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Kinetics of Epidermal Cells in Skin from Human Cadavers

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No systematic investigations and only two pilot studies have been published on cytokinetics in cadaveric skin [1, 2]. Many findings, however, have been reported on the kinetics of epidermal cells in live humans (for review, see [3]).

We took single or repeated biopsies from a total of 45 human cadavers at different postmortal intervals (PMI). The cadavers were stored at 4 °C for a PMI of 4 to 75 h. The biopsy specimens were incubated in vitro with radioactively labeled DNA precursors, ^{3}H-thymidine only as well as ^{3}H-thymidine and ^{14}C-thymidine consecutively, exposed at a temperature of 37 °C and 2.2 bar O_2 [4]. The following results were obtained:

Even though the single values were broadly scattered, no statistically relevant change in the kinetic data was observed under the described storage conditions of the cadavers. The labeling index (LI) was 2.7 ± 0.8 % (approx. 20 h PMI) or 2.8 ± 0.9 % (approx. 40 h PMI); the DNA synthesis time (t_s) was 4.7 ± 1.4 h (approx. 30 h PMI) or 3.2 ± 1.1 h (approx. 40 h PMI); and the potential doubling time (t_{pot}) was 181.3 ± 57.2 (approx. 30 h PMI) or 137.7 ± 40.4 h (approx. 40 h PMI). No indications of biorhythmic changes were observed.

For the female cadavers, mean LI was 2.6 ± 0.8 %, t_s 3.9 ± 0.2, and t_{pot} 168.5 ± 34.3 h. For the male cadavers, mean LI was 2.5 ± 0.8 %, t_s 5.0 ± 1.6, and t_{pot} 183.9 ± 27.2 h. No statistically relevant differences were established.

Age dependency was investigated by determining LI in the epidermis of thigh and knee. No statistically relevant age-dependent differences were established for either region.

Finally, the cytokinetic data were evaluated with respect to their dependency on topography. Epidermis from the following regions was examined: temple, anterior part of neck, mamma (upper outer quadrant), lateral chest wall, lower abdomen, thigh (extensor side), knee (extensor side), upper arm (flexor side), and elbow. The LI was highest in the elbow (3.1 ± 1.0) and lowest in the lower abdomen (2.1 ± 0.8 %). The t_{pot} was shortest in the elbow (109.3 ± 72.5 h) and comparatively long in the lower abdomen (183 ± 38.7 h). No statistically relevant differences were established for these two biopsy sites; roughly the same proliferative behavior was observed in the other sites.

Our findings indicate an extremely short t_s and a decrease of t_s and t_{pot} dependent on the storage time of the cadavers. The question arises whether the calculated t_s and t_{pot} correspond to a real DNA synthesis time or a real potential doubling time. The double-labeling method for determining t_s might be influenced by the increasing PMI leading to a change of the cell flux through the cycle. Since the calculated t_{pot} depends on t_s, t_{pot} tends to decrease with t_s. In spite of these considerations, the LI as well as the t_{pot} (up to a storage time of 30 h) of cadavers are comparable with those reported for live humans [3]. Differentiation according to sex, age, and site revealed no statistically relevant differences in LI, t_s, and t_{pot}.

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The Avian Inner Ear

Continuous Production of Hair Cells in Vestibular Sensory Organs, but not in the Auditory Papilla

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Most lower-vertebrate sensory organs, such as the olfactory organs, the taste buds, and the eyes show a production of new elements throughout the full span of life [1]. In the inner ear of such animals with growth throughout life, a production of new elements has been demonstrated in some elasmobranchs, teleosts, and amphibians [2]. Most addition of hair cells has been reported to occur along the periphery of the sensory areas, but a considerable production in more central areas may also take place [3]. Contrarily, mammals and birds with terminated growth are considered to cease production of new inner-ear hair cells shortly after birth [4].

As mitoses in most sensory organs, including the inner ear, of postembryonal stages are rare, autoradiography with tritiated thymidine has been used to label nuclei with newly synthesized DNA. Employing this technique on adult budgerigars (*Melopsittacus undulatus*), which were given intramuscular injections each morning and evening in 19 consecutive days (total dose 1 mCi per kg body weight), resulted in labelled cells in conventional sections of all

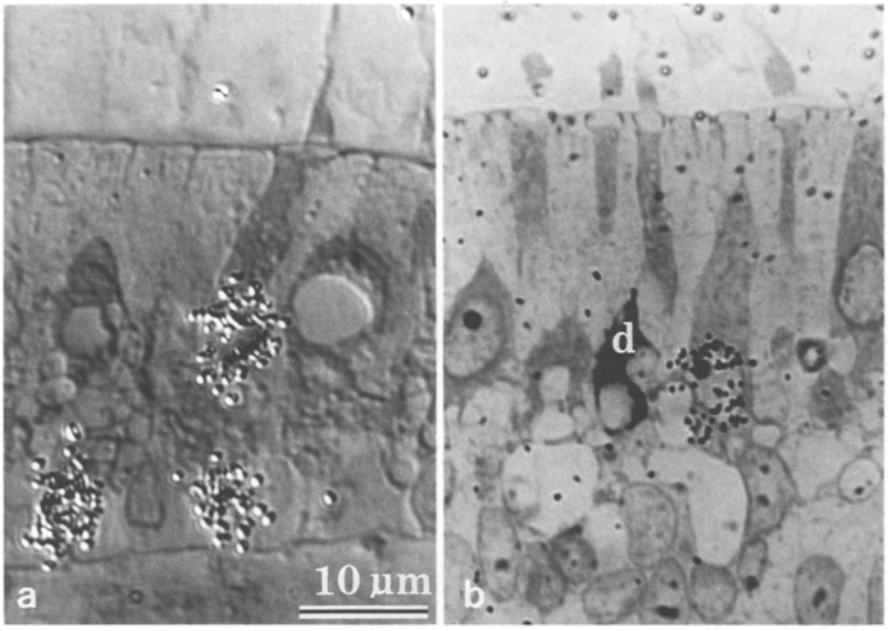

Fig. 1. Labelled nuclei of some hair cells and basal cells from the budgerigar crista lateralis, a) micrograph taken with Nomarsky interference contrast, b) with normal light microscopic optics; *d* dark cell

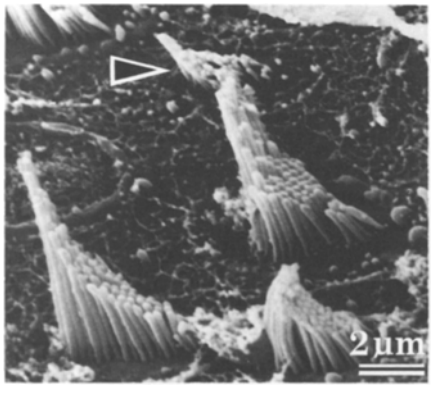

Fig. 2. Scanning micrograph of some central hair bundles of the utricular macula of a black-headed gull. *Arrowhead* indicates a hair bundle with short and thin sensory hairs

cristae and maculae, i.e., the vestibular organs, of the inner ear. Nuclei of both hair cells (Fig. 1) and supporting cells were labelled. Complete series of 2-µm serial plastic sections of three cochleae were carefully examined, but no labelled cells were found in the basilar papillae, while the lagenar maculae, positioned at the end of each cochlea, had many labelled nuclei.

Counting of 925 labelled cells in three utricular maculae shows that more than 80 % of the labelled cells are found central to a marginal zone arbitrarily given a width of six hair cells, so there is little indication of a peripheral production. Eight labelled hair cells were found in the marginal zone, while the epithelium central to this had more than 125 labelled hair cells. This finding is in agreement with results from a scanning electron microscopic examination of the maculae of a black-headed gull (*Larus ridibundus*). Scattered among sensory hair bundles of normal size, bundles with short and thin sensory hairs are arising from cells with small apical surfaces (Fig. 2). No such hair bundles were found in the basilar papillae.

Thin sensory hairs have previously been described from the inner ears of a number of vertebrates [5]. Recent examination of the ontogenetic development of the stereocilia in the chick basilar papilla has shown that these sensory hairs first grow to the full length and then widen in diameter [6]. The thin stereocilia in the black-headed gull probably belong to recently formed hair cells. Occasionally, dark cells are found in the inner-ear vestibular sensory epithelia (Fig. 1). Their cytoplasm, as seen in the light and transmission electron microscope, have numerous vacuoles and an irregular outline and show additional signs of degeneration. The presence of recently formed hair cells as well as a series of hair cells with progressive signs of degeneration, may indicate a turnover of the vestibular hair cells [7]. However, at present we cannot rule out the possibility that only some hair cells degenerate.

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