Vol. 4 No.3 June 2002

ChemoSense

EDITORIAL

Detect and Identify

By Graham Bell

Director
Centre for ChemoSensory Research, UNSW
g.bell@unsw.edu.au

To identify something we need to find or detect a possible form of it, then we need to recognise something crucial about it, to distinguish its identity. The human brain is nature's supreme identification machine, and our senses provide streams of information upon which it acts. Consider our ability to recognise places, and faces, and aromas. Difficulties in answering questions about the world from a knowledge of its chemistry, can also be treated in this way: with a stream of very complex information, processed cleverly and quickly, resulting in successful detection and identification.

Sensing technology for gases continues to develop on many fronts as described in our leading review by Srivastava and Levy and by an overview of our Centre's sensor and e-nose programs described herein by Hibbert and Barnett. Solutions to many problems are turning out to mimic nature's way of doing things: many a lesson will yet be learned from the biological chemosensory and nervous systems.

This issue of ChemoSense will reach, in print, around 4000 influential people in science and industry, particularly in the Australasian region. On www.chemosensory.com , selected extracts from back issues of ChemoSense may be found and freely accessed by the global audience ■

Gas Sensor Monitoring of Environmental Air Quality

Arvind K. Srivastava and David C. Levy

Computer Engineering Laboratory
Department of Electrical & Information Engineering
The University of Sydney, Sydney, Australia
arvind@ee.usyd.edu.au dlevy@ee.usyd.edu.au

Methods of monitoring environmental air quality in general and factory odours in particular are reviewed here. Gas sensors offer cost-effective solutions to real-time odour monitoring, compared with other existing techniques. The following questions are addressed: what kinds of environmental problems exist; how have they been solved in the past; what problems have not been addressed and why; what solutions might solve problems of factory odour; and do gas sensors offer special advantages?

Introduction

There is growing public concern over industrial impact on the environment. Monitoring environmental quality in a broad sense includes global air quality monitoring, local air quality monitoring, indoor air quality monitoring and outdoor air quality monitoring. This depends upon the kind of pollutants, source of pollutants and how they affect the environment. Global monitoring is generally related to the detection of chemicals such as greenhouse gases (CO2, CH4, N2O, NO and CO) whereas local and indoor/outdoor monitoring includes determination of toxic and explosive gases as well as malodours, most of which are often volatile organic compounds (VOCs). There are the various sources commonly responsible for the emission of these gases: the energy industry, production industry, transport, small-scale combustion, industrial processes, solvents, agriculture and landfill (Greatorex, 2000). Humans in the path of gaseous emissions from such sources can find their health, comfort and well-being dramatically impacted upon. In addition, flora and fauna that may make contact with the pollutants can also be altered, stunted or destroyed. Chemical sensing and monitoring of the presence,

cont. pg 2

Centre for ChemoSensory Research
The University of New South Wales
ISSN 1442-9098

Gas Sensor Monitoring of Environmental Air Quality continued

identity and degree of severity of pollutants is of growing importance to enforcement of and compliance with laws designed to sustain acceptable and safe standards of air quality.

Requirements for Air Quality Monitoring

Requirements of air quality monitoring techniques depend upon the type of problem, such as global, local, indoor or outdoor. Each of these applications has different requirements that depend upon the concentration range of the priority pollutants, background effect (meteorological and presence of interfering species), variation in pollution level, measurement period, and instrument calibration.

An air quality monitoring system should:

1. Be sensitive enough to measure air quality over a specified range of concentrations. The sensitivity of a system is a function of its detection limit and quantification range. These two parameters determine the concentration range over which a given air quality monitoring system can be employed.

2. Be reliable enough to provide reproducible, consistent measures of air quality. For an air quality monitoring system to provide useful and reliable data it must be sufficiently accurate, precise and selective to be able to differentiate unambiguously between typical local background levels of air quality. *Accuracy* is the measure of deviation of the obtained value of the system from an absolute (or true) value for a given parameter. *Precision* is the measure of reproducibility that determines *analytical resolution* of a given monitoring system. *Specificity* is the measure of how selective the monitoring system is. For a monitoring system to work well, reliability, accuracy, precision and selectivity should be determined under both laboratory and in-situ conditions. A secondary factor affecting usefulness of a system, is the *potential effect* of the local environment or range of extremes possible upon the monitoring data. It is widely accepted that both local topographical (i.e. geographical forms) and meteorological effects (eg. wind derived eddies) can produce highly localized air quality variations, Ropkins and Colville (2000).

3. Have suitable resolution. Resolution of any monitoring system is the shortest time-scale over which the system can produce a reliable measure of local air quality. The time scale typically incorporates a measurement period over which the analyte is quantified, and any associated 'recovery' time or inter-sampling delay that the system requires, is allowed prior to subsequent measurement. For a pollution monitoring system to perform efficiently, variation in local air pollution level, time-resolution and 'recovery' time should be taken into account, Ropkins and Colville (2000).

cont. pg 4

Vol. 4 No.3 June 2002

E-MAIL from Italy

Graham Bell
Centre for ChemoSensory Research

Italy is everything and nothing you've ever learned about it. You feel you've been here all your life, and you never want to leave, but you know this place is bigger than Ben Hur. Australians already know Italy, from our schooling and from Italians in Australia. We already have a great affinity with this country, its people and its language. But Italy is without doubt bigger (over three times our population) and different in ways that befuddle you to the point of madness. What gives me this impression in so short a time?

Firstly, it is the diversity. There are many distinct regions: geographically, climatically and culturally separate, each with its own traditions, history and cuisine.

Secondly, there is a most deeply rooted practice of Christianity here, the likes of which you may never have seen or felt before. With it comes compassion, sensitivity, conflict and anguish, as the ancient and modern lifestyles play out their differences.

Happy without Tourists: a Village near Latina, Southern Italy.

Thirdly, there are the many competing powers: such as money, sport, and social ideologies. Positions are strongly held. People still polarise into extremes we have long forgotten or no longer try to understand, like Fascism and Communism, both of which continue to manifest and oppose each other here. Then there is the Mafia, which is a real and feared presence still - at least in people's minds. This is competition for wealth and resources of a kind we don't know much about. Then there is Sport: such as soccer and motor racing, all sections of which are proclaimed by magnificently bright flags everywhere you look, even in the idyllic countryside. It seems difficult not to be on some side or other here. Rather daunting for those of us who are not too sure where we stand on anything.

Fourthly, I look around at the faces and the mode of dress. The post office lady looked like Sophia Loren. The men on my plane to Milan had faces like Roman sculpture and were dressed like Paul Keating. How can you ever hope to impress with your downunder food fabrications, folk such as these?

Luckily, in Italy, no first impression survives the first engagement with a truffle omlette. Soon my fears are allayed. I am swept away by the fantastic hospitality, the charming warmth of friendship, quick and witty humour -

Silky Light on Castle Steps: near Latina.

very comfortable to an Australian - and a universal joy of food and wine.

Despite the freedoms of the EU markets, the tremendous sophistication of Italian cuisine and the devoted enthusiasm of its consumers, Italy, like much of Europe, is a growing market for Australian food products. Many people here can afford our products. Working people want convenient food, priced to deliver sufficient quality and an assurance of safety and health.

As the summer approaches, Italy's population begins to change significantly with the coming of the tourist hordes. They arrive from the USA, Japan, UK and elsewhere in Europe in their millions and spend, I am told, well over AUD$100 Billion, all within a short few months! There must be some special opportunities or niches for Australian exporters: the question is what?

I leave with great optimism for this wonderful country, its people and the future relations between us. I will no doubt return amongst the tourists before too long, and hope meanwhile, I never forget the tastes and aromas of Italy and that beautiful Italian light that seems to bathe the whole world in silk.

Ciao! ■

Milanese School Teachers give me a Lesson in Food and Wine

Photographs: Graham Bell

4. Have a low failure or instrument fault rate. Failure rate of a monitoring system is a function of the reliability of the instrument and the nature of the demands on both the equipment and the human operator involved. Consequently, both the perceived reliability and maintenance of the analytical instrument can be important factors in design specifications of an air quality monitoring system.

   In addition to analytical requirements, a number of practical requirements are also likely to restrict the range of analytical systems that are suitable for either indoor or outdoor air quality monitoring. If one air quality monitor per pollutant is installed, significantly large number of air quality monitors will be required and financial costs of setting up and running such a large number of instruments are likely to restrict the number of viable monitoring systems. Similarly, the size of monitoring equipment, power and communication requirements are likely to further restrict the air quality monitoring systems. Consequently, an air quality monitoring device should be low-cost and small, have low power requirements and a simple communication interface, Ropkins and Colville (2000).

Air Quality Monitoring Techniques

There are various kinds of air quality monitoring techniques available today. Depending upon the type of sampling and analysis technique. Ropkins and Colville (2000) have classified air quality monitoring methods into six basic classes: 1) Passive indicator methods; 2) Passive sampling and analysis methods; 3) Active sampling and direct measurement methods; 4) Active sampling and analysis methods; 5) Automatic local monitoring; and 6) Integrated path monitoring.

1. *Passive Indicators:* Passive indicators are the materials that react with analyte species upon exposure and can be used to provide 'on-the-spot' information about air quality or individual airborne pollutants. Passive indicators are most commonly used quantitatively or semi-quantitatively, to indicate the presence of given pollutants at hazardous concentration. Most passive indicators use a chemical trapping material that reacts with the pollutant to produce a visible colour change. Stain-length dosimeters are probably the most commonly used quantitative indicators. These are small glass tubes, typically about 1 cm or less in diameter and 10 cm in length that are packed with trapping material and sealed prior to use. To use a dosimeter, the operator simply breaks the seal at both the ends of the tube and exposes the tube in air for a specified time. The amount of the pollutant in the volume of air sampled can then be estimated visually by measuring the proportion of packing material that has been stained.

   Use of dosimeters is usually restricted to the situations where high concentrations are the focus of concern. Such passive indicators have to be deployed for a long period of time (i.e. > 1 day for most pollutants) to achieve detection limits. These are not readily automated procedures. Quantitative passive stain dosimeters have been used for numerous pollutants, including carbon monoxide, nitrogen dioxide, sulphur dioxide, benzene, 1-3-butadiene, and alkyl lead.

2. *Passive Sampling and Analysis:* Like passive indicators, passive sampling and analysis methods employ materials that react with analyte species upon exposure, to measure airborne pollutant concentrations. However, these materials require laboratory based analysis to determine the amount of pollutants retained. Passive sampling and analysis is commonly used in large scale, short time period studies, eg. site screening and surveys for inorganic and reactive organic species. Physical trapping materials tend to be used for stable species. The most widely used passive sampling tool is probably the 'diffusion tube'. These sampler tubes, normally made of stainless steel, glass or plastic that are packed with absorbent material or a chemical trapping agent and filled with mesh end-stops to retain this packing material. Sampling is conducted as described above for passive indicators, then retained for the analysis. Numerous analytical techniques have been used to analyse exposed sampling tubes, including chemical, spectrographic and chromatographic (GC, UV or ion) processes.

   Passive sampling methods allow analysis of VOCs like benzene, toluene, xylene, ethyl benzene, and other volatile hydrocarbons. This method has also been used for the analysis of 1-3-butadiene, nitrogen dioxide, and sulphur dioxide in the parts per billion (ppb) range of concentration.

3. *Active Sampling and Direct Measurement:* Like passive indicator monitors, these methods employ the same trapping materials and trapping configuration, however, unlike passive indicator methods, sampling is achieved by passing a fixed volume of air through the sampler with the help of a normal gas syringe or pump. Like the first two methods, this method is most commonly used either qualitatively or semi-quantitatively, but rarely employed in environmental air quality monitoring.

4. *Active Sampling and Analysis:* These methods use gas syringe, air pump or vacuum pump, to draw a fixed volume of air through an analyte trap, which is to be subsequently retained for analysis. This method is commonly used qualitatively, especially in large scale, short time period air quality studies eg. site screening exercises and surveys. Analysis is typically conducted by spectrographic or chromatographic methods, atomic absorption, total-reflection x-ray fluorescence spectroscopy, inductively coupled plasma spectroscopy (ICP), gravimetric or optical analysis. Detection limit for SO2 has been reported around 10-100ppb.

5. *Automatic Local Monitoring:* This measures analyte concentrations directly by exposure to a sensor. Such systems are typically highly accurate, precise and reliable, producing hourly-average, minute-average or even real-time data. Consequently, they can be deployed to provide continuous site data both with and without prior sampling depending upon the requirement. However, they are significantly more expensive than either passive or active sampling procedures. A number of monitoring methods are now available that can provide low-cost, real-time air quality data e.g. solid-state gas sensors and related technologies. Recent investigations have shown that these methods are most suitable for use in routine air quality monitoring.

6. *Integrated Path Monitoring:* The 'integrated' concentration (i.e. average concentration) of airborne species between a light source unit and a detector unit is measured. The instrument uses absorption of specific wave-lengths of light by airborne species to detect and quantify individual airborne species, in a similar manner to spectroscopic techniques. Most conventional spectroscopic instruments typically comprise a unit containing a light source, a sample cell and a detector unit. However, integrated path instruments are in effect two instruments, a light source and a detector, plus ambient air between source and detector, which is analysed without prior sampling. They can provide simultaneous near-real-time measurements of a wide range of chemical species, including both priority pollutants and trace pollutants. Consequently, integrated path techniques can provide a comprehensive description of local air quality.

cont. pg 5

vironmental Air Quality continued

Integrated path techniques are mostly associated with remote satellite applications (>100Km path length). However, an increasing number of short path applications i.e. <100m have been developed in recent years. Examples of commonly employed techniques includes: DOAS (differential optical absorption spectroscopy), FTIR (Fourier transformed infrared) and LIDAR (Light detector ranging). Such techniques are typically highly expensive and significant skill is required to interpret the data they provide.

Conventional air quality monitoring approaches, as discussed above, are generally time consuming, and require indirect means of measurement and are not suitable for automatic monitoring. Hence these techniques cannot be employed for routine air quality monitoring. Furthermore, for many pollutants, significant doubts exist regarding specificity, accuracy and precision of such methods. In contrast to conventional air quality monitoring techniques, automated local monitoring systems and integrated path monitors offer many advantages. As these methods are capable of providing real-time data, which, in many practical applications, is of utmost importance, they are therefore regarded as most suitable techniques for environmental monitoring purposes.

Continuous Environmental Monitoring

There are lots of studies devoted to monitoring environmental constituents in real-time, but most of them are confined to the laboratory. In real-world applications, the rigorous experimental conditions, which apply in the laboratory are no longer usable in the field. "In the field of environmental monitoring, the background is an ever -changing chemical mixture against which we want to detect the rise of a particular odour - although the exact profile of that rise is both unknown and variable" (Gardner et al., 1999 and Nicolas, 2000). Fluctuations in meteorological parameters such as temperature, humidity, air pressure and wind velocity affect sensor responses. Besides this, interaction of odour constituents with the sensor also results in an adverse effect on the sensing ability of the sensor with the passage of time. These factors constitute a real challenge in real-time monitoring.

Automatic local monitoring techniques and integrated path monitoring are potential alternatives to the above. The basic difference between these two techniques is that that former is 'reactive' technique whereas later is 'non-reactive'. Most solid-state sensor technologies (e.g. such as electrochemical sensors, metal oxide sensors, polymer sensors and resonance sensors) can be classified as 'reactive', i.e. an analyte reacts chemically with the sensor elements, providing an electrical signal that is proportional to the gas concentrations. If reactive sensors have some advantages (i.e. low-cost and high sensitivity), at the same time they have certain disadvantages as well. Reactive sensors suffer from: 1) incomplete reversibility of chemical changes at the end of reaction; 2) depletion of chemicals in the sensor elements over time; 3) lack of specificity to the desired analyte; and 4) interference from other environmental factors, such as humidity, temperature fluctuations and pressure/ wind direction (Chelvayohan,1999). Integrated path monitoring (e.g. Infra-red technology), being 'non-reactive' in nature, is free from these shortcomings. However, these techniques cannot be used at night and most are likely to provide incomplete or inaccurate data if monitoring is conducted during poor visibility or bad weather, Ropkins and Colville(2000). This is due to the fact that integrated path monitoring employs an indirect means of sensing (see Fig. 1).

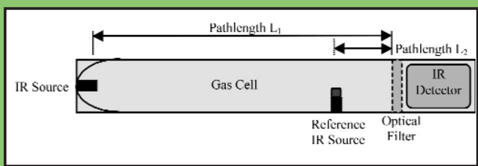


Figure 1: Schematic drawing of operation principle of infrared gas sensor, Chelvayohan (1999).

Even with the number of limitations, reactive techniques remain popular and are recognised as cost-effective alternatives for accurate and reliable identification and quantification of the environmental pollutants.

Sensor Arrays

An emerging strategy, inspired by the biological olfactory system, makes an attractive tool for environmental monitoring: An array of several sensors with partially overlapping sensitivities and associated signal processing for pattern recognition, is employed for sensing complex chemical mixtures (see Fig. 2). The electrical signals generated by the sensors upon exposure to the vapours are processed by an electronic circuit that provides an analogue signal which than can be amplified, pre-processed and digitised prior to being fed into a pattern classifier system. Such reactive sensor technology provides an odour exposure profile beyond the capability of a human nose or a gas chromatograph/mass spectrometer (GC/MS) or other related technologies described herein (Nagle et al. 1998).

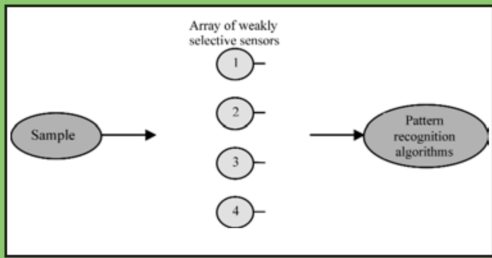
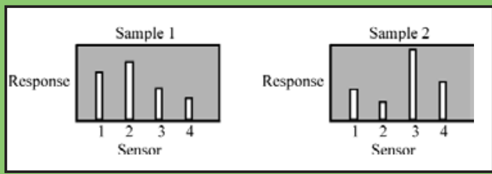


Figure 2: Reactive sensor technology. (a) The olfactory concept.



(b) Each sensor responds to several compounds, but the pattern from the array is chemically specified., Byfield et al. (1996).

Reactive sensor technology finds applications in a wide variety of disciplines ranging from electrochemical analysis through biomedical measurements, to pollution monitoring and industrial control. They have been applied in many applications in environmental pollution monitoring and detection of contaminants such as in landfill sites, waste water treatment plants, piggeries, paper or sugar factories, and breweries.

Recently, Nicolas et al. (2000) reported identification of sources of environmental malodour from compost facilities, printing houses, paint shops, waste water treatment plants, rendering plants and settling ponds of sugar factories, using arrays of metal oxide gas sensors. Their study aimed at supplying information requested by the final user in the field: a warning signal when malodour level exceeded a given threshold value; the identification of source of odour on the site; or on-line identification and monitoring of an odour in the field. Analysis of the sensor array data by discriminant analysis (DA) and principal component analysis (PCA) is found to be fairly good in the classification and monitoring of malodours.

Continuous monitoring of indoor air quality in a lavatory was recently reported by Oybu et al. (2001) using an array of six plural metal oxide ($SnO2$ and ZnO) gas sensors. Hydrogen sulfide, methyl mercaptan, trimethylamine in the ppb range, and occasional emission of ammonia and various other odorants are generated in a lavatory. The kind of excretion could be recognised by this system, suggesting further applications may be developed for use in indoor air quality management, building maintenance as well as in medical and health areas.

Gas Sensor Monitoring of Environmental Air Quality continued

Recent research on metal-oxide gas sensors by Becker et al. (2000) has shown that such devices respond to environmentally relevant concentrations of O3, NO2, NO and CO. Tin-oxide sensors were embedded into microchambers to form a microreaction chamber. By enclosing samples of polluted air within the chamber, gas depletion reactions were observed, which provided analytical information about the pollutant species enclosed. They have extended this approach to a microanalysis system containing two sensor chambers, one equipped with thin-film and other with a thick-film tin-oxide sensor element. They were able to obtain analytical information about air pollutants in relevant concentrations for indoor as well as outdoor applications.

Baby et al. (2000) have employed a combination of two arrays of eight sensors (tin oxide sensors and quartz microbalance - QMB sensors), to detect industrial water contamination: eg. nitrobenzene coming from the leather industry and lindane from insecticide manufacturers. Residues of insecticides (lindane and synthetic pyrethroids) and products from leather manufacturing (phenols, nitrobenzene, anilines) often find their way into streams and rivers. Their report claims discrimination of lindane and nitrobenzene, in very low concentrations (1 and 500 ppm, respectively), through fast, reproducible analysis of their odours.

The control of pollution levels of waste water produced, for example, in oil rendering plants, is of primary importance for minimising the impact on the surrounding environment, including its air quality. The performance of waste water cleaning systems is usually controlled by measuring, at intervals of one or more days, key dissolved gases, such as oxygen (related to the presence of microorganisms), hydrogen (pH), ammonia and phenols. A gas sensor system consisting of eight thickness-shear-mode resonators (TSMRs) or QMB sensors, each coated with different kinds of pyrrolic macrocycle film, has been used to measure these gases in waste water. PCA analysis of the gas sensor data showed clear distinction between steps in the water cleaning process (Natale, 2000).

For the rapid on-site screening of pollutants in environment 'KAMINA' is an attractive gas detector for on-site screening of flat surfaces directly in the environment (Andlauer et al., 2000). The sensory heart of KAMINA is a gradient microarray of SnO2 and WO3 based sensors. The microarray consists of 38 sensor elements with different selectivities obtained by gradient technique. One application of this kind is the screening of soil for the localisation of patches of organic pollutants near to the surface of solids. A mobile extractor-hood assembly equipped with KAMINA and a reference of clean air was able to detect contamination patches of toluene, methylene chloride and car fuel. Through PCA analysis it was possible to categorise different contaminants with a response time of less than 2 minutes.

Conclusions

This overview is intended to provide general information about the currently available practice of air quality monitoring using gas sensors. Conventional monitoring techniques offer low costs. But where there is need for continuous monitoring, these methods are not suitable as they are difficult to automate. For routine jobs both the reactive sensor technology and integrated path monitoring are potential methods. However, reactive sensor technology is preferred in most environmental monitoring applications. In a situation where a conventional monitoring system is currently used, a number of low-cost solid-state sensors could be deployed to map air quality trends ■

REFERENCES

Andlauer W., Korber R., Pulschen S. and Goschnick J. (2000) On-site pollutant control of flat areas such as grounds with segmented metal oxide films, **7th International Symposium on Olfaction & Electronic Nose (ISOEN 2000)**, Brighton, UK, 20-24 July pp. 93-94.

Baby R. E., Cabezas M. and Walsoede Reca E. N. (2000) Electronic Nose: a useful tool for monitoring environmental contamination", *Sensors and Actuators B* **69** pp.214-218.

Becker Th., Muhlberger St., Bosch-v Chr., Braunmuhl, Muller G, Ziemann T. and Hechtenberg K. V. (2000) Air pollution monitoring using tin-oxide-based microreactor systems, *Sensors and Actuators B* **69** pp.108-119.

Byfield M. P. and May I. P. (1996) Olfactory sensor array systems: The electronic nose, *GEC Journal of Research*, **13** (1), 17-27.

Chelvayohan M. (1999) Patented Virtual Reference Infrared Gas Sensor, Texas Instruments, Inc.

Gardner J. W. and Bartlett P. N. (1999) *Electronic Noses-Principle and Applications, Oxford University Press* , Oxford, pp.245.

Greatorex J. M. (2000) A review of methods for measuring methane, nitrous oxide and odour emissions from animal production activities, *JTI-Rapport, Nr.* 274, JTI-Institutet for jordbruks-och miljoteknik, Upasala. ISSN-1401-4963 pp.1-30.

Nagle H. T., Schiffman S. S. and Gutierrez-Osuna R (1998) The how and why of Electronic Noses, *IEEE Spectrum*, Sept. pp.22-34.

Natale C. Di., Macagnano A., Mantinelli A., Nardis S., Paolesse R. and Amico A. D. (2000) Application of an electronic nose to monitoring of waste water cleansing systems of an oil rendering plant, *7th International Symposium on Olfaction & Electronic Nose (ISOEN 2000)*, Brighton, UK, 20-24 July pp.109-110.

Nicolas J., Romain A. C., Wiertz V., Maternova J. and Andre P. (2000) Using the classification model of an electronic nose to assign unknown malodours to environmental sources and to monitor them continuously, *Sensors and Actuators B* **69** pp. 366-371.

Nicolas J., Romain A. C., Monticelli D., Maternova J. and Andre P. (2000) Choice of a suitable E-Nose output variable for the continuous monitoring of odour in the environment, *7th International Symposium on Olfaction & Electronic Nose (ISOEN 2000)*, Brighton, UK, 20-24 July pp.127-128.

Oyabu T., Nanto H. and Onodera T. (2001) Odour sensing characteristics of a lavatory in a general domicile, *Sensors and Actuators B* **77** pp. 1-6.

Ropkins K. and Colville R. N. (2000) Critical review of Air Quality Monitoring Technologies for Urban Traffic Management and Control (UTMC) Systems, *http://www.utmc.dtlr.gov.uk/utmc28/utmc28.htm.*

Vol. 4 No.3 June 2002

Heron Meeting Update

Plans are going well for the exciting ChemoSensory Meeting at Heron Island, Queensland Australasia from 7-11 December 2002. Organisers for the Australasian Association for ChemoSensory Science (AACSS) report strong bookings and a good-sized contingent from USA, Japan and Europe. Some space is still available, and anyone wishing to come must book very soon to avoid disappointment.

This is a rare opportunity to learn from each other, discuss and present research results, identify important issues, and meet the "famous names" in your field, all in the unique setting of a Barrier Reef coral atoll.

Student Assistance Offers Made

Sponsorship income has been directed exclusively at student participants and seven assistance offers have now been made.

Inspection Completed

Meeting Organiser, Graham Bell, visited the island in May and checked all rooms and facilities. His report to AACSS Members and people who have already booked was totally positive. The facilities have been recently upgraded and the meeting venue is well equipped and located for easy access to all other amenities. The service, organised activities, comfort and quality of food was exemplary, he said.

Program Plans Progressing

The Program will provide over seven hours of sessions per day, at times that maximise the enjoyment of the ecology of the island and reef, which, in December, will be turtle and bird breeding time. Days 1 and 5 are mainly devoted to arriving and departing from the island either by the fast catamaran launch or by helicopter. Once a person has obtained a confirmed booking (the essential first step - see below) they are contacted concerning registration, symposium participation and abstract submissions.

Submissions of abstracts for symposium, oral and poster papers must be sent to the Programme Chair, John Prescott, John.Prescott@stonebow.otago.ac.nz by the Abstract Deadline: 30 September, 2002.

Symposia

- Targeting, Development, Regeneration (Chairs: Anne Cunningham and Brian Key)
- Taste, Olfactory & Trigeminal Psychophysics (Chair: John Prescott)
- Marine, Aquatic and Invertebrate Systems (Chair: Tim McClintock)
- Large Mammal Chemical Ecology and Olfaction (Chair: Bets Rasmussen)
- Cerebral Processes (Chair: Caroline Owen)
- Chemosensory Memory and Cognition (Chair: Bob Boakes)
- Clinical Issues - smell and taste loss (Chairs: Graham Bell and Alan Mackay-Sim)
- Industrial Issues: more competitive wine, food and beverages (Chair: Jenny Weller)
- Machines and Models - Chemosensory Devices & Sniffers (Chair: David Levy)

How to Book

A confirmed resort booking (Heron Island Resort and transfers to and from the island) is essential for registration at the Meeting, as this is the only accommodation available. Rates quoted here are at a special 20% discount exclusive to AACSS Meeting participants and their parties. Stays may be extended at these rates before and/or after the Meeting, depending on room availability. The Resort provides three meals inclusive in the room rates.

Many Spotted Morwong, Heron Island: Photo Graham Bell

Room numbers are limited and will available on a first-come first-served basis. AACSS accepts no responsibility for attendees' hotel, transfers or travel bookings or any matters arising therefrom. Attendees must see to their own accommodation and travel arrangements. All bookings must be finalised by the Hotel Deadline: 23rd August 2002. Thereafter, unreserved rooms will be returned for sale to the general public and cancellation fees will apply.

All your accommodation on Heron Island and launch/helicopter transfers must be made directly by you through Wendy Burchmore of Tourism Queensland Groups and Conferences (see contact details below). Once you have a confirmed booking the AACSS Organisers will contact you regarding conference presentations and registration.

Wendy.Burchmore@tq.com.au
Phone +61 7 3535 5837
Fax: +61 7 3535 5045

Rates per person per night, twin share x 4 nights (AUD$*). Includes full board:

Class	Rate	Sole Use	Extra adult	Child (3-14y)
Turtle Rooms	157.50	232.50	112.50	67.50
Reef Suites	202.50	277.50	112.50	67.50
Heron Suites	247.50	322.50	112.50	67.50
Point Suites	330.00	405.00	n/a	n/a

Transfer to and from Island:

	Adult		Child	
Ex Gladstone	One way	Return	One way	Return
Launch	61.50	123.30	30.75	61.50
Helicopter	274.00	466.00	137.00	233.00

Meeting Registration Fees:

Non-student $120 Student $60
Payable on arrival at the Island.

* 1AUD$ is approximately equal to 57 cents US (June 2002).

IMPORTANT DATES:

Booking Finalisation Deadline: 23rd August 2002
Abstract Deadline: 30 September, 2002
Meeting: 7-11 December, 2002

IMPORTANT CONTACTS:

Heron Island Accommodation: Wendy.Burchmore@tq.com.au
Meeting Organiser: g.bell@unsw.edu.au
Program Chair: John.Prescott@stonebow.otago.ac.nz
Web info: www.chemosensory.com

SEE YOU IN PARADISE!

Chemical Sensor and E-Nose

Introduction - Why Analytical Chemistry?

The goal of chemical analysis is not, as some would believe, to analyse the world in chemical terms. It is to answer questions about the world from knowledge of its chemistry. Questions like "Can I drink the water?" "Should I invest in the gold mine?" or "Will this food product's taste be acceptable?" No one, generally, gives a proverbial cuss about how much lead is in the soil, just if their child has eaten a handful of it, is it likely to harm?

This knowledge has implications for chemical analysis, in that it may be possible to answer society's questions without doing 'proper' chemical analysis. A food product may be passed fit for consumption if an analytical device can be engineered to give the same answer as a human taste panel. Neither the device, nor the panel, will ever know the complex chemistry that they are investigating, just the result that it smells or tastes right and has no obvious microbiological bugs in it). It may be prudent to have a good knowledge of the chemistry of the sensor, because we all like to know why something works, and such knowledge may help us to understand the working of the biological system.

We are led, by the arguments above, to conceive of an analytical device that when pointed at some part of our world will provide a suitable answer. Such sensors when interacting with gases have been dubbed "Electronic Noses" (or e-noses for short). In solution they are called "Electronic Tongues".

The concept should not be confused with Cochlear Ltd's "Bionic Ear" which is designed to be implanted in patients: the e-nose is an electronic mimic of the biological organ, not a potential replacement for human sensation.

Constructing an e-nose

The e-nose concept is shown in Figure 1. An array of sensing elements that will respond to the atmosphere of interest pass signals to a computer program that extracts the useful information and supplies the answer to the user. Like the receptors in a biological nose_ the sensing elements are best if they are not absolutely specific for one chemical. It would not be possible to have a sensor for every chemical in the world, nor is it likely that evolution would have provided biological species with such sensors. Instead, we, and the electronic analogues, have arrays of sensors that respond to classes of compounds - perhaps based on shape, weight, electronic properties or chemical reactivity. It is the pattern of response of these arrays that becomes the 'signature' of the gases detected, and, as shown in the figure, this signature can be understood in terms like "a ripe blue cheese".

A human can detect about 10,000 different smells and may have only one thousand different receptors. Artificial e-noses that are on the market and being researched have between two and one hundred sensing elements, and are thus much more restricted in their useful range of smells (although, of course, they are not restricted to gases humans can smell). In our UNSW group, we have concentrated on making small, highly portable e-noses with rather few sensors (up to eight) that are calibrated for specific uses. It may not matter that a wine e-nose is confused by the smell of dead fish if we ensure that our wine tasting is done upwind of the Fisherman's Coop. Table 1 gives some of the areas in which we have sniffed.

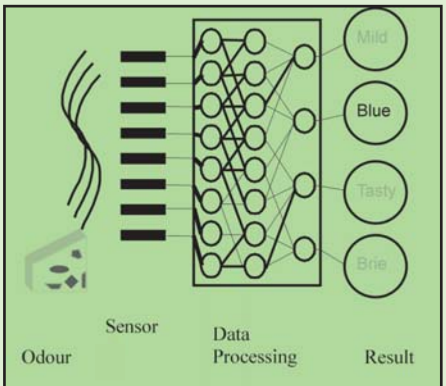


Figure 0: Schematic of an electronic nose identifying a cheese using an artificial neural network

Table 1: Electronic noses have been produced for these uses by the Centre for Chemosensory Research

- Air pollution monitoring from cars.
- Air pollution from factories and construction sites
- Detection of volatile organic compounds (VOC) in ground water
- Detecting truffles
- Wine identification
- Food shelf life monitoring
- Food quality assessment
- Fruit ripening
- Medical diagnosis
- Drug detection

Principle of operation

Many e-noses are based on the change in electrical resistance of a tin oxide film (Taguchi sensors), or of a conducting polymer such as poly pyrrole. Recently an e-nose has come on the market that has sensing elements that are polymers loaded with graphite powders. The polymers interact with gases and swell, thus changing the resistance of the powder matrix.

Tin oxide is a semiconductor that is very sensitive to the amount of surface oxygen. A gas that interacts with oxygen increases the conductivity of the tin oxide. When the source of the gas is removed, oxygen re-oxidises the surface and the lower conductivity is restored. These sensors are sensitive (typically ppm detection limit), and respond quickly to changes in gas concentration. They can be made reasonably small, and given some degree of selectivity by doping. The sensor is heated which gives it some protection from interference from water vapour and changes in ambient temperature.

Other principles of operation include the measurement of mass changes by quartz crystal microbalances and surface acoustic wave devices, and the measurement of the optical properties of a film. Although most e-noses are 'electronic', recently optical-based arrays have been reported. Use of polymers with an embedded fluorescent molecule, such as Nile Red, can lead to changes in the patterns of fluorescence as gases dissolve in the polymer causing changes in the polarity of the environment. We have filed a patent on a device in which fluorescent species are produced when a target gas (aldehyde or amine) interacts with the sensor (Hibbert, Barnett and Doran, 2000). Commercialisation of potential technology using this intellectual property is proceeding. Inquiries regarding investment and participation are now welcome.
(Contact g.bell@unsw.edu.au).

Chemometrics

Unless the system being monitored is extremely simple, we will need to extract the useful

Program

By Professor Brynn Hibbert and Associate Professor Donald Barnett

b.hibbert@unsw.edu.au
donald.barnett@unsw.edu.au

information in the signal using pattern recognition techniques. Like any nose, an e-nose needs to be trained by exposing it to the odours it must recognise in the future. The software then builds a model of the odour in terms of the output of the sensor, which will allow the system to give the correct response when that odour is encountered again. There are a number of techniques of varying complexity, which can be divided into supervised and unsupervised methods. Supervised methods are calibrated by exposing the e-nose to target odours and building an appropriate model. Examples are SIMCA, linear discriminant analysis and most artificial neural networks. Unsupervised methods let the output from a number of smells group as they will, according to the method. A scores plot from a principal components analysis (PCA), or a self-organising neural network are examples of this approach. The e-nose shown in Figure 1 is being processed by an artificial neural network that has been calibrated by sniffing a range of known cheeses. The lines joining the 'neurones' (the circles in the network) represent weights that combine, perhaps in a similar way to brain neurones, to give an ultimate result.

Some examples

In 1991 the Sydney Harbour tunnel opened to a certain amount of controversy, which included claims that there was a build up of pollution in the tunnel. We drove through the tunnel and showed that the levels of carbon monoxide and unburnt petrol were no higher than found in the Central Business District. A few days later, we returned with a local television station to see a cloud of white fumes at the end of the tunnel. Our e-nose showed the expected rise in signal (see Figure 2), and we gained a certain amount of notoriety as "Pollution Busters". What had happened was that the ventilation, which blows air into the middle of the tunnel, was not sufficient to clear the fumes from the tunnel but managed to compress them at the end. A change in the settings soon cured the problem but the use of a portable sensor was perfectly demonstrated.

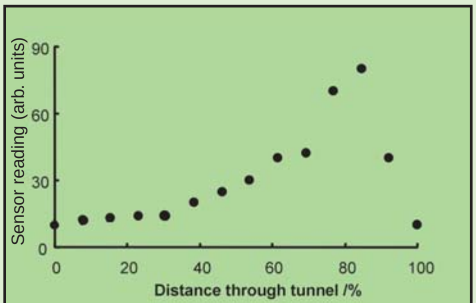


Figure 2: Response (arbitrary units) of a tin oxide sensor that is sensitive to carbon monoxide taken through the Sydney Harbour Tunnel.

In a piece recorded for the ABC program *"Quantum"* (ABC Television, 1999), we were asked to sniff a wine and identify it. Here we showed the groupings from a small number of wines using an eight-sensor e-nose in a principal component analysis (Figure 3). It may not appear a great coup to distinguish between a white and a red wine, but it is surprising how poor people are at doing just that, when blindfolded and only allowed to sniff. In fact the wine problem is probably the hardest challenge for an e-nose. There is a high background of ethanol to which the sensors respond, and the human response which we are trying to mimic, is itself not well understood and difficult to model.

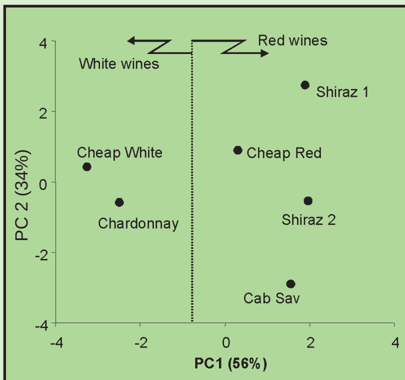


Figure 3: Plot of the scores of the first two principal components (PCs) of the output of an 8-sensor e-nose showing discrimination between white and red wines.

Most of our serious applications are much more straightforward!

In January, 2001, Associate Professor Don Barnett spent a week in France sniffing for truffles (Barnett, 2001). While the biological nose of a pig or dog wins against the current state of e-nose art, in such applications, e-noses do not need feeding, do not get tired, do not get distracted by other e-noses or e-noses of the opposite sex, do not need trained human handlers (particularly once the e-nose is built into an automated process line or system), and are considerably cheaper to run and maintain!

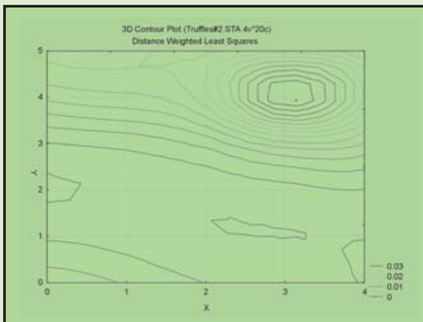


Figure 4: Contour map of the response from an e-nose above a 75 x 75 cm area of soil with buried truffle

Other applications include on-line process control with instant feedback to warn of variations in a manufacturing process. An electronic nose can replace the taking of grab samples and off-line analysis later. The electronic nose is thus cheaper and gives information quickly, hopefully in time to make amendments to, or stop, the process if the product becomes out of specification.

Sentinels

Electronic noses can be used in combination to monitor areas, such as construction sites or large factory sites for odours that may cause nuisance to the local populace. In much the same way as we obtained odour contours for the truffles, it is possible to produce a similar map over a wider area. Knowledge of wind direction and other meteorological factors can allow prediction of possible complaints and suggestion of remedial action. The Centre has conceived of and is working on a "sentinel system" of linked e-noses to monitor pollution from factories that give offence to neighbouring communities. The system will monitor the odours given off by the factory 24hours a day to help take remedial action before disputes arise and resolve disputes about where the odour has come from: "my stink or yours?"

Odour recognition by humans

A unique aspect of the Centre for ChemoSensory Research is that it can provide research and analysis of the response of humans

cont. pg 10

Chemical Sensor and E-Nose Program continued

to particular odours, and can analyse chemically those odours. We have a fully equipped sensory laboratory and can perform odour threshold and other psychophysical studies. In the School of Chemical Sciences at UNSW we have access to a range of chemical analysis instrumentation including GC, GC-MS, HPLC etc.

It is possible, therefore, to take an environmental problem, collect air from the site and identify the particular chemicals that are objectionable to the public. An electronic nose can be constructed that will be sensitive to those chemicals and by proper calibration will be programmed to give an alarm when they rise to a nuisance level.

Plate 1: Photograph of a four sensor nose – dimensions: 5 x 10 x 20 cm

Electronic Tongues and in situ sensors

In collaboration with the UNSW School of Chemical Sciences, several novel biosensors have been developed. In particular, we are researching the use of immobilised peptides as metal ion sensors in environmental waters. We have claimed ppt (parts per trillion) sensitivity for copper in water (Yang et al., 2001). Our approach is similar to that of the e-nose, in that we are developing arrays of different peptides on a chip. The voltammetric responses from, for example, sixteen peptide modified electrodes may then be calibrated for a number of target species.

What can the Centre for ChemoSensory Research offer?

All of the above examples of electronic noses have been developed by us with public and private funds. We hold the IP on all of our inventions, and have protected by patent one of the configurations. The rest embody considerable know how.

We do not mass produce our systems, but offer solutions to specific problems, including the development and supply of e-nose arrays, software and training of personnel. Each of our projects is governed by appropriate IP agreements between the University and the client.

The lack of success of large, expensive commercial electronic noses is inevitable. It will never be possible to produce a 'one size fits all' nose. When the complexity rises (some instruments have 40 - 60 sensors) problems of noise, sensor failure and general robustness of the calibrations has meant that the potential advantages of this technology are lost. We believe that by offering small, cheap, dedicated portable instruments will lead to useful devices that can find their place in the analyst's portfolio of methods.

Bibliography

Barnett D. (2001) E-mail from France. *ChemoSense,* 3(3), 16.

Doran, D. Hibbert, D.B. and Barnett D.(1999) Studies of the Reactions of Tyramine and Lysine with Aldehydes to give Fluorescent Substances, In Iles, P. and E Knox E. (Eds.) *Proceedings of the Australian International Symposium on Analytical Science,* 131 - 134.

Doran, D., Hibbert D.B., Kumar N. and Barnett D. (1999) Deriving A Kinetic Model for the Reaction Of Amines and Aldehydes. *Fluorescence Spectrophotometry (Abstracts),* 6th International Conference on Methods and Applications of Fluorescence Spectroscopy, Paris, France, 12-15 September 1999, 26.

Hibbert D.B.(1999) Electronic noses for sensing and analysing industrial chemicals, In G.A. Bell and A. J. Watson (Eds.) *Tastes and Aromas, The Chemical Senses in Science and Industry.* Sydney: UNSW Press, 180-188.

Hibbert D.B.(1997) Chemometric analysis of data from essential oils. In H.F. Linskens and J.F. Jackson (Eds.) *Modern Methods of Plant Analysis.* Vol. 19, Analysis of plant fragrance, Springer, Berlin Heidelberg New York 119 - 140 (1997).

Hibbert D.B., Barnett D. and Doran D.(2000) *Odour sensor,* Australian Provisional Patent, PQ 9371.

Yang W., Jaramillo D., Gooding J. J. , Hibbert D. B., Zhang R., Willett G. D. and Fisher K.J. (2001) Sub-ppt detection limits for copper ions with Gly-Gly-His modified electrodes, *Chem. Comm.*, 1982-1983.

Upcoming Events

21-24 July 2002
Combined 35th Annual AIFST Convention and FOODPRO'2002
Sydney Convention and Exhibition Centre
Darling Harbour, Sydney, Australia
Contact: aifst@aifst.asn.au and www.aifst.asn.au

21-23 July 2002
Symposium on Trigeminal Sensitivity (ECRO Satelite)
University of Erlangen, Nuremberg, Germany
Contact: Thomas Hummel: thummel@rcs.urz.tu-dresden.de

23 July 2002
Olfaction in Drosophila (ECRO Satelite)
University of Erlangen, Nuremberg, Germany
Contact: Thomas Hummel: thummel@rcs.urz.tu-dresden.de

26 July 2002
Sense-ation 2002: Sensory Analysis and Consumer Research Seminar
Food Science Australia, Werribee, Victoria
Contact: Alison Johnson: alison.johnson@foodscience.afisc.csiro.au

23-27 July 2002
ECRO XV Congress
University of Erlangen, Nuremberg, Germany
Contact: http://www.tu-dresden.de/medkhno/ECRO preliminary.htm

27-28 July 2002
Symposium on Genetic Variations in Taste Sensitivity (ECRO Satelite)
University of Erlangen, Nuremberg, Germany
Contact: john.prescott@stonebow.otago.ac.nz

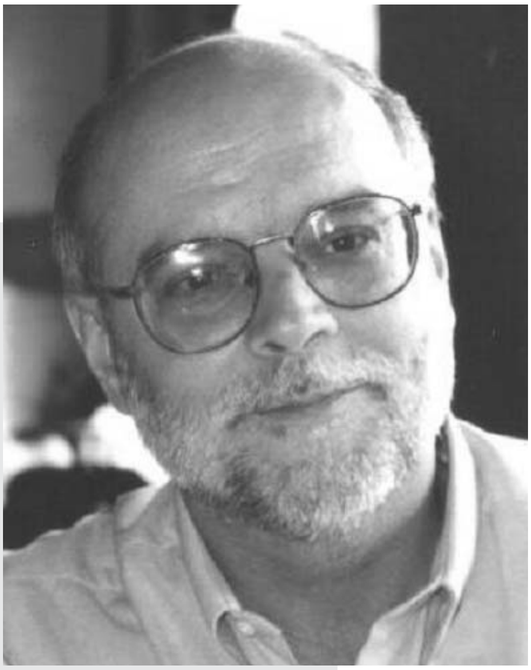
31 July - 2 August 2002
The 6th Sensometrics Meeting
Dept. Statistics, Univ. Dortmund, Germany
Contact: www.stastik.uni-dortmund.de/sensometrics/

17-20 November 2002
The 8th Pacific Rim Biotechnology Conference
Sheraton Hotel, Auckland, New Zealand
Contact: info@biotenz.org.nz

3-5 December 2002
Third Asia Pacific Symposium on Neural Regeneration
Sheraton, Perth, Western Australia
Contact: Sarah Dunlop, Ph. +618 9380 1403
sarah@cyllene.uwa.edu.au
http://neuro.zoology.uwa.edu.au/symposium.html

7-11 December 2002
Chemical Senses Meeting at the Great Barrier Reef
AACSS Fifth Annual Meeting and International Symposium
Heron Island, Queensland, Australia
Contacts: Wendy.Burchmore@tq.com.au
g.bell@unsw.edu.au

Vale: Bob Johnson, Flavour Chemist, 1945 - 2002



Robert Leonard (Bob) Johnson

Robert Leonard (Bob) Johnson died on 17th April 2002, aged 57, a victim of terminal Motor Neurone Disease.

Bob recently said that a reason he became a flavour chemist was "the fearful wince" his father made with his face when eating his breakfast grapefruit.

"My father's pained expression would last five long seconds after which he would look up, smile and declare 'delicious'! The bitter and sour taste that made my father's morning ritual so memorable was such a major problem that it made it into the top 101 problems facing the food industry in 1969. It plagued the Australian orange industry for over eight decades."

Bob joined the CSIRO, in 1972, after completing a PhD in physical chemistry at the University of New England. Bob found that the compounds responsible for bitterness in oranges could be selectively extracted using cellulose beads, which he manufactured innovatively from cellulose powder. He tested a range of absorbents, the best of which is now used around the world in what is commonly called the "Australian Debittering Process". The improved process reported in 1981 could debitter navel orange juice cost-effectively and also reduce acidity of early season citrus fruit.

Impact on Citrus World

In response to industry requests for a method for detecting orange waste extracts *(pulp wash)* in commercial juices, Bob developed a method now used around the world, which definitely identified the use of pulp wash in fresh orange juice. He also studied methods for differentiating freshly squeezed juice, not-from-concentrate juices, and reconstituted concentrated orange juices. Industry experts acknowledge Bob's method as having a major impact on the world citrus trade.

Bob sat on various august bodies charged with writing and regulating juice industry practices and was a member of the Food and Nutrition Sciences Advisory Board of the University of Western Sydney.

Bob turned his attention to such diverse and complex areas as extracting cholesterol from foods, chlorophyll from kiwifruit, lysozyme and avidin from hens' egg white, and lactose from whey. His work included the chemistry underlying formation of cooked meat aromas and flavours by extrusion processes. He also pioneered use of piezo-electric sensors for food process control.

Bob's patience, diplomacy, persuasion and generosity have been an inspiration to the many young scientists he has supervised over the years. It is testament to his nature that the disease never broke his spirit: he remained bright and cheerful throughout, always putting family and friends first. It is fitting that Bob, who was never bitter during three years of suffering with Motor Neurone disease, had made such a profound impact on the food industry by removing bitterness. Next time you sip your orange juice spare a thought for this great man and scientist. He is survived by his wife Norma, two daughters, Susan and Lucy, and a grandson, Benjamin.

Acknowledgment: Text and photograph, Rob Sleigh and Bob Steele, CSIRO, Sydney, Australia.

The Smart Foods Centre

The Smart Foods Centre (SFC), an Australian Research Council Key Centre, was founded in 1999 on the concept of developing a healthier food supply through alliance between the higher education sector, government, food industry, University of Wollongong and the community. Its primary role is to support Australia's food industry in an area of national, social and economic importance, viz. the development of healthier value added foods.

The Centre

The SFC is able to play a vital role for food industry through education and research. This is particularly relevant with the changing food regulation and policy climate. Food industry has a need to pose nutritional questions and have them addressed through credible research and development targeting specific population groups. The Smart Foods Centre with its strengths encapsulated by the personnel who work within the programs and their research interests is well positioned to help address these issues. Of particular interest to industry is Smart Foods Centre ability to conceptualise nutritional issues from the population back through to the agricultural level - table to farm. Coupled with broad ranging experience in research in obesity, cardiovascular disease and diabetes (metabolic research), the SFC has great ability to conduct distinctive research. The building of a human calorimeter -the only one in the region, is currently enhancing this expertise. With the established proficiency in human nutrition and dietetic research the Smart Foods Centre has unique capacity in research areas of critical health concern to the Australian population and the "western" world.

Research Areas

Broadly the research areas fall under the following key areas:

- Human performance: *Extending nutrient effects on human physiology well beyond the classical cardiovascular risk factors of blood pressure, cholesterol, triglycerides and lipoproteins to discovery and applied research in heart function, cardiac metabolism, arrhythmia risk, skeletal muscle function, physical activity and fatigue.*
- Human Calorimetry: *Evaluation of human energy balance at rest and in exercise both in healthy and morbid populations. Emphasis will be placed on the opportunities for foods and nutrients to improve the quality of life.*
- Diet and Metabolic Syndrome: *The relationship between dietary factors and elements of the metabolic syndrome at mechanistic and clinical intervention levels.*
- Biomarkers of Oxidation and Antioxidant Function: *Detection and measurement of biomarkers of oxidation and potential identification of antioxidant components in foods that could manage oxidative stress as it relates to human performance and metabolism.*
- Consumer Choices: *Developing a framework for conducting systematic and critical consumer research linked to the development and marketing of new food products and the evolution of the food regulatory system. Focussed research identifying consumer needs, attitudes and beliefs in relation to food and acceptability and adaptability of specific research outcomes into mixed diets*
- Human Trial Methodology: *Further development of dietary intervention trials as a means of establishing evidence for health benefits of nutrients and/or foods. This includes advances in diet methodology, food databases, consideration for exercise/activity and assessment of cardiovascular and other clinical outcomes.*

The Education Program

The Nutrition Management program supports the mission of raising nutritional awareness and developing a healthier food supply. By providing short intensive courses it enables working individuals to undertake pertinent continuing education as part of their career development. The courses seek to expose key nutritional areas of concern and draw upon the key experts in the area both internal to the Smart Foods Centre and externally to other Universities, professional bodies and non-profit organizations. The nutrition management program targets industry personnel responsible for the integration of nutrition into the food supply. Students can choose to undertake short courses as individual units, enroll in Graduate Certificate or Masters program, or undertake a research PhD program or follow up the basic Masters program with a Masters of Business Management.

Areas to be covered this year in the short courses include Food Regulation and Policy, Contemporary Issues in Food and Nutrition, and Food Innovation incorporating issues and opportunities with new technologies including biotechnology. Nutrition Research skill development is also being offered in a condensed course incorporating eight (8) half day sessions and internet materials.

For further information on the Smart Foods Centre please contact Anne McMahon, Education Co-ordinator at the Smart Foods Centre on email anne_mcmahon@uow.edu.au or phone (02) 4221 4829 ■

Vol. 4 No.3 June 2002

NEWS

Phantosmia Unmasked

From the ChemoSense Literature Snout

Imagine waking up to the sickly smell of rotting garbage and doggie dos. You brush your teeth and taste burned rubber and rugby socks that have been used to trample the juice out of corpses. Your cornflakes, with cream, honey and strawberries, dissolve into the flavour of very old fish heads and foul meat dipped in puke.

Some people have these ghastly experiences, even for years on end, and they are not stimulated by anything resembling the horrible things they smell or taste of. Their doctors may even tell them they are insane and prescribe the treatments reserved for lunatics. Others do go mad; in as much as they decide it is better to commit suicide.

The condition is called *phantosmia*. It is defined as "the intermittent or continuous perception of an odour independent of nasal airflow without change in the odour perception when nasal airflow is blocked unilaterally or bilaterally" (Leopold et al., 2002).

At first, the perceived phantom malodour arrives spontaneously. Sometimes heralded by a loud sound, a strong smell or an "aura" (a premonitory feeling akin to those reported to precede epileptic episodes), it usually lasts a few minutes, but it may recur and with increasing frequency from monthly, to weekly, to daily. Each episode can last all the waking day. The condition can then persist for years and decades.

A recent paper (Leopold et al, 2002) helps clarify what may be occurring in this unpleasant affliction. They report a follow-up study of eight people who had a specific kind of phantosmia: one which appeared to result from breathing through one (and always the same) nostril. Their symptoms had plagued them for from 4 to 19 years. Blocking that nostril could always stop the perceived odour.

The patients were aged 21 - 35 years, and seven were female. All were deemed to be psychiatrically stable, had no history alcohol or drug abuse, and were not unusual emotionally or intellectually. They all received surgery to the apparently affected side of the nose. In four patients the first operation did not eliminate the phantom and the procedure was repeated. Two patients had both sides operated on.

First, it was ascertained that cocaine, dripped into the apparently offending nostril, eliminated the phantom odour. The patients were then anaesthetised and, by means of endoscopic surgery, their olfactory nasal mucosa (the smell "retina" of the nose) was removed from the surface where the olfactory nerves enter the brain through the bony "sieve" called the cribriform plate. The resulting bare surface was then plugged with grafting tissue to prevent leakage of cerebrospinal fluid into the nose. In short, the operations were a success and all eight patients, on follow-up, 1 to 11 years later, all answered in the affirmative to the question "If you had to do it over again, would you have the surgery".

At the time of interview, phantosmia had disappeared from 7 out of the 8 patients. It is postulated that neural regrowth may have occurred in the single odd case. Although we do not know how many patients would have lost their phantosmias if not operated upon, the long endurance of the condition in untreated people suggests that the surgery was responsible for the elimination of the phantosmia.

The surgery is radical, removing the primary sensory apparatus for the sense of smell (akin to blinding one eye to eliminate visual disturbances). It requires skill and is risky (imagine having cerebrospinal fluid from your brain trickling down your snout).

Nevertheless, the results of this research, with ancillary histology and various hi-tech scans of the patient before and after surgery, firmly places the seat of the phantosmia in the periphery of the system, that is, in the olfactory mucosa and its connections into the olfactory bulb. If these are removed, the phanosmia disappears. Had the condition been a "psychiatric" one, the operation to the primary receptive tissue would have been ineffectual. We know, now, that these ghastly phantosmic experiences, of these patients, originated in the nasal apparatus.

For this specific unilateral phantosmia, then, there are prospects of cures (immediately, if you don't mind having your olfactory epithelium stripped out and losing your sense of smell on one side), and for better treatments, as the causal factors at the periphery of the system become identified.

Reference:

Leopold, D. A., Todd, A.L. and Schwob, J.E. (2002) Long-term follow-up of surgically treated phantosmia. *Archives of Otolaryngology, Head and Neck Surgery,* 128(6), 642-647.

Coming up in ChemoSense

Pheromones for Humans
Fat Facts
Smell and Taste Clinic
South Africa Revisited

*Visit our Site: www.chemosensory.com

NEWS

PROP POPS UP TOPS?

"PROP" (6-n-propylthiouracil) is an intensely bitter-tasting substance, at least to *some* people. To others, it has *no taste at all.* A special international symposium of chemosensory scientists researching the genetic basis, cultural and health implications of taste perception will gather in Erlangen, Germany on 27-28 July 2002 to talk about PROP. The satellite meeting of the European Chemoreception Research Organization (ECRO) will thoroughly review and discuss the research findings, including its predictive power for food choice by individuals, chemosensory sensitivities in populations, dietary disorders such as obesity, cardiovascular disease, alcohol and fat intake. Contributors include CCR associate John Prescott (University of Otago, N.Z.), who has co-organised the meeting, and CCR members Graham Bell and Hae-Jin Song.

Hemp Food Complies with Zero THC

Food Online reports that US Company HempNut Inc announced on 7 February that it believes it is the only DEA-compliant hempseed food company in the USA.

A new Drug Enforcement Administration regulation bans THC in hempseed products for human consumption. HempNut Inc claims its hempseed foods have been compliant with the zero THC standard since 1994.

Hempseed food is said to be highly nutritious, high in omega-3 fatty acid and higher in protein than meat or fish. Removal of the seed's shell makes it more edible. In this form it tastes like sunflower seed. HempNut Inc makes a range of products from hempseed, including corn chips, food bars, choc chip cookies, a cheese alternative and a veggie burger.

More information:
http://www.thehempnut.com
http:// www.foodonline.com

ChemoSense (ISSN 1442-9098)

Published quarterly by the Centre for ChemoSensory Research, The University of New South Wales,
Australian Technology Park, Sydney, Australia 1430.
Ph. (+61 2) 9209 4086; Fax (+61 2) 9209 4081
Web: http://www.chemosensory.com

Production Team
Editor: Graham Bell, Ph (+61 2) 9209 4083 g.bell@unsw.edu.au
Advertising & Subscriptions:
Brian Crowley, Ph (+61 2) 9209 4082, b.crowley@unsw.edu.au
Design and Layout: Lawton Design pty ltd

THE UNIVERSITY OF NEW SOUTH WALES