the development of pedal-operated rice mill. The pedal-operated rice mill can overcome the drudgery of rural women.
R. K. Syal, Suresh Baburao Talegaonkar, Suresh Krishna Saud, Krishna Digambar Borole and Jayant Ramchandra Peshave of High Energy Materials Research Laboratory, Pune have been jointly awarded Rs 75,000 for the development of combustible cartridge cases for tank gun ammunition.

**TIFAC's Home Grown Technology Scheme yields commercial launch of rapid diagnostic kits**

On 11 May, the first National Technology Day, Dr Murli Manohar Joshi, Union Minister for Science & Technology and HRD released a do-it-yourself advanced diagnostic kit for poultry and cattle farmers. Developed by Bharat Agro Industries Foundation (BAIF), Pune under the Home Grown Technology Programme of TIFAC/DST, the kit is being commercialized.

Cattle and poultry farmers are in constant dread of infectious diseases which lead to large scale mortality and economic losses. If the farmer is able to diagnose an infectious disease early enough, then veterinary professionals can be called immediately to vaccinate all the farm animal population to prevent spread of the disease.

A reliable, easy to-use and inexpensive diagnostic kit is an essential aid to the farmer, to regularly screen cattle or poultry. At present, even for diagnosing the disease it is necessary to take an afflicted animal to a hospital, which is both expensive and effortful.

Under its Home Grown Technology (HGT) Scheme, TIFAC of DST supported BAIF’s project with both financial support on ‘soft’ terms and as well as with technical inputs through a group of experts nominated by TIFAC.

**Contemporary issues in olfaction**

The meeting* on olfaction was an informal symposium attended by speakers from India and abroad. New work highlighting both the rapid advances in the field, and the contributions of olfaction in understanding major issues in neuroscience, were presented in six sessions.

**Session 1: Receptors**

Nirao Shah introduced the molecular aspects of mammalian olfactory transduction. Buck and Axel found a family of 7-pass transmembrane olfactory receptors which are expressed in a scattered manner in the mammalian main olfactory epithelium, though a given receptor is restricted to one of four broad zones. Peter Mombaerts et al. showed specificity of projection of neurons expressing a given receptor to specific glomeruli in the olfactory bulb. The current work relates to the expression of receptors in the septal organ (SO) which separates out from the main olfactory epithelium during development. Possible roles of the SO include suckling and alerting behaviour. At least three serpentine receptors were found to be expressed in the SO. Interestingly, these receptors are expressed in a larger fraction (between 5 and 50% of neurons per receptor) of neurons in the SO. By contrast, only 0.1–1% of the neurons in the main olfactory epithelium express any given receptor. One of the SO receptors has been genetically targeted by Nirao Shah and Michelle Kim to reveal its projections into the olfactory bulb.

Leslie Vosshall introduced insect olfactory receptor, with particular reference to Drosophila which is a very powerful system for studying chemoreception. It has excellent genetics, molecular biology, electrophysiology and behaviour. Despite these advantages, the olfactory receptors in Drosophila had not been identified even seven years after the mammalian receptors were cloned. This report describes a breakthrough in cloning Drosophila olfactory receptor proteins. Initially, a very large screen of an antennal-specific library in collaboration with Hubert Amrein revealed a single protein which met the criteria (expression in antenna/maxillary pulp, 7-pass transmembrane protein) for a putative odour receptor. In collaboration with Andrey Rzhetsky and Pavel Morozov, this was used to scan for homologous genes from the available data from the Drosophila Genome project, which is 10–20% complete. Several such genes were found, exhibiting very low homology but some conserved residues. Based on statistics of expression, there are an estimated 100–200 such genes in Drosophila. Expression of the receptors identified to date was not seen in larvae, but was seen in pupae. A large number of behavioural, genetic and electrophysiological studies are now feasible to further study Drosophila chemoreception.

Emily Troemel described olfaction in C. elegans which has only 302 neurons, but has a well-developed olfactory system. C. elegans detects hundreds of chemicals using only 11 pairs of chemosensory neurons and it also exhibits several kinds of olfactory responses, including attraction and repulsion. Using a chemotaxis screen, an odorant receptor called ODR-10 was identified. ODR-10 is a predicted 7-transmembrane domain protein that is required for responses to the attractive odorant diacetyl. C. elegans may have about 500 chemosensory receptors in total, based on information from the genome project and expression studies. The ODR-10 receptor is subcellularly localized to the cilium of

*Held at Orange County, Coorg, 28 Nov.–2 Dec. 1998. Organized jointly by the Indian Academy of Sciences and the National Centre for Biological Sciences, Bangalore.
olfactory neurons and this localization is disrupted in two olfactory mutants that do not respond to diacetyl. ODR-10 is normally expressed in the AWA neurons, where it mediates attraction to diacetyl. Misexpression of ODR-10 in AWB, a neuron that detects repellents, elicits repulsive responses to diacetyl. This result suggests that the quality of an odorant stimulus is encoded by the neuron and not the receptor protein. One candidate odorant receptor is expressed in a bilaterally asymmetric fashion and this expression appears to be regulated by cell–cell interactions involving Ca$^{2+}$ and cGMP signalling.

Session 2: Olfactory signal transduction

Barbara Talamo discussed olfactory signalling, many aspects of which are still poorly understood. The canonical olfactory pathway is as follows: Odorant dissolves in mucus → Receptor → $G_{olf}$ → Adenylyl cyclase III (ACIII) → cAMP formation → Cyclic nucleotide gated channel opening → Cell activity change. A turnover cascade involving Calcium entry → Calmodulin binding → Phosphodiesterase (PDE) activation → cAMP breakdown is also widely accepted. In addition, the inositol (1,4,5) bis-phosphate (IP3) pathway has been implicated. Very few clear cases of receptor activation are known. The specificity of odorant tuning is also unclear. In some model cells, ACIII activation leads to cytosolic Ca$^{2+}$ oscillations, a phenomenon that could play a role in receptor sensitivity to odorant. In dissociated olfactory receptor neurons, Talamo’s group has observed several kinds of responses to treatment with selective and nonselective phosphodiesterase blockers, indicating diversity in signalling pathways. To address many of these questions, they are also working with a model system, an immortalized olfactory cell line.

Klemens Stoertkuhl described odorant adaptation in Drosophila. Despite its small size Drosophila has many genetic, molecular and behavioural advantages. His group studies odorant adaptation using behaviour in a T-maze test and electroantennograms (EAGs). Behaviourally, adaptation occurs within 30 s and recovers within 3 min. Adaptation is abolished by transient receptor potential (TRP), a Ca$^{2+}$ channel mutation in a haplo insufficient way. From EAGs, 50% recovery normally takes 3 min but in

trp it takes about a minute. InaD (inactivation no after potential D) mutations also recover more quickly. Direct Ca$^{2+}$ imaging experiments will help to narrow down the odorant adaptation pathway.

Gaiti Hasan introduced several approaches to studying olfactory transduction in Drosophila. The genetic approach was problematic as there are many olfactory mutants where the defect does not affect transduction. Molecular techniques revealed several putative molecules involved in bringing odorants from the air to the receptor neurons. Hasan and her group examined the IP3 pathway in olfaction by probing for $G_{olf}$ mutants, but did not find any expressed specifically in the antenna. EAGs were used to probe for deficits in two PLC mutants, but no effects were seen. Similarly the rare survivors of an IP3 hypomorphic allele had no EAG deficits. They propose that the other arm of the PLC pathway, DAG, may be involved in olfactory transduction.

Luca Turin discussed a novel hypothesis for olfactory transduction. It is difficult to specify predictive rules for relating chemical

![Figure 1](https://via.placeholder.com/150)

**Figure 1.** a, Optical micrograph of Drosophila antenna. TS and BS represent location of Sensillae trichoidea and basiconica respectively. S. coeloconica are distributed throughout the antenna. B, Colour schematic of location of sensillae types. Below: electron micrographs of the three types of sensillae. Sketch: structure of a complete sensillum and associated cell types. (Courtesy V. Rodrigues).
structure to odour quality. One possibility is the spectroscopic properties of molecules. A form of spectroscopic analysis could be biologically implemented using inelastic electron tunnelling between the odorant and the receptor. A set of ten to twenty receptor classes would then span the range of odorants. One would predict then that the boranes, which have the same IR vibration band as S-H, would smell similar, which they do. A further prediction is that deuterated odorants would have a different smell, even though their chemical properties should be the same as their hydrogen counterparts. Indeed, acetophenone and perdeuterated acetophenone do smell different. Initial results with calculated inelastic electron tunnelling spectra correctly predict an ambergris odour for four structurally very different ambergris odorants.

Session 3: Olfactory neuronal processing

John Kauer introduced several ideas about olfactory encoding. There are good data that support the hypothesis that olfactory sensory information is encoded by a continuum of both specific and broadly responsive receptor sensors. The olfactory universe can be considered as a N-dimensional space with each dimension representing a different odorant attribute. His group has carried out simulations to examine the relationship among the breadth of receptor responses and the number of receptors required to capture the information in a defined “olfactory universe.” They use the salamander for optical and electrophysiological observations, as it has technical advantages for recordings and because it manifests odour-guided behaviour. Both electrical shock and odour stimuli generate complex temporal patterns of activity as seen using optical recordings. These activity patterns in space and time encode odour information in a combinatorial manner. They have combined these theoretical and experimental ideas to build an “artificial olfactory system” using optically-based sensors that use broad-specificity polymer detectors coupled to dyes and biologically-based pattern recognition algorithms.

Uppinder Bhalla discussed computational neuroscience with regard to olfaction. The primary function of a brain is computation. Each of the operations of sensing, cognition and behaviour involve heavy computation. Neural nets suggest that one of the key principles for understanding this computation is the representation of information. Distributed encoding is likely to be a good representation for multi-dimensional stimuli like olfaction. In vivo studies are necessary to understand olfaction because of the

Developmental sequence of cells in the olfactory sensillum of a Drosophila antenna (left) along with model of steps of development (right). (Courtesy V. Rodrigues).
encoding of responses by the respiratory cycle. In the bulb, there is a centre-surround organization of response similarity with nearby responses more similar and distant responses less similar than chance. This organization vanishes during rapid sniffing. Respiration tuning and broad response profiles are seen both in the bulb and in preliminary recordings from olfactory epithelium.

Giovanni Galizia described olfactory encoding in the honey bee brain. Calcium imaging of the antennal lobe of the honey bee was carried out to monitor activity in the bee glomeruli following odorant stimuli. Glomeruli can be identified in animals with the help of a computerized brain atlas which can be rotated to match the image of the glomeruli obtained by injecting a fluorescent dye after each experiment. Galizia found consistent response patterns to different odors in different animals, when the identity of each glomerulus is taken into account. Chain length is represented systematically both in strength of response, and also in position of activated glomeruli. Odour identity does not have an obvious systematic representation.

Session 4: Olfactory behaviour

Martin Heisenberg described fly olfaction from a viewpoint of behavioural objectives and strategies that the fly might adopt in order to achieve them. The fly must be able to perform several kinds of neural functions. These include extraction of odour quality and quantity information, formation of memory templates, generalization, and obtaining fine temporal information about the odours. The mushroom bodies of flies have been shown to be involved in olfactory learning and are thought to play a role also in other aspects of odorant perception. Several independent routes can be taken to obtain flies without functional mushroom bodies: mutants, lesions induced by chemical treatment in early development and genetic targeting of cytotoxic transgenes to the mushroom bodies. Recently, it was found that the mushroom bodies are required for context generalization in vision. It seems possible that they play a similar role for olfactory discrimination.

Obaid Siddiqi described experiments which showed that olfactory behaviour of Drosophila melanogaster is not genetically predetermined. It involves learning from experience. Its responses to a set of odours change depending upon the odour environment in which the fly grows. Freshly emerged flies were shifted to simple media to which specific odours had been added. They developed a preference for the odours to which they were exposed and an aversion to other odours which they had not experienced. Exposure to pulses of odours at different times showed that conditioning is age-dependent; the strongest effect is seen between two and five days. Experiments suggest that a form of associative learning is involved.

Kei Ito described how flies are a good system for studying the brain, because they are good for molecular and genetic techniques and for behavioural experiments. The small brain size and the relatively few number of neurons make it easier to apply reverse engineering. A standard approach is to examine connectivity and to identify the functions of each region of the brain. Various neuro-anatomical techniques can be used to examine connectivity. One powerful technique for identifying function is to disrupt the function of a small region of the brain and then compare the normal and abnormal situation. Using sex mosaics is a good way to disrupt function without inducing other damage. The UAS-GAL4 system is useful for this approach, since it enables us to feminize a selected subregion of the brain by inducing the expression of the sex-determination gene trl. The affected behaviour is courtship. Ito found non-sexual behaviour only when a very large fraction of the brain is feminized. This suggests that a diverse type of neurons are involved in the control of the male courtship behaviour.

Session 5: Olfactory development

Thomas Keil described insect antennal development. In all insects, the antenna starts developing in the early embryo. A chain of pioneer neurons leading to the central nervous system is formed, and the growing axons from the developing sensilla follow this path. Different patterns of adult antennal development are followed by hemimetabolous and holometabolous insects. In the former, the larval antenna is transformed by successive steps into the adult one. In the latter, the adult antenna develops in one big step during metamorphosis. The insect olfactory receptor neuron has a modified cilium formed from a centriole pair. Olfactory neurons in all animal groups have cilia, but these develop in different ways.

Reinhard Stocker (presenting author) and Gertrud Heimbeck discussed function and development of the olfactory pathway in Drosophila. To elucidate the function and development of the Drosophila olfactory system, they used transgenic lines that express Gal4 in different neurons. Gal4-driven lacZ, tau and GFP reporters enable visualization of expression. For identifying expression in the glomeruli of the antennal lobe (AL), they developed a computerized 3-D map of the AL. Gal4-driven tetanus toxin-light chain expression causes blockage of synaptic transmission in selected neurons, which allows one to study their function, by testing chemosensory behaviour. Applied to the larva of a line which expresses tetanus toxin in most of the olfactory receptor neurons and a few gustatory neurons, they observed anosmia to most of the tested odors, but only slightly reduced taste responses. Hydroxyurea ablation of an early dividing neuroblast in interneuron-specific lines leads to the loss of local interneurons and a subset of projection neurons in the adult AL, suggesting that these neurons all are formed by this neuroblast. Developmental expression indicates that many of the adult projection neurons are derived from larval projection neurons.

Veronica Rodrigues spoke on antennal patterning. There is a high degree of patterning in the Drosophila antenna. The three sense organs are distributed in a stereotyped way; the neuronal number varies systematically, functional patterning may occur and patterning in projections is also organized. It is interesting to understand the basis of these patterns. Examination of development shows that the atonal gene selects founder cells for one class of sensilla - the sensilla coeloconica. Lozenge determines the choice between sensilla trichodea and sensilla coeloconica. Work is in progress to examine the role of sensory neurons in the formation of glomeruli in the antennal lobe.

Session 6: Human olfaction

Uma Ladiwala described her work on human olfaction. There has been very little study of human olfaction in India. This would be important both for appli-
cation of odour diagnostics for disease and also to examine odorant responses in the interesting gene pools in Indian populations. Uma and her group examined odour function in a sample of normal individuals as well as individuals with a variety of medical conditions. Preliminary results were sometimes at odds with those reported elsewhere. They had difficulty in applying the UPSIT tests, perhaps due to technical reasons.


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**RESEARCH NEWS**

**Atom laser**

*K. G. Manohar and B. N. Jagatap*

One of the significant achievements of the present decade in the area of basic sciences is the experimental demonstration of Bose–Einstein condensation (BEC) in dilute alkali vapours. Development of very effective non-contact methods of cooling and trapping of atoms using lasers, magnetic fields, RF, etc. resulted in lowering the temperature limits steadily from millikelvin to microkelvin to nanokelvin ranges. With the achievement of BEC in rubidium atoms at a temperature of 170 nanokelvin by Anderson et al.¹ in 1995, a new field of physics has started which deals with coherent macroscopic matter waves. While the physics of superfluid helium does involve description in terms of coherent macroscopic matter waves, the strong interaction between the helium atoms makes the study of BEC in liquid helium rather complicated. The experimental realization of BEC in dilute alkali vapours was followed eventually by the demonstration of interference effects between Bose condensates, thus establishing the coherent nature of matter in BEC. The strong parallelism between conventional lasers and Bose condensates has led to the idea of atom lasers, i.e. coherent atomic beam generators. Development of techniques for output coupling of coherent atoms from the condensates is the key to this issue and was demonstrated for the first time by Ketterle and his group² at MIT. Very recently, a Raman laser-based output coupling scheme has been reported by Hagley et al.³, in which the output pulses from a Bose condensate have been shown to possess extremely low divergence of a few milliradians. This is comparable to the beam divergence of a typical optical laser. It is but natural that scientists have already started looking for matter wave equivalents of optical effects involving lasers. One such effect that has been demonstrated recently is the nonlinear four-wave mixing of matter waves in a Bose condensate of sodium atoms⁴.

**Photon laser**

Since the atom laser is a concept which is derived from the conventional laser, it is instructive to briefly recall some of the basic aspects of a conventional or photon laser. The main features of a photon laser are: (i) an optical gain medium; (ii) an optical cavity and (iii) a coherent photon field in the form of allowed eigen modes of the cavity. The resonator, which is formed by two or more mirrors, defines a confining volume in which the photons are trapped. The trapped photons are in a standing wave field from which a small fraction is leaked out through one of the resonator cavity mirrors which is made partially transmitting. The loss of photon field from the cavity is compensated by the