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Chemo sense

EDITORIAL

## "Think Like an Ant"

By Graham Bell

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A colleague once said "to solve chemical sensing problems, *think like an ant*".

In this issue we welcome a review from one of Australia's foremost insect neuroethologists, Judith Reinhard, on how insects process chemical information, if not how they actually think. Insects are exquisite users of chemical senses. Insects have solved many problems - can we learn from them?

*New Zealand wines* are reaching new levels of excellence, assisted by programs on the sensory quality of their best styles, such as the project starting on understanding aroma and flavour of Sauvignon blanc, described in this issue of *Wine Sense*, by Wendy Parr. New Zealand's investment in sensory research on wine will leave competitor countries "eating their must".

The 7th Annual Scientific Meeting of the Australasian Association for ChemoSensory Science *(AACSS)* takes place at Noosa, Queensland, from 1-3 October 2004 (see http://get-me.to/aacss). The meeting after that will be held from 2-6 December 2005 at Heron Island. Plan your trips now ■

# Insect Chemical Communication

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## INTRODUCTION

**Communication, signalling, and sensory perception among insects** probably invokes in most of us the image of chemical messages and chemical senses that operate through the nervous system. By various accounts, this is accurate: Whether measured by the percentage of insect species that rely on chemical messages, insect behaviours that are modulated by chemical senses, or the complexity of structures responsible for chemical signalling and perception, the chemical communication channel is a predominant feature of insects (Greenfield, 2002). The chemical channel arose quite early in the evolution of life and has been exploited for communication by many organisms from bacteria to humans. In insects it serves a variety of communicative functions, including kin and predator recognition, defence, orientation, recruitment, and mate attraction.

The small to minute body sizes of insects may be largely responsible for their general reliance on chemical senses. Typically, the opportunities for effective communication over long distances along the mechanical and visual channels are limited by the physical dimensions of insects, and their morphological and physiological constraints (Greenfield, 2002). Chemical signalling and perception, however, may not suffer such debilitating effects of scale. Considering insect body sizes and levels of structural complexity, chemical communication can offer several

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advantages over alternative modalities, not least because of its potential for very high specificity. An organism may transmit a variety of chemical signals across considerable ranges and around barriers, regulate their emission, and perceive and discriminate these compounds with a high level of sensitivity. Drawbacks are that chemical signals cannot be sent rapidly and a signaller's control over the direction in which it transmits its messages is quite limited. Additionally, it may be difficult for a receiver to localize the source of a distant chemical signal (Greenfield, 2002). Nonetheless, insects have evolved some amazingly effective mechanisms of chemical communication.

This article reviews major types of chemical communication signals with examples from the insect world. It then briefly describes the sensory mechanisms involved in insect chemoreception and concludes with some of the recent advances and progress made in the field.

## CHEMICAL COMMUNICATION SIGNALS

A broad term for chemicals involved in animal communication is semiochemical, from the Greek *semeion* sign (Law and Regnier, 1971). Semiochemicals are usually divided into two subclasses: *pheromones*, used for communication within the species (intraspecific signals), and *allelochemicals*, used for communication between species (interspecific signals).

*Pheromones* were originally defined as 'substances secreted to the outside by an individual and received by a second individual of the same species in which they release a specific reaction, for instance a definite behaviour [releaser pheromone] or developmental process [*primer pheromone*]' (Karlson and Lüscher, 1959). While releaser pheromones, such as trail or alarm pheromones (see below), have an immediate effect on the behaviour of the receiver, primer pheromones have longer term physiological effects on the receiver, in the original definition by 'stimulating olfactory sensory neurons that send signals to the brain to release the hormones of the endocrine system' (Wilson and Bossert, 1963). Examples of primer pheromones include caste determination in social insects such as termites, ants, bees, and wasps, and locust development rates (Wyatt, 2003). The most famous example of a primer pheromone is the honey bee queen mandibular pheromone (a mixture of two fatty acids: 9-ODA and 9-HDA) which suppresses ovary development in worker bees (Free, 1987).

*Releaser pheromones* are often divided by function. The most commonly known are *sex pheromones*, which are highly species-specific and serve to attract mates for reproduction. The first sex pheromone was identified in 1959 from the silk moth *Bombyx mori* (Butenandt et al., 1959). Many further insect sex pheromones have been identified to date and a number are commercially used in pheromone traps for pest control (Bell, 2004). Another important group are *trail pheromones*, employed by social insects for orientation and to recruit nest mates to a suitable food source. They are produced by a variety of glands and can be composed of numerous different, mostly volatile compounds. When navigating their territory, ants and termites deposit these pheromones on the ground thus developing an extensive net of chemical routes (Hölldobler and Wilson, 1990; Pasteels and Bordereau, 1998; Kaib, 1999). Other social insects use airborne *orientation pheromones*. For example, the honeybee releases a mixture of geraniol, citral, farnesol and other minor compounds from her Nasonov gland into the air in a number of orienting situations, including nest entrance finding, forage marking, and swarming (Free, 1987; Winston, 1987).

*Alarm pheromones* are another type of pheromone most highly developed in social insects. They are often multi-component, usually composed of small and highly volatile compounds, such as mono- and sesquiterpenes or acetates, and many of them also have a defensive function (Winston, 1987; Hölldobler and Wilson, 1990; Schmidt, 1998; Quintana et al., 2003). Depending on species, alarm pheromones can trigger a panic and escape response, or simultaneously alert, attract and evoke aggression. The most famous

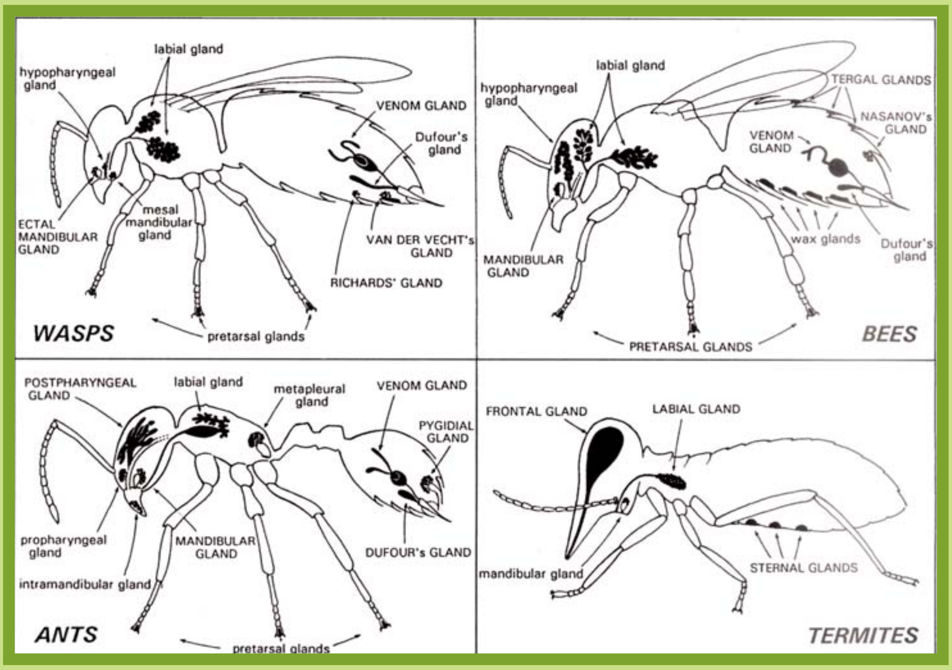


Fig. 1: Schematic profile drawings of the commonly found exocrine glands in wasps, bees, ants, and termites, Glands with a pheromonal function are given capital lettering. Figure reproduced with acknowledgement to Wyatt, 2003; original figure from Billen and Morgan, 1998.

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# Insect Chemical Communication continued

example is the so-called killer bee, where the alarm pheromone from a single bee can within seconds alert the entire hive to attack and kill a potential predator (Winston, 1992). *Kin recognition pheromones*, as used for social recognition in social insects do not fit the original pheromone criterion of a 'defined chemical mixture eliciting particular behaviour or other response'. The cues used for social recognition of kin, clans, colony members and the like are complex, greatly varied mixtures of many compounds, mostly long chain hydrocarbons on the insect cuticle (Vander Meer et al., 1998). The differences between the odour mixtures in quantity and quality of compound composition are the actual message.

The best example for *aggregation pheromones* are bark beetles. The first beetles arriving on a suitable tree start to bore into the bark and release a long-range aggregation pheromone, a mixture of terpenoids some of which are synthesized de novo, others produced by symbiotic bacteria in the beetle gut or sequestered from host tree compounds (Greenfield, 2002; Wyatt, 2003). The pheromone attracts conspecifics of both sexes in great numbers, leading to a mass attack and often killing of the host tree.

*Allelochemicals*, the second subclass of semiochemicals, deal with interspecific communication. They are further divided depending on the costs and benefits to signaller and receiver (Nordlund, 1981). Chemical signals can be eavesdropped ('overheard') by unintended recipients: for example, specialist predatory beetles use the pheromones of their bark beetle prey as *kairomones* to locate them (Wyatt, 2003). Other signals are emitted in order to benefit the signaller at the cost of the receiving species. Chemical signals used in such deceit are termed *allomones*: for example, bolas spiders synthesise particular moth pheromones to lure male moths of those species into range for capture. (Wyatt, 2003). Semiochemicals benefiting both signaller and receiver in mutualisms are termed *synomones*. An example of such mutual but unintended benefit is hydroquinone, a phagostimulant secreted by many different termite species from their labial glands (Reinhard et al., 2002). This chemical signal acts as pheromone when perceived by nest mates (=same species), however could be used as synomone when perceived by a different termite species which happens to share the same foraging territory.

The independent and multiple evolution of semiochemicals is illustrated not only by the diversity of compounds produced but also by the enormous variety of specialised secretory glands (Fig. 1). Importantly, most semiochemicals are multi-component blends, where not only the qualitative composition but also the ratio of compounds is crucial, contributing to the high specificity of chemical communication signals. Specificity can also be gained by using different stereoisomers or enantionmers of the same compound; for example, among sympatric scarab beetles in Japan (Leal, 1999), one uses (S)-japonilure as its female sex pheromone, whereas the other uses (R)-japonilure.

As this brief overview demonstrates, classification of semiochemicals rapidly becomes complicated, not least because the same chemical may be used as a pheromone within a species but may be exploited as kairomone or synomone by another. The

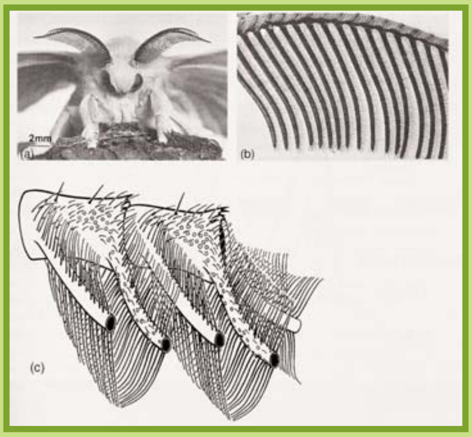


Fig. 2: (a) Male silk moth *(Bombyx mori)* showing the numerous side branches and sensillary hairs of the antennae which form an effective olfactory sieve. (b) Scanning electron micrograph close-up of the antennae. (c) Two segments of a moth antennae drawn in schematic detail. Figure reproduced and modified with acknowledgement to Wyatt, 2003, original figures from Kaissling, 1987, Steinbrecht, 1999, photo/micrographs (a), (b) by R.A. Steinbrecht.

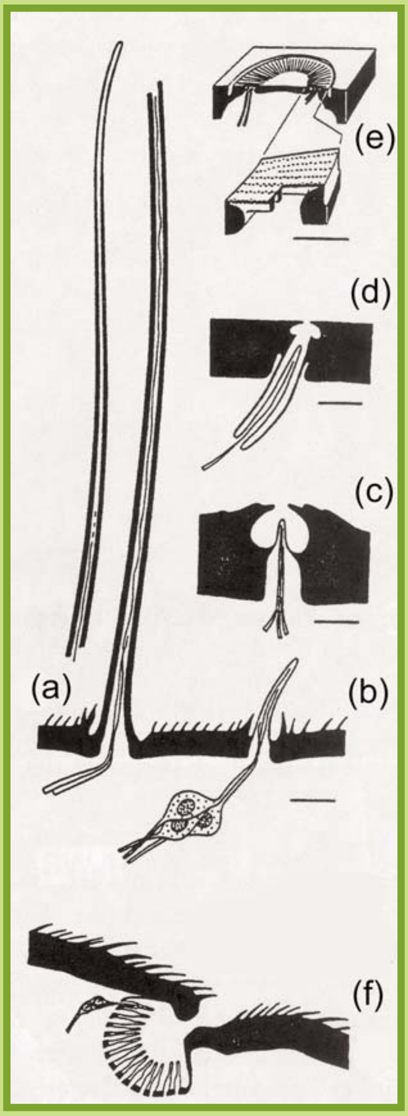


Fig. 3: Schematic outline of the different types of olfactory sensilla. All cells except chemosensory neurons omitted for clarity. (a) Sensilla trichoidea, (b) S. basiconica, (c) S. coeloconica, (d) S. ampullacea, (e) S. placodea, (f) sensilla field on antenna of the fly *Sarcophaga argyrostoma*. Scale in (a) - (d): 10µm, in (e): 1µm. Figure reproduced and modified with acknowledgement to Kaib, 1999; original figure from Kaissling, 1971.

above definitions should therefore be used with caution, always keeping in mind that the insect chemical world is much more complex and intertwined than we might be aware of.

## INSECT CHEMORECEPTION

The insect antennae are the major organs for

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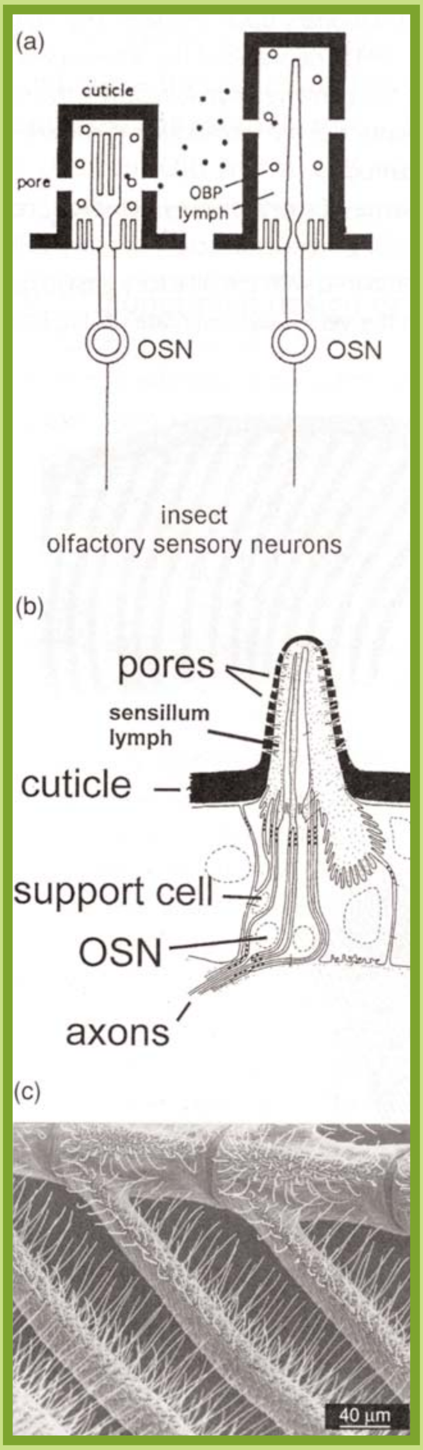


Fig. 4: (a) Schematic diagram and (b) drawing of chemosensory sensilla showing odour molecules diffusing through pores in the cuticle of the sensillum, and carried by odorant binding proteins (OBP) through the sensillum lymph to the olfactory sensory neuron (OSN). (c) Scanning electron micrograph of silk moth antenna, showing long trichoideal sensilla. Figure reproduced and modified with acknowledgement to Wyatt, 2003; original figures from Hildebrand and Shepherd, 1997, Kaissling 1998, Steinbrecht 1999, photo/micrograph by R.A. Steinbrecht.

perception of chemical signals (Fig. 2). They carry chemosensory sensilla in great numbers and of various types (Fig. 3). However, the key sense insects use to detect the chemical cues in their environment is olfaction rather than what we know as taste from vertebrates. Taste in insects refers to contact chemoreceptors, i.e. sensilla that need to come into direct contact with a cue that is non-volatile or of very low volatility. As in the case of an ant tapping its antennae on a fellow ant to detect the complex mixtures of long-chain hydrocarbons on its cuticle that allow distinction of nest mates from strangers. If considering invertebrates it is often difficult to make a clear distinction between olfaction and taste, as some cues can be perceived by both olfactory and gustatory sensilla depending on the physical phase a cue occurs in at a specific moment. Therefore, it may be better to use 'chemoreception' as a more conclusive term for insects covering both olfaction and taste (Wyatt, 2003).

Across the animal kingdom, chemoreceptive systems are remarkably similar. All have chemosensory neurons with one end exposed to the outside world, in case of insects sheathed by a sensillum, the other end extending into the processing centres of the nervous system (Fig. 4). In insects, a chemical signal enters the sensillum lymph through a pore, where it first binds to pheromone- or odorant-binding proteins (BPs: PBPs and OBPs, respectively), the former often highly specific (Wyatt, 2003) (Fig. 4, 5). It is believed that the signal-PBP/OBP-complex is then transported to the chemosensory neuron, where it binds to a specific olfactory receptor protein (OR or R) in the neuron membrane (Fig. 5). In insects, the first of these receptor proteins were only identified in 1999 (Clyne et al., 1999; Vosshall et al., 1999). They all belong to the same 'seven-transmembrane-domain' protein family, however they differ between taxa a great deal (Pilpel and Lancet, 1999).

From a molecular perspective, binding to the OR activates so-called G-proteins, which are also located in the neuron membrane and part of a phosphorylation dependant energy exchange, triggering a cascade of

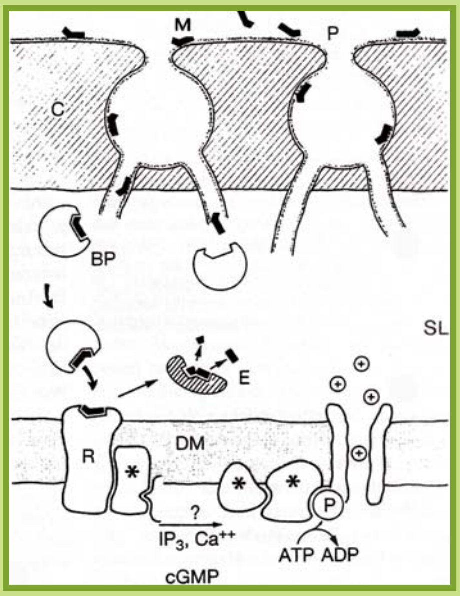


Fig 5: Simplified schematic concept of perireceptor events in insect chemosensory sensilla. Absorbed stimulus molecules (M) diffuse from the hair surface through pores (P) in the cuticle (C) into the sensillum lymph (SL). There, they are taken up by odorant- or pheromone-binding proteins (BP) and are transported through the aqueous lymph until they reach a specific receptor molecule (R) on the outer dendritic membrane (DM). This activates dendritic ion channels via membrane bound proteins (*) and intracellular second messenger cascades. The stimulus molecule is degraded by specific enzymes (E) into inactive metabolites so that it can no longer activate the receptor. Figure reproduced and modified with acknowledgement to Kaib, 1999; original figure from Boeckh, 1995.

signalling reactions (Fig. 5). These eventually lead to electrical impulses being sent down the axon of the neuron to the antennal lobe (AL) (Fig. 6). The AL is structured into a number of neuron groups (glomeruli) that are innervated separately and only in response to specific, individual odours or classes of chemically similar ones (Hansson, 1999). From the AL the processed signal is then sent on to higher integrative centres of the brain, such as the mushroom bodies (MB, Fig. 6), which are believed to be involved in the control of complex behaviours.

As an insect moves through its environment, it is constantly bombarded by a large number of chemicals and it has the ability to detect, discriminate and distinguish innumerable different molecules as different odours. However, not all chemicals are detected and perceived as

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# Insect Chemical Communication continued

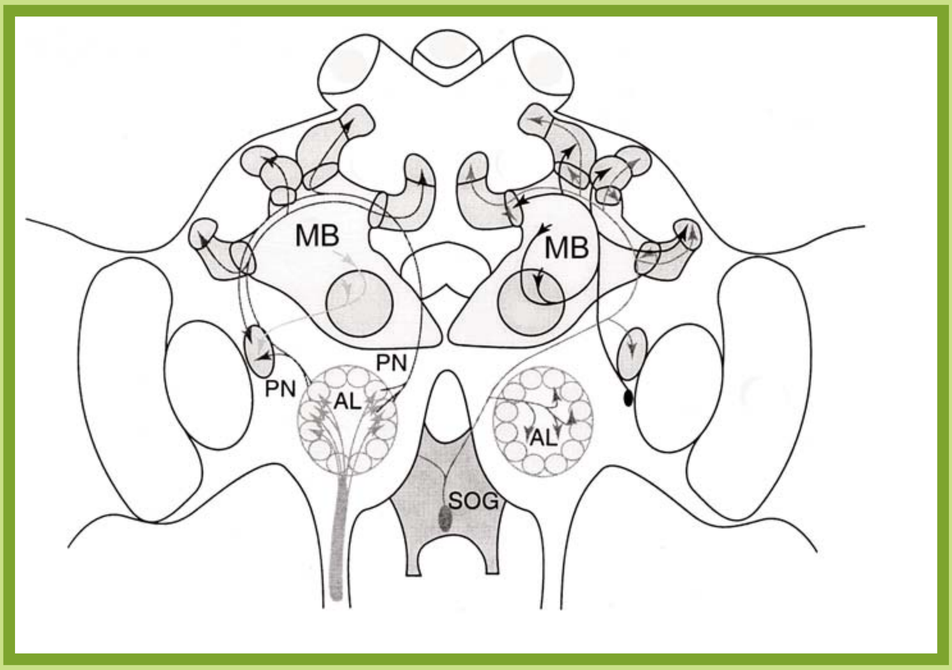


Fig. 6: Schematic view of the central brain area of the honeybee showing the antennal lobes (AL) with their specific glomeruli (small circles). From the AL projection neurons (PN) send olfactory information into the mushroom bodies (MB). The MBs are higher order integration centres of olfactory, visual, and mechanosensory information and are believed to play a role in control of complex behaviours as well as learning and memory. SOG: sub-oesophagial ganglion. Figure modified and reprinted from Trends in Cognitive. Reprinted and modified from Trends in Cognitive Sciences, 5, Menzel, R. and Giurfa, M., Cognitive architecture of a mini-brain: the honeybee, pp. 62-71, Copyright (2001), with permission from Elsevier.

described above. Only the molecules for which evolutionary pressures have led to the development of specific binding proteins and specific receptor sites present on individual chemosensory neurons will be recognised. This selectivity bestowed upon chemosensory neurons by the receptor types expressed represents one level of signal filtering in the insect olfactory system. Further levels of filtering are accomplished after these signals reach the AL glomeruli. It is within the glomeruli that each of the different features of the olfactory signals - their quality, quantity, and temporal and spatial characteristics - are filtered out and represented as specific patterns of neural activity to higher brain centres (Hansson, 1999).

## RECENT ADVANCES

Classical methods for the study of insect chemical communication include behavioural assays using extracts of whole insects, their glands or synthetic compounds to modulate insect behaviour. Chemical signals are characterised and isolated using methods of chemical analysis specific to the signal's molecular characteristics. The most common ones are High Performance Liquid Chromatography (HPLC), Gas Chromatography (GC) coupled with Mass Spectrometry (GC-MS) or an ElectroAntennographic Detector (GC-EAD). The latter uses insect antennae as biological detectors greatly facilitating identification of the active compounds from complex mixtures (Rostelien et al., 2000) (Fig. 7). Biosynthetic pathways of signal production are studied using radioactive labelling of precursors in the insect itself or in potential food sources.

On a neurophysiological level, insect chemoreception has been studied for decades recording activity from whole insect antennae (electroantennograms, EAG) or from single neurons (single cell recordings, SCR). In the last couple of years the development of sophisticated imaging techniques for insects has led to the discovery of the olfactory code, i.e. how different molecules are represented in the higher brain centres (Joerges et al., 1997; Sachse et al., 1999; Galizia and Menzel, 2000). As these studies are carried out in

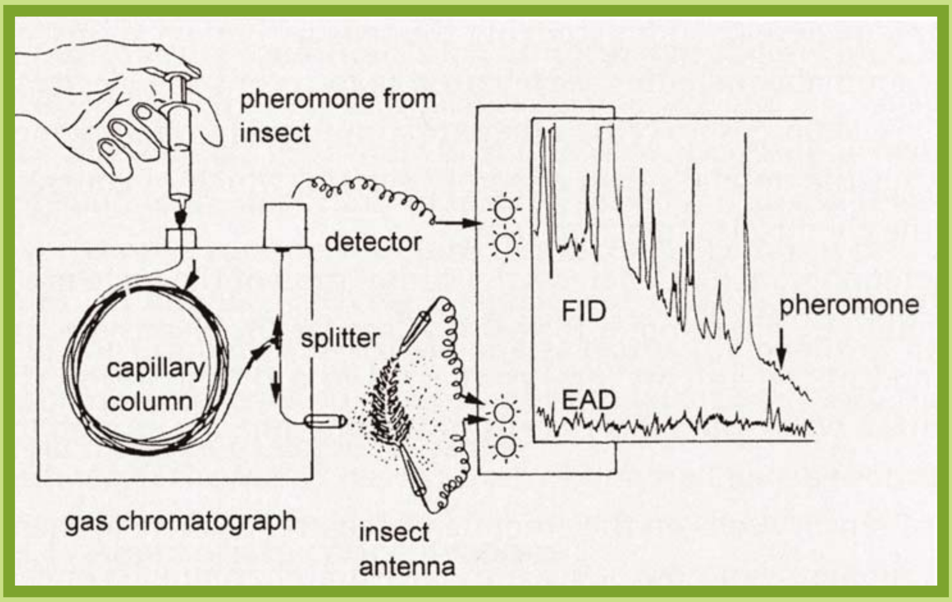


Fig. 7: GC-EAD, a powerful way of identifying possible semiochemical components. The gas chromatograph (GC) separates the mixture of compounds into a series of peaks, which are detected by the FID. Part of the GC output is diverted over the electroantennographic detector (EAD, an insect antenna), which reacts only to certain biologically active components of the mixture. The FID and EAD traces are lined up so that the positive EAD responses can be matched up with the GC peaks. Figure reproduced and modified with acknowledgement to Wyatt, 2003; original figure from Löfstedt, 1986; artist J. van der Pers.

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vivo on an insect brain, they also shed light on synaptic plasticity, that is how the odour representation in the brain changes over time, covering phenomena such as adaptation, habituation and memory formation. Combined with the brand new neuroanatomical method of micro tomography - currently only in use in Switzerland - imaging studies might help us unravel the mystery of learning and memory.

With the completion of the *Drosophila melanogaster* genome project and more recently the sequencing of the mosquito, honeybee, and silk moth genomes, a new era of research in insect chemical communication has begun. Numerous studies on odorant- and pheromone binding proteins have been published and the discovery of the first olfactory receptor proteins in *Drosophila* (Clyne et al, 1999; Vosshall et al, 1999) has led to many new studies on ORs and the chemical signal transduction pathways in insects. The discoveries from molecular genetics are likely to greatly expand our knowledge concerning the role and evolution of these receptor proteins in chemical communication systems. The recent rapid progress in understanding chemoreception will continue as powerful new technologies in genomics, molecular genetics, neuroanatomy and imaging are combined with classical methods from chemistry and animal behaviour. For perhaps the first time, we can now investigate questions of chemical causality at every level: molecular, neurobiological, behavioural, ecological, and evolutionary.

## ACKNOWLEDGEMENTS

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# NEWS

## Should Edible Packaging Taste Terrible?

*By Graham Bell: g.bell@atp,com.au*

**A colleague was unpacking** a consignment of books recently, when I noticed him putting the "styrene worms," that formed the loose packaging material inside the carton, into his mouth. Expecting to see him choke and possibly even die within a short time, and wondering whether the insurance would cover these events, I felt compelled to make urgent inquiries as to the motives for his gustatory behaviour.

"Edible packaging", he replied blithely, and proceeded to munch on.

What looked like the usual styrene packaging was actually an expanded starch-based foam. The colour was lighter and pleasantly translucent. After trying a couple of the tubular structures (about 1 cm diameter by 3 cm long) and not feeling any immediate side effect, I had a couple more. Hmmm! Its taste was somwhere between a witchetty grub and a rice bubble. A little salt, chili and cheese or bacon powder...and yum!

Then the doubts arrived: What if this packaging had been recycled, and from what or where? Had it previously been in contact with things unclean, or been swept up off the floor of a packing shed? Oi! This stuff tastes *too* good!

I am left wondering about the economics and philosophy behind the use of such fundamental edible packaging: Yes, it will degrade once discarded and should make a positive organic contribution to land-fill. But is this worth it? When will we hear about children choking on it? Can diseases or insects travel in this packaging material?

It is also rather sad to reflect that some places in the world can use *food* as packaging, while elsewhere in the world, children are starving.

Perhaps responsible makers of "edible" packaging should make it *inedible*, that is, unpalatable, horrible, disgusting. Edible confectionery packaging may be perfectly safe and an appropriate part of the meal (e.g. an ice cream cone), but packaging around inedible items in a carton is not an appropriate context to start munching.

Can we realistically expect to stop our children (and colleagues) sampling the various kinds of packaging that arrive at home or office, despite the risk?

It should not be too difficult to make "edible" packaging safe to eat but disgusting if tried. Perhaps the chemosensory community can make some suggestions to the manufacturers. It would also need a sufficiently low odour, so as not to taint the goods (such as a books) it was packed around ■

## Heron Island in 2005

**By popular demand**, the 8th annual scientific meeting of the Australasian Association for ChemoSensory Science (AACSS) will take place at Heron Island, Queensland from 2 - 6 December 2005.

Book your accommodation now, through Wendy Burchmore (Wendy.Burchmore@tq.com.au). For program information, suggestions for symposia or helpful suggestions on the program, contact John Prescott (john.prescott@jcu.edu.au). For other conference information and particularly offers of sponsorship, please contact Graham Bell (g.bell@atp.com.au). More information will be published in the forthcoming issues of ChemoSense ■

Heron Island Resort.

# Kyoto Magic

## 14th ISOT and 38th JASTS

There would be few more gorgeous venues on earth than Kyoto and few more happy and stimulating scientific gatherings than ISOT: The International Symposium on Olfaction and Taste, which met conjointly with the 38th meeting of the Japanese Association for Taste and Smell from 5-9 July 2004.

The weather was not entirely sympathetic, being hot and steamy, and left me wishing to return to Kyoto in the cool of spring and the glorious cherry blossoms. However, the main purpose was business and the meeting organisers turned on a fine program at an excellent venue.

### NEW STANDARD SET

A large budget provided in part by several generous sponsors ensured that the conference wanted for nothing. Indeed, it set a new standard in excellence for international scientific meetings. Five gold stars to the organisers! This will be a hard act to follow for future ISOT organisers.

Plenary lectures, given by Gordon Shepherd on the importance of human smell, and by Gary Beauchamp, on individual differences, made a good start to the program consisting of 279 posters and about 220 oral presentations. The latter were arranged into about 36 symposia covering most issues current in the field today. Receptions and the banquet were excellently catered and embellished with wonderful atmosphere and entertainment , giving delegates ample opportunity to talk informally and try the various solid and liquid pleasures of Japan.  Delegates also had an opportunity to attend a formal tea ceremony in a garden tea-house.

Kyoto is the great city of Japanese temples, ancient palaces, gardens and cultural icons, which provided delightful as well as educational spare-time activities. Some of us made a pilgrimage to Hiroshima, which could be visited in half a day by bullet train. The experience, though very sobering, is highly recommended and life-expanding.

### AACSS WELCOMED ON BOARD

Anne Cunningham represented AACSS at the ICOT board and we have been welcomed onto it as an associate member. This means AACSS is acknowledged by the international body, while not having to fulfil the cost and organisational obligations of full member organisations. AACSS will not be running ISOT 2008, but may ask for the privilege of running a future ISOT, at a future meeting.  ISOT 2008 will be hosted by AChemS, somewhere in the USA: the venue and dates have yet to be announced.

### MOLECULAR GASTRONOMY

An ancient temple was the venue for satellite meeting called "Master Class in Molecular Gastronomy" hosted by the Umami Information Center. This unique meeting brought together chemosensory scientists with food technologists and several world-famous chefs including Yoshihiro Murata ("Kikunoi", Kyoto), Yasuhito Sasajima (Italian Restaurant Association of Kyoto) and Heston Blumenthal (The Fat Duck, Berkshire, UK). Scientists included Gary Beauchamp (Monell, USA), and Edmund Rolls (Oxford, UK). This very hybrid event was chaired by Kathy Sykes (U. Bristol UK, science communicator) and proved valuable and enjoyable for all participants, and reminded everyone of the value of sharing our various points of view on the phenomenon and practical applications of umami.

# Useful Chemical Senses Book

Tastes and Aromas: The Chemical Senses in Science and Industry, Edited by Graham Bell and Annesley J. Watson. 214 pages. Published by UNSW Press and Blackwell Science, 1999. ISBN: 0-86840 769 0. Hard Cover. Price: US$30 or AUD$40 (includes tax if applicable, postage and handling). Order from: g.bell@atp.com.au

A limited number of this extremely useful volume are, for a short time only, available at over 50% discount. *Tastes and Aromas* has been hailed as a great teaching aid and resource for the practicing sensory scientist. Written by leaders in their fields as fundamental information, the volume retains its value and is rich in scientific and practical quality. Beautifully packaged in hard cover, it will continue to be a durable reference for many years to come.

Chapters include mini-reviews by (first authors) Stoddart; Bartoshuk; Youngentob; Prescott; Lyon; Weller; Bell; Saito; Lambeth; Noble; Morgan; Best; Barry; Sullivan; Key; Mackay-Sim; Atema; Hibbert; Barnett; and Levy.

Content covers the chemical senses in human culture; fundamentals of smell; taste; pungency; oral touch and pain; applied sensory evaluation; cross-cultural studies; perfumery and flavour chemistry; wine preference; psychophysics; sensory mapping; physiology of odour encoding; anatomy, growth and aging; emerging chemosensory technologies; sensors; marine chemical signals; electronic noses and chemosensory machines.

*Avail yourself of a copy while these limited stocks last.*
Every sale will support *ChemoSense.*
Order from: g.bell@atp.com.au

# NEWS

## Spider uses Smell to Lure Prey

An Australian spider, *Nephila edulis*, knows its poo, so to speak, when it wants a fly to come to dinner. It hangs rotting *plant* material in its web - according to Mark Elgar of Melbourne University. This is the first known case of an arachnid using scented bait. Unlike other scraps that spiders are known to hoard, the plant material is not eaten by Nephila. The smell created is powerful enough to attract that little Aussie battler, the sheep blowfly. (Now why would you want to know *that*? - Editor.) Source: *Nauturwissenschaften*, **91**, p. 245. With acknowledgement to *New Scientist*, 17 July 2004 p.14 ■

## Sensory splashes at AWITC (24-29 July 2004)

The 12th Australian Wine Industry Technical Conference (AWITC) got off to a splendid start in Melbourne in July with a session dedicated to sensory issues in wine. The four speakers included three international guests: David Lyon, Isabelle Lesschaeve and Linda Bartoshuk, plus AWRI's (and an AACSS 2003 prize-winner) Heather Smyth. For a very production-oriented conference, this was a welcome start and the audience responded with great interest. Several posters featured sensory issues and, with the opening session, represented the gradual and welcome uptake of sensory science into this economically important industry.

The conference was well supported by suppliers of machinery, materials and packaging, as well as publishing interests. It was a pleasure to attend such a well-oiled meeting ■

# WineSense: New developments in Sensory Research: Understanding Aroma and Flavour of New Zealand Sauvignon blanc

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Marlborough Wine Research Centre, Blenheim, N.Z. and Lincoln University, Canterbury, N.Z.

**The largest and most ambitious** research project ever launched in New Zealand's wine industry has recently received a boost in the form of close to $9.6 million dollars in funding from the Foundation for Research, Science, and Technology (FoRST) over the next six years. The project's overall aim is to provide an understanding of the key volatile compounds responsible for aroma and flavour of Sauvignon blanc wines.

International interest in New Zealand as a wine-producing country was ignited in the 1980s as a direct result of the success of New Zealand's Sauvignon blanc wine styles. Sauvignon blanc now accounts for more than half of New Zealand's wine exports. It is interesting to note that just as the FoRST-funded research project is budding, the New Zealand wine industry is celebrating its 30th anniversary of Sauvignon blanc wine production. Ross and Bill Spence, founders of Matua Valley, are credited with introducing Sauvignon blanc to New Zealand in 1974. Ironically, given the iconic status that New Zealand's Sauvignon blanc wines enjoy today, the 1974 Matua Valley vintage apparently proved hard to sell.

## Who is involved in the research project?

The Sauvignon blanc aroma and flavour project brings together researchers and industry professionals in a project that emphasises collaboration. The project was developed by a consortium led by Auckland University, with the Marlborough Wine Research Centre and HortResearch as major subcontractors. Lincoln University in Canterbury is also closely involved as a subcontractor to the Marlborough Wine Research Centre.

## Why Sauvignon blanc?

New Zealand's Sauvignon blanc grapes produce a highly distinctive wine style with intense flavours and beautifully-balanced acidity. Sauvignon blanc has been chosen as the wine varietal to undergo intense chemosensory analysis for two reasons. The first relates to economics, where the international status of the varietal makes it commercially important for New Zealand. The second reason is that research to date suggests that the aroma and flavour of Sauvignon blanc is dominated by a relatively small number of volatile compounds (Allen et al., 1988; Murat et al., 2001). Manipulation of aroma and flavour in this varietal, to produce novel wine styles, therefore appears relatively feasible.

## What's going to happen and where?

There are several key components to the research project. Aspects relevant to the sensory component of the project include the following:

- Auckland University scientists will focus on yeast genetics and chemical analyses of wines. In determining the chemical aroma profile of Sauvignon blanc, researchers will be developing improved methods for chemical analyses of grape juice, musts and wines. Yeast technology and analytical chemistry methods will be used to identify, quantify, and manipulate aroma compound precursors in Sauvignon blanc juice, must and wine to produce novel wine styles.
- Marlborough Wine Research Centre (MWRC) and HortResearch scientists in Marlborough will establish the relationship between concentration of volatile aroma compounds and (i) key geographic factors and (ii) key viticultural factors (e.g., berry size, light, water deficits, fruit maturity, and vine nutrition).
- Lincoln University scientists will characterise environmental effects such as UV-B radiation on Sauvignon blanc aroma precursor synthesis.
- Sensory scientists at HortResearch in Auckland will investigate sensory profiles of Sauvignon blanc wine styles with the aim of developing consumer preference maps to relate consumer behaviour to wine styles. As well, a lexicon will be created for use by winemakers, and key impact flavour compounds will be assessed by sensory means and related to wine chemical composition.
- A new sensory science laboratory at MWRC will allow sensory scientists to take advantage of the physical proximity of Marlborough's world-renowned vineyards and

*cont. pg 13*

# WineSense continued

winemaking expertise. Work investigating the concept of "Marlborough Sauvignon blanc" as a brand (Parr et al., 2004) will be extended to consider a wider range of New Zealand Sauvignon blanc wine styles as a function of geographical region, sub-region, and vintage. Innovative methodologies, soundly based in psychophysics and cognitive psychology, will be employed to investigate the relation between chemical composition and perceived quantitative and qualitative changes in wine aroma and flavour.

### Why study aroma and flavour of Sauvignon blanc?

A sound knowledge base concerning New Zealand Sauvignon blanc is expected to assist the wine industry in several ways. One expected outcome from the research is the enabling of grape-growers so that they will be able to use environmental data and vineyard management practices to influence the aroma precursor profile of grape juice. A specific goal within the project includes development of a simple-to-use chemical test kit to identify and quantify the odourless precursors responsible for the major aromatic components of Sauvignon blanc wines. Knowledge of the precursor profile should allow prediction of the flavour and aroma profile of the finished Sauvignon blanc wine.

The overall goal of the project, namely manipulation of the precursor profile in Sauvignon blanc juice by vineyard practice and in wine by oenological management, should lead to improved understanding of how particular variables influence expression of the precursors in must and wine. This in turn will permit development of new styles of Sauvignon blanc wine within the overall concept or brand known as 'New Zealand Sauvignon blanc'.


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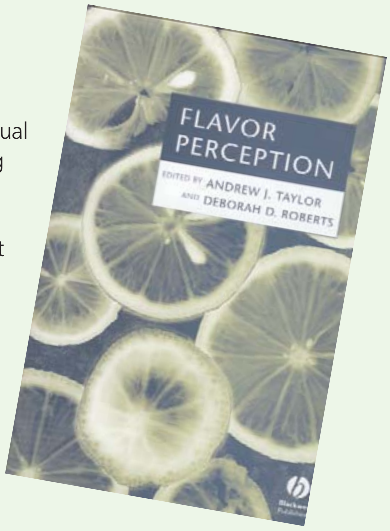
Parr, W.V., Frost, A., White, K.G., & Marfell, J. (2004). Sensory evaluation of wine: Deconstructing the concept of 'Marlborough Sauvignon blanc'. The Australian & New Zealand Grapegrower & Winemaker: 32nd Annual Technical Issue 485a, 63-69.

# Flavour as Multimodal Perception

## A New Book and Building Block for Discovery

*Book Review, by Graham Bell.*



Taylor, Andrew J. and Roberts, Deborah D. (Eds.) Flavor Perception, Oxford: Blackwell Publishing, 2004, 283 pp, Hardcover, AUD$99.50.

> Think, for instance, of the flavour of a ripe peach. The etherial odour may be ruled out by holding the nose. The taste components - sweet, bitter, sour - may be identified by special direction of attention on them. The touch components - the softness and stringiness of the pulp, the puckery feeling of the sour - may be singled out in the same way. Nevertheless, all these factors blend together so intimately that it is hard to give up one's belief in a peculiar and unanalysable peach flavour.
>
> E. B. Titchener, 1909.

This is an exciting collection of papers on flavour perception, bringing bright new light onto an old subject.

The topic of flavour requires a synthesis of points of view, which is admirably achieved in this valuable volume. As flavour involves the inputs of several sensory systems or "modalities", it can be argued that it is the most multi-modal of all human experiences. The editors acknowledge that flavour is a perception *which does not exist without the contribution of at least two independent sensory modalities*. This concept is not new, but seldom has flavour perception been given such a clear voice, by many authors from different disciplines, and in a virtual chorus. The reader is guided to appreciate both progress in research on flavour, and the empty places in our knowledge: gaps which will surely now begin to close.

By concentrating on perception, the work brings chemosensory information to a focus on the *human experience* of flavour. As Titchener realised in 1909, the flavour of a peach emerges from its component sensations as an exclusive ("peculiar, unanalysable") experience.

But the book shows that with the new tools available nearly a century after Titchener, the topic is most certainly wide open to analysis.

The reviewer found himself thinking about visual depth perception and the wealth of psychological and physiological research on it across throughout the twentieth century. The powerful human experience of depth perception requires the overlapping but displaced retinal fields caused by the spatial separation of two eyes and the neural fusion or compounding of the two images into a rich three-dimensional visual experience, achieved in the visual cortex. The result is something profoundly different from the visual experience produced by each eye separately. The effect is enhanced by many so-called cues, such as perspective, masking, aerial effects, and texture gradients. So too with flavour, the experience provided by the nearly simultaneous inputs of smell and taste create a rich illusion of a flavour happening in the mouth.

Is there any comparable synthesis when either smell or taste is not present? Do the various combinations of oral senses including texture, temperature, and chemical irritation similarly compound themselves into an exclusive experience, or are these the additional cues analogous to the ancillary visual cues to depth perception?

The chemosensory literature contains many reports of multi- or cross-modal interaction, such as the influence of colour on taste perception. Such experiments, however, do not address the "compounded" experience of flavour, though they have revealed important phenomena of enhancement and suppression and have revealed sub-threshold effects. In their opening chapter, Taylor and Hort make a case for approaching flavour perception with methodology and notation that extends traditional psychophysics into multi-dimensional models that define the flavour experience.

Other chapters take the reader into the modality favoured by each author, and describe their contributions to flavour. For instance, Prinz and de Wijk explain the processes of flavour release in the mouth as food is broken up in the presence of saliva. We are reminded that how we eat determines what we perceive. This chapter carries an important message for food developers.

Chapters on cellular mechanisms by Rawson and Li (Ch 3) and Pernollet and Briand (Ch 4) occupy 93, or over one third, of the text pages and come dangerously close to swamping the book with detail on ultrastructural anatomy and molecular biology, while leaving the theme of sensory perception of flavour for other

cont. pg 14

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# Flavour as Multimodal Perception continued

authors.

What remains to be shown is how such molecular and neurobiological processes could bring about the unified phenomenon of flavour perception.

Chapter 4 covers a large swathe of neural and psychophysical literature across the sensory modalities. At its conclusion it touches on the subject of changes in perception of flavour with aging, one which has growing importance to individuals, therapists, gerontologists and providers of food for an aging population. It is important to remember that important insight into the nature of flavour perception may come from measuring the effects of chemosensory components that fail or diminish with age.

The important topic of the contribution to flavour by the trigeminal sense, or oral chemesthesis, is covered succinctly in Ch 5 by Green. In Ch 6, Blake introduces the subject of learning, which as the literature shows, makes its presence felt in the higher brain regions in which flavour perception is synthesised. This chapter also introduces liking or hedonics, by which, with learning and gene expression, flavour becomes more or less palatable.

Functional MRI brain imaging is explained by Weismann et al., in Ch 7. Literature on olfaction and f-MRI is still in its formative stage and allowed a comprehensive summary. This chapter primes the reader to understand forthcoming studies that use this important investigative tool. The challenge for future f-MRI studies will be to link brain images to flavour experience and hence clarify the nature of flavour in terms of brain and behavioural processes. The state of this f-MRI physiological art is in its infancy - we expect more and better things.

Human psychophysics and various avenues of research are described in the final, and possibly most important chapters, by Keast et al., and Prescott. There are now adequate methods to study flavour perception and the cognitive processes attendant upon it, however, the need to understand flavour as an integration of multimodal inputs is only now being realised. This book's editors and contributors can take much credit for finally consolidating multiple disciplines and clarifying this important issue: that flavour perception is a multimodal perceptual phenomenon, available for and deserving study.

This book can be regarded as a cornerstone in the scientific explanation of flavour perception. We can expect more work, and books, on this topic, as workers across the disciplines, and particularly the human behavioural fields, realise the untapped potential of the science that can be directed to it. We are left with no doubt that the phenomenon of flavour perception is open to analysis. It may be "peculiar" but it is not "unanalysable".

The book makes a major contribution to both the literature and conceptual development of chemosensory science and will be appreciated widely by researchers and scholars in science and industry ■

# Upcoming Events

| | |
|---|---|
| 1-3 October 2004 | Australasian Association for ChemoSensory Science (AACSS) 7th Annual Meeting<br>Noosa, Queensland, Australia<br>http://get-me.to/aacss |
| 23-27 October 2004 | Society for Neuroscience<br>San Diego USA<br>http://apu.snf.org |
| 6-8 November 2004 | Obesity 2004<br>Grand Hyatt, Melbourne<br>Info: www.obesity2004.com.au |
| 25-29 November 2004 | Wine Australia<br>Darling Harbour, Sydney<br>Info: www.wineaustralia2004.com.au |
| 8-11 March 2005 | Foodex, Japan<br>(30th Anniversary)<br>Tokyo<br>Info: www.jma.or.jp/FOODEX |

*cont. pg 16*



# Upcoming Events

| | |
|---|---|
| 13-15 April 2005 | **International Symposium on Electronic Noses (ISOEN)**<br>Barcelona, Spain<br>Info: www.isoen2005.org |
| April 2005 | **AChemS**<br>Sarasota, Florida, USA<br>Info: www.achems.org |
| 21-24 June 2005 | **11th Weurman Flavour Research Symposium**<br>Comwell Roskilde, Denmark<br>Info: weurman2005@staff.kvl.dk<br>www.weurman2005.kvl.dk |
| 10-13 July 2005 | **38th Annual AIFST Convention and FoodPro 2005**<br>Sydney Convention & Exhibition Centre<br>Info: www.aifst.asn.au |
| 7-11 August 2005 | **Pangborn Sensory Science Symposium**<br>Harrogate, North Yorkshire, UK.<br>Abstract Deadline 31 January 2005<br>Info: www.pangborn2005.com |
| 2-6 December 2005 | **AACSS on Heron Island** (Australian Great Barrier Reef)<br>**Australasian Association for ChemoSensory Science**<br>8th Annual Meeting<br>Accommodation: Wendy.Burchmore@tq.com.au<br>Conference info: g.bell@atp.com.au<br>Program info: john.prescott@jcu.edu.au |

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