# CILIATED CELLS, COCHLEAR CILIA & LOW FREQUENCY NOISE

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**Introduction** In 1992, animal models began to be used to investigate the effects of low frequency noise (LFN) (≤500 Hz, including infrasound) exposure on the respiratory and auditory systems. This investigation occurred within the context of studies into vibroacoustic disease, a whole-body pathology caused by LFN exposure [1].

**Tracheal ciliated cells** Through scanning electron microscopy (SEM), several features were consistently identified in LFN-exposed tracheal ciliated cells. They were observed either shaggy, sheared or bald. Sometimes, shaggy and sheared are seen within the same field (Fig.1). Despite shagyness, transverse cuts of cilia suggest that the axoneme's internal structure (9+2 arrangement of microtubules) is not altered. Some tufts of cilia appear sheared, as if clipped by scissors. It is unclear how this is related to the tufts of cilia seen lying upon the epithelial surface (Fig.2). The established primary function of tracheal cilia is to sweep layers of mucous and trapped particles of dust and dead cells away from the respiratory tract. However, a possible secretory function has recently been described in both control (kept in permanent silence) and LFN-exposed tracheal cilia [2]

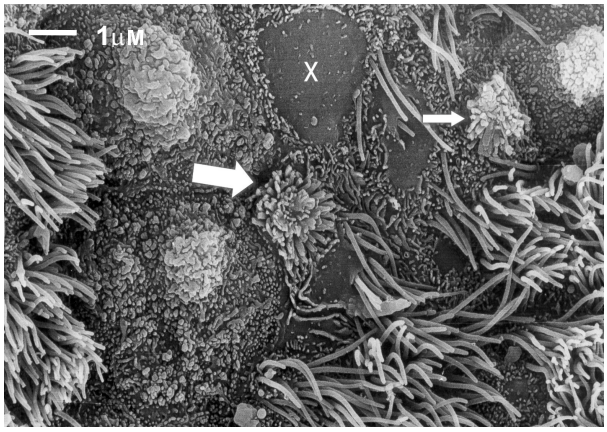


Fig. 1. SEM of LFN-exposed (4399 hours) rat trachea. Brush cells (arrows) have fused microvilli and central indentations. Bald ciliated cells (X) can be seen as well as a decrease in the amount of cilia.

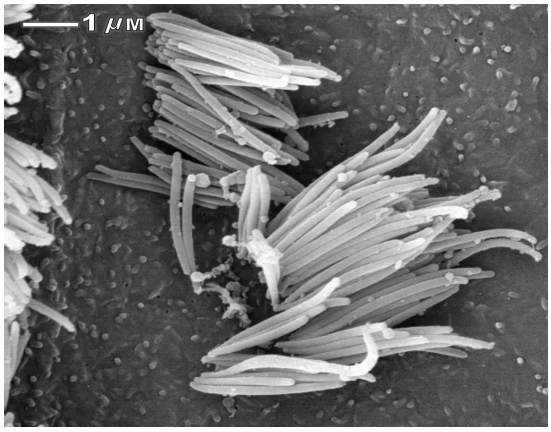


Fig. 2. SEM of LFN-exposed (2160 hours) rat trachea. Bundles of sheared cilia seem top lie horizontally upon the surface of the tracheal epithelium. Other similar images of sheared cilia were observed.

**Cochlear cilia** Cochlear cilia differs from tracheal cilia in that it is structurally composed by actin, and not tubulin. Their function is to transduce acoustic pressure waves from the basilar membrane to the upper tectorial membrane, thus producing the perception of sound. In LFN-exposed animals, cochlear cilia was conserved and fused among themselves and with the upper tectorial membrane (Fig. 3). This is in contrast with age-matched controls that lost cochlear cilia with the normal aging process [2]. It is postulated that these events may be related to the hypersensitivity to noise of vibroacoustic disease patients [1,2].

**Question** Given that under LFN exposure a) actin-based cochlear cilia fuse, and b) the tracheal epithelium is greatly affected, then it would be of interest to examine what occurs to actin structures in the tracheal epithelia.

**Tracheal Actin-Based Structures** Actin is the protein that forms microvilli (MV), which is especially abundant in epithelial cells, such as those in the trachea. Here, MV are associated with two different cell types: secretory cells (SC) and brush cells (BC). Under LFN exposure, SC microvilli become uniformly short and stunted (Fig. 1), while in controls they are exuberant and of different sizes; BC microvilli fuse among themselves forming central indentations (Fig. 4), whereas in controls they are uniformely distributed and each microvillus can be individually identified and stand upright.

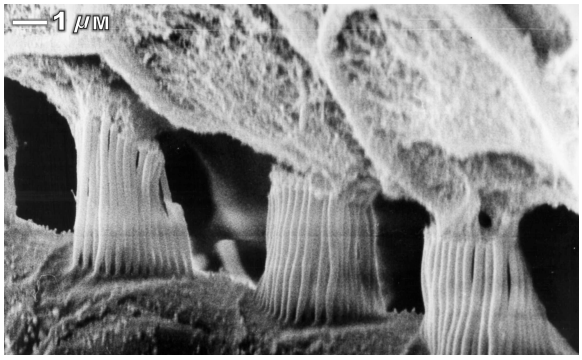


Fig. 3. SEM of LFN-exposed (4399 hours) rat cochlea. The stereocilia are seen fused both with the upper tectorial memebrane and among themselves.

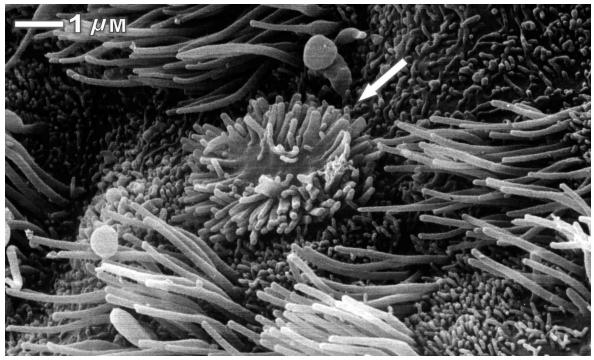


Fig. 4. SEM of LFN-exposed (4399 hours) of rat trachea. BC (arrow) microvilli have fused and are seemingly spreading outward to form a central indentation.

**Discussion** There are distinct and intriguing responses from actin- and tubulin-based structures when exposed to LFN. Tubulin-based cilia are also found in normal human pericardium, however in the pericardia of LFN-exposed individuals, not one cilium was ever identified [3]. Shaggyness and sheared cilia may be related to the loss or dysfunction of the GTP cap and coated protein pathways. Actin-based stuctures of the BC and cochlear cilia seem to have similar behaviors in the presence of LFN. This fact seems highly relevant even though pathways, mechanisms and purpose of this response are unknown. Studies into the possible whole-body consequences, in light of vibroacoustic disease, continue into other LFN-exposed actin-based structures. Possible specific frequency bands, in the light of new concepts on occupational and environmental noise [4] must be taken into account.

**Keywords:** vibroacoustic disease, trachea, electron microscopy, microvilli, actin, tubulin

**References**

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