Vol. 8 No.3 July 2006

Chemo sense

EDITORIAL

Come FLY with me...

By Graham Bell
g.bell@atp.com.au

If humans and flies have noses, it should come as no surprise that we will sooner or later learn something from the fly that will have importance to knowledge of the human chemical senses. The latest "buzz" is now coming from the geneticist's old friend *Drosophila melanogaster*, which is proving to be an exciting model on which to study olfaction. The fruit fly lends itself to creating mutated and transgenic expression of olfactory receptors in different or previously "empty" olfactory neurons. This provides science with a new tool for studying receptors, identifying ligands for them and their signal transduction mechanisms. The isolation of functional receptors for ligands of interest remains an important goal with wide-reaching applications. This issue carries a review by representatives of two Australasian groups who are collaborating on using *D. melanogaster* to meet these aims.

Scientists flying to Melbourne next July (12-17) to attend the (IBRO) International Brain Research Organization's meeting, and who have an interest in flying noses, should

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Smelling the difference - it's all in the combination! What the fly can tell us about the sense of olfaction.

Andrew V. Kralicek[1], Coral G. Warr[2] and Richard D. Newcomb[1].

[1]The Horticulture and Food Research Institute of New Zealand, Auckland, New Zealand.

[2]The School of Biological Sciences, Monash University, Victoria, Australia.

akralicek@hortresearch.co.nz

In animals olfaction is mediated by the interaction of volatile ligands with a set of specialized membrane proteins known as olfactory receptors (ORs). The genomics revolution has facilitated the discovery of large gene families of these ORs. In mammals such as mice and dogs there are upward of 1000 OR genes (Zozulya *et al.*, 2001; Olender *et al.*, 2004) while zebrafish have 143 OR genes (Alioto and Ngai, 2005). The genetic model insect, the fly *Drosophila melanogaster,* has far fewer OR genes, with only 60 genes encoding 62 receptors (Robertson *et al.*, 2003). Given this small number of ORs, *Drosophila* still has a keen sense of smell and is proving to be a powerful model system to study how these receptors function, as it is very amenable to genetic manipulation and is easy to study using molecular, electrophysiological and behavioural techniques.

The *Drosophila* equivalents of the human nose are its third antennal segment and maxillary palps. Extending from the surface of these structures are specialised hairs known as olfactory sensilla. These hairs contain olfactory receptor neurons (ORNs) which have ORs expressed within their dendritic membranes

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EDITORIAL CONTINUED

Come FLY with me... continued

Fruit fly Drosophila melanogaster
courtesy of: static.flickr.com

consider attending a satellite meeting at Heron Island on avian brain and behaviour (modeled on the successful AACSS meetings there) from 19-23 July 2007. It will include a session on Avian Olfaction. See this issue for details.

Flying in the face of the receptor approach to explaining sensory events, comes a useful contribution to literature on higher processes of olfactory perception from Wilson and Stevenson, in a book entitled *Learning to Smell*, reviewed herein■

Smelling the difference - it's all in the combination! continued

What the fly can tell us about the sense of olfaction.

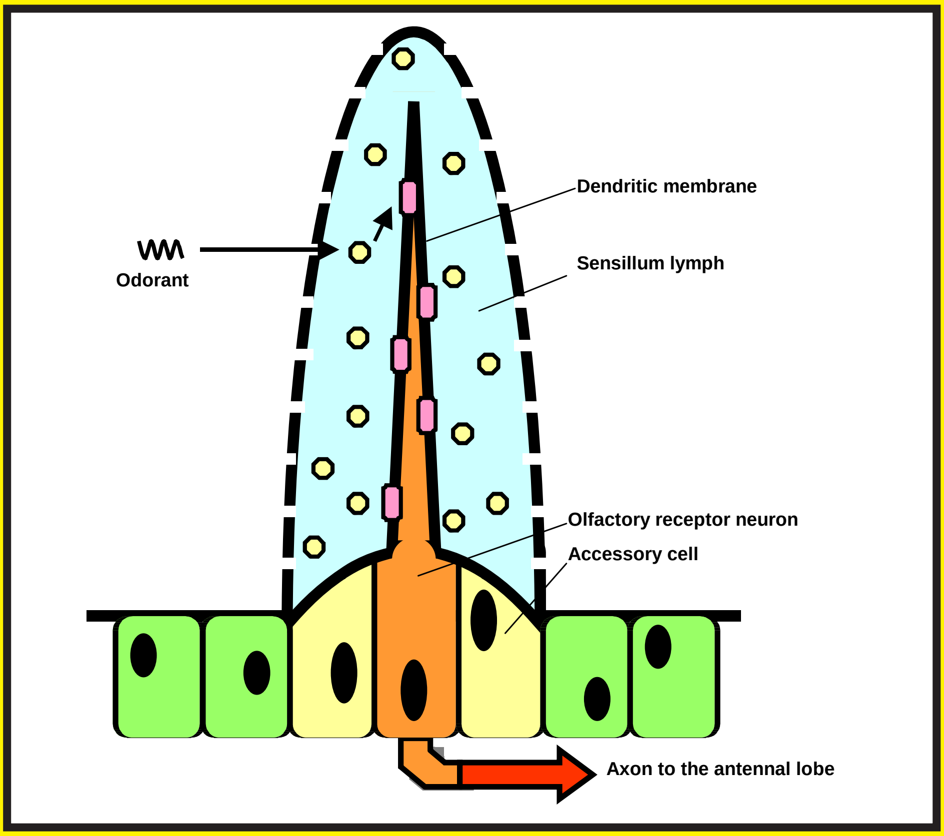

Figure 1: Overview of the *Drosophila* olfactory sensillum. Odorant binding proteins (OBPs) are shown in yellow, and are produced from accessory cells. OBPs bind odorants that enter through pores in the sensillum, ferrying them to olfactory receptors (ORs) which are shown in pink. The ORs become activated, causing depolarisation of the olfactory receptor neuron (ORN) shown in orange, and a signal is sent to the antennal lobe.

(Figure 1). It is thought that odorants enter the lymph of an olfactory sensillum through cuticular pores. Abundant in the sensillum lymph are soluble odorant binding proteins (OBPs). Insects have large families of OBPs, and they have been proposed to have a role in transporting odorant molecules to the dendritic membrane of the associated ORN, where they interact with membrane bound ORs. Binding of the odorant to the OR activates a signalling cascade within the ORN, resulting in neuron depolarisation and the sending of a signal to the antennal lobe and onto the brain (For reviews see - Hallem and Carlson, 2004; Rutzler and Zwiebel, 2005, de Bruyne and Warr, 2006).

Odorant specificity is encoded by ORs

Groundbreaking studies in *Drosophila* have resulted in an *in vivo* experimental system that can be used to functionally characterise ORs. This system exploits a mutant strain of *Drosophila* lacking one endogenous OR. In this strain the corresponding ORN no longer responds to odours. Specific ORs can be expressed in this "empty neuron" and their odorant response profiles determined by placing an electrode into a sensillum containing the "empty neuron" and then measuring the electrophysiological response of the neuron when different odorants are "puffed" over the antennae (Dobritsa *et al.*, 2003; Hallem *et al.*, 2004).

This elegant approach has enabled the measurement of the response of 24 *D. melanogaster* ORs to a diverse range of over 100 odorants including amines, lactones, acids, sulphur compounds, terpenes, aldehydes, ketones, aromatics, alcohols, and esters (Hallem and Carlson, 2006). Almost all of the odorants caused a response from at least one OR and many ORs responded to the same odorants. Also

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most receptors showed both excitatory and inhibitory responses, i.e., compounds can elicit an increase or decrease in the spontaneous firing rate of the neuron. Furthermore, a form of intensity coding was observed as larger concentrations of the same odorant resulted in responses from a greater number of receptors. Each OR was found to have its own unique odorant response profile and range from being broadly to narrowly tuned.

We have recently developed a heterologous cell assay system based on insect Sf9 cells for the determination of OR response profiles (Kiely *et al.* 2006). An OR can be recombinantly expressed in this system and activated by odorants dissolved in water. The response pattern of the OR is detected by measuring changes in intracellular calcium levels caused by OR activation. Our studies demonstrate that an OR produces a similar response pattern to that observed from electrophysiological recordings (Fig. 2), and that ORs are highly sensitive. For example the *Drosophila* ester receptor OR22a can detect ethyl butyrate with an EC_{50} value of 1.58 ± 0.815 x 10^{-11} M (Fig. 3). This response does not require the addition of exogenous factors such as OBPs, suggesting that the receptor-odorant interaction is the sole determinant of an OR's response profile. This conclusion is supported by the "empty neuron" studies which show that the odorant response profile, spontaneous firing rate, response dynamics and signalling mode of an ORN are all dependent on the particular OR that is expressed within it (Hallem *et al.*, 2004).

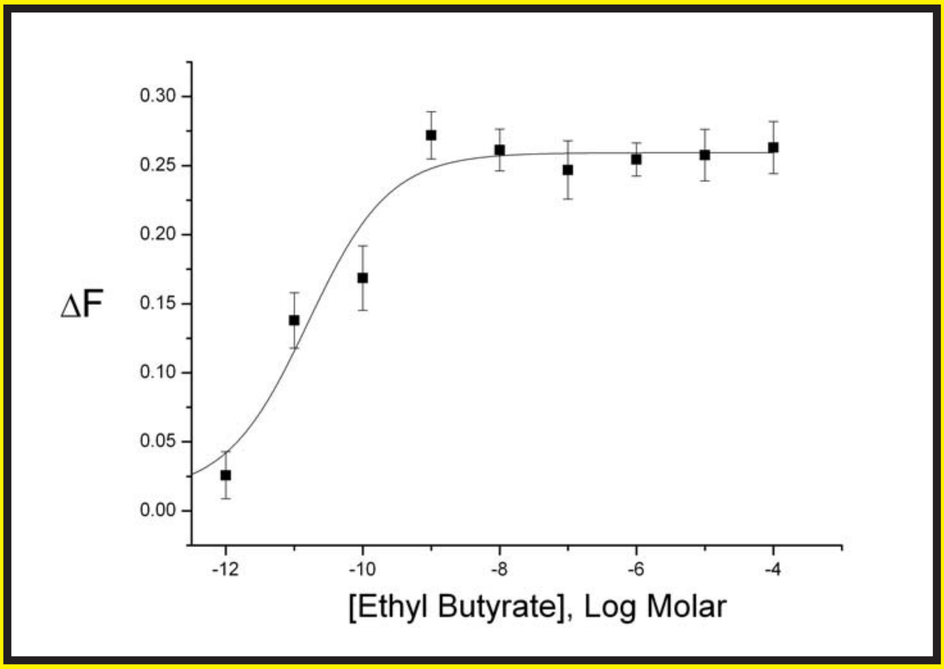

Figure 3: Dose response curve exhibited by Sf9 cells expressing *Drosophila melanogaster* receptor Or22a for the ligand ethyl butyrate.

A combinatorial approach is the key to odour detection

Insects use ORs to detect a wide range of volatile compounds, helping them to locate food sources, mates (using sex pheromones), oviposition sites and predators. How can such a limited number of receptors, 62 in the case of *D. melanogaster*, enable an insect to distinguish between the thousands of volatile compounds and blends it is likely to encounter in its olfactory environment? The key is the inherent functional characteristics of each OR, which include their unique odorant response profiles, functional overlap, odorant specific activation or inhibition, and different responses to odorant intensity. Together these features dramatically expand the complexity of the odor code that can be employed. *Drosophila* ORNs therefore recognise a combinatorial odour code resulting from the interpretation of the global response of their full OR repertoire. Thus a particular odorant will cause different ORs to be excited, inhibited or unaffected, leading to differential firing

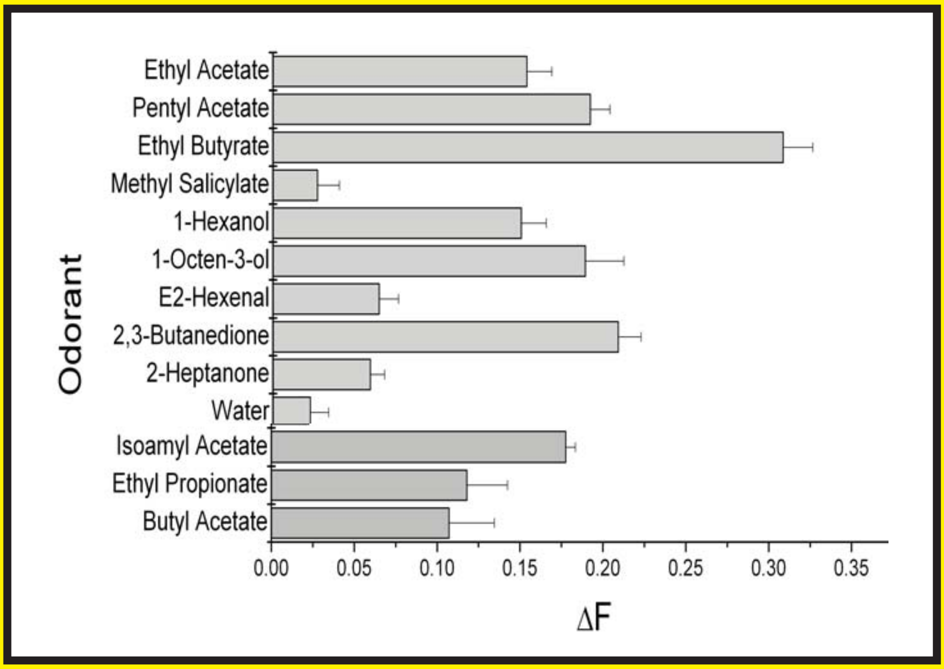

Figure 2: Odorant response profile of the *Drosophila melanogaster* receptor Or22a expressed in insect Sf9 cells to a range of odorants. ΔF is the ratio of the change in cell fluorescence upon addition of the odorant, to the maximal change in cell fluorescence which occurs with addition of the ionophore, ionomycin. For experimental details see Kiely *et al.* (2006).

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What the fly can tell us about the sense of olfaction. continued

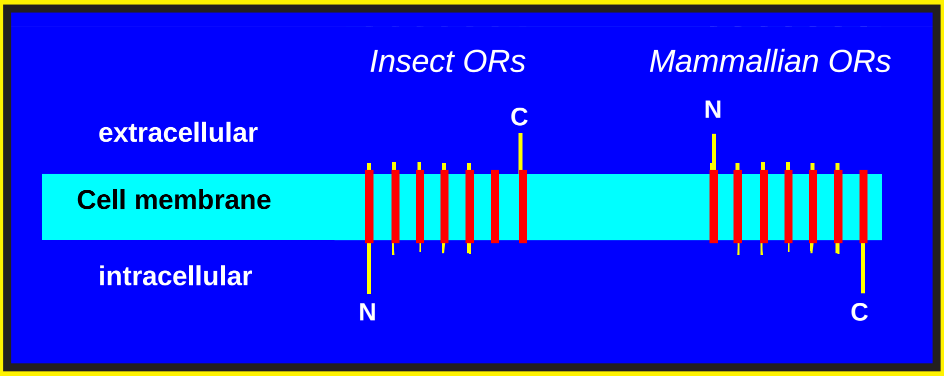

Figure 4: Predicted topologies of insect and mammalian ORs by Benton *et al.* (2006), showing opposite orientations of the N- and C- termini. Transmembrane helices are shown in red.

rates of their associated ORNs. The action potentials generated by these neurons will produce an odorant specific pattern of activated glomeruli in the insects antennal lobe. This pattern is then analysed and interpreted by the higher processing centres of the insect brain to produce a behavioural response (Hallem and Carlson, 2004).

The mechanism by which odorant receptors transduce the odorant signal is only just starting to be understood

Drosophila ORs are predicted to have seven transmembrane helices, and have thus been proposed to be G-protein coupled receptors. However, their structural conformation is difficult to predict due to the fact that they are extremely divergent in amino acid sequence from each other (~20% identity at the amino acid level) and from all other known proteins, including OR proteins from vertebrates and *C. elegans*. It should also be noted that conclusive evidence for the *Drosophila* OR proteins activating G protein-coupled signal transduction pathways has yet to be obtained (see below). Intriguingly, a recent study has suggested that insect ORs have the opposite membrane orientation to their mammalian counterparts (Benton *et al.*, 2006), stimulating much debate. In this study biochemically acquired membrane topology data indicated that insect ORs have an N-terminus that is intracellular and a C-terminus that is extracellular (Figure 4). The authors suggest that because of their unique structure, insect ORs may represent a family of proteins that have evolved independently to couple to G proteins, or that they may use a different type of signalling pathway that does not involve G proteins.

If insect ORs do utilise G proteins, there are two major candidate signal transduction cascades which they may activate: the inositol phospholipid (IP_3) signalling pathway and the cAMP signalling pathway. These G protein-activated signal transduction cascades are used by many sensory systems to transduce ligand detection into electrophysiological activity of the receptor neuron. Vertebrate ORs primarily utilise the cAMP pathway, although there is some evidence for a role of the IP_3 pathway as well (for review see Barry, 2004).

Of the two pathways, there is more evidence that the IP_3 pathway is involved in insect olfactory signal transduction, but this evidence is not conclusive. For example, *Drosophila norpA* mutants, which lack the phospholipase C that is an essential component of phototransduction (an IP_3 signalling cascade), exhibit reduced (but not eliminated) olfactory responses of the maxillary palp, however, the antennal responses are unaffected (Riesgo-Escovar *et al.*, 1995). The *Drosophila Gα49B* gene, which encodes a Gqα that activates phospholipase C in the visual system, has been shown to be expressed in ORNs (Talluri *et al.*, 1995) and flies expressing an RNAi construct for this gene exhibit olfactory behavioural defects to some, but not all, tested odorants (Kallidas and Smith, 2002). Finally a rapid and transient increase in IP3 has been observed in response to pheromones and odorants in cultured ORNs from various insect species (Breer *et al.*, 1990), and this increase can be suppressed by pertussis toxin, which inactivates G proteins (Boekhoff *et al.*, 1990).

Any model of the olfactory transduction mechanism needs to include the highly conserved OR, OR83b. Insect ORNs all co-express a regular OR with OR83b, a chaperone like membrane protein that helps target ORs to the dendritic membrane (Larsson *et al.*, 2004). OR83b is not known to bind odorants, but it does form heterodimers with other ORs (Neuhaus *et al.*, 2005), and co-expression of OR83b is essential for olfaction in vivo (Larsson *et al.*, 2004, Benton et al., 2006). Also, increases in odour sensitivity are seen in heterologous assays when ORs are co-expressed with OR83b (Neuhaus et al., 2005). These findings could simply reflect an increase in the amount of the OR protein that is correctly localised to the plasma membrane in the presence of OR83b, or alternatively OR83b may have a second role such that the functional odorant receptor is actually an OR-OR83b complex.

How do insect ORs bind ligands?

What is responsible for the ORs different levels of affinity and how is differential odorant binding translated into different strength signals by an OR? It is likely that the different odour preferences of an OR are determined by the shape of the ligand-binding pocket within the receptor, however the location and nature of the binding pocket is yet to be determined. We have performed comparative sequence analyses of sets of orthologous *OR* genes from related *Drosophila* species, revealing small numbers of amino acid changes that are correlated with affinity changes seen in comparative electrophysiological studies (Tunstall *et al.*, 2006). Some of these differences are under positive selection and may provide clues to the location of

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continued

the ligand-binding region. The two assays for OR function described above will enable us to test the role of these regions by expressing ORs containing specific changes and assaying for functional changes.

Conclusion

Drosophila is proving to be a wonderful model to study olfaction. With the ability to create genetic mutants and transgenic flies expressing ORs in different ORNs we will see major advances in coming years. Similarly, cell-based assays for ORs and other components of the signal transduction system will reveal how these proteins recognise various volatile ligands and how the proteins interact, directly or indirectly, to produce a signal transduction cascade.

While *Drosophila* is paving the way in research on insect olfaction, an important question is whether this knowledge will be completely transferable to other insect systems. As other insect genomes come on line we are seeing that other insects such as mosquitoes contain larger numbers of ORs and soon we should know the complement of ORs in bees, moths and beetles. Whether these insects will have ORs more tuned to odorants that are important in their local environment and social organisation will be an interesting question. Already, two ORs from the mosquito *Anopheles gambiae* have been expressed in the *Drosophila* "empty neuron" system (Hallem *et al.*, 2004) with results indicating that they responded to compounds commonly found in human sweat.

The application of this knowledge to industry is also going to be of interest. The isolation of ORs and functional testing in cell lines will allow the identification of compounds that block their activation by normal ligands (antagonists) or inhibit their ability to interact with the down stream signal transduction machinery. Such compounds would have application in pest control systems to modify the behaviour of the pest insects perhaps making them 'odour blind' to the crops or to humans, in the case of mosquitoes. Finally, it is even becoming conceivable that we will one day be able to use ORs as the central sensing components of "cyber noses", devices that can smell ■

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Heron Island and its coral reef (NASA image)
Acknowledgement to Voyages for bird image

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BOOK REVIEW

Learning to Smell. Wilson, D. A. and Stevenson, R. J. (2006)

Baltimore: The Johns Hopkins Press. Hardcover, 309 pages. (Due for release 7th July 2006.)

As the title implies, learning is of utmost importance in odour perception according to the book's authors. In their words, "experience-based, synthetic olfactory processing leads to treatment of multifeature odorants as odor-objects." The synthetic process is not confined to inputs from the main olfactory sensory apparatus, but includes other sensory modalities such as taste, as well as other brain processes such as emotion.

The reader can judge whether the authors' claim to establishing a new theory of olfaction is justified. What they certainly do offer is a refreshing overview of, and a conceptual framework for the role of higher cognitive processes in what occurs when a person (or animal) experiences odour. An "odour object" is the single percept of the source of possibly hundreds of different volatile compounds about which we have no consciousness, except perhaps two or three key compounds. What is perceived is not the component molecular species, but a wholistic unitary percept of the object attributed to the odour source. Names of odours invariably tie the odour to its physical source. The authors address the questions of how odour percepts are formed, how they are shaped by experience and how synthesis in formation of the object results in unique capabilities of and limitations for olfactory perception.

The book's basic premise is that odour objects are learned through experience: through plasticity in the central nervous system that forms within it a percept or odour image that is resistant to background interference, intensity fluctuations or partial degradation. Learned odour objects may include inputs from other sensory modalities (e.g. a "sweet smell") and recognition of the objects can be moulded through familiar contexts, expectation and attention.

To neglect the role of learning in the process of olfactory perception, in favour of a purely receptor-based analysis, the authors argue, may be to ignore the greater part of the subject, certainly as far as understanding human olfaction is concerned. Living creatures, they argue, derive a great advantage in expanding their communicative repertoire by being capable of recognising complex mixtures of odorants. Hence even the simplest forms of animal life tend to have complex odorant perceptual capability. With odorant mixtures, there arises in insects, the need to extract features, such as key ratios between component concentrations of a small number of compounds, required for recognition of quite a number of objects: odour trails or plumes, conspecifics, larvae, food, nest, mates, prey or predator, etc. Are such processes required for such a response repertoire hardwired? Why should we even contemplate that the olfactory receptor sheet connects directly to the appropriate motor neurons? It has been known since long before the discovery of any kind of neural receptor (in the early 1980s), that an insect has a neural capability to process sensory stimuli and to learn the consequences of a novel odour.

Hence the authors seem to attack the "stimulus approach" to olfaction, one that emphasises how particular features of a chemical stimulus are represented in the olfactory system, with a repetitive, rather unnecessary verbal battering ram. They mistake the recently active area of research on the olfactory receptor sheet and olfactory bulb for a "traditional approach" to olfactory perception. Apart from the steep growth of interest in olfactory receptors and transduction mechanisms (and the Buck-Axel Nobel prize in 2004) in the recent two decades (precipitated by the tools of protein biochemistry and the PCR method), there is a good *tradition* of olfactory knowledge, particularly in the field of animal behaviour, which stands proudly in biology and psychology, and which has involved fairly comprehensively, theories of learning and memory. It is perhaps only because some molecular biologists, to their disadvantage, pay scant regard to any field other than their own, that people in other areas, in recent years, might feel underappreciated, such is the glare of attention enjoyed by the new users of genetic tools.

Nevertheless, the authors have made a good presentation of the scientific evidence for their thesis on the way odour objects are learned, and the kinds of experiments that we might see in future. The book is a valuable contribution to the field of the chemical senses. It is also a clarion call for psychologists and neuroscientists to engage in the more complex "higher processes" of the chemical senses. For those who seek mechanisms for natural phenomena in neural and molecular processes, this book documents many questions requiring an explanation in the vocabulary of their disciplines.

The authors draw on insights from much of the psychology of perception, particularly visual perception. This is a much needed overview and synthesis of work in the field of olfaction. The authors' considerable personal contributions to their fields of olfactory neuroscience and psychology are put to good use, but in addition, their scholarship is wide-reaching, deep and thorough, with the effect that this book is likely to attain foundation status in the years to come.

Mostly, the language is smooth and the style engaging (the opening "smell this book" is delightful), although occasionally becoming too lofty for the average paying reader. Like equations in a textbook, words such as "instantiate" and "redintegration" will lose the audience.

Learning to Smell is essential reading for any student or researcher entering, or already working, in the field of olfaction. The book also deserves attention from beyond the chemical senses, and may well serve as a beacon for scholars and researchers in the psychology and neurobiology of other sensory modalities, and particularly for anyone interested in questions where perceptual modalities clearly overlap, perhaps in subjects such as pain perception, perceptual-motor skills and, of course, perception of food.

Reviewed by Graham Bell ■

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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 / 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 a 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.

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NEWS

Cleaner Air in Victoria at Enviro 06

By Graham Bell

Australia's premier environment conference and exhibition took place in Melbourne in May. With crucial support from the Victorian Government, the conference ran a full program of sessions over three days, attended by over six thousand delegates from science and industry, and over 200 hundred government leaders. A large trade delegation from China, attended and the function it hosted attracted Aussie business men like flies to a honey-pot.

The environment is now big business. Waste and sustainable processes involving land, water and air, were among the most prominent topics covered in the 24 sessions. Environmental issues are no longer a nuisance issue to companies, such as the growing cost of waste removal, or following procedures for recycling. The environment now mean considerable risk to companies if things go wrong or due diligence is not performed. With this comes a growing need for good science and technology to reduce the risks and disastrous consequences of environmental damage. The overall environmental "market" in this country is worth $billions. On a global scale the figures are measured in trillions.

Of most interest to *ChemoSense* readers were the sessions on developments in odour science and management. In these there were two main themes: measurement and control, which are the core considerations for any odour emitting plant or industry.

So how are they measuring smell? The meeting showed that dynamic olfactometry and GCMS (gas chromatography and mass spectometry) are still the only topics making any impact in the hard-driven world of environmental management. Papers on these were given by Richard Steutz of UNSW, Mirko Schlegelmilch of Hamburg University and three industrial consultants. No time was given to given to human perception, psychophysics, psychology of odour measurement, the nature of environmental complaints, new sensing or e-nose technologies. These are no doubt going to be addressed in future conferences, when the academic communities produce people with sufficient expertise to make a much-needed contribution.

Eight papers were presented on practical experience with odour management: varying pressures, scrubbing gasses, filtering, etc. This is where the big money gets spent, even though their measurement techniques serve them rather poorly. The need to marry good measurement with control is obvious, though little discussed. The atmosphere remains dark and foggy in this general area.

The exhibition provided a useful mix of buyer and seller companies on display. The large water treatment companies loomed large in their wide-spread booths and many interesting large scale engineering companies had machinery and products on the floor for inspection. Many new and home-spun technologies were on display and clearly Environ 06 was a great place for new companies to raise their flags. E-Nose Pty Ltd ran a constant odour monitor on passers by and attracted a constant stream of interest to continuous real-time odour monitoring.

The next Australian "Enviro" conference is scheduled for 2008 and may be held in Victoria once again if co-operative sponsorship is not forthcoming from other states. Victoria clearly has lead the way in environmental responsibility by supporting Enviro 06 and Melbourne is positioning itself as a hub for the large and lucrative industry that surrounds our region's growing environmental concerns and our potential to contribute to wider, global markets ■

Vale: Frances Scriven

The Australian sensory community mourns the loss in June 2006 of *Frances Scriven*, after a 20 month struggle with cancer. Frances made an impact on the academic world, including a period of lecturing in Food Science at UNSW, and on the business world with her dynamic marketing company SMART Research Pty Ltd. *ChemoSense* wishes to convey the condolences of readers and staff to her family and friends ■

NEWS

Congratulations: Nobuyuki Sakai wins Japanese Award

May 30th saw a ceremony in Tokyo in which Nobuyuki Sakai received an award from the Japan Association on Odor Environment (backed by the Japanese Ministry of Environment). The honour recognises Sakai's research on: brain mechanisms of odour and taste association; the effect of instructions on olfactory perception, adaptation and hedonics; and brain mechanisms underlying the effect of cognitive processes on olfactory perception ■

Dr. Matsuo, President of Toyo University and President of the Japan Association on Odor Environment presents an achievement award to Dr Nobuyuki Sakai.

NEWS

AACSS Meeting Embraces Wine Technology

Stephen Trowell (CSIRO Food Futures Flagship) has volunteered to organise the next scientific meeting of the Australasian Association for ChemoSensory Science (AACSS) which will be held in Adelaide, South Australia in 2007, probably dove-tailing with the AWRI Wine Technology meeting (28 July - 2 August). Details of dates and venue for the AACSS meeting will be announced in due course. Program proposals and sponsorship offers are now welcome. Contact Stephen.Trowell@csiro.au ■

New Sting for NSW Stinkers

The risks associated with odour pollution have risen five-fold in New South Wales, with the toughening of penalties for polluters, as of 1st May 2006. Tough consequences lie in store for companies prosecuted under the Protection of Environment Operations Amendment Act 2005. Fines for the most serious pollution offences (such as wilfully or negligently dumping harmful waste) will increase from $1Million to $5Million and individuals will face up to seven years jail and fines up to $1Million. There is also now a wider range of penalties, including attendance at relevant training programs or implementing compliance systems. The courts can also order that money be paid to environmental organisations to fund restoration or other worthy projects.

Commenting in the Sydney Morning Herald on 13 May, Peter Briggs, a partner in the legal firm, Clayton Utz, warned of the significant cost and time involved in a government investigation after a pollution incident. The Act requires personal responsibility to be shouldered by staff and company directors, similar to that in health and safety legislation. "The only practical defence for a director is to demonstrate all due diligence," he said ■

Cleaner Guidelines

New and significant amendments to clean air regulation in NSW now provide greater clarity for companies, concerning what standards to apply to specific activities and equipment ■

Save that Parrot

A "Bio-Banking" scheme will soon be piloted in the lower Hunter and far North Coast of NSW, to make threatened species a valuable market asset. Under an "offsets" scheme, transferable credits will be earned by people setting up, owning and managing protective areas in perpetuity, in designated areas identified as important for sustaining or building biodiversity. These credits may be sold to developers of housing and employment in other areas to offset the environmental impact of such development. It is hoped that the scheme will be more efficient for developers, more transparent for the community and better for environmental conservation. Although this is the first Bio-Bank in Australia, a similar scheme has operated in the USA for over a decade.

For more information: www.environment.nsw.gov.au ■

Upcoming Events

9-12 July 2006
39th AIFST Convention: "Festival of Food"
Adelaide Convention Centre
Adelaide, South Australia
Contact: aifst@aifst.asn.au

2-4 August 2006
8th Sensometrics Meeting: Imagine the Senses
Ås, Norway.
Contact: www.sensometric.org

4-8 September 2006
European Chemoreception Research Organisation (ECRO)
Granada, Spain
www.ecro.cesg.cnrs.fr

26-29 September 2006
Second European Conference on Sensory Consumer Science of Food and Beverages. A Sense of Diversity
The Hague, The Netherlands
www.eurosense.elsevier.com
Contact general: Clare Moloney at eurosense@elsevier.com

21-25 October 2006
Society for Neuroscience
New Orleans
Info: www.sfn.org

13-15 April 2007
ISOEN (International Symposium of Olfaction and Electronic Nose)
St Petersburg, Russia
Info: www.isoen.org

25-29 April 2007
AChemS
Sarasota, Florida, USA
Abstract Deadline: early Jan 07
Info: www.achems.org

July 2007
(dates and venue to be announced)
AChemS: 9th Annual Meeting
Adelaide, South Australia
Contact: Stephen.Trowell@csiro.au

12-17 July 2007
IBRO (International Brain Research Organisation)
Melbourne, Australia
Contact: http://www.ibro2007.org

19-23 July 2007
IBRO Satellite on Avian Brain, Cognition and Behaviour
Heron Island, Queensland, Australia
Contact: Marie.Gibbs@med.monash.edu.au

28 July - 2 August 2007
The 13th Australian Wine Industry Technology Conference
Adelaide, South Australia
Contact Rae Blair: rae.blair@awitc.com.au

ChemoSense (ISSN 1442-9098)
Web: http://www.chemosensory.com
Published by **E-Nose Pty Ltd**
P.O. Box 488 Gladesville, NSW Australia 2111
Ph. (+61 2) 9209 4083 ; Fax (+61 2) 9209 4081

Production Team
Editor: Graham Bell, g.bell@atp.com.au
Advertising: Brian Crowley, b.crowley@atp.com.au
Design and Layout: Lawton Design Pty Ltd

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