spontaneous activity. The pst-histogram of responses to the simultaneously presented two tones at the frequencies slightly different from each other had no ripples corresponding the beat between the two sounds regardless whether or not their phases were locked at their starts, but the histogram showed a slowly progressing monophasic suppression. The suppression by the c-tone on the spontaneous activity and on the sound-evoked activity grew up slowly to its maximum and maintained the plateau with slightly progressive decrease till cessation of the suppressing sound. The discharge rate then recovered gradually to its control level with or without rebound.

The latency, the peak latency and the recovery time of the suppression after cessation of a c-tone ranged 10-28 msec, 20-84 msec and 60-280 msec respectively. These values were not inconsistent with those for the inhibition caused by the electrical stimulation of the COCB. Increasing the intensity of one of the two sounds by more than 15 dB, the mechanical interaction observed on the majority of cochlear nerve fibers became no more recognizable, whereas the suppression on the minority of neurons became more dominant and the extent of suppression increased with elevation of the suppressing c-tone level.

The c-tone frequency was just the neuron's best frequency and the c-tone leakage from the contralateral ear was strong enough at the cochlea under observation to activate the neuron. The c-tone did not activate the neuron, but suppressed it. The suppression can not be considered to be due to a direct action of the leaked c-tone on the opposite cochlea but it may result from the interaural neural inhibition. As any neural connections are not morphologically found between afferent dendrites and the efferent synapses in the cochlea are solely originated from the OCB, the inhibition might come from via the OCB.

An effective c-CF-tone level for the inhibition was so high that it exceeded 60 dB SPL and was around 100 dB SPL in some neurons. The population of cochlear nerve fibers which were inhibited by a c-CF-tone was small; less than 10 % of the fibers examined precisely in the present study. It was reported that the electrical stimulation of the crossed OCB beneath the fourth ventlicle inhibited most of cochlear nerve fibers. These facts imply that the OCB might not be expected to be an automatic gain control system, but, besides an input sound, synaptic convergence of any other additional gating signals to the OCB neurons in the superior olivary complex, probably from the higher level of the CNS, might be necessary to activate the OCB extensively enough to inhibit the transduction in the cochlea.

Structural bases of crustacean mechano-sensory hair function

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Crustacea and insect are the main member of arthropod, whose external surface is protected with sclerotized chitinous cuticle. Those animals therefore must have cuticular structure on the exoskeleton as sensory interface with the environment. Hair structure is employed as the crustacean cuticular mechanoreceptor. Antennular basal segment of crayfish carries several groups of mechano-sensory hairs including those of the statocyst

organ. Functional polarization of the statocyst hairs and its role in encoding the positional information has been reported.[1] Another group of mechano-sensory hairs was previously identified as the sensory input of a large interneuron in the CNS.[2] Structural bases of the receptive mechanism of these sensory hair were studied here with both scanning and transmission electron microscopy. The structure was identified as of the scolopidial type. This structure has so far been reported only in chordotonal organ and Johnston's organ.

External hair structure is found to be connected to the sensory cells with an extracellular chitinous thread. Thus the external force deflecting the hair is transferred to the sensory cells via this subcuticular 'chorda' thread in form of tension change. The chorda is surrounded by several layer of sheath cells and 1 to 2 μm in diameter and, in an extreme case, close to 5 mm in length. The transducing element is spindle shaped scolopidium with dimension of 40 μm in length and 4 μm in diameter. Scolopidium consists of three sensory cells together with one scolopale cell and several sheath cells. The scolopale cell contains electron dense fibrous material, i.e. scolopale, in the cytoplasm. The scolopale cell forms a spindle shaped cavity in which three sensory processes are enclosed and the scolopale seems to act as the framework of the cavity.

Sensory neurons are bipolar cell of 10 μm in diameter and 15 μm in length of somata. Each neuron has one sensory process protruding into the scolopale cavity. The distal part of the sensory process is slightly dilated and is rich in microtubules. The distal end of the scolopale constricts a set of three dilations of the sensory process. The middle part of the process is a ciliary segment with 9 + 0 type ciliary organization. The proximal processes are rich in mitochondrion. Three sensory cells adhere tightly together by desmosomal contact at this part of the process. A ciliary rootlet or axial filament runs through the proximal process from the base of cilium to the perikaryon.

Three sensory processes run together along a particular side of the inner wall of the scolopale cavity. Thus the ciliary process follows the curvature of the scolopale which itself warps along the cavity. This ciliary bending seems to play a significant role in sensory transduction as in the hair cell of vertebrate acoustico-lateralis. The schematic reconstruction is given in Fig. 1. It should be noted that the scolopidial structure is exaggerated about 10 times in size compared with the cuticular hair.

The structure revealed is in good accordance with the functional polarization observed in these hairs. Deflection of the hair in a direction of pulling of chorda can exert a stretch in the ciliary part of the sensory cell. And an in due increase in firing frequency of the cell results.

The structure described here resembles closely to the sensory element of the chordotonal organ found in shore crab.[3] Similar scolopidial structures were reported in insect chordotonal organ[4] and in Johnston's organ.[5] However, these sensory organs are generally regarded as the subcuticular sense organs and thought to have no corresponding structure on the exoskeleton. On the contrary, sensory hairs and campaniform sensillum are thought to be of a different type of sensory structure, and have been classified as the cuticular sense organs.

Present finding of the scolopidial structure as the sensory element of the crustacean external sensory hairs necessitates a new unified view of the homologous origin of these sensory structures of both cuticular and subcuticular sense organs in arthropods.
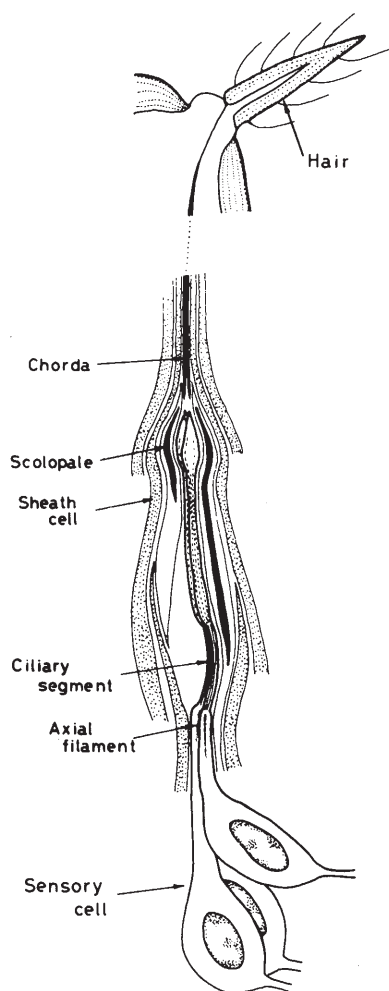
Fig. 1

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