Pheromones

The chemical word of information

Animals perceive the world and interact with their environment through sense organs. The sense organ collects information from the environment in various forms such as light (eye), sound weave (ears), tactile information or touch (skin or tactile sense organs such as antennae of insects), non-volatile chemicals (tongue and test organs), and volatile chemicals (nose and smell sense organs) etc.

The chemical senses of olfaction and taste are different from vision and hearing. The chemical information relies on the physical transfer of molecules from the signaller to the sense organ/ receptor of the recipient. This is dependent on either diffusion or flow of current and therefore, rarely instantaneous.

Chemical signals are perhaps the oldest and are shared by all organisms including bacteria. Although there is considerable variation in the precise mechanism through which it works, the basic mechanism is the same. They work through a process called signalling where a chemical molecule interacts with chemoreceptor protein in a lock and key manner.

The chemical information is not just limited between organism and environment, it can also be used for interactive exchange between two individuals of different/same species or between two cells within one individual.

The chemicals that are used for interaction or information exchange between two or more individuals are called Semiochemicals.

The chemical information can be classified as follows (see figure below).

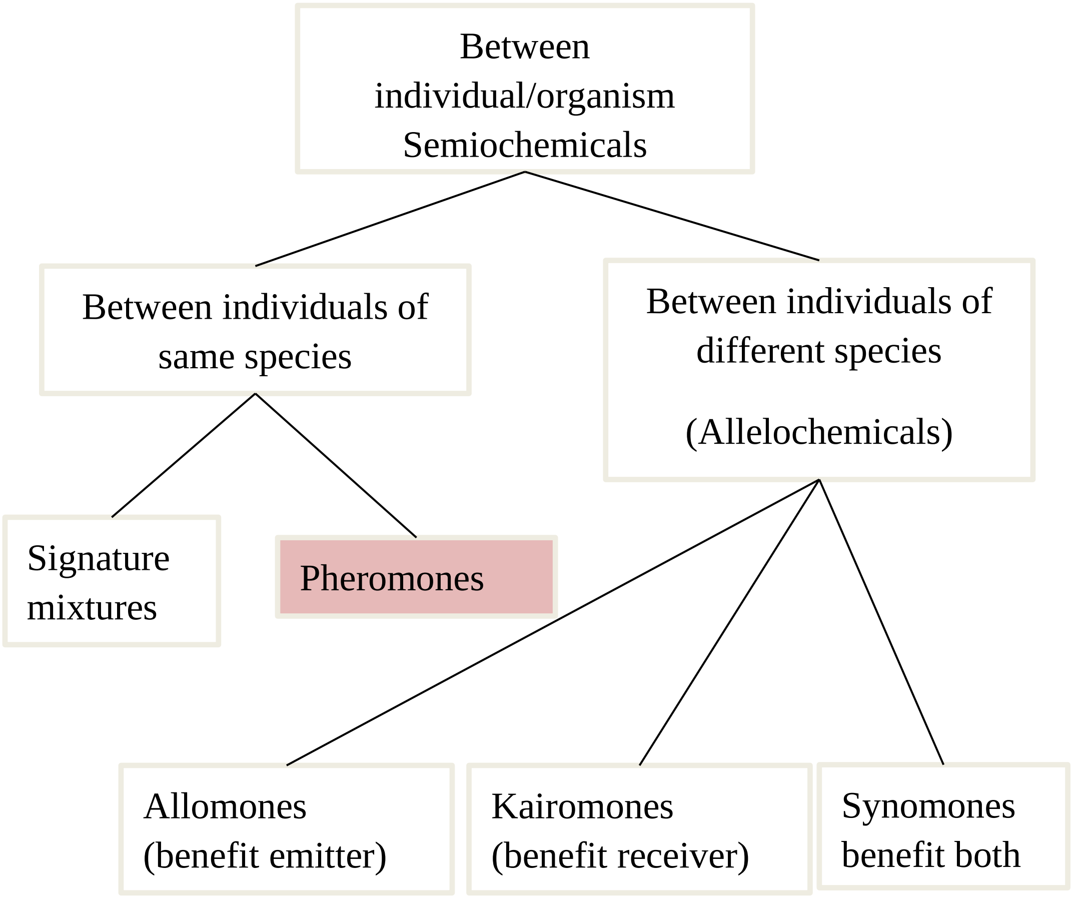


Figure 1:diagrammatic representation of different kinds of chemical signals and their relationship

Semiochemicals: is a chemical substance or mixture released by an organism that affects the behaviours of other individuals. Semiochemical communication can be divided into two broad classes: communication between individuals of the same species (intraspecific) or communication between different species (interspecific)

The chemical information exchange between members of the same species can be classified into two types Signature mixture and Pheromones.

Signature mixture: a variable chemical mixture (a subset of the molecules in an animal's chemical profile) learned by other conspecifics and used to recognize an animal as an individual (e.g., lobsters, mice) or as a member of a particular social group such as a family, clan, or colony (e.g., ants, bees, badgers). (Wyatt, 2010; derived from Johnston's "mosaic signal" sensu 2003, 2005; Hölldobler and Carlin's, 1987 ideas; and Wyatt's, 2005 "signature odor").

Pheromones: These are informational molecules that are secreted outside the body (in minute amount) and work between members of the same species i.e. emitted and received by the different members of the same species. It differs from a signature mixture in that it is capable of inducing a specific reaction in the receiver, such as inducing stereotype behavior or change in the developmental pattern (other than just recognition). Pheromones work similar to hormones but outside the body so it is also called ectohormones.

The first pheromone discovered was "Bombykol" (10,12-hexadecadien-1-ol), the silk moths sex pheromone, by Adolf Butenandt (1959). And the term "Pheromone" (Gr. Pherein = to transport and hormone = to stimulate) was introduced by Peter Karlson and Martin Luscher in the same year.

Pheromones are widespread among insects and vertebrates (unknown in birds) these have also been reported in crustaceans.

The pheromones may be secreted by special glands or they may be incorporated in other substances such as urine or sweet. The chemicals may be shed freely in the environment or maybe deposited in carefully chosen sites.

Apart from animals pheromones have been also reported in fungi, slime molds, and in algae.

Classification of Pheromones

Classification of pheromones on the basis of the nature of the action.

i) Releaser pheromones: the pheromones that elicit the "releaser" reaction fall under this category. A releaser response is an immediate and reversible response operated directly through the central nervous system, e.g. recognition, or through rapidly acting neurohumoral channels, as exemplified by the milk-ejection reflex.

ii) Primer pheromones: The exteroceptive response implicating the anterior pituitary gland. This type is slow to develop, demanding prolonged stimulation which initiates a chain of physiological effects in the recipient.

iii)Pheromones of imprinting: Stimulation at a critical period during development may result in a permanent modification of behavior in the adult.

On the basis of interaction mediated, pheromones are sub-divided into the following categories which are as follows:

i) **Territorial Pheromones**: The territorial pheromones can be classified based on purpose and characteristics interactive evolution of behavior and ecology:

Type A: Large defended area: Courtship, mating, nesting and food gathering

Type B: Large defended area: Used for breeding but not foraging

Type C: Small defended area around nest

Type D: Mating territory for courtship activities only

Type E: Roosting or shelter positions

In dogs, these pheromones are present in the urine, which they deposit on landmarks serving to mark the perimeter of the claimed territory. Boars, cats do possess territorial pheromones.

ii) **Trail Pheromones**: These pheromones are common in social insects. For example, ants mark their paths with these pheromones, which are non-volatile hydrocarbons (Brian et al., 1993). Certain ants lay down an initial trail of pheromones as they return to the nest with food. This trail attracts other ants and serves as a guide. As long as the food source remains, the pheromone trail will be continually renewed. The pheromone must be continually renewed because it evaporates quickly. When the supply begins to dwindle, the trail making ceases

iii) **Alarm Pheromones:** Alarm pheromones serve to rapidly disperse a group of insects usually as a response to predation. These kinds of pheromones are usually of short duration and the dispersed individuals usually reform aggregations. Some individuals release this pheromone to exhibit aggressive behaviour in the presence of predators. Alarm pheromones have been recorded in the mites, treehoppers, aphids and the true bugs etc.

iv) **Aggregation Pheromones:** Aggregation pheromones may or may not be produced by either sex to congregate the species for feeding or reproduction. In India, a few of the researchers have reported the occurrence of the aggregation pheromones. Mondal (1990) revealed that when larvae of rust red flour beetle, Tribolium castaneum were reared on an artificial diet containing 200 ppm, 2-methyl-1,4-benzoquinone and/or 1 ppm of the aggregation pheromone 4,8-dimethyldecanal, there was a significant reduction in adult emergence, and adults exhibited elytral deformities.

v) **Sex Pheromone:** Sex pheromones generally originate from females and attract males for mating. It is the sex pheromone of insects that is of particular interest as a component to be used in IPM in agriculture both field and storage. E.g. butterfly Edith's checkerspot release sex pheromones to attract a mate.

vi) Epideictic (spacing) Pheromones/Oviposition Deterrent Pheromone (ODP) / Mating deterrent pheromones: This pheromone is otherwise called spacing pheromone. There pheromones prevents oviposition of insects in the same place. Oviposition deterrence by various concentration of methanol-eggwash: More the concentration more was the deterrence.

vii) Nasonov Pheromones: The Nasonov gland pheromone of Apis cerana indicawas analysed for the first time and reported to contain neral ((Z)-citral) as the main component (Naik et al., 1988). Nasonov gland pheromone (NGP) having a mixture of components produced in the Nasonov gland of worker honey bees. These worker bees use Nasonov pheromone as an assembly pheromone.

viii) Royal Pheromones: These pheromones are secreted by queen honey bees to control the worker bees.

ix) Calming (appeasement) Pheromones: It is known as a "DogAppeasing Pheromone" (DAP). A bitch exudes a special pheromone when she has pups. Once the pups begin to explore, they can easily become terrified, as everything is so enormous, especially in today's homes, with people and furniture. Wild pups may meet predators and have to get used to wind and weather and their own surroundings, such as enormous trees and bushes. The DAP pheromone calms them, tells them everything is OK, not to worry, Mum's here, and they rush back to the bitch for safety, and are re-assured.

x) Primer pheromone: See earlier section

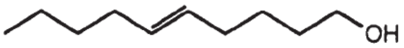
xi) Signal Pheromone: Signal pheromones cause short-term changes, such as the neurotransmitter release that activates a response. For instance, GnRH molecule functions as a neurotransmitter in rats to elicit lordosis behavior.

Chemical nature and structure of Pheromones:

Pheromones are often low molecular weight organic compounds of diverse structural types. Double-bonds and stereogenic centers in pheromone molecules further enrich their diversities by rendering stereoisomerism possible. Some of the major classes of pheromones are –

5.1.1 Acetates, alcohols and aldehydes

(a) Mono-unsaturated

Entry	Compound	Insect
5.1.1		Turnip moth (*Agrotis segetum*) (France)
5.1.2		
5.1.3		Peach twigborer (*Anarsia lineatella*)
5.1.4		
5.1.5		Turnip moth (*Agrotis fucosa*)

(b) Di-unsaturated

(i) Conjugated

5.1.32		Pine caterpillar (*Dendrolimus punctatus*)
5.1.33		
5.1.34		Western tent caterpillar (*Malacosoma californicum*)
5.1.35		Grape berry moth (*Lobesia botrana*)

(ii) Non-conjugated

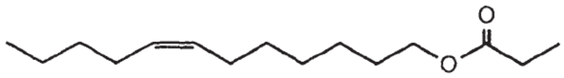
Entry	Compound	Insect
5.1.51		Potato tuberworm (*Phthorimaea operculella*)
5.1.52		Tobacco moth (*Ephestia elutella*)
5.1.53		
5.1.54		Saltmarsh caterpillar (*Estigmene acrea*)

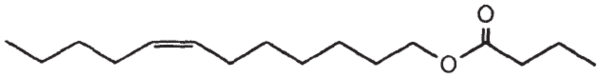
(c) Tri-unsaturated

5.1.66		*Ectomyelois ceratoniae*
5.1.67		Tobacco hornworm (*Manduca sexta*)
5.1.68		*Samia cynthia ricini*
5.1.69		

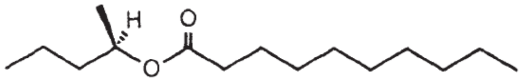
5.1.2 Esters of other acids

Entry | **Compound** | **Insect**

5.1.72 

5.1.73 

Soybean looper (*Pseudoplusia includens*)

5.1.74 

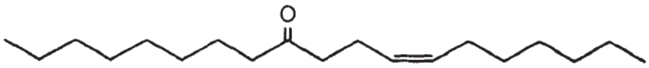
Bagworm moth (*Thyridopterix ephemeraeformis*)

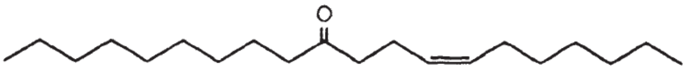
5.1.3 Ketones

5.1.79 

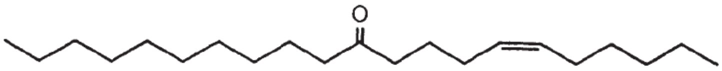
5.1.80 

Yellow-headed fireworm (*Acleris minuta*)

5.1.81 

5.1.82 

Peach fruit moth (*Carposina niponensis*)

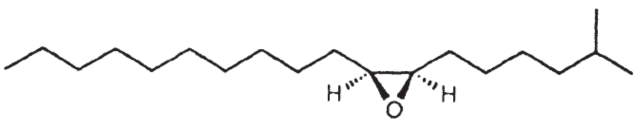
5.1.83 

Douglas-fir tussock moth (*Orgyia pseudotsugata*)

5.1.84 

Peribatodes rhomboidaria

5.1.4 Epoxides

5.1.85 

Gypsy moth (*Lymantria dispar*)

5.1.86 

Xanthotype sospeta

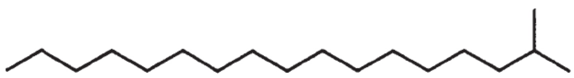
5.1.87 

Abraxis grossulariata

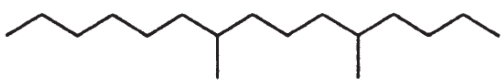
5.1.5 Hydrocarbons

5.1.93 

Whitemarked tussock moth (*Orgyia leucostigma*)

5.1.94 

Tiger moth (*Holomelina lamae*)

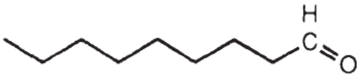
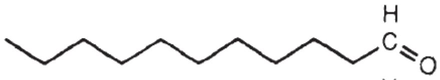
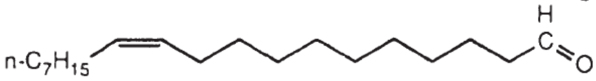
5.1.95 

Perileucoptera coffeala

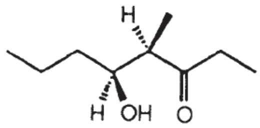
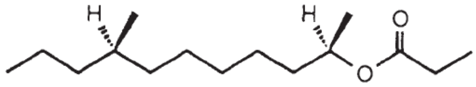
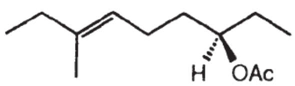
Fig. 5.2 Acyclic pheromones of other Orders and of males of Lepidoptera
(Key: M. = male; F. = Female; aggr. = aggregation)

5.2.1 Straight chains and simple branched-chain compounds

(a) Straight chains

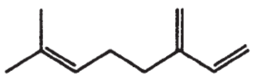
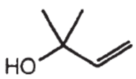
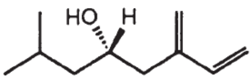
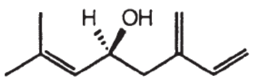
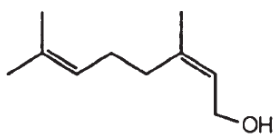
Entry	Compound	Insect (Order) and action
5.2.1		Greater waxmoth (Lepidoptera) *Galleria mellonella:* M. sex
5.2.2		
5.2.3		Lesser waxmoth (Lepidoptera) *Achroia grisella:* M. sex
5.2.4		Trinidad butterfly (Lepidoptera) *Lycorea ceres ceres:* M. sex

(b) Branched chains

5.2.15		Rice weevil (Coleoptera) *Sitophilus oryzae:* F. sex
5.2.16		W. corn rootworm (Coleoptera) *Diabrotica virgifera virgifera:* F. sex
5.2.17		Square necked grain beetle (Coleoptera) *Cathartus quadricollis:* F. sex

5.2.2 Acyclic terpenoids

(a) Monoterpenoids

5.2.28		Western pine beetle (Coleoptera) *Dendroctonus brevicomis:* M. aggr.
5.2.29		
5.2.30		Eight-toothed engraver beetle (Coleoptera) *Ips typographus:* M. aggr.
5.2.31		
5.2.32		African weaver ant (Hymenoptera) *Oecophylla longinoda:* alarm

(b) Sesqui- and diterpenoids

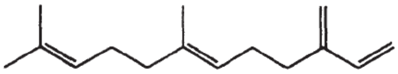
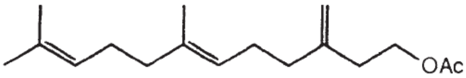
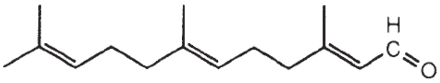
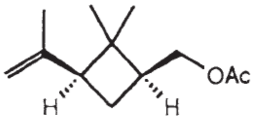
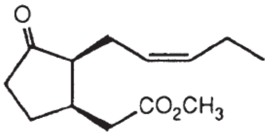
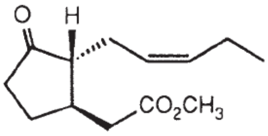
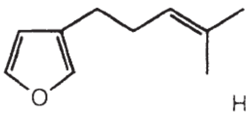
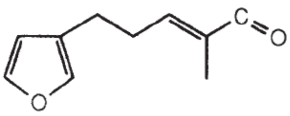
5.2.41		Many aphid species (Hemiptera): alarm *Solenopsis* spp. (Hymenoptera): alarm
5.2.42	 	Western click beetle (Coleoptera) *Agriotes ustulatus:* F. sex
5.2.43	 	Rice moth (Lepidoptera) *Corcyra cephalonica:* M. sex

Fig. 5.3 Cyclic pheromones of other Orders and of males of Lepidoptera
(Key: M. = Male; F. = female; aggr. = aggregation)

5.3.1 Carbocyclic structures

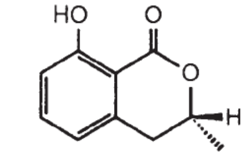
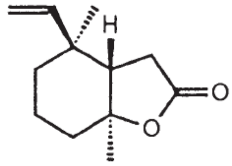
Entry	Compound	Insect (Order) and action
5.3.1	 	Citrus mealybug (Homoptera) *Planococcus citri:* F. sex
5.3.2	 	Oriental fruit moth (Lepidoptera) *Grapholita molesta:* M. sex
5.3.3	 	

5.3.2 Heterocyclic structures: monocyclic ethers and lactones

Entry	Compound	Insect (Order) and action
5.3.21	 	*Tertramoriini anguilinode* (Hymenoptera): trail
5.3.22	 	European pine sawfly (Hymenoptera) *Neodiprion sertifer:* M. aggr.

5.3.3 *Heterocyclic structures: polycyclic compounds and ketals*

(a) Fused rings

Entry	Compound	Insect (Order) and action
5.3.43		Oriental fruit moth (Lepidoptera) *Grapholita molesta:* M. sex
5.3.44		Mexican fruit fly (Diptera) *Anastrepha ludens:* F. sex

(b) Spirocyclic rings

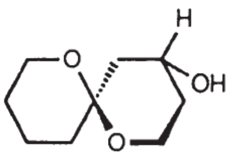
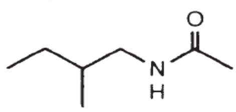
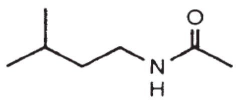
Entry	Compound	Insect (Order) and action
5.3.53		
5.3.54		Olive fruit fly (Diptera) *Dacus oleae:* F. sex
5.3.55		

Fig. 5.4 Cyclic pheromones of other Orders and of males of Lepidoptera (Key: M. = male; F. = female; aggr. = aggregation)

5.4.1 Nitrogen-containing compounds

5.4.1.1 Acyclic and carbocyclic

Entry	Compound	Insect (Order) and action
5.4.1		
5.4.2		Melon fly (Diptera) *Dacus cucurbitae:* M. sex
5.4.3