

Chemical Signaling

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Overview

- Chemical Signaling is the oldest method of communication
- Primary function is the detection of food for most chemical reception organs
- More advanced organisms typically have two types of chemical detection systems: smell and taste (human terms)
- There are three basic ways that chemical signals are transmitted:
 - Current flow
 - Diffusion
 - Direct Contact

Chemical vs Visual and Auditory signals

- Directionality: Unlike sound and light, chemical signals follow an irregular path from high to low concentration (diffusion). Within a current, chemical signals will move in the general direction of the current flow.
- Speed: Much slower than sound and light. Delay times between sender and receiver can last days for odors.
- Temporal pattern: Unlike sound and light, any temporal pattern calculated for chemical signals is rendered inaccurate within a short distance from the source.
- Spectrum: Unlike sound and light, chemical signals cannot be arrayed in one continuous dimension. For example, arranging molecules by molecular weight tells us a lot less than frequency and wavelength does for sound and light.

Forms of Chemical Communication

- Hormones: internal communication between the brain and various organs
- Pheromones: communication between conspecifics
- Allelochemicals: communication between heterospecifics
 - Kairomone: Receiver benefits
 - Allomone: Sender benefits
 - Synomones: Both species benefit
- Semiochemical: inclusive term for all types of chemical communication
- Detection: Olfactory and contact

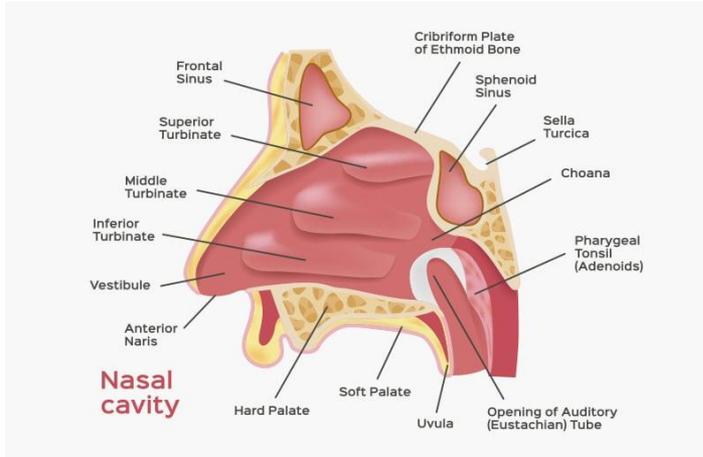
Production Mechanisms

- Secretory glands that manufacture specific products
 - Both endocrine and exocrine glands
 - Exocrine glands can further divided into: Merocrine, Holocrine and Apocrine (see glossary)
- Products released with excreted waste material
- Products derived from plants
- Breakdown products from co-opted microorganisms

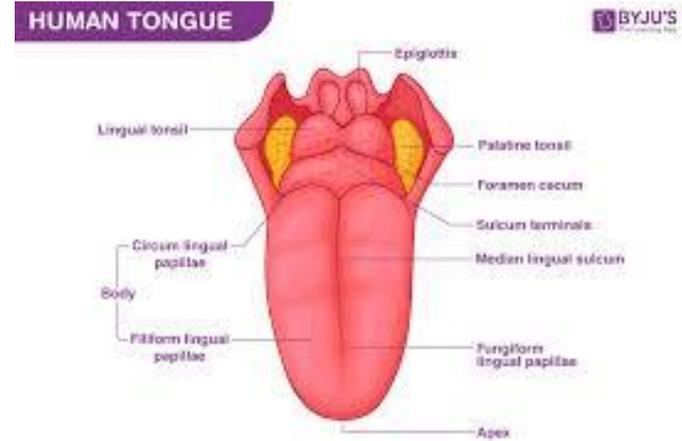
Dissemination Methods

- Where:
 - Direct release into fluid medium
 - Spreading odorants onto sender's own body surface
 - Depositing secretions onto other solid surfaces
- How:
 - Passive exposure
 - Piggybacking onto other activity (for example urination)
 - Specialized release behaviors

Chemoreception



Olfaction (Smell)



Contact (Taste)

Olfaction

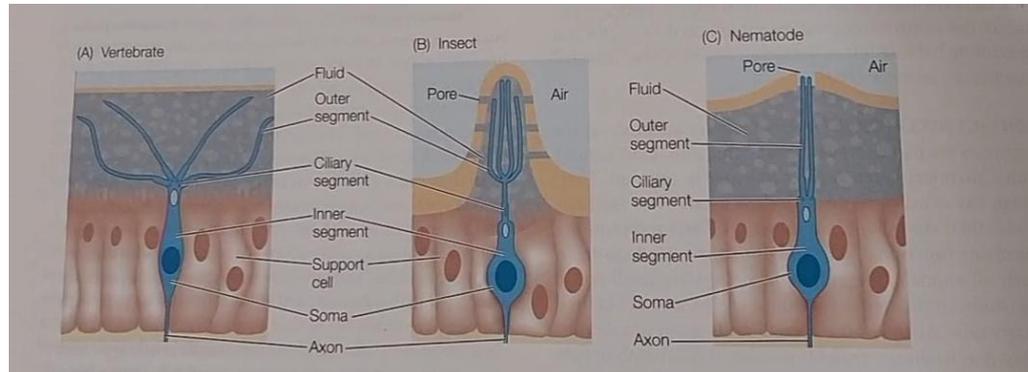
- Olfactory Organs
 - Internal cavities through which medium is drawn
 - Hairlike projections exposed to ambient currents
- Intake Mechanism
 - Terrestrial air-breathing vertebrates: Sniffing
 - Elasmobranch fishes: Gill action
 - Aquatic mammals: Bubble-touching

Contact

- Taste receptors
 - Arrays of small units (i.e. taste buds, bristles, pores) in locations involved in feeding
 - Sensitive to critical components of food
- Conspecific communication
 - Antennation: touching the surface of another individual with antennae (hydrocarbon detection)
- Vomeronasal organ
 - Specialized in detecting non-volatile chemicals

Chemoreception (cellular level)

- All chemosensory cells other than vertebrate taste bud cells are bipolar neurons
- This structure allows the cells to form a sensory epithelium sheet
 - Includes support cells to isolate nerve cells electrically and secrete necessary products
- Receptor proteins consist of seven transmembrane helices with a binding pocket in the center
 - Large number of sensory receptor cell types with each sensitive to different chemical features

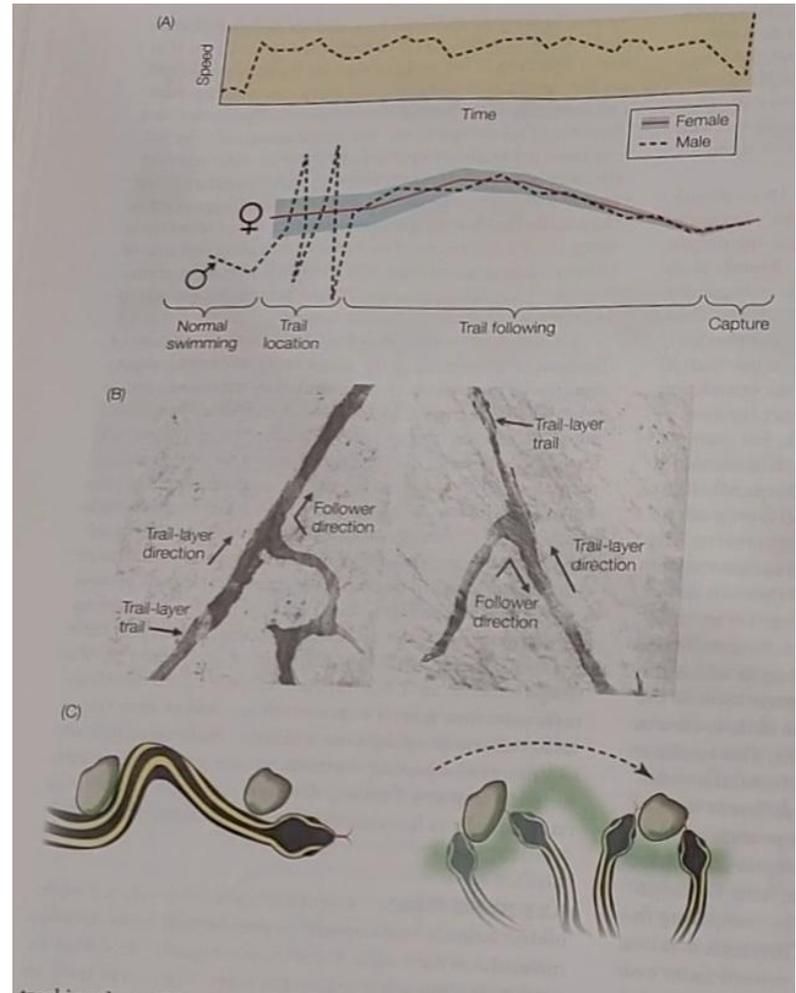


Finding the source

- Animals live in an odor landscape and are under strong selection to move in specific ways in relation to the source of an odor (Function).
- Smooth gradients (diffusion):
 - Kinesis: Biased random walk (altered rate)
 - Taxis: Straight line approach (altered orientation)
 - Tropicaxis: simultaneous sampling
 - Klinotaxis: sequential sampling

Finding the source (cont.)

Chemical trails: usually deposited on substrate but can also be short-term trails in open water or air



Finding the source (fin.)

- Orientation in a turbulent flow field:
 - Anemotaxis: orientation with respect to wind in terrestrial habitats
 - Rheotaxis: orientation with respect to currents in water
 - Direction of current using mechanosensors
 - Eddy rheochemotaxis
 - Visual Landmarks using visual sensors
 - Optomotor anemotaxis

