adopted by the bat at rest (see cover picture) and, Calford *et al.* argue, implies that the cerebral cortex analyses spatial information in terms of the habitual orientation of an animal's body in extra-personal space.

The study is typical of many in which maps of visual space, auditory space or the body surface are being detected in the cortex. The maps in the somatic sensory cortex are revealed by stimulating small portions of the body surface and recording the resulting localized electrical activity in the cortex with microelectrodes. Each map is usually a systematic representation of the body surface, with adjacent parts of the body surface sending information to, and thus represented by, neighbouring groups of cells in the cortical area containing the map<sup>2</sup> — hence the term 'somatotopic representation'. The somatotopic maps are usually illustrated in popular cartoon form as homunculi, simiusculi, felisculi, rat-tusculi and so on, their numbers limited only by the availability of species and the patience of the investigator, and their names only by the investigator's familiarity with Latin. The maps on page 477 could be called chirunculi or pteropusculi.

In common with all other mammals investigated, this bat has three somatic sensory areas, each with a complete somatotopic map, and multiple visual and auditory areas, each with their own maps. Like other mammals, too, the map of the body surface, though systematic and, thus, somatotopic, is distorted; certain peripheral regions, such as the rhinarium, facial whiskers, the free first digit of the wing and the regions adjacent to it, have disproportionately large representations. *A priori*, therefore, it can be inferred that these regions have a greater density of innervation than other structures, reflecting their functions in this species as the major sensory and manipulating surfaces.

A significant difference between the bat and virtually all other mammals that have been studied<sup>2,3</sup> is that the mapping of forelimb digits is reversed in two of the maps so that the representations of the tips of the digits point posteriorly instead of anteriorly. The representation of the belly surface of the trunk is also reversed.

These results are interpreted by Calford *et al.* as indicating that the constraints on mapping the body surface in the somatic

sensory cortex include the necessity for maintaining the relative dispositions of body parts to one another and to the head. The bat's forelimb is usually held with the digits directed behind the head during flight and above it during rest; that is, according to the authors, its spatial relationships to the rest of the body are the reverse of those in most other animals. In other words, the relationship between the receptor surface and extra-personal space must be preserved in the cortical map. This has far-reaching implications for the anatomy of the somatic sensory system, because the nerve fibres bearing information to the somatic sensory cortex must have been reshuffled during evolution to create the reorganized map, and their source, the thalamus, must also have been modified.

The analysis of personal and extra-personal space by the mammalian cerebral cortex is an accepted dogma<sup>4</sup>; it is also widely accepted that this is accomplished in terms of a series of two-dimensional maps. It is not too great a flight of fancy to imagine that somewhere in the distant evolutionary past, advantages conferred by this propensity for forming maps constituted an irresistible pressure upon the cerebral cortex, leading it to expand as an enormous flat sheet rather than as a bolus of cells. It is not easy to see what the advantages of map-making are for the cortex, because some degree of spatial

analysis could presumably be carried out by a kind of flying-spot analysis in a bolus of cells that received information from the peripheral sense organs.

Calford *et al.* would argue that the necessity of preserving spatial relationships is a major constraint imposed by the periphery on map-making in the cerebral cortex. That the somatic sensory map is mutable and can be influenced from the periphery is demonstrated in recent experiments on monkeys, where changes in the somatotopic map can be induced extremely rapidly in response to peripheral manipulations, such as severing nerves or amputation of a finger<sup>5,6</sup>. Whether the spatial domain is pre-eminent seems moot, for the several sub-modalities of somatic sensation must also maintain their differential representations in the same area of cortex. When these are mapped independently, the resulting map has often appeared remarkably unlike that based on somatotopy alone<sup>7</sup>. It is in the co-mapping of space and modality that the somatic sensory cortex is most remarkable. □

1. Calford, M.B., Graydon, M.L., Huerta, M.F., Kaas, J. & Pettigrew, J.D. *Nature* 313, 477 (1985).
2. Woolsey, C.N. in *Biological and Biochemical Bases of Behavior* (eds Harlow, H.F. & Woolsey, C.N.) (University of Wisconsin Press, 1958).
3. Kaas, J., Sur, M. & Nelson, R.J. in *Cortical Sensory Organization, Multiple Somatic Areas* (ed. Woolsey, C.N.) Vol. 1 (Humana Press, Clifton, New Jersey, 1981).
4. Mountcastle, V.B. *Bull. Johns Hopkins Hospital* 136, 109 (1975).
5. Merzrich, M.M. *et al. J. comp. Neurol.* 224, 591 (1984).
6. Merzrich, M.M. *et al. Neuroscience* 10, 639 (1983).
7. Sretavan, C. & Dykes, R.W. *J. comp. Neurol.* 213, 381 (1983).

Edward Jones is in the Department of Anatomy, University of California, Irvine, California 92717, USA.

## Eukaryotic genes

## Are introns structural elements or evolutionary debris?

from Athel Cornish-Bowden

THE discovery of introns — sequences of non-coding DNA that interrupt the coding sequences of genes but are excised from gene transcripts — burst upon an unsuspecting world in 1977. Since then, much information has accumulated about the ubiquity of introns in the genes of higher eukaryotes and their absence from those of prokaryotes and lower eukaryotes, but it is still not really clear why they are there or what they do. There is still argument over whether they were present in the primordial genes and have been eliminated in the interests of efficiency by prokaryotes, or whether, instead, they were introduced after the eukaryotes separated from the prokaryotes. Papers in this issue of *Nature* and the January issue of *Cell* contribute to the debate.

It is scarcely tenable to propose that all introns are functionless, opportunistic

pieces of selfish DNA which have invaded eukaryotic genes by taking advantage of the biochemical machinery that normally excises them. If so, why then did the excision machinery evolve in the first place? At least some introns, therefore, must have had a function, at some stage in the evolution of the gene. The most plausible suggestion is that the existence of introns makes it much easier for large and complex proteins to evolve, as they can be assembled from the small functional units or domains into which introns split genes. Moreover, new functions could in principle be produced by rearranging such domains. Once introns evolved, however, it became possible for parasitic DNA to take advantage of the excision machinery. Thus although some, perhaps most, introns must have a functional origin, it is not necessary to assume this for every intron.