Insect Structure Function & Physiology

Touch, movement & sound

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Touch is sensed by mechanoreceptive sensilla, usually in the form of hairs sitting on a flexible socket

macrochaetes (mechanoreceptors) microchaetes (mechanoreceptors) campaniform sensilla (mechanoreceptors) olfactory chemoreceptors



At joints, movement is detected via mechanoreceptors that detect movement of segments against each other (proprioception). Some proprioceptors (campaniform sensilla) operate by detecting shear stresses in the cuticle Movement through the substrate (air, water) is detected by mechanoreceptors on the outside of body

Sound

Is detected by mechanoreceptors that monitor movement of a structure such as an antenna or a membrane (tympanum)



http://www.sdbonline.org/fly/atlas/00atlas.htm

From Volker Hartenstein's Atlas of Drosophila Development

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Type	Formal name/s	Primary function
Hair-types seen externally	Sensilla chaetica Sensilla trichodea Setae	Touch; air movement; some sound (via air movement); body position (i.e. proprioception); and pressure (in aquatic insects)
Dome-types seen externally	Campaniform sensilla	Shearing stresses in cuticle; body position monitoring (proprioception); pitch, yaw, roll and wingbeat in flight.
Externally invisible but attached to the epidermis of the cuticle	Scolopidia Chordotonal organs	Displacement; pressure; and sound (insect 'ears'): Involved a variety of 'organs' (subgenual organ; Johnston's organ; tympanal organs) that respond to changes in air pressure and therefore sound.
Externally invisible multipolar cells without associated specialized structures	Multipolar stretch receptors	Stretch of internal organs and muscles is involved in monitoring feeding, growth and reproduction. Monitoring of muscle tension is involved in proprioception.

The sensillum (plural: sensilla)

Insects detect touch through cuticular structures called hairs or setae.



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Multi-celled, all derived from a single cell in a specific lineage

The "tubular body" is a cytoskeletal element composed of microtubules and proteins that forms a scaffold







Electrophysiology

Ion channels in membrane around tubular body generate receptor potentials Receptor potentials received at the nerve cell body can generate action potentials at the spike generating zone APs can be phasic or tonic



Interommatidial bristles

Many tactile hairs on eyes Between ommatidia (facets) Feedback during grooming? Detect dust and possible injury?



SEM honeybee Apis mellifera Bronwen Cribb

Tarsus

Many tactile hairs as well as gustatory hairs. Blunt-tipped hairs are gustatory Serrated hairs are touch receptors



SEM tarsus fly Bronwen Cribb



Blunt-tipped hairs are gustatory Sharply pointed hairs are touch receptors Note conservation of a pair of gustatory receptors (green) between fly species despite large difference in size

Wing veins

Lacewing tactile hairs on wing veins Detect airflow over wings?





SEM Bronwen Cribb

Campaniform sensilla

Detect cuticular shear stresses Same groundplan as a tactile sense organ except the hair shaft has been reduced to a dome



Campaniform sensilla

Halteres of Diptera have dense clusters of campaniform sensilla





Cranefly Wikimedia Commons



Sane S P , McHenry M J Integr. Comp. Biol. 2009;49:i8-i23

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Campaniform sensilla (CS) on fly legs

CS are blue Gust green Touch red



Campaniform sensillum placement highly conserved at many taxonomic levels. Important proprioceptors.

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Campaniform sensilla

Around sockets of filiform hairs

Stimulated when filiform hair is "hard over"



Hair plates

At joints

Stimulated when body parts move in relation to one another; e.g. when hairs touch the next segment of the leg or when head is moved



Hair plates

Located at joints

Stimulated when body parts move in relation to one another; e.g. when hairs touch the next segment of the leg or when head is moved



Chordotonal Organs

Also called *scolopidia* The sensillum is obviously related to the external sensilla (olfactory touch and gustatory) but has a different number and arrangement of cells

Main features:

one or two neurons with the dendrite suspended in an extracellular space Completely internalised attaching to cuticle at tip and base

internal proprioceptionsound detectionvibration detection



Chordotonal Organs

Frequently many hundreds or thousands can be clustered together, leading to acute sensitivity

Subgenual organs



Chordotonal Organs

Tympanal Organs

Tympanum is a thin skin of cuticle with attached chordotonal organs



coxa

tympanum (ear)

100×m

tibia

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Multipolar receptors

Also called *multidendritic* neurons Nerve cell body under the cuticle Many sensory dendrites Ramify under epithelium or over internal organs

Main features: In *Drosophila* •internal proprioception

damaging stimuli (heat)



Boulina M et al. Development 2013;140:1605-1613