Spatial Organisation of the Cone Photoreceptor Mosaic of the Domestic Chicken (Gallus gallus)

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The domestic chicken, like most birds, has a keen sense of colour. This is due, in part to the presence of pigmented oil droplets found between the inner and outer segments of the cone cells. The oil droplets serve as a filter, sharpening the spectral response of the photoreceptor. These droplets can be classified using a combination of bight field and fluorescence microscopy. This method yields six classes of cone, named by their appearance: Red (R), Yellow (Y), Clear (C), Transparent (T) and the two 'halves' of the double cone: Principal (P) and Accessory (A) (Bowmaker et.al, 1996, Vision Research, 37(16), 2183). The loci of these photoreceptors form a uniformly distributed mosaic, with each type uniformly distributed within it, yet attempts at assigning a 'crystalline' structure have been unsuccessful. However, a measure of order (Cook J.E., Visual Neuroscience, 1996, 13(1), 15) indicates that the mosaic is in fact highly ordered. To investigate this further, a statistical analysis of the connections found using a Voronoi based nearest neighbour analysis was undertaken. The results suggested that the high order may be explained by spatial constraints and a principle of exclusion – where the single cones exclude other single cones from the area surrounding them. A simple generative model constructed using this principle produced the same statistical distribution of neighbour pairings. Another analysis, using autocorrelograms (e.g. L.Galli-Resta et. al.1999, European Journal of Neuroscience, 11, 1461) was consistent with this mechanism. This analysis showed the retina to be unlike most reported in the literature. There is long range order amongst the double and C-type cones (reflected also by the individual order parameters) contrary to the apparent absence of a crystalline structure. This anomaly is compounded by the lack of circular symmetry in the autocorrelograms (the highest symmetry observed is D_2), and non-central exclusion zones in the crosscorrelograms. This aside, it would seem that the apparent complexity is due to the number of cone types, and thus a result of the need for a uniform sampling of a large number of spectral components.