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Chemo Sense

EDITORIAL

Sense and Consequence of Taste - and Iodine

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If our noses draw us to food, we are governed mostly in what we allow into our bodies by our tongues: by our sense of taste. If we cannot stomach something we are "disgusted". Our gustation rejects the intruder. To swallow the bitter pill we need a sugar coating. There is no word that applies more purely to not liking the taste of something than "disgust".

Does taste play a part when the food is not rejected? Is there a gustatory rating for reward or pleasantness? As you will learn from our privileged review by Tom Scott, the answer is "yes". The sense of taste (gustation) reports to the body what it is receiving, and readies the metabolism for the consequences. A memory system records the experience against the taste information. Working in conjunction with our capacity to learn, without the necessity of consciousness, our taste sensory system shapes our preferences, as we go through life. *cont. pg 2*

The Sense of Taste

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The chemical senses first appeared in coelenterates some 500 million years ago, and represent the most primitive specialized sensory systems. It is appropriate, therefore, that they manage the two most fundamental biological drives: eating to sustain the individual, and reproduction to sustain the species. Smell has become more specialized for the control of reproduction, while taste has specialized in the control of eating. Receptors for the sense of taste are located at the threshold between the external and internal worlds of the animal. The individual may select foods according to familiarity, appearance, or odor, and yet the final decision to swallow is made only with the approval of the sense of taste.

The mouth is the beginning of a long chemosensory tube that extends from tongue to duodenum. Gustatory receptors are not manifestly different from chemoreceptors elsewhere in the body. Glucose is recognized by beta cells in the pancreas and by gustatory receptors on the tongue through similar mechanisms. Sodium ions in the kidney control water balance whereas the same ions entering taste cells elicit a sense of saltiness. Monosodium glutamate is recognized on the tongue by the same metabotropic glutamate receptors as exist throughout the brain, though at a thousand fold higher concentration. What is unique about taste receptors is not that they recognize chemicals, but that they do so before the decision to swallow has been made. Therefore, the information can be used to drive reflexes of acceptance or rejection, and to provide the animal with a sense of reward for the consumption of nutrients, or disgust at the taste of toxins. *cont. pg 6*

INSIDE:

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Sense and Consequence of Taste - and Iodine, continued

Tom Scott shows how the fundamental mechanisms of the system do this and how it is we know about it. When we are lacking a nutrient, our gustatory system guides us to the food we need. Improvement in health marks the food as a preferred substance. The taste of what is lacking is not what is important, only the identifying features provided by taste to find and recognise the same food again.

So for, say, iodine deficiency, (concern for which, Australian nutritionist Rosemary Stanton has recently signalled - thanks to TV program "Burke's Backyard") foods providing this vitally important micronutrient would tend to be preferred.

What if the Cupboard is Bare?

A big problem arises when there is no food or source available containing enough iodine. Then the consequences are potentially devastating: the "clever country" could turn into the "cretinous country": intelligence declining and people becoming universally slow-witted, as thyroid disorders take their toll. Some may believe we are already well on that path, and that is not a comment on the recent election!

Our traditional source of iodine (milk, from sterilisation of vats with iodine) has disappeared with modern non-iodine sterilisation. Our soils are generally low in iodine, and our fresh foods are inadequate sources. We are cutting down on salt in the home, and people are forgetting why they should buy iodised salt. So there is a real danger that our taste system, described so eloquently by Tom Scott, will not save us. Rosemary suggests a remedy: persuade the cereal and bread manufacturers to use iodised salt in their products, where salt is a technological necessity, to bind the chemistry of bread ■

Fourth Annual Meeting of The Australasian Association for ChemoSensory Science

Held at The Sydney Children's Hospital, Randwick, NSW, Australia on 6th August, 2001.

Plenary Lecture

The Insect Olfactory System - Structure and Function

Bill S. Hansson

Department of Crop Science, Chemical Ecology, Swedish University for Agricultural Sciences, Alnarp, Sweden

Insects depend to a great extent on odours to find sexual partners, locate suitable oviposition sites or identifying food sources. This heavy dependence on olfactory cues has caused the evolution of a highly sensitive and often extremely specific olfactory system. Interestingly, the system's bauplan is highly conserved over evolution. Receptor neurons detect airborne molecules. The signal is delivered to a single glomerulus located in the antennal lobe. Here, local neurons serve as local communicators between glomeruli. Projection neurons in turn lead the processed signal from the antennal lobe to higher brain areas as the mushroom bodies and the lateral protocerebrum.

Central coding of olfactory information, both within the pheromone- and the host-odour-processing system occurs within the antennal lobe glomeruli. Here we have studied activation patterns elicited by different odours by optical imaging using calcium sensitive dyes. Coding of specific odours typically appears as a spatial map among the glomeruli.

In insect sex pheromone communication the female typically emits very low amounts of a species specific mixture, usually composed of between two and seven components. The male has to identify these components that often only differ by being isomers. The male also has to establish that the components are present in the right ratios, as some species only differ in mixture ratio. We have studied the neural correlates to these capabilities, at the peripheral and at the central level. Receptor neurons are narrowly tuned to identify molecules extremely specifically, while some antennal lobe neurons serve as "blend detectors." Insects are also dependent on the temporal structure of an odour plume. Both on the antenna and in the antennal lobe neurons coding for very fast fluctuations in concentration have been identified.

The host odor detecting system was long considered to be inferior to the pheromone system. Host specific receptor neurons were reported to be unspecific and non-sensitive, compared to pheromone neurons. Recent investigations have, however, shown that this traditional view was wrong, probably depending on the fact that key stimuli were lacking. In investigations of several different insects orders, using combined gas chromatography and electrophysiology, we have shown that host odour-detecting neurons can be as specific and as sensitive as those found in the pheromone system.

Abstracts of Conference Presentations

1. The Permeation and Selectivity Properties of Native and Recombinant Mammalian Olfactory CNG Channels

P. H. Barry[1], W. Qu[1], R. Kaur[1], X. O. Zhu[1,] S. Bieri[2], A. M. Cunningham[2,3] and A. J. Moorhouse[1]

[1]School of Physiology and Pharmacology, [3]School of Women's and Children's Health, Faculty of Medicine, The University of New South Wales, Sydney, Australia, and [2,3]Neurobiology Program, Garvan Institute of Medical Research, Darlinghurst, NSW, Australia

Cyclic nucleotide-gated (CNG) ion channels play critical roles in olfactory transduction in olfactory receptor neurons (ORNs) and appear to be present at a much higher density than IP3-gated channels in mammalian ORNs [2]. We have shown that the permeation properties of recombinant α homomeric olfactory (rOCNC1) channels in HEK293 cells are very similar to those of native CNG channels, with both α and β subunits. From both recordings of macroscopic and single channel currents, we have shown [3] that the recombinant channel has selectivity sequences for monovalent alkali and organic cations, which are similar to those of the native CNG

cont. pg 10

Chemical Senses on Heron Island 7-11 Dec 2002

Photo: Courtesy of Heron Island, P & O Resorts

John Lennon should have written this:

"Imagine there is a heaven, it's easy if you've been to Heron Island."

The Australasian Association for ChemoSensory Science (AACSS) will hold its annual scientific meeting on Heron Island, off the coast of Queensland, Australia, from **7-11 Dec, 2002.**

After a survey of membership and of the international chemosensory community (AChemS, JASTS and ECRO) in May 2001, and a very favourable general response, it was decided to run the 2002 meeting at this heavenly venue.

The international community is invited to attend. Be assured that this will be a memorable and intellectually valuable experience.

Further details will be given in ChemoSense, in February 2002. Please mark your diary and calendar now, for the meeting dates of 7 to 11 December 2002. Extended stays can be arranged. AACSS has negotiated these at the same discount rates that apply to the conference.

Start planning now. A general brochure on Heron Island is enclosed with this issue of ChemoSense. For information on the Heron resort, consult www.poresorts.com.au (follow links to Heron Island). When bookings open they will be at conference discount rates, and made through Queensland Travel Centre: Wendy.Burchmore@tq.com.au.

For other questions about the meeting please contact g.bell@unsw.edu.au until further details are published ■

Great Events In Europe in July

The next meeting of the European Chemoreception Research Organisation (ECRO) will be held in Erlangen-Nuremberg, a medieval town in Bavaria, Germany from July 24 - 27, 2002. Held every two years, this meeting typically contains the latest research on olfaction and taste from European, American and Australasian laboratories.

For further information, contact the society's website: http://www.ecro-online.org.

Next year's ECRO meeting will be particularly important because of two satellite symposia.

Immediately prior to ECRO (July 21-23), a **Symposium on Trigeminal Sensitivity** will be held in Pommersfelden/Erlangen. This symposium will feature presentations by key researchers in the area including Sid Simon, Gerd Kobal, Earl Carstens, Pam Dalton, Thomas Hummel, Norbert Thuerauf, Peter Reeh, Barry Green and Karl Messlinger.

The aim of the symposium is to bring people from different areas of nociceptive research together with a specific focus on trigeminal chomeosensory nociception. This includes researchers on cutaneous nociception, irritation in the upper and lower airways, and oral and nasal cavities, the processing of nociceptive input, and psychological aspects of pain/irritation.

For futher information contact Dr. Thomas Hummel (thummel@rcs.urz.tu-dresden.de).

On the evening of July 27th and during July 28th, an international **Symposium on Genetic Variations in Taste Sensitivity** will be held at the same venue as ECRO. For the first time, key researchers from the USA and elsewhere will present plenary talks on the measurement and significance of human sensitivity to the bitter compound 6-n-propylthiouracil (PROP), and its anatomical and genetic basis. Several talks will focus on the implications of PROP tasting for food choice and health. The meeting also aims to critically assess past studies of PROP status, with a view to reaching conclusions regarding optimal measurement procedures. In addition to presentations by Linda Bartoshuk, Adam Drewnowski, Valerie Duffy, Dannielle Reed, Beverley Tepper, and Rick Mattes, there will also be opportunities for attendees to present their own PROP data at a poster session.

For further information, contact John Prescott (john.prescott@stonebow.otago.ac.nz) ■

Introducing 'ZNose'

Recent developments of "electronic nose" technology have largely focussed on the development of selective sensors to mimic the response of the human nose. By putting the sensors in an array, and using sophisticated software, it is possible to deconvolute the responses of the sensors, and output a "fingerprint" of the odour, allowing the recognition of differences of odour type and intensity.

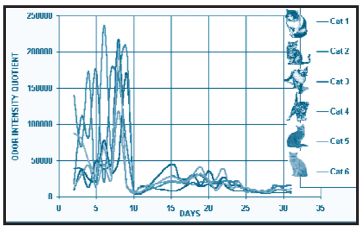
There are however major practical limitations of this approach:

- The overlapping responses mean that the recognition only works for a constant matrix, so even a very specific effect such as rancidity or contamination won't be recognised unless it is in an identical starting material
- The effects seen are so sensitive to variables such as humidity, sample presentation, and vessel cleanliness that often the real effect is swamped
- The sensors invariably drift with time, and drift correction, which is of only marginal benefit, requires running large numbers of stable samples over an extended period, supervised by highly qualified technicians
- It is necessary to run 3-5 replicates, each of which takes 10 to 60 minutes, so that the results are slow to emerge
- The sensor technologies, including MOS and conducting polymers, produce considerable overlap in response which makes the recognition process more difficult
- Even where clear recognition occurs, it is not usually possible to identify what chemicals caused the measured effect

Considerable effort has been devoted to developing highly selective sensors, which can be effective in limited single applications. However because of their narrow recognition range it is impossible to have a coverage of a wide range of possible odour producing compounds.

A new development in gas chromatography has suddenly allowed GC to be effective in odour measurement. Using a highly focussed, uncoated Surface Acoustic Wave (SAW) sensor, EST have managed to produce a revolutionary GC detector which is extraordinarily sensitive and very fast. By coupling the SAW sensor with a unique high speed column and injection system to separate the molecular species, the "ZNose" can measure volatile organic compounds in the parts per trillion range, at the limit of human olfactory response. It produces a single output for each compound, removing the confusing effects of moisture, solvents or matrix changes, is inherently calibratable and quantifiable, free from drift, portable and fast enough so that operators can check a sample and get real time feedback within a few seconds.

The resulting instrument is inherently very simple and reliable to use, and is achieving rapid acceptance by major organisations within Australia and overseas for tracking the quality of food, beverages and packaging from raw materials through intermediates to finished products, as well as for a range of environmental measurements and rapid identification of chemical compounds at low levels. An example of the use of the Znose for monitoring the odour of cat excretions, which resulted from the introduction of a new low odour food after 8 days on a conventional diet, is shown in the accompanying diagram, and shows the remarkable sensitivity and reproducibility of the technique. The individual measurements took 10 seconds each and method development took approximately 10 minutes.



For information on the ZNose contact:
Technical and Scientific
Phone 03 9886 9055
www.techsci.com.au ■

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Pigs *Can* Fly

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Sensory Research Opens Export of Pork to Singapore

Smell and Taste Issues Raise Concern

Australia's initial efforts to establish a market for pork in Singapore met with concern that consumers in Singapore might perceive shortcomings in the eating quality of Australian pork. Shoppers and trade representatives hinted that the taste and smell of Australian pork was not as good as competitors' pork.

The Confederation of Australian Pork Exporters (CAPE) commissioned a sensory study in Singapore by the Centre for ChemoSensory Research of UNSW. The objective was to determine if smell and taste is a real issue, and more specifically to identify potential actions for improving the competitive position of the Australian product.

Controlled inspection of raw and cooked pork was set up, structured discussion groups were conducted and sensory evaluation panels judged a full set of attributes of cooked pork and soup made from pork bones. Only Singaporean consumers, in Singapore, evaluated three Australian and two competitor products. The products were all blind coded when assessed and the Singaporean and Centre staff did not know the origins of the various products. This was therefore a "double blind" study.

Sensory Research Sets "Aunties'" Record Straight

Our measured consumer experience of the Australian product compared with European and South-East Asian competitor products showed *no reason for concern* about the eating quality of Australian product. In fact, the double-blind procedure proved that the three Australian products were superior to the competitors' products.

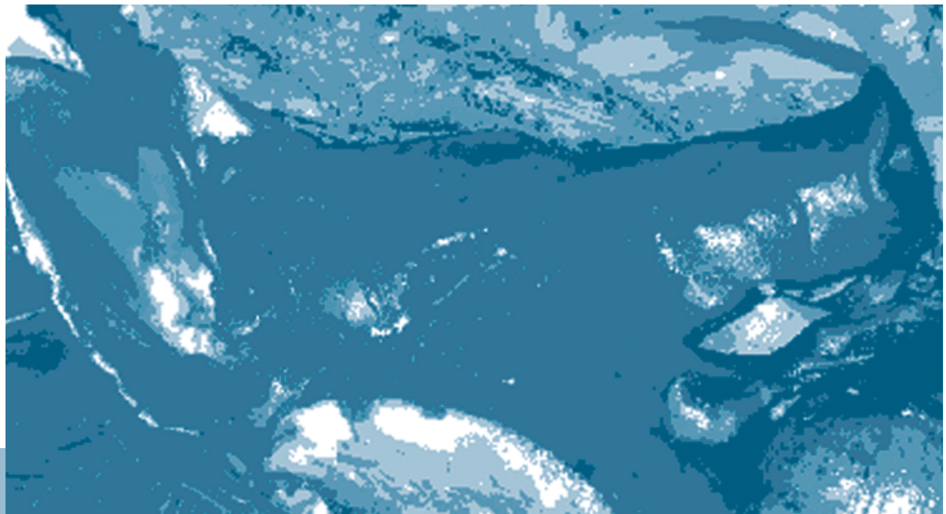
The smell of pork during cooking was not a major issue. The Australian products smelt no better or worse than competitor products during cooking. The focus groups did however, reflect the attitudes detected in the previous consumer survey by CAPE that Singaporeans *think* there is an unpleasant smell in Australian pork. The subjects were unable to differentiate any of the products on the basis of smell during cooking.

The smell of raw pork was differentiated, in terms of liking it, by the consumer panel. Interestingly, the panel liked the smell of one Australian Product, were indifferent to the smell of a second Australian product and did not like the smell of a third. They did not like the smell of either of the two competitor products.

The smell of pork in raw state or during cooking is not a crucial factor for two Australian products but was a concern for the third.

The visual characteristics of the Australian product may be below par with competitor's products. This had not previously come to light in consumer research or focus group discussions.

Australian products were superior in both meat and soup form. So, both the meat and the bone of Australian product were highly acceptable to the consumers. The research showed that meat and bone quality goes hand in hand.



Sensory attributes related to specific production variables showed where further action may be taken in the various steps needed to make pork exports a successful foreign exchange earner for Australia.

Age of consumer did not adversely change the sensory assessments.

Supermarket hygiene and convenience was rated highly by younger participants, but loyalty to wet markets lives on in some young individuals.

A qualification system involving grading and labeling pork for export was recommended.

It was recommended that all care possible should be taken to preserve the fresh appearance, aroma and flavour of the Australian product. More attention to the role of diet in pork taste quality is warranted.

Frequent reference to urinous odour and off odour in the discussion group suggests extreme caution is needed in the elimination of boar taint from pork exported to Asian markets such as Singapore.

Pork exporters should not be complacent about freshness quality of their products if they are to penetrate and hold a position in these Regional markets.

The information from this study can be used to dispel the misgivings in the trade and industry and to correct the misinformation that might have been circulating in Singapore at the time through, it was rumoured, a mysterious "aunty network." The "aunties" now have no legs (of Aussie pork) to stand on!

Onward and Upward into Asia for Australian Pork

CAPE could then proceed with confidence in communicating the qualities upon which this product stands out from the rest. Decision-leaders in Singapore would be appraised of these findings. Negative opinions would be minimised by ensuring that no batches of inferior pork are sold into Singapore. In addition, that inferior pork from other sources is not being falsely labeled as Australian and that the public image of Australian pork is positively developed by whatever means is at the disposal of CAPE and Australian pork producers ■

The Sense of

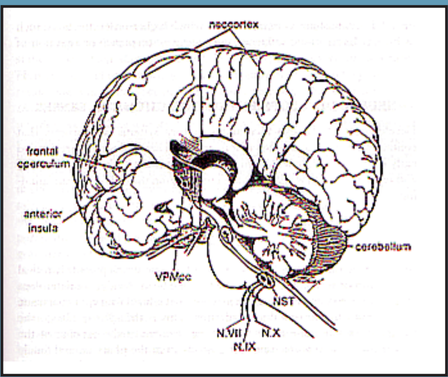


Figure 1. Overview of the central taste system. Three cranial nerves (VII, IX, X) bring taste input to the front part of the nucleus of the solitary tract (NST), while the back part of the nucleus receives visceral input. Taste signals proceed from NST to the thalamus (VPMpc), and then to the taste cortex in the frontal operculum and anterior insula. Drawing Mr. Birck Cox. Adapted from Pritchard, 1991.

Taste information enters the brain through three cranial nerves: VII, IX, X (Figure 1). The first gustatory relay in the central nervous system is in the nucleus of the solitary tract (NST), which serves as the engine for the rest of the system. The NST has the highest activity levels in the gustatory system, and drives at least three processes. First, information about taste passes to a variety of motor nuclei in the hindbrain that collectively orchestrate the reflexes of acceptance or rejection. Rewarding tastes, those that are normally associated with nutrients, elicit acceptance reflexes that include swallowing, licking, and expressions of satisfaction (Grill and Norgren, 1978). Offensive tastes, normally associated with toxins, evoke rejection reflexes which include a gaping mouth, use of the tongue as a plow to discharge the chemical, and vigorous shaking of the head. These reflexes are fully integrated in the hindbrain, and are well developed in humans even at birth.

Secondly, the nucleus of the solitary tract helps initiate digestive reflexes to prepare the body for food that is about to be consumed. Immediately beneath the NST lies the dorsal motor nucleus of the vagus nerve, which sends fibers throughout the viscera to control autonomic processes. Neurons in the dorsal motor nucleus send dendrites up into the NST where the perception of, for example, sweet, may cause them to stimulate the release of insulin from the pancreas. Thus, taste input may directly influence certain facets of metabolism.

Thirdly, taste input from the NST projects forward to higher levels of the brain where it provides two types of information: the identity of the chemical along with its strength, and an analysis of the reward value of that chemical. In macaques, the identification of a taste is probably made in primary taste cortex; the analysis of reward value probably occurs in secondary taste cortex and in the ventral forebrain.

From NST, taste information proceeds to the thalamic taste relay, and then to primary taste cortex which is located in the insula and operculum of the parietal lobe (Figure 1). From here, taste information is relayed forward to the orbitofrontal cortex (OFC), and also to the amygdala. Both OFC and amygdala have reciprocal connections with the lateral hypothalamic area.

TASTE AND THE CONTROL OF NUTRITION

The most basic issue in understanding any sensory system is to define what information it is extracting from the external world. Color, for example, is information on stimulus wavelength; pitch, on stimulus frequency. For taste, however, there appears to be no single physical dimension that controls all responses. The pH of a stimulus has impact on some neurons; molecular weight, molecular configuration, and hydrophobicity influence others. However, the single dimension that accounts for most taste activity is not physical at all. Rather, it is physiological: the consequences of swallowing a chemical. Taste is, at its foundation, an internal sense. Its mission is to select from the complex and dangerous chemical world that surrounds us, those few substances that will serve our biochemical processes. These are carbohydrates and fats as sources of energy, proteins for the amino acids from which we reconstitute human tissue, and salt as the primary ion for controlling water balance throughout the body. Therefore, the taste system must be responsive to more than any single physical dimension. Yet it must reduce the full range of chemical information it receives to a decision of whether or not to swallow, i.e., whether to turn "other" into "self." Those among our predecessors who chose wisely from the chemical environment-those who accepted nutrients and rejected toxins-survived to become our ancestors, and so to pass on the wisdom of their taste systems. The role of taste is not to provide a continuous and often dispassionate analysis of our surroundings, as it is for vision or hearing, but rather to sample the chemical world occasionally and to render a judgment of pleasure or revulsion, always in relation to the body's needs.

If the purpose of taste is to serve the biochemical needs of the body, then it cannot be static because needs are in constant flux. The inherited wisdom that serves a species may not serve every member: a missing enzyme might prevent the digestion of a normally nutritious substance, rendering it toxic only to that individual. Seasonal fluctuations in the availability of certain prey or the maturity of particular crops may throw the balance of an individual's biochemistry toward or away from proteins, fats, or carbohydrates. A satiating meal might make the acquisition of additional nutrients undesirable for a period of time. If the taste system is to serve the animal, it must be adaptable in the face of these changing circumstances. And so it is, as the following evidence demonstrates.

CONDITIONING

The experiences of an individual have a profound effect on their later taste

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Taste contin.

preferences. Suckling rats mature to show preferences for tastes that were incorporated into their mother's milk. Children come to prefer the familiar cuisines of their native culture, for the characteristic tastes are associated with the satisfaction of nutritional needs.

Conversely, when a novel taste is followed by illness, a powerful aversion develops that warns the individual against further consumption of that food, even for a lifetime. We gave three groups of naïve rats quite different experiences with the novel taste of saccharin and asked whether those experiences would influence the way in which saccharin was subsequently processed by the taste system (Chang and Scott, 1984). The first group of rats (CS) tasted saccharin for the first time with no physiological consequences. The second group drank only water and then received an injection of LiCl into the peritoneum that made them desperately ill. However, they had no gustatory referent upon which to blame the illness. The third group was critical. These rats tasted saccharin for the

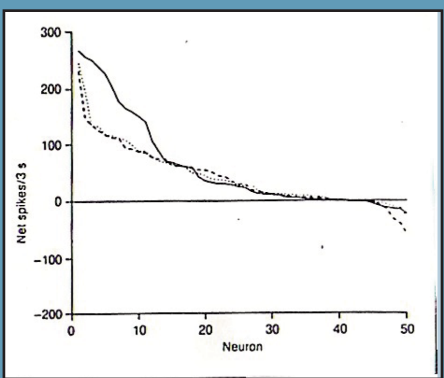

Figure 2. Responses of 50 individual neurons in each of three groups of rats to 0.0025 M NaSaccharin, the CS. The control group (...) experienced only the saccharin taste with no malaise. The US group (–) experienced malaise with no clear gustatory referent; the CTA group (   ) experienced three pairings of NaSaccharin taste with lithium-induced nausea. Only the neurons most responsive to the saccharin where influenced by the conditioning procedure. From Chang and Scott, 1984.

first time and were then injected with LiCl to generate the nausea that would be blamed on the saccharin. We then recorded the neural responses of all three groups to saccharin and an array of other tastants in the nucleus of the solitary tract.

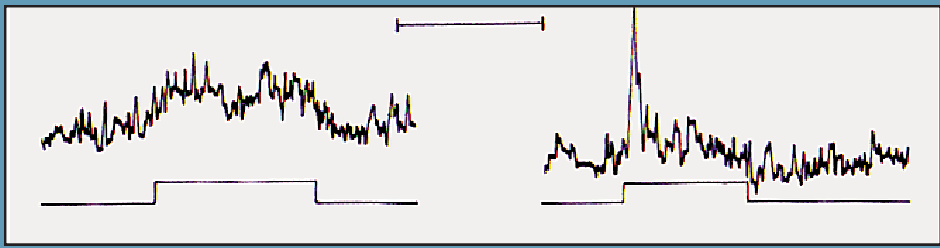

Figure 3. Typical time courses of responses to 0.5 M sucrose (left) and to 0.001 M quinine HCl (right). The bar beneath each response indicates the period of stimulus application. The time bar at the top represents 5s.

There were 50 neurons in each group (Figure 2). In those that tasted saccharin but remained healthy, or that were made ill but had no taste to which to attribute that illness, the responses were comparable. In the conditioned taste aversion group, however, responses of the most saccharin-sensitive neurons were distinctly elevated, by a mean of 60%. Furthermore, in analyzing the time course of the response, it became clear that this increase resulted from an extraordinary burst of activity that rose to a peak about one second after tasting the saccharin and which declined back to baseline within about three seconds. The normal time course of a response to sugar and to quinine are shown in figure 3. The saccharin response of the two control groups mimics a typical sugar response, as it should. The profile derived from the conditioned rats resembles that of quinine, implying that saccharin is now treated as a toxin by these animals (Figure 4).

Accordingly, rats that have had this conditioning experience reject saccharin with the full range of reflexes that they would normally show toward the taste of quinine. Saccharin no longer causes the release of chemicals in the rat's brain that are associated with reward (Mark et al., 1991). The simple act of conditioning has altered the gustatory perception of saccharin, changing it from the presumed nutrient it never was into a presumed toxin that it never became.

DEPRIVATION

We have seen that a preferred stimulus can be made aversive if it is deemed to cause harm. What of the converse? Can a previously aversive salty taste be made desirable by rendering the animal sodium deficient so that it seeks salt for survival? We recorded the neural responses in the

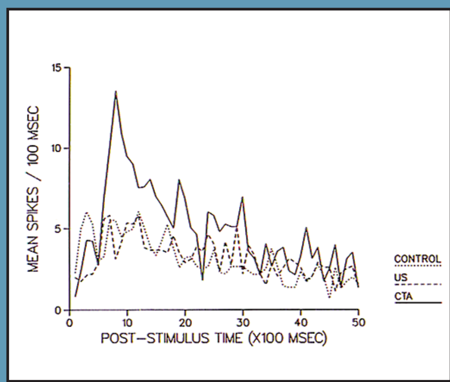

Figure 4. Post-stimulus time histograms of the responses of sweet-sensitive NST neurons to 0.0025 M NaSaccharin in CS, US, and CTA rats. Neurons in conditioned animals showed a burst of activity that occurred about 1s following stimulus onset.

NST of two groups of rats (Jacobs et al., 1988). The control group had normal levels of sodium in their diets and in their bodies. The experimental group was deprived of sodium in their diets for two weeks during which time they became severely sodium deficient. In these animals, taste cells that code for salt became much less active, while those that code for sweet became hyperresponsive. Placing hypertonic 3% sodium on the tongues of these desperately salt-deprived rats aroused activity in the very cells that signal hedonic reward. This does not necessarily mean that sodium tasted sweet to these animals; it implies only that it tasted good.

As one would expect, the same 3% sodium that evoked rejection reflexes from control rats was greeted with enthusiastic acceptance by their sodium-deprived

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The Sense of

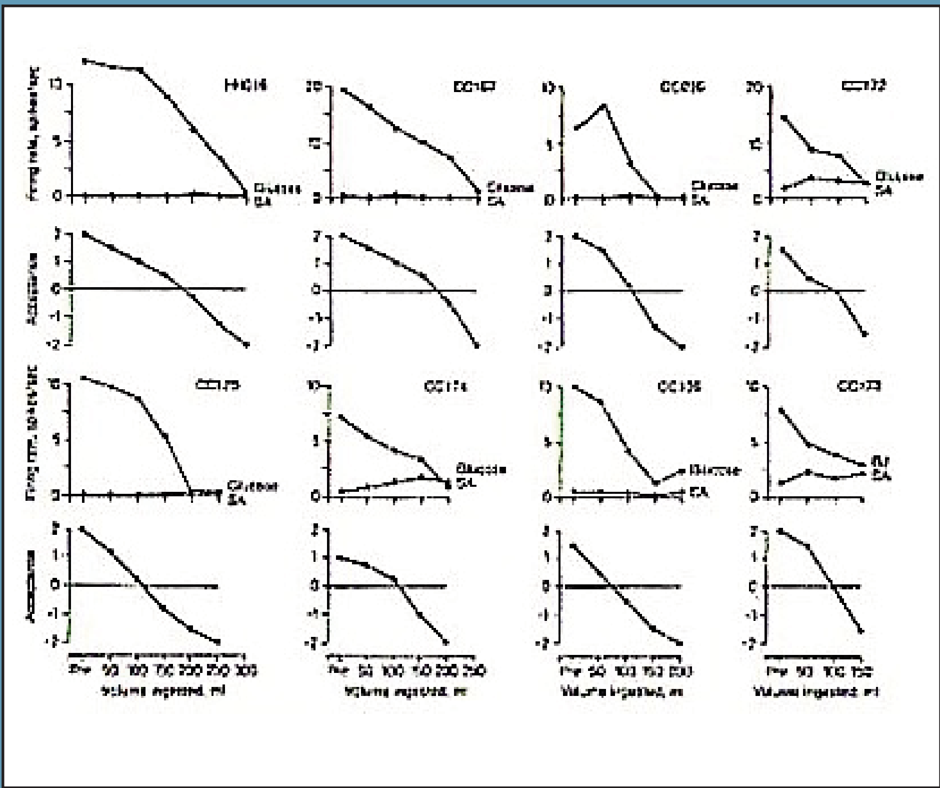

Figure 5. Spontaneous activity (SA) and neural responses elicited from cells in the NST by the taste solution on which the monkey was fed to satiety. Each graph represents the results of a separate experiment during which the monkey consumed the sugar solution in 50-ml aliquots as labeled on the abscissa. Represented below the neural response data for each experiment is the behavioral measure of acceptance of the solution on a scale of 2.0 (avid acceptance) to -2.0 (active rejection). The satiating solution is labeled on each graph. BJ- Blackcurrant juice. Responses in the NST were not affected by increasing satiety. From Yaxley et al., 1985.

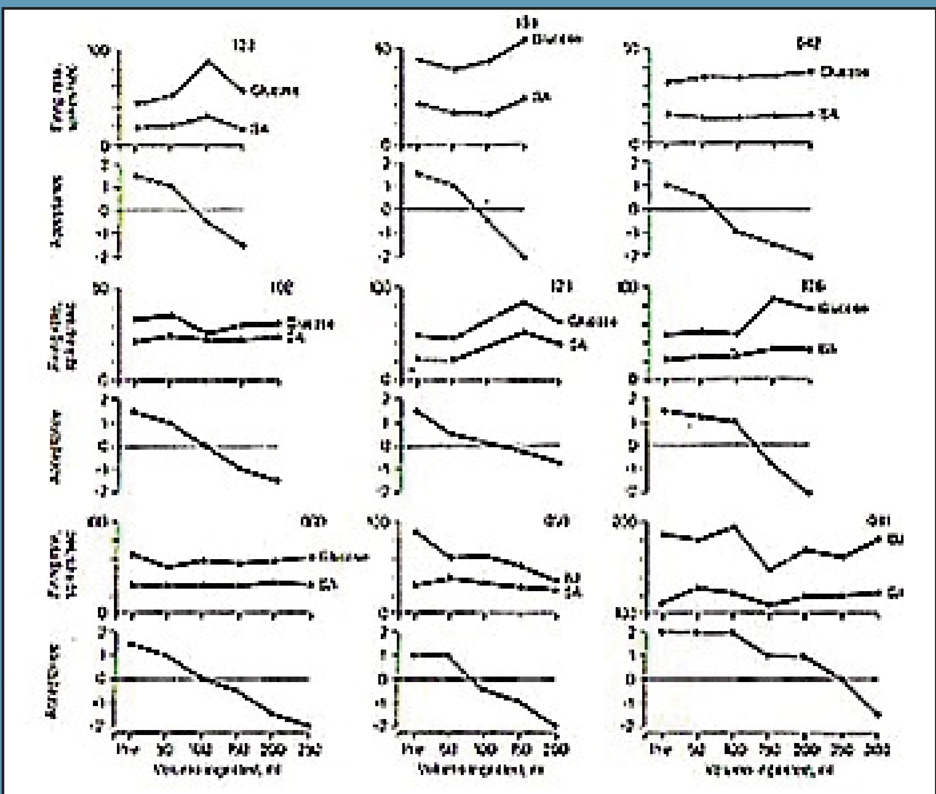

Figure 6. Same format as Figure 5, except that responses are derived from single neurons in the caudolateral orbitofrontal cortex of the monkey (OFC). At this level of processing, discharge rate is a function of level of satiety rather than the purely sensory aspects of the stimulus. The letters and numbers in each frame identify the monkey and the recording track, respectively. From Rolls et al., 1989.

counterparts. Therefore, the altered taste response to sodium in these animals was manifested in a reversal of their acceptance behavior. It also caused the release of neurotransmitters that are associated with reward.

EATING

The events discussed so far are uncommon. We are unlikely to develop more than a few conditioned taste aversions in our lifetimes, though the mechanism for this lifesaving ability is always at the ready. We fall into severe mineral imbalance only in certain habitats. It is perhaps not surprising that the taste system makes accommodations for such extraordinary circumstances.

But what of the daily events of eating? It is common experience that foods taste better when we are hungry, and lose their appeal as we become satiated. Does the taste system lose its sensitivity or its capacity to activate reward mechanisms? We recorded responses to the four basic tastes from the nucleus of the solitary tract in control rats and in those that had been made hyperglycemic by an intravenous injection of glucose (Giza and Scott, 1983). The hyperglycemic rats responded just as well as controls to the taste of quinine and nearly as well to the applications of HCl and NaCl. However, their responses to glucose were reduced by 18% during the 20 minutes following the glucose infusion. As blood glucose levels fell under the influence of insulin, taste sensitivity recovered. Analysis of the contribution of different types of taste cells revealed that this reduction was almost completely attributable to a profound loss of sensitivity of the subset of sweet-sensitive neurons. Therefore, during hyperglycemia, sugar temporarily lost the capacity to activate taste neurons whose responses give the greatest pleasure to the animal. The same effect has since been shown at the level of the parabrachial nucleus following an infusion of fat into the duodenum (Hajnal et al., 1999). Other manipulations that also make glucose more readily available to the brain result in a similar, though smaller,

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Taste contin.

reduction in taste sensitivity. The implication is that taste becomes less of a driving force for reward as our need for calories is reduced.

Humans, however, do not behave as the implications of these neurophysiological studies would imply. If neural responsiveness were reduced deep in the hindbrain, then the perceived intensity of foods ought to decline, as it does for a rat (Giza and Scott, 1987). Whether we are hungry or full, people do not report that the quality or intensity of foods is changed, only the reward value that they derive from them. Therefore, it became important to monitor responses in the human nucleus of the solitary tract to determine whether satiety reduced their responsiveness, as it did in rats. The best available surrogate for humans is the macaque monkey (Scott and Plata-Salamán, 1999). Therefore, we recorded the activity of cells in the NST while feeding a hungry macaque as much glucose as it was willing to accept. As the monkey progressed from eager acceptance of the glucose through neutrality to active rejection when he was totally satiated, the neural response to glucose in the NST remained unmodified (Figure 5). This is in sharp distinction to the results from rats, and implies that the responsibility for taste modification in primates shifts to higher neural levels.

We then turned our attention to the primary taste cortex where taste stimuli are presumably identified. The same manipulation led to the same result: whether the macaque was hungry or completely satiated, the response elicited by glucose was the same (Rolls et al., 1998). Rolls and his colleagues then proceeded to do the corresponding experiment in secondary taste cortex (Rolls et al., 1989). Here, they found the opposite results, one that corresponded to the findings in rats from deep in the hindbrain. As the macaque was fed to satiety with glucose, the neural response evoked by the taste of glucose declined to reach zero as the monkey achieved total satiety (Figure 6). In primary taste cortex, cells are interested in the quality and intensity of chemicals in the mouth, not in their reward value. In secondary taste cortex and beyond to the amygdala (Yan and Scott, 1996) and hypothalamus (Burton et al., 1976), cells signal not the quality or strength of the stimulus, but its reward value.

The implication of this series of experiments is that taste serves as an effective guide to dietary selection. We inherit a system from successful ancestors that confers upon us a broad wisdom about which substances to eat and which to reject. Upon this, we overlay the capacity to tailor our individual taste systems according to our experiences through conditioned aversions and conditioned preferences. Finally, the taste system is subject to adjustment in its sensitivity according to either extraordinary physiological demands such as sodium deprivation or to daily ones like the rise and fall of blood sugar or insulin levels. Thus, the better something tastes, the better it should be for you at that moment.

It is curious, then, that taste is seen not as a guide to optimal nutrition, but as an enemy to the dieter. Taste goads us towards the consumption of fats, carbohydrates, proteins, and salt, whereas our nutritionist advises us to reduce our intake of fats, salt, and calories in general. It is not the case that taste evolved to harm us. Rather, the environment in which the taste system operates has changed diametrically. Until recent centuries, people died predominantly not of heart disease, strokes, or type II diabetes, but of malnutrition or to infectious diseases with which the poorly nourished person was inadequate to cope. The goal of good nutrition was to permit the individual to bear children and raise them to the age of independence, a commitment that might require the adult to live for 35 or 40 years. In recent years, however, food in industrialized countries has become plentiful, and the sale of proteins, carbohydrates, fats, and salt has become a major industry. The taste system that evolved to provide great rewards for consuming these foods remains intact but the over consumption that inevitably follows from this reward reveals a whole new set of pathologies that hardly played into our evolutionary heritage: heart disease from arteriosclerosis, strokes from hypertension, and type II diabetes (adult onset) from chronic hyperglycemia. The definition of good health has shifted from survival until age 40 to having low cholesterol at age 75. Our taste system evolved to serve us effectively in a biologically competitive world of scarcity while we now inhabit an industrialized world of plenty ■

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channels [1] and that both the recombinant and native mammalian CNG channels exhibit anomalous mole fraction effects in the presence of Na+/NH4+ and Cs+/Li+ mixtures [4]. These results suggest that the recombinant channels should be a good model for structure-function studies of permeation and selectivity in these CNG channels. We now also have preliminary data indicating for the first time that mutating the only charged residue in the putative pore-forming region of the CNG channel, from a negatively charged glutamate to a positively charged lysine, has switched the channel from being cation-selective to anion-selective, indicating a critical role for this residue in its ion selectivity.

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Supported by the ARC, NHMRC, The Garnett Passe and Rodney Williams Memorial Foundation and CRC for International Food Manufacture and Packaging Science

2. Antibodies to Olfactory Receptor Proteins Reveal Two Different Forms of the Proteins in Olfactory Neuroepithelium and Olfactory Bulb Glomeruli

Vadim N. Dedov and Anne M. Cunningham

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Odorant receptors belong to a 7-transmembrane-domain multigene family consisting of up to 1000 members in mammals. Sensory neurones within the olfactory neuroepithelium expressing the same odorant receptor (OR) mRNA project axons terminating in one of a small number of glomeruli in the olfactory bulb, and this convergent projection is fundamental to the olfactory code. The precise mechanism by which these axons navigate past an array of potential synaptic targets to select the appropriate glomerular target is not known, but knockout studies have suggested that the OR protein itself plays a critical role in this process (Mombaerts et al., 1996; Wang et al., 1998). Using two polyclonal antibodies generated to recognise the family of OR proteins, one to the 2nd intracellular (IC) domain and one to the C-terminal region, we demonstrated for the first time, that OR proteins are present in the axon terminals of olfactory sensory neurones. Additionally, we found two distinct patterns of immunoreactivity: the C-terminal antibody labelling cilia and filling the presynaptic compartment of the glomerulus, in a manner similar to OMP and synaptophysin. In contrast, in the neuroepithelium the 2nd IC domain antibody selectively labelled intracellular accumulations of receptor in the olfactory sensory neuron and its dendritic projection. In the olfactory bulb, this antibody heavily labelled olfactory nerve fibres as they entered the glomerulus, in a distribution more like that of GAP43, which labels outgrowing axons. We believe these antibodies may distinguish between the folded, membrane-inserted form of the OR and pre-inserted intracellular proteins and will be valuable in understanding modifications that occur in the functional OR. Finding the membrane-associated form of the OR in the glomerulus is supportive of a dual role for this family of proteins in chemosensation and olfactory axonal targeting.

Supported by the Garnett Passe and Rodney Williams Memorial Foundation and the NH&MRC of Australia

3. The Influence of Molecular Structure on the Types of Interactions Between Odorants in Mixtures

Laing, D.G., Jinks, A.L., Segovia, C. and Hutchinson, I.

Centre For Advanced Food Research, University of Western Sydney, Richmond, NSW, Australia

Commonly, the choice of odorants for studies of interactions in odor mixtures is based on similarity of odor quality (eg Jinks & Laing, 1999). Although these studies have defined many of the characteristics of the types of interactions which occur between odorants, none have given information on the role of molecular structure in interactions. However, since it is now accepted that odor receptors are transmembrane proteins and to activate receptor cells an odorant must fit and bind to receptor sites, mixture studies can now be focussed on the structural features of odorants that may produce interactions that define molecules as agonists or antagonists in a particular mixture. Based upon physiological data which suggest the type of interactions that may occur between aliphatic aldehydes (Imamura et al, 1992), a study was conducted of the interactions of binary mixtures of heptanal (a C7 aldehyde) and the shorter chain C3, C4, C5 and C6 homologues. For the first time systematic changes in the types of interactions were observed, with non-reciprocal, reciprocal and additive interactions occurring as the difference in chain length between the molecules decreased. In brief, it is concluded that the C3 odorant is an antagonist for C7 and the interaction is predominantly peripheral; C4 and C7 interact predominantly centrally; whilst the additivity seen with C5, C6 and C7 suggest they operate through the same receptor and neural pathways.

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4. Ambiguous Odours: Effects of Prior Exposure to Other Odours on the Perceived Properties of Durian

Boakes, R.A.[1], Stevenson, R.J.[2] and Bilanenko, T[1]

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We tested whether the perceived properties of a synthetic durian odour would vary according to what odours the participants had just sniffed. In the first experiment one group was exposed to a set of three unpleasant context-setting odours that were followed by durian. These participants liked the smell more than a second group that had been exposed to three pleasant odours. This effect could not be due to sensory adaptation because dummy and water trials were interspersed between the context-setters and the durian test. Such a contrast effect was also obtained in a second experiment that used the same basic design, but the test now consisted of ratings of the *flavour* of durian when presented in an aqueous solution that participants sipped. This context-sensitivity of the perceptual properties of some odours suggests a role for top-down influences in olfactory perception.

5. The Basis of Glutamate Palatability in Foods: Does it Act as an Energy Source to Condition Preference?

J. Prescott

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Adding glutamate to appropriate foods enhances palatability and may increase intake. Carbohydrates and fats are also innately palatable in foods, and this is thought to signal their ability to deliver energy. The delivery of energy is able to modify liking for foods with which it is associated, in turn influencing intake. That glutamate taste may also signal provision of energy is suggested by the fact that, like sucrose, it can trigger increases in pancreatic secretions. There is also metabolic evidence that glutamate is used as an energy source in the gut. To test this, subjects were given a novel food containing added glutamate, fat or no addition, either consumed or tasted, over a series of 16 exposure sessions. Preliminary data have shown that subjects who consumed the food containing added glutamate had an increased liking for the

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food, relative to the taste-only condition. We interpret this as evidence that glutamate can act as an energy source to condition preference.

6. An Investigation of the Relationship Between Taste Papillae Density and taste Sensitivity for PROP in Children

Maryam Shabake, Ian Hutchinson, David G Laing and Anthony L Jinks

Centre For Advanced Food Research, University of Western Sydney, Richmond, NSW, Australia

Research in this laboratory (Hutchinson et al 2000) has shown that the taste bud density of 8-9 yr old children is higher than that of adults in the anterior tongue and their sensitivity to sucrose on small regions of the tongue is greater than that of adults. Elsewhere, it has been shown that taste bud density in adults is related to sensitivity to PROP a bitter tastant, with supertasters and non-tasters having high and low densities, respectively. The present study examines this relationship in children using anatomical (videomicroscopy) and psychophysical techniques. Children were trained to indicate the strength of salty and sweet tastants using a 9-point category scale before obtaining their ratings for the bitter intensity of three concentrations of PROP. The number of fungiform papillae and taste pores on each papillae were filmed and recorded for a small region of the anterior tongue. The results indicate that as with adults there is a strong relationship between taste sensitivity to PROP and the number of papillae. Current measurements are determining taste bud densities. It is concluded that by mid-childhood the structure and functionality of the peripheral taste system has characteristics similar to those found in adults.

Hutchinson, I., Segovia, C., Laing, D.G., Jinks, A.L. (2000). Fungiform papillae - differences between adults and children. 13th International Symposium on Olfaction and Taste, Brighton, England.

7. E-Enabling Multi-Plant Sensory Data Collection and Analysis

G. J. Organ, W. Taylor, D. Nelson, A. King, and A. B. Chapman

Lion Nathan, Silverwater, Sydney, NSW, Australia

Lion Nathan is a multi-plant brewing company which conducts sensory evaluation sessions in each of its breweries. Several years ago it was decided to store all the ensuring data in the one centralised database. It was concluded that the best means to achieve this was by utilising the capabilities of the internet. The talk begins with a discussion of the design criteria for the ensuring software system, referred to as SIP. SIP incorporates the two main aspects of Lion Nathan's sensory programs, ie flavour profile and flavour stability monitoring tests. The capabilities of SIP in each of these two areas are discussed.

8. Axon Convergence in a Disrupted Olfactory System

J.A. St John and B. Key

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The olfactory neuroepithelium is a highly plastic region of the nervous system that undergoes continual turnover of primary olfactory neurons throughout life and is capable of regeneration. Even after deafferentation, primary olfactory neurons regenerate and reinnervate the olfactory bulb. We are interested in determining the mechanisms responsible for persistent growth and guidance of primary olfactory axons along the olfactory nerve during normal development and after injury. Primary olfactory axons expressing the same odorant receptor gene sort out from axons expressing unlike receptors and converge to topographically fixed glomerular targets in the olfactory bulb. We have examined the guidance of axons expressing the P2 odorant receptor when they were challenged with different cellular environments in vivo. Convergence without targeting occurs during regeneration following both chemical ablation of the olfactory neuroepithelium and bulbectomy. In these mice primary olfactory axons converge and form a locus without appropriate targeting. Thus, the behaviour of olfactory axons in these models indicates that the convergence of axons expressing the same odorant receptor occurs independently of the bulb. It appears that cues in the nerve pathway are essential for axon convergence. Moreover these results indicate that convergence and targeting of olfactory axons are separate events mediated by different guidance cues.

9. Expression of the Intermediate Filament, Nestin, in the Mature Olfactory Neuroepithelium

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Health, Faculty of Medicine, University of New South Wales, Sydney, Australia

The intermediate filament protein, nestin, has been widely used as a marker for proliferating progenitor cells in the developing nervous system. The mammalian olfactory neuroepithelium is a region of the nervous system which supports ongoing neurogenesis, yet nestin has not been reported to mark proliferating olfactory progenitors. Using immunohistochemistry, we examined nestin expression in the mature olfactory neuroepithelium and found it to be restricted to the basal compartment of the neuroepithelium. The pattern of immunoreactivity was consistent with expression of nestin by the endfeet and inferior processes of the sustentacular cells, rather than the adjacent basal cells. Using a bank of antibody markers, we confirmed nestin's pattern of distribution to be different to that of cytokeratin, the GBC-1 antigen, used to mark globose basal cells, GAP43, carnosine and vimentin. Following unilateral surgical bulbectomy, nestin immunoreactivity was upregulated bilaterally and appeared to span the neuroepithelium from apical to basal regions, also becoming prominent in the cell bodies of some sustentacular cells.

Nestin is an intermediate filament protein, thought to be important in cell motility and fluidity of cell shape, critical processes during development. During embryonic CNS development it is expressed by radial glial cells, upon which young neuroblasts migrate. Very recently, radial glia themselves have been reported to be a form of progenitor cell, which can give rise to neurones (Alvarez-Buylla et al. 2001) which then migrate along their processes during development. Nestin's upregulation in olfactory sustentacular cells postbulbectomy may reflect the intense requirement for cell mobility and remodelling in the regenerating neuroepithelium. Furthermore, nestin may play a role in the migration of recently proliferated olfactory neurons on the scaffolding of sustentacular cells, in a manner analogous to its proposed role in radial glial cells.

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10. A Glutamate-Lysine Mutation in the Putative Pore-Forming Region of rOCNC1 Channels Reverses Their Ion Selectivity

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Our previous results have shown that the recombinant homomeric rat olfactory cyclic nucleotide-gated channel (rOCNC1) is a good model system for investigating the basic structure-function properties of olfactory CNG channels because both the native and recombinant channels have similar ion permeation and selectivity properties [1,3,4]. All

Upcoming Events

3-4 December 2001
E-Nose 2001
St Petersburg, Florida, USA
Contact: www.enose-2001.com or www.techpub.com

26 February, 2002
Seminar on Asian Food Exports
Centre for ChemoSensory Research, UNSW
Australian Technology Park, Sydney, Australia
Contact: m.styles@unsw.edu.au

24-28 April, 2002
Association for Chemoreception Science (AChemS) Annual Meeting
Hyatt Hotel, Sarasota, Florida, USA
Contact: www.achems.org

24-28 June 2002
Weurman Flavour Research Symposium
Dijon, France
Contact: www.dijon.inra.fr/aromes/weurman

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
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23-27 July 2002
ECRO XV Congress
University of Erlangen, Nuremberg, Germany
Contact: Gerd Kobal
gkobal@physpharm.uni-erlangen.de
www.ecro-online.org

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

7 - 11 December 2002
The Fifth Annual Scientific Meeting of AACSS
Heron Island, Queensland, Australia
Contact: Wendy.Burchmore@tq.com.au
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Abstracts of Fourth AACSS August, 2001, contin.

CNG channels and subunits contain a single negatively charged glutamate residue in their pore-forming P loop region. Extensive mutagenesis of this residue has revealed its important role in both monovalent and divalent cation permeation (e.g., [2]). However, no one has reported on its role in ion charge selectivity. Thus, we wished to assess whether this glutamate was important in the permeation of the rOCNC1 channel and whether the cation selectivity of the channel could be reversed if the residue was mutated to a positively charged lysine (E342K). We have now shown that this is the case. Preliminary data from these mutant E342K rOCNC1 channels, using inside-out patches from HEK293 cells, indeed do indicate, from P_{Cl}/P_{Na} data obtained by fitting reversal potentials in different NaCl dilutions, that ion selectivity has reversed, with P_{Cl}/P_{Na} changing from 0.14 in the WT channels to 7.5 ± 1.8 in the mutant rOCNC1s.

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11.Psychophysical Effects of Fat in Flavour Mixtures.

Hae-Jin Song

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The fat content of food impacts its flavour properties through effects on the texture, odour and taste of the food. Given the practical difficulty in assessing the various flavour modalities separately, due to the simultaneous stimulation of multiple senses when a food enters the mouth, the degree to which each modality contributes to the perception and hedonics of fat-containing foods is unclear. Many studies to date have investigated the effect of fat on the textural and flavour release characteristics of food while largely dismissing any taste effects, as conventionally fats were not considered as gustatory stimuli. However, recent electrophysiological and psychophysical studies suggest a gustatory role for fats in moderating flavour profile and thus in the present study, the influence of fat content on the perception of flavour mixtures was investigated using milks of differing fat content as stimuli and a trained panel of subjects as assessors, with the aim of determining whether fats have taste effects. Results from previous experiments using texture-controlled model emulsions of deodorised fats showed that fats enhanced near-threshold sweet and suprathreshold savoury taste intensity. In the present series of experiments using milk samples, near-threshold sweetness and saltiness was greater in whole milk than skim milk. Suprathreshold savoury taste intensity was greater in whole milk although not significantly. Interestingly, when flavours (vanilla, pineapple) were introduced, sweetness was significantly subdued for the whole milk samples when the olfactory input was negated (by use of nose-clips). Possible mechanisms for these observations will be discussed in this presentation ■

Book Review

The Basic Chemistry of Aromatherapeutic Essential Oils

E. Joy Bowles,
Published by E. Joy Bowles, Sydney, 2000
ISBN: 0 6646 29413 X

Joy Bowles is to be congratulated for the production of this volume which aims to provide a more balanced and rational understanding of the nature and action of essential oils when used as aromatherapeutic agents.

As stated in the introduction, "the purpose of this book is to give an introduction to the chemistry of the constituents of essential oils." It starts with a basic explanation of the scientific world view and a simplified explanation of the atomic and molecular structure of essential oils. This is followed by how plants make essential oils, the different types of molecules that are found in essential oils, and some pointers towards how the essential oils actually effect the human body therapeutically (or otherwise).

The text is presented in seven chapters and is a very timely attempt to present some of the science and current understanding behind the wide mythology surrounding aromatherapy.

An often ignored aspect of aromatherapy i.e. the possible toxic effects of inhaling or application to the skin of essential oils is considered and caution advised where appropriate.

There are many useful scientific references throughout the text, generally as numbered footnotes. However, the information presented in the extensive table in chapter 6 is separated from its references which then appear in what is almost an appendix at the back of the book. This is done presumably for simplicity but can be a little confusing because the numbering is not distinguished from the footnote numbers.

The book is of interest those who wish to know more of the background to essential oils and is a useful introduction to the very broad nature of chemistry which may determine the oil properties.

Adjunct Associate Professor Donald Barnett
Deputy Director, The Centre for Chemosensory Research ■

NEWS

Book Review (reprinted with permission)

Tastes & Aromas: The Chemical Senses in Science and Industry

Graham A. Bell and Annesley J Watson

UNSW Press
ISBN: 0-86840-769-0
RRP $65.00

If a mouth-watering lamb roast has ever brought a tear to your eye, or the delicate aroma of a partner's perfume evoked a response, then you will enjoy this book.

Although knowledge about the role of smell and taste in human biology is 'still fragmentary', *Tastes & Aromas: The Chemical Senses in Science and Industry* helps educate it audience on these most bacchanalian of our senses.

Though neglected by researcher, smell and taste provides us with rich sensory experience.

In evolutionary terms, they are the most ancient of the senses. They were 'designed by nature to serve the needs of hunter/gatherers of long ago'. In the modern world, smell and taste are no less important. The business world is using sensory science to test products before distributing them on the market.

Tastes & Aromas details the efforts of both commercial and academic researchers.

We are told of the basics behind these senses - how the 'spaghetti-like' cilia high in the naval cavity are connected to the olfactory lobe in the brain, for example - and then given specific examples on how this knowledge can be applied in contexts outside the laboratory.

Commercial context - how this knowledge might be applied to food, wine and perfume industries - dominates the book and applications for medicine, leisure and technology are given more cursory treatment.

Nonetheless, this is an excellent read for undergraduates, and post graduates with advanced knowledge will be interested in how sensory science is being applied in a world of commercial imperatives.

Anecdotes accompany the scientific material, making this book accessible to general and scientific readers alike. Whether it is interesting tit bits on the place of odours in mammalian reproductive biology, or how the Egyptian hieroglyph for happiness is a nose, *Tastes & Aromas* entertains as much as it educates.

ALEX KONRAD
Editor, Monitor Newspaper, University of Canberra, ACT

To order your own copy of Tastes and Aroma please send your details along with a cheque for AUD$79.90 (includes postage and handling) to Centre for ChemoSensory Research, Australian Technology Park, N.I.C Building, G18, Eveleigh N.S.W. 1430, Australia ■

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NEWS

Pure Organic Tofu Turkey

Organic foods in the USA are growing and the cash registers are singing. A company, Whole Foods Market, in Austin, Texas, specialising in foods that conform to organic specifications (including no GMOs, no additives, no preservatives, no growth hormones, and no unnecessary processing) has reached sales of AUD$3.6 Billion in 2000, through 130 stores.

They offer customers recipes and suggestions for creating delicious meals with fresh ingredients instead of "the same old boxed products full of unwanted artificial ingredients", says company chef Janet Chaykin.

With Thanksgiving and Christmas near, turkey eaters may want to know that conventional supermarket turkeys in the USA are likely to be stuffed with more than sausage meat and breadcrumbs. Fast-reared on growth hormones, they are also likely to be injected with food starch and sodium phosphates to supplement the moisture of the meat after preparation. The pre-mixed, ready-to-go stuffing and gravy is likely to be overloaded with flavour enhancers, sulfites, and scary long-named chemicals like butylated hydroxyanisole and butylated hydroxytoluene.

Whole Market Foods supplies foods with none of these modern-day artifices. And for the vegetarian guest, why not offer one of their 50 000 tofu turkeys? Designed to resemble a roast turkey complete with stuffing of wild rice-bread crumbs, tempeh drummettes with imitation giblet gravy.

If food preparation puts you off or you are busy, there is a full-service catering department that can be called in.

The challenge for organic food providers is to be **true** to their labels and promotional claims (how do you *know* the tofu is not made from GMO soy?); to be **safe** (fresh and no preservatives means very short shelf life - are you sure you're not infecting yourself?) and to be at least as **delicious** as conventional products. Affluent health-conscious people will pay a premium and make quality sacrifices in the interest of health or ethics, but ordinary people rarely will continue, beyond a try-out, to buy "healthy" food that does not meet their taste and safety expectations.

Information sources:

http://www.foodonline.com/read/nl20011113/474915

www.foodsmarket.com ■

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THE UNIVERSITY OF NEW SOUTH WALES

E-MAIL from Mexico City

Graham Bell
Centre for ChemoSensory Research

Contract sensory evaluation has brought me to this amazing place: a great world capital and the site of an ancient and strange civilisation. Flying in at night I knew I was seeing a form of human habitation I'd never seen before. This is a rare feeling: that of a never previously imagined foreignness. The surface of the earth was covered in geometric lines of light, then there would be a void of blackness (possibly water or a volcano), then another endless surface of triangles and straight lines going to the horizon.

Day of the Dead Shrine

Getting to Mexico with transit connections in the USA was a bit of an ordeal. In the customs halls, long slow lines of foreigners face stern officials wearing black pistols. In the interests of diplomacy, I'll cut this short, but suffice to say that I promise never again to complain about the system at Sydney airport.

Now let me tell you about Mexico City:

Firstly it is the VW Beetle capital of the world. And nearly all of them are painted green and white, and are taxis. The one I took had no front passenger seat, as this is where your luggage goes. There is room for two or three passengers on the back seat and that useful void for long legs on the right hand side.

Next I noticed the architecture of quite an ancient (by Australian standards) Spanish colonial era: superbly balustraded balconies and ornate gables and facias on buildings, and many small public areas where roads intersect.

There is abundant subtropical vegetation. Standing in shirt-sleeves in November, it is hard to believe I am at an altitude higher than Mount Kosiusco, as I gaze upon Bougainvilleas, poinsettias, oleanders, strangler figs, umbrella trees, fruit bulging out of small gardens: oranges limes and loquats, tempting the pedestrian to tarry. And, there they were, possibly arrived via California, the Australian gum trees. These newly acquired, yet ancient Australian trees look like they've never been anywhere else. Mexico seems to welcome the best of other lands.

Then, the faces of the people: faces of the Pre-Columbians, everywhere you look, everywhere you go. This is an entirely new image of humanity to someone who has not been to South America before. The Aztec lives on. The tequila lives on here too and exceeds its reputation: smooth, light, delicious and devilish. A great way to start a Mexican meal. The variation and sophistication of the cuisine made me cringe when I remembered the pale imitations of Mexican food beyond the borders.

I arrived on the eve of the Day of the Dead, a day of celebration of mortality and of the memories of the deceased. Skeletons and red devils, colourful paper bunting and orange flowers have started to appear all over the city.

In public places shrines are set up on the pavements and in the town squares. The subject of the shrine can be a person or a whole family, a local politician, or yes, the Twin Towers (complete with model planes). Food offerings and things that the deceased once liked, such as musical instruments, books, and bottles of hooch, are added to the display. A portrait of one man had a cigar stuck to the glass. The orange marigolds are piled up into cruciform shapes. Elsewhere, skeletal effigies of living people, such as President Fox, complete with cowboy boots and holding a hobbyhorse, are erected or dangled. They clearly proclaim: "the paths of glory lead but to the grave."

The Day of the Dead celebrations were in full swing when we reached the silver mining town of Taxco, about 100 km west of Mexico City. This small city, of around two hundred thousand people, clings to the mountainside like a tenacious colony of swallows' nests. Our hotel is clean and comfortable. The silver shops are enticing. The restaurants are indulging. But the best moment so far has been watching the sun appearing on the horizon, across a hundred valleys, bathing in gold the white façade of this strange vertical mountain city. I realised that this is a city in which, with few exceptions, *every house has exactly the same view of the morning sun*. Perhaps this touches on a secret, of an ancient and deeply seated humanity, that values, above all, the unremitting rising of the sun.

Anyway, there's a lot to learn here. Adios ■

Sunrise on Taxco