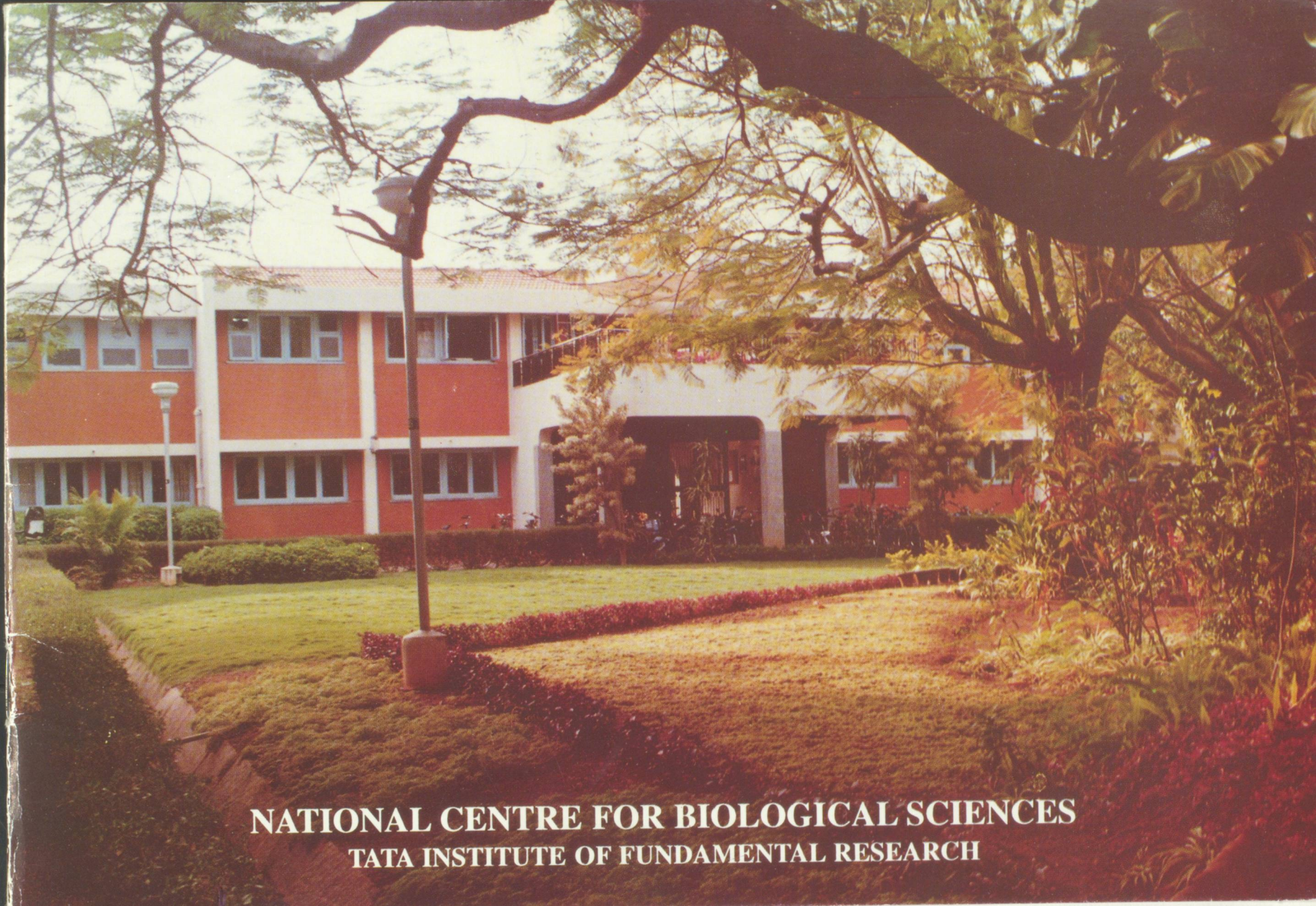


NATIONAL CENTRE FOR BIOLOGICAL SCIENCES

TATA INSTITUTE OF FUNDAMENTAL RESEARCH

NATIONAL CENTRE FOR BIOLOGICAL SCIENCES

Areas of Research

CELL & MOLECULAR BIOLOGY

STRUCTURAL BIOLOGY

GROUP I

Mechanism of ion transport across biological membranes

M.K. Mathew

Subhendu Sett[1]
Baron Chanda[1]
Y.D. Ramu[3]
Rajeev Sivasankaran[2]

GROUP II

Protein Folding

J. Udgaonkar

M.C.R. Shastry[3]
Ritu Khurana[1]
Utpal Nath[1]
Vishwas Agashe[1]
Jayasri Srinivasan[2]
S.Ramachandran[2]
B.R.Krishan[2]

BIOLOGY OF INFECTIOUS DISEASES

Pathogenesis of Papilloma Viruses

Sudhir Krishna

Vinay Tergaonkar[1]
R. Annapoorni[1]
Nirupama Deshpande[2]
Betty Bagyam[4]

DEVELOPMENT AND BEHAVIOUR

NEUROGENETICS OF DROSOPHILA

GROUP I

Genetic analysis of chemosensory perception

O. Siddiqi

Avinash D.S. Bala[1]
Sudipta Saraswathi[1]
Ravi Ranjan[4]
Balaji Krishnan[2]
Neelam Shirsat[3]
Yasmin Mistry[3]
Zea-ur-Rahman[2]
Anil Gupta[5]
Champakali Ayyub[5]

GROUP II

Nerve & Muscle Development

K. VijayRaghavan

Sudipto Roy[1]
Sumita A. Anant[1]
L. S. Shashidhara[3]
Anindya Sinha[3]
B. V. Shyamala[3]
Archana Hayaran[3]
Sujata Varadarajan[2]
Balachandra Nadig[2]
Sanjay Sane[2]
Dawa Norboo[2]

GROUP III

Molecular Analysis of Olfaction in Drosophila

Gaiti Hasan

P. Raghu[1]
Anuradha Bhalekar[1]
K. Venkatesh[2]
Srikanth Rajagopalan[2]

NEUROBIOLOGY

GROUP I

Gene regulation in nervous System

M.M. Panicker

Suma Sundaresan[3]
Preeta Guptan[1]
Anuradha Sehgal[1]
Sohong Chatterjee[2]

Gopal Krishna - Visiting Professor

1 - Research Scholar
2 - Jr. Scholar/Sc.Asst./JRF
3 - Visiting Fellow/Post Doct. Fellow/SRF
4 - Teacher Trainee
5 - Scientific Officer

Front Cover : A view of TIFR Centre, Bangalore

1. Background

The Tata Institute of Fundamental Research set up a Molecular Biology unit over 30 years ago in its Physics Faculty at Bombay. The unit was the first of its kind in India. During three decades of its existence, the group at TIFR has contributed significantly to the development of modern biology in this country. In 1992, the Tata Institute established a National Centre for Biological Sciences (NCBS) at Bangalore. NCBS is at present housed in the TIFR Centre, located in the campus of the Indian Institute of Science, which also houses the TIFR Applied Mathematics Centre. The permanent campus of NCBS is under construction at the University of Agricultural Sciences, Bangalore.

2. Objectives of NCBS

NCBS has been conceived as a centre of excellence. Its aim is to conduct fundamental research and teaching in biology at the frontiers of knowledge and generate a body of scientists who can apply modern biology and biotechnology to practical needs of agriculture, industry and medicine. NCBS is developing a broad-based programme of research covering molecular and cellular biology, biophysics, developmental biology of animals and plants, neurobiology, behaviour ecology and theoretical biology.

3. Research Programmes

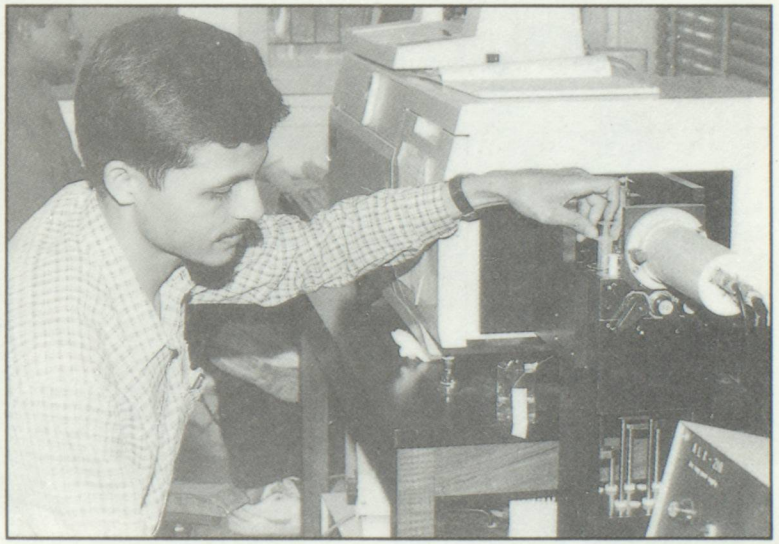
At present the centre has seven different research groups. These groups are inter-disciplinary and concentrate their activity in the following selected areas:

I. Structural Biology
Dr. Jayant B. Udgaonkar
Dr. M.K. Mathew

II. Biology of Infectious Diseases
Dr. Sudhir Krishna

III. Neurogenetics and Developmental Biology of *Drosophila*
Prof. O. Siddiqi.
Prof. K. VijayRaghavan
Dr. Gaiti Hasan
Dr. Mani Ramaswami (Till January '95)

IV. Molecular Neurobiology
Dr. M.M. Panicker



Apart from forthcoming addition of faculty in existing research groups, a systems neuroscience group is being developed. NCBS faculty have collaborative research programmes with other institutions in the country and abroad. Research interests and programmes of individual faculty are outlined separately.

4. Education

The academic programme of NCBS includes the training of graduate students for Ph.D. and M.Sc.degrees by research. The programme is very intensive with the major focus on research. In addition, courses offered cover the basic areas of molecular biology and biophysics, genetics and developmental biology, neurobiology, immunology and virology. The graduate student programme is announced through advertisements in February of each year. A selected number of students are called for interviews in June and the programme begins in August. There is no specific time for the selection of students for the Masters programme. In addition, NCBS offers a post-doctoral training programme. Selections are normally made twice a year, but interested candidates may apply at any time of the year. Further information on any of the training programmes can be obtained from :-

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Fax 080-3343851; Tel 080-3344062/3342816/3345615
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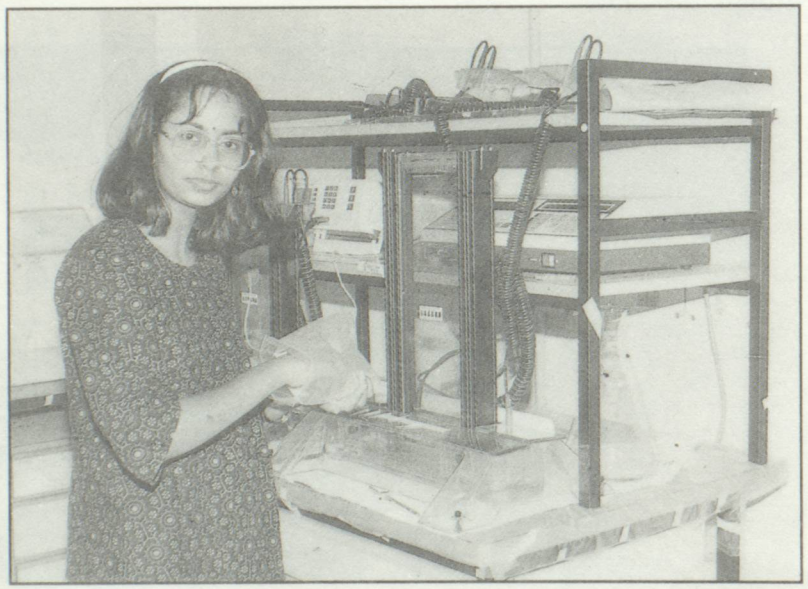


Gaiti Hasan

Molecular Analysis of Olfaction in *Drosophila*

Invertebrate olfaction is thought to occur through a pathway requiring the second messenger inositol 1,4,5- triphosphate (Ip3). In order to test if Ip3 is indeed the only second messenger involved we are studying the role of the inositol 1,4,5- triphosphate receptor (Ip3R) in Drosophila olfaction. The two approaches we have taken are

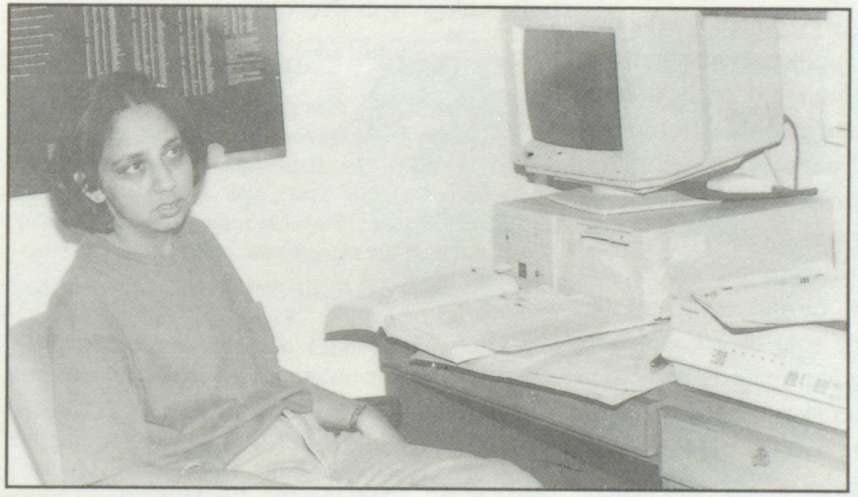
a. to try and disrupt the normal functioning of the Ip3R gene by making mutants in the gene.
b. to understand the normal function of this gene by looking at the protein distribution using an Ip3R specific antibody.

In order to obtain other components of the olfactory transduction pathway, we have constructed a PCR-based subtractive cDNA library from *Drosophila* antennae. This work was done in collaboration with Dr. C.W. Pikielny at Prof. M. Rosbash's lab in Brandeis University, USA. Currently we are studying two classes of genes from this library. One encodes a family of small secreted proteins that share homology with the moth pheromone binding protein. The spatial distribution of the mRNAs encoding these proteins in the antennae suggest that they may be involved in odor discrimination. The second class of genes encodes enzymes like cytocrome P450 and UDP - glucuronyl transferase (UGT). Similar enzymes have been found in the vertebrate olfactory epithelium and are presumably required for odor-degradation. The presence of these enzymes in *Drosophila* antennae suggests that similar mechanisms of odor-degradation occur in invertebrates.

In addition, we are studying the gene for an olfactory behaviour mutant olfE, in order to understand its function at a molecular level. This gene encodes two transcripts of which one has been sequenced and found to encode a putative membrane protein. We are currently searching for cDNAs for the second transcript.

Selected Publications:

1. Hasan, G. (1990), Proc. Natl. Acad. Sci. (USA), 87, 9037-9041. Molecular cloning of an olfactory gene from *Drosophila melanogaster*.
2. Hasan, G.& Rosbash, M. (1992), Development, 116, 967-975. *Drosophila* homologs of two mammalian intracelluar Ca^{++} release channels: Identification and expression patterns of the inositol 1,4,5- triphosphate and the ryanodine receptor genes.
3. Pikielny, C.W., Hasan, G., Rouyer, F. & Rosbash,M. (1994), Neuron, 12, 35-49. Members of a family of *Drosophila* putative odorant-binding proteins are expressed in different subsets of olfactory hairs.



Gaiti Hasan is a graduate of the University of Delhi and has a MSc and M.Phil from the Jawaharlal Nehru University, Delhi. She obtained her PhD from the University of Cambridge and has held post doctoral positions at the Tata Institute of Fundamental Research and Brandeis University.

Sudhir Krishna

Molecular Pathogenesis of human papillomavirus infections

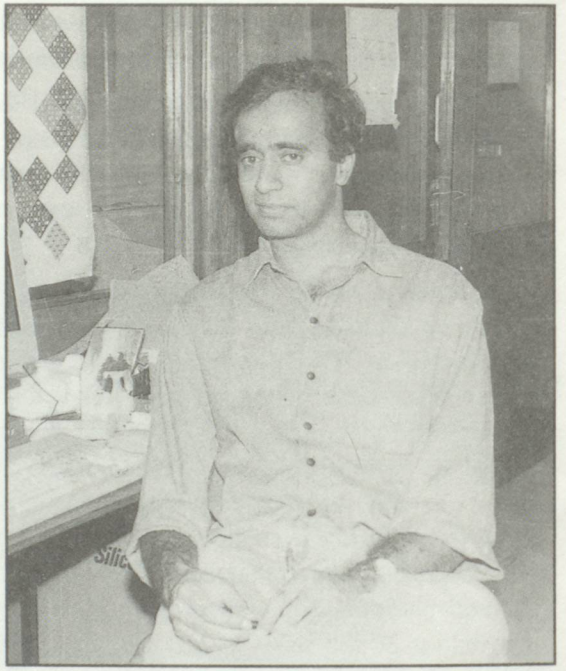
Recent research has established a dominant role for human papillomaviruses (HPV) in the development of cervical cancers, one of the major cancers found in India. We are developing approaches to analyse the various molecular events that take place during the replication and assembly of the virus.

Papillomavirus replication is specific to the epithelial surface and the viral life cycle is tightly coupled to the differentiation program of keratinocytes. Our current interest is in understading the regulation of transcription of the E6 and E7 genes of HPV, which are the two key genes involved in papillomavirus induced transformation. This region is under the control of both host cell factors and a viral DNA binding protein E2, which is believed to function predominantly as a repressor of transcription. We are using *in vitro* systems wherein keratinocyte cell lines differentiate on dermal equivalents to form the various layers of the epidermis to analyse the role of E2 and host factors. In addition, we are analysing the regulation and patterns of HPV transcription in cervical biopsies from patients who present with dysplasias, precursor lesions of cervical cancer. This work will be coupled with both an analysis of the major histocompatibility alleles (HLA) and of the immune response to the virus.

Recently, the human transcription enhancer factor (TEF -1) was shown to be involved in the transcription of the E6 and E7 genes of HPV. The *Drosophila* homologue of this gene, *scalloped*, was recently cloned at TIFR in the labs of Drs. Rodrigues and VijayRaghavan. We are attempting to rescue the *Drosophila* scalloped phenotype with TEF -1, in order to develop genetic approaches for analysing the molecular interaction of human genes with homologues in Drosophila.

Selected Publications:

1. Krishna, S., Blacklaws, B.A., Overton, H.A., Bishop, D.H.L. & Nash, A.A. (1989), J. Gen. Virol., 70, 1805-1814. Expression of Glycoprotein D of herpes simple virus type 1 in a recombinant baculovirus: Protective responses and T cell recognition of the recombinant infected cell extracts.
2. Blacklaws, B.A., Krishna, S., Minson, A.C. & Nash, A.A. (1990), Virology, 177, 727-736. Immunogenicity of herpes simplex type 1 glycoproteins expressed in vaccinia recombinants.
3. Galvin, K., Krishna, S., Ponchel, F., Cummings, D.E., Frohlich, M., Carlson, R., Wands, J.R., Isselbacher, K.J., Pillai, S. & Ozturk, M. (1992), PNAS, 89, 8452-8456. The MHC Class I binding protein p88 is the product of the calnexin gene.
4. Krishna, S., Benaroch, P. & Pillai, S. (1992), Nature, 357, 164-167. Tetrameric cell surface MHC Class I Molecules and Benaroch, P., Krishna, S. & Pillai, S. (1993), Nature Scientific Correspondence, 362, 23-24. Tetramer data reinterpreted.



Sudhir Krishna is a graduate of St. John's Medical College, Bangalore. He obtained his PhD from the University of Cambridge and held a post doctoral position at the Massachusetts General Hospital and Harvard Medical School Cancer Centre, Boston.

M.K.Mathew

Membrane Transport Systems

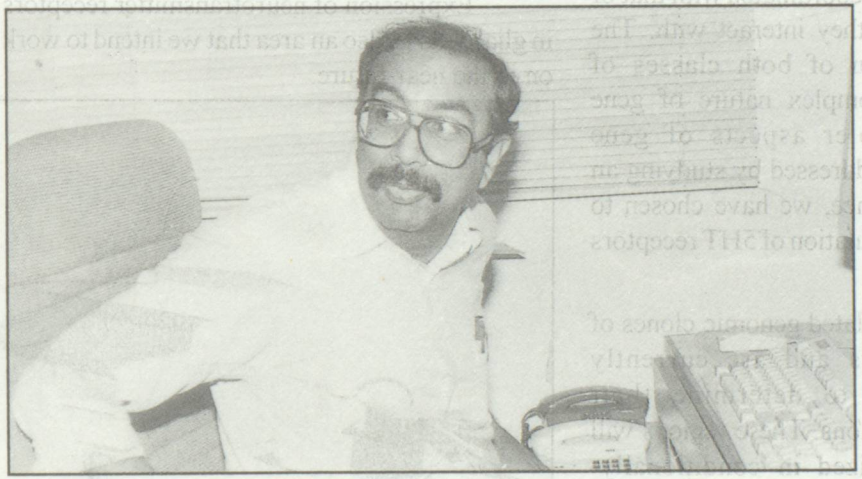
Our group is interested in the structures responsible for the transport of ions across biological membranes. Since the biological membrane is lipophilic (oil-like) and ions are charged moieties, there is a large energy barrier to the movement of ions into or through membranes. Most transmembrane ion traffic is mediated by specialised transport systems, usually proteins, many of which are exquisitely selective for specific ions: transporting potassium for instance, while ignoring sodium.

We have cloned cDNAs for a family of voltage-sensitive, potassium-selective channels of human origin. We are now trying to determine which aspects of their structure are responsible for specific functional attributes. We are also attempting to overexpress the protein encoded by these cDNAs so as to study its structure spectroscopically. In an attempt to simplify the problem of structure determination, we are in the process of putting together a synthetic gene for a polypeptide which is designed to form an ion channel. This polypeptide is also designed for ease of spectroscopic studies. In addition, we are striving to clone genes encoding sodium/proton antiporters from *Drosophila melanogaster*. Antiporters are involved in maintaining intracellular pH and in building up ion gradients by exchanging proton gradients for sodium gradients. We would also like to see if they play a role in the development of the organism.

We have chosen representative examples of transporters that either build up or dissipate transmembrane ion gradients. Detailed analysis of both their structure and function should allow us to build up a picture of how these remarkable proteins work.

Selected Publications:

1. Mathew, M.K., Nagaraj, R. & Balaram, P.(1982), J. Biol. Chem., 257, 2170-2176. Membrane channel forming polypeptides: Aqueous phase aggregation and membrane modifying activity of synthetic fluorescent alamethicin fragments.
2. Ramaswami, M., Gautam, M., Kamb, A., Rudy, A., Tanouye, M.A. & Mathew, M.K. (1990), Mol. Cell. Neurosci., 1, 214-223. Human potassium channel genes: molecular cloning and functional expression.
3. McCormack, K.J., Tanouye, M.A., Iverson, L.E., Lin J.-W., Ramaswami, M., McCormack, T., Campanelli, J.T., Mathew, M.K. & Rudy, B. (1991), Proc. Natl. Acad. Sci. (USA), 88, 2931-2935. A role for hydrophobic residues in the voltage-dependent gating of Shaker K^+- channels.



M.K.Mathew is a graduate of the Indian Institute of Technology, Delhi and obtained his PhD from the Indian Institute of Science, Bangalore. He has held post doctoral positions at the University of California at San Francisco; Columbia University; and the California Institute of Technology.

Mitradas M. Panicker

Gene Regulation in the Mammalian Nervous System

Gene regulation in the mammalian nervous system is the main interest of my laboratory. Serotonin (5HT) plays an important role as a neurotransmitter in the mammalian nervous system. A large number of subtypes of 5HT receptors have been recently identified and cloned. Though similar in structure, the 5HT subtypes are expressed in discrete areas in the mammalian brain with overlap in many cases. This would suggest that their expression is regulated in a very specific manner. Most of these receptors are members of the G-protein-coupled receptor family and therefore their expression in the nervous system must be coordinated with that of specific G-protein that they interact with. The coordinated expression of both classes of proteins reflects the complex nature of gene regulation. The simpler aspects of gene regulation can also be addressed by studying an individual receptor. Hence, we have chosen to study as a model the regulation of 5HT receptors in the nervous system.

We have recently isolated genomic clones of mouse 5HT receptors and are currently characterizing them to determine their cisacting regulatory regions. These regions will be further characterized in conditionally-immortalized murine neuronal cell lines that express these receptors. The cell lines are generated by transducing mouse embryonic neurons with a retrovirus carrying a temperature-sensitive oncogene. Emission studies would help us determine the important cisacting regulatory sites. Comparisons with other genes that have similar expression patterns should also help us to understand their role.

Our laboratory is also involved in developing a variety of new molecular techniques that would allow us to isolate novel neuronal and glial markers and analyze the expression patterns of various biomolecules in the nervous system

Expression of neurotransmitter receptors in glial cells is also an area that we intend to work on in the near future.

Selected Publications :

1. Parker, I., Panicker, M.M. & Miledi, R. (1990), Mol. Brain Res., 7, 31-38. Serotonin receptors expressed in *Xenopus* oocytes by mRNA from Brain mediate a closing K^+ membrane channels.
2. Panicker, M.M., Parker, I. & Miledi, R. (1991), Proc. Natl. Acad. Sci. (USA), 88, 2560-2562. Receptors of the serotonin 1c subtype expressed from cloned DNA mediate the closing of K^+ membrane channels encoded by brain mRNA.
3. Woodward, R.M., Panicker, M.M. & Miledi, R. (1992), Proc. Natl. Acad. Sci. (USA), 89, 4708-4712. Actions of dopamine and dopaminergic drugs on cloned serotonin receptors expressed in *Xenopus* oocytes.

Mitradas Panicker is a graduate in chemistry from Maharaja's College, Kerala. He obtained his PhD from Carnegie-Mellon University, Pittburgh. He has held post doctoral positions at the Beckman Research Institute, at the City of Hope, California and at the University of California, Irvine.

O. Siddiqi

Neurogenetics of Chemical Senses

Our group is interested in the chemical senses. We study olfaction and taste in the fruit fly, *Drosophila melanogaster*.

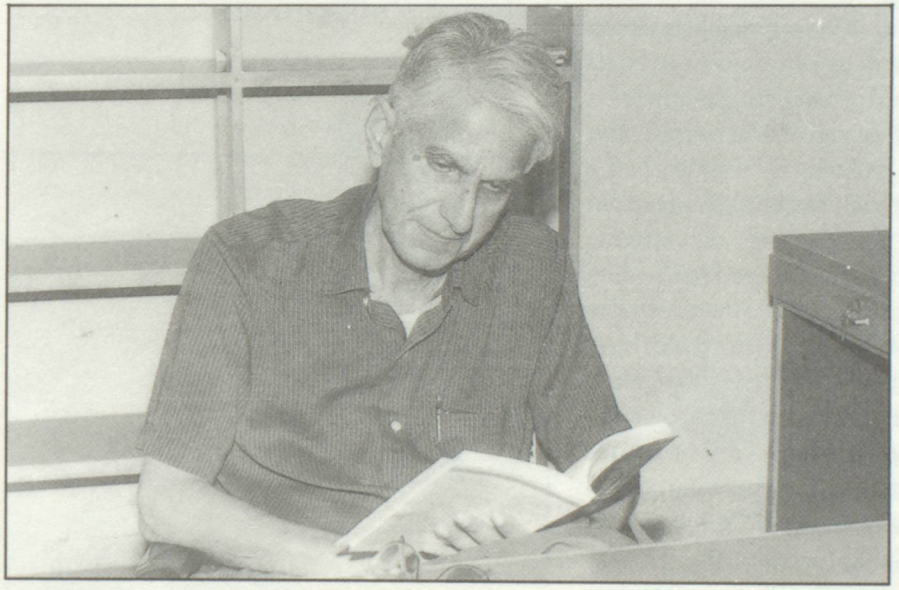
The approach employed by us involves the isolation of single gene mutations which alter the behaviour of *Drosophila* towards chemical stimuli. A combination of experimental techniques including genetics, electrophysiology, neuroanatomy and molecular biology can be employed to determine the neurological lesions in the mutants. Molecular analysis of the genes provides information about the structure and function of their products and throws light on the mechanisms underlying normal chemosensory behaviour.

Over two dozen olfactory and gustatory genes have been identified. Mutations of these genes either affect sensory neurons in chemoreceptor organs, or the processing of information in the brain. For instance, there are mutants blocked to pyranose sugars, sodium ions, ethyl acetate or iso-amyl acetate. Further up in the heirarchy are modality-specific mutations which exhibit altered responses to a range of unrelated chemicals. Finally, there are genes which affect a combination of sensory modalities, eg. olfaction and taste or olfaction, taste and vision.

In vertebrates, the patterns of excitation in the brain, produced by olfactory stimuli vary from individual to individual and are modified by experiential inputs. It is not known whether the central representations of odour and taste in *Drosophila* are hard-wired or plastic. Recent developments in neurogenetics and molecular biology of olfaction open up the exciting possibility of understanding the mechanisms of olfactory learning and memory.

Selected Publications:

1. Arora, K., Rodrigues, V., Joshi, S., Shanbhag, S. & Siddiqi, O. (1987), Nature, 330, 62-63. A gene affecting the specificity of the chemosensory neurons of *Drosophila*.
2. Ayyub, C., Rodrigues, V., Paranjpe, J. & Siddiqi, O. (1990), J. Neurogenet., 6, 243-262, Genetics of olfactory behaviour in *Drosophila melanogaster*.
3. Shirsat, N. & Siddiqi, O. (1993), Current Opinion in Neurobiology, 3, 553-557. Olfaction in invertebrates.



O.Siddiqi, FRS, is a Professor of Eminence at the Tata Institute of Fundamental Research, and the Director of the National Centre for Biological Sciences.

Jayant B. Udgaonkar

Protein Folding

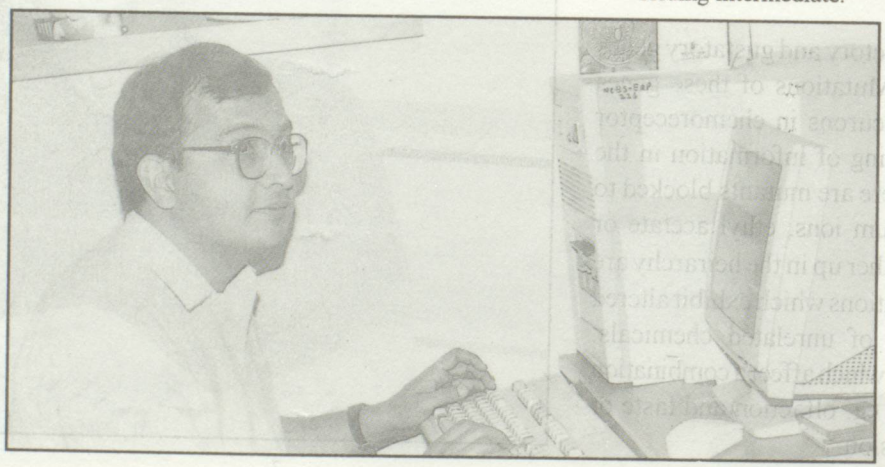
Our laboratory is focussed on the problem of protein folding, on how the amino acid sequence of a protein determines its three-dimensional structure. The tools of physical biochemistry and protein engineering are being used to identify and characterize partly-folded structures, or folding intermediates, that form on the folding pathway of barstar, a small protein that serves as an archetypal model protein for folding studies in our laboratory.

Folding intermediates are being studied using three different strategies. One approach has been to look for intermediates at extremes of pH and ionic strength. In this way, a molten globule form of barstar was identified and characterized, and its role on the folding pathway is currently being studied. Another approach has been to use rapid kinetic methods to identify and characterize intermediates that form transiently on the folding pathway. At least four such kinetic intermediates including 2 molten globule-like intermediates have been identified, and their further characterization is in progress. Using stopped flow circular dichroism spectroscopy, the secondary structures of these intermediates are being characterized. A third approach has been to use PCR based site-directed mutagenesis to perturb the tertiary structure while only minimally affecting secondary structure so as to generate equilibrium unfolding intermediates. The mutant proteins obtained are being characterized by thermodynamic and kinetic methods.

In addition, with the goal of using NMR to characterize the structures of folding intermediates, both kinetic and molten globule, the complete proton NMR assignment of barstar has been completed in our laboratory.

Selected Publications :

1. Udgaonkar, J.B. & Baldwin, R.L. (1990), Proc. Natl. Acad. Sci. (USA), 87, 8197-8201. Early Folding Intermediate of ribonuclease A.
2. Khurana, R. & Udgaonkar, J.B. (1994), Biochemistry, 33, 106-115. Equilibrium unfolding studies of Bar star: Evidence for an Alternative Conformation which Resembles a Molten Globule.
3. Shastry, M.C.R., Agashe, V.R. & Udgaonkar, J.B. (1994), Protein Science, 3, 1409-1417. Quantitative analysis of the kinetics of denaturation and renaturation of barstar in the folding transition zone.
4. Agashe, V.R. & Udgaonkar, J.B. (1995), Biochemistry, *In Press*. Thermodynamics of denaturation of barstar: evidence for cold denaturation and evaluation of the interaction with Guanidine hydrochloride.
5. Nath, U.& Udgaonkar, J.B. (1995), Biochemistry, 34,1702-1713. Pertubation of a tertiary hydrogen bond in barstar by mutagenesis of the sole His residue to Gln leads to accumulation of at least one equilibrium folding intermediate.



Jayant Udgaonkar is a graduate in Chemistry from Bombay University and an MSc from the Indian Institute of Technology, Madras. He obtained his PhD from Cornell University and held a post doctoral position at Stanford University.

K. VijayRaghavan

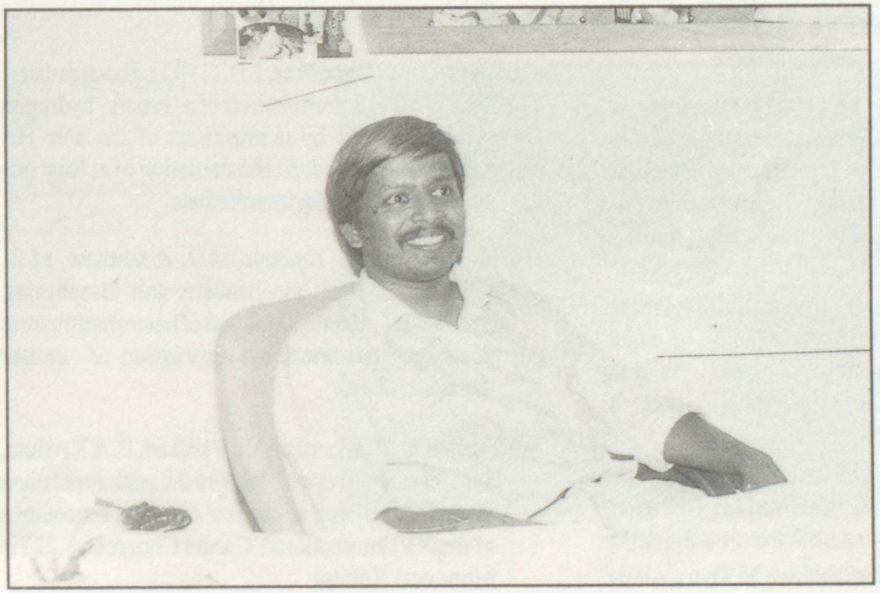
Developmental Genetics of Nerves and Muscles

We investigate the mechanisms that operate to pattern the nervous system and muscles in the fruit fly *Drosophila melanogaster*. Our studies on the formation of the adult indirect flight muscles (IFMs) have dissected the roles of the epidermis, the nervous system and myoblasts in patterning muscles. We have shown that one group of IFMs develop on templates derived from modified larval muscles whereas another develops without the use of such templates. Our studies suggest a role for the target muscles in some aspects of nerve patterning. We have shown that sites on the epidermis where adult muscles will attach are laid down early in larval development and are present on group of cells, the imaginal discs, that will differentiate to form the adult thoracic cuticle. Our studies on the role of homeotic selector genes in muscle development have shown the importance of inductive interactions between germ layers in IFM development.

Another goal, using chemosensory mutants, is to understand the mechanisms underlying the formation of "connections" between peripheral neurons and their central targets during development. The analysis of one of the genes we study, *scalloped*, reveals that this locus interacts with the genes *Notch* and *Serrate* in some aspects of development.

Selected Publications:

1. Fernandes, J., Bate, M. & VijayRaghavan, K. (1991), Development, 113, 67-77. Development of the indirect flight muscles of *Drosophila*.
2. Inamdar, M., VijayRaghavan, K. & Rodrigues, V.(1993), J. Neurogenetics, 9, 123-139. The *Drosophila* homolog of the human transcription factor TEF-1, SCALLOPED, is essential for normal taste behaviour.
3. Fernandes, J., & VijayRaghavan, K.(1993), Development, 118, 215-227. The development of indirect flight muscle innervation in *Drosophila* melanogaster.
4. Volk, T. & VijayRaghavan, K. (1994), Development, 120, 59-70. A central role for epidermal border cells in the induction of muscle patterning in the *Drosophila* embryo.
5. Fernandes, J., Celniker, S.E., Lewis, E.B. & VijayRaghavan, K. (1994), Current Biology, 4, No.11, 957-964. Muscle development in the four winged *Drosophila* and the role of the *Ultrabithorax* gene.



K. VijayRaghavan is a graduate of the Indian Institute of Technology, Kanpur, and obtained his PhD at the Tata Institute of Fundamental Research, Bombay. He held a post doctoral position at the California Institute of Technology, Pasadena.

Selected Recent Publications :

1. Shirsat, N.& Siddiqi, O. (1993), Current Opinions in Neurobiology, 3, No. 4, 553-557. Olfaction in invertebrates.
2. Fernandes, J. & VijayRaghavan, K. (1993), Development, 188, 215-227. The development of indirect flight muscle innervation in *Drosophila melanogaster*.
3. Inamdar, M., VijayRaghavan, K. & Rodrigues, V. (1993), J. Neurogenetics, 9, 123-139. The *Drosophila* homologue of the human transcription factor TEF-1, SCALLOPED, is essential for normal taste behaviour.
4. Volk, T. & VijayRaghavan, K. (1994), Development, 120, 59-70. A central role for epidermal border cells in the induction of muscle patterning in the *Drosophila* embryo.
5. Hasan, G. & Rosbash, M. (1992), Development, 116, 967-975. *Drosophila* homologs of two mammalian intracelluar Ca^{++} release channels: Identification and expression patterns of the inositol 1,4,5-triphosphate and the ryanodine receptor genes.
6. Pikielny, C.W., Hasan, G., Rouyer, F. & Rosbash, M. (1994), Neuron, 12, 35-49. Members of a family of *Drosophila* putative odorant - binding proteins are expressed in different subsets of olfactory hairs.
7. Khurana, R. & Udgaonkar, J.B. (1994), Biochemistry, 33, 106-115. Equilibrium Unfolding Studies of Barstar : Evidence for an Alternative Conformation which Resembles a Molten globule.
8. Shastry, M.C.R., Agashe, V.R. & Udgaonkar, J.B. (1994), Protein Science, 3, 1409-1417. Quantitative analysis of the kinetics of denaturation and renaturation of Barstar in the folding transition zone.
9. Swaminathan, R., Periasamy, N., Udgaonkar, J.B. & Krishnamoorthy (1994), J. Phys. Chem., 98, 9270-9278. Molten globule - like conformation of Barstar: a study by fluorescence dynamics.
10. Agashe, V.R. & Udgaonkar, J.B.(1995), Biochemistry, *In Press*. Thermodynamics of denaturation of barstar: Evidence for cold denaturation and evaluation of the interaction with Guanidine hydrochloride.
11. Nath, U. & Udgaonkar, J.B. (1995), Biochemistry, 34,1702-1713. Pertubation of a tertiary hydrogen bond in barstar by mutagenesis of the sole His residue to Gln leads to accumulation of at least one equilibrium folding intermediate.
12. Ramaswami, M., Tanouye, M. A. & Mathew, M.K. (1994), Ind. J. of Biochemistry and Biophysics, 31, 254-260. Facile formation of heteromultimetric potassium channels by expression of cloned human cDNAs.
13. Daniel, B., Tergaonkar, V., Vallikad, E. & Krishna, S. (1994), Analysis of HPV16 E2 gene expression in the progression of cervical cancer. Proceedings of the XVI International Cancer Congress, 3,2271. Monduzzi Editore
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TIFR Centre gardens

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Prof. Virendra Singh, Director, TIFR, visiting the new Campus