Various research, clinical, technological, environmental, military, and biosecurity applications require rapid detection and quantification of small amounts of proteins, either as a single solute or mixed with tens of thousands of other proteins. Arrays of individually addressable analytical agents for each protein of interest (protein antibodies or DNA and RNA aptamers are envisioned as such agents) are thought to possess the selectivity and sensitivity needed for these tasks.

We develop a novel principle of construction and operation of protein analytical arrays, based on a novel method of localized, self-focusing deposition of proteins/polymer droplets on < 1 mm size electrodes. The method utilizes liquid–liquid phase separation in a non-uniform electric field droplets of volume~ 100 attoliters containing an analytical agent for a protein analyte, and a custom-made block copolymer. Self-focusing deposition on the microelectrodes is governed by a non-uniform electric field.

The block copolymers enable the liquid-liquid separation and provide for crosslinking to ensure preservation of the analyte function outside of the solution. The electrical readout of the signal can be directly fed into sensor electronics. This method of solution deposition and rapid parallel readout can be the basic part of a massively parallel procedure to manufacture protein arrays with density of analytical elements ~ 1 sq. mm. The advantages of this method are:

- Deposition on < 1 mm size electrodes in a self-focusing procedure
- The arrays’ size, compatible with operation in field conditions and in living organisms
- Massively parallel mode of deposition on numerous arrays and of many proteins in identical conditions
- Tunable concentration of protein in analytical element

The small size of the resulting analytical array would allow its use as a probe for real-time in situ analyses in living organisms, e.g., for profiling disease-related proteins in patients, or for detection of toxic proteins, bacteria or viruses in biosecurity and military applications.

**Short Biography**

Professor Peter G. Vekilov received his B.S., M.S. and Ph.D., all in Chemistry, from Moscow State University and the Russian Academy of Sciences. He joined the Department of Chemical Engineering at UH in 2001 and is currently a professor of Chemical and Biomolecular Engineering and of Chemistry. He is the recipient of the UH Excellence in Research and Scholarship Award, DuPont Research Award, International Union of Crystallography Young Scientist Award, Research Awards by the International Human Frontiers Science Program and the Science and Technology Agency of Japan and the Shubnikov Prize of the Russian Academy of Sciences.

**Selected Publications**

Quantum Dots and Biosensing

at University of Houston Cullen College of Engineering

In recent years, quantum dots have generated enormous interest from the life sciences community due to their (largely) untapped potential in biomedical applications; particularly in bio-labeling and sensing.

While empirical work already exists on the use of quantum dots as bio-labels, their development as biosensors requires a thorough scientific understanding of their interactions with conjugated biomolecules that together ‘sense’ the molecule of interest. Some recent experiments have claimed a marked variation in the luminescence of Cadmium Selenide quantum dots conjugated to macromolecules linked to bacteria.

The origin of this large shift in luminescence of the quantum dot (and thus by implication, the band gap) appears to be poorly understood. The knowledge of the exact nature of the interaction causing the ‘shift’ may hold the key to designing better bio-sensors.

We have computational addressed the aforementioned interaction. We analyzed a prototypical model consisting of a capped Cadmium Selenide quantum dot interacting with a DNA molecule. This problem is inherently multiscale due to the relatively large number of atoms, complex nature of the interactions involved in the quantum dot-DNA system and the disparate length scales present in the problem requiring a combination of methods ranging from approaches that utilize empirical molecular mechanics force fields on one hand and ab initio electronic structure (based on density functional theory) calculations on the other hand.

Our initial results indicate a wavelength shift of roughly 19 nm in the spectrum of a 1.1 nm sized dot upon interaction with a typical DNA molecule. However, upon increase of quantum dot size, the shift decreases and thus suggests a re-examination of singular experimental data available in the literature. This suggests that active engineering of quantum dots is requires for their use as sensors.

Selected Publications

- S. Anandampillai, X. Zhang, P. Sharma, G. Lynch, Quantum dot – DNA interaction: A preliminary study, invited for publication, special issue on Recent Advances in Computational Studies of Nanostructures, CMAME, in press
Perceptual & Cognitive Dynamics

at University of Houston Cullen College of Engineering

The nervous system processes information on a time scale in the order of milliseconds. This is significantly slower than the time-scale of modern electronic devices. Yet, the real-time performance of the nervous system in most perceptual and cognitive tasks is beyond the reach of artificial systems.

Our long-term goal is to “reverse-engineer” the nervous system in order to gain insights into the principles of information coding and processing in the brain. Currently we are investigating the perceived form and position of moving objects, perceptual asynchronies across stimulus dimensions (such as color and motion), visual masking, dynamic interactions between conscious and unconscious as well as perceptual and sensorimotor processes, and spatio-temporal dynamics of focal attention.

Our research combines psychophysical, computational (neural modeling), and neurophysiological (visual evoked potentials) approaches.

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Short Biography
Professor Haluk Ogmen received B.Sc.A. and Ph.D. degrees in electrical engineering from Université Laval, Quebec, Canada. He is an Honorary Visiting Professor of Computational Neuroscience, at the University of Bradford, (UK). He received the W.T. Kettering Outstanding Teacher Award, the Junior Faculty Research Award, and the Senior Faculty Research Award from the College of Engineering. He was recently selected as a Fellow of the Hanse Wissenschaftskolleg (Hanse Institute for Advanced Study) in Germany. Currently he is serving as a member of the Central Visual Processing Study Section (CVP), Center for Scientific Review, National Institutes of Health.

Selected Publications
Neurocircuitry
at University of Houston Cullen College of Engineering

Autism is a severe developmental disorder in humans that adversely affects social-emotional behavior and understanding as well as communication and cognitive functioning.

Current hypotheses point to a deficit in local and long-range connectivity in the brains of individuals with autism. Most past studies of the brain in AD have focused on the neural basis of “core deficits” such as social-emotional differences, but few have addressed the reasons for the frequent association of autistic core deficits with sensory and motor differences.

The goal of our research is to understand the phenotypic differences in cortical circuitry in disorders of the autism spectrum and to correlate these neural differences with deviations from typical behavior.

To this end, in collaboration with researchers at the University of Texas Medical School, Houston, we are applying a neuroimaging technique called magnetoencephalography (MEG), which records the magnetic flux arising from electrical currents in the brain’s neurons with high spatial and temporal precision.

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Short Biography
Professor Bhavin R. Sheth earned his B.S. in Computer Science, M.S. in Computer Science and M.S. in Electrical Engineering from the University of Southern California, and his Ph.D. in Cognitive Neuroscience from MIT. After postdoctoral studies in Biology at Cal Tech, he joined the UH Department of Electrical and Computer Engineering in 2004. His research on the developmental disorders, in particular autism, and on the functions of sleep in humans.

Selected Publications
Imaging Brain Function

at University of Houston Cullen College of Engineering

This project addresses the issue of ‘gating’, the ability of the brain to inhibit its response to incoming, irrelevant sensory stimuli or to re-respond when the stimulus becomes relevant.

Using electrophysiological studies, we have found that phase resetting of the ongoing electroencephalogram (EEG, electrical activity generated by the brain) plays an important role in auditory evoked potential (EP) generation in healthy subjects and patients suffering from schizophrenia.

Also, repeating stimuli cause significantly less phase reorganization and we have found that schizophrenia patients have a phase reorganization deficiency, as compared to a normal control group, especially for the first (‘novel’) stimulus.

It also appears that relevant (or ‘novel’) stimuli do not consistently produce responses, and that schizophrenia patients produce responses less consistently than healthy subjects. The neurophysiological mechanisms underlying this behavior are unclear.

Therefore, the objective of the project is to explore which brain areas are involved in gating, and what is the mechanism behind this inconsistency, through simultaneous measurement of the brain's electrical activity (electroencephalogram) and metabolic activity (functional magnetic resonance imaging).

This project is pursued in collaboration with Merrill Hiscock, Ph.D., professor of psychology at the University of Houston, Anne Jaap Jacobson, Ph.D., professor of philosophy at UH, and Amin Kajali Ph.D., research assistant professor in the UH Department of Electrical and Computer Engineering.

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Short Biography
Ben H. Jansen received his PhD in Medical Informatics from the Vrije Universiteit, Amsterdam, The Netherlands in 1979 and joined UH in 1982, where he is presently a Full Professor in Electrical and Computer Engineering. He was Consulting Editor of Clinical Neurophysiology, and continues to serve on NIH review panels.

Selected Publications
- Bonala B, Boutros NN, Jansen BH (2007): Target probability affects the likelihood that a P300 will be generated in response to a target stimulus, but not its amplitude. Psychophysiology, in press.
Brain Plasticity

Contrary to the widespread belief that the adult brain is “hard wired” there is a growing body of evidence that it actually has a large capacity for reorganization. Understanding the mechanisms of this reorganization is very important for both basic sciences (remodeling of the underlying neuronal circuitry) and clinical applications (treatments for loss of function due to injury, diseases, and ageing). We aim to determine the capacity of cortical remodeling and measure its dynamics with high spatial and temporal resolution in adult visual cortex.

Brain plasticity is at its peak in infancy, when brains are most capable of adjustment. Babies who suffer significant brain trauma, for example, will often make near-complete recoveries. This is because their brains are in the process of organizing themselves and are able to assign tasks normally performed by the damaged areas to the still-functioning portions.

Because adult brains are already organized, they have much less plasticity and make only very small adjustments when damaged. We intend to determine the plasticity level of the adult brain – the degree of which is currently unknown.

We are pursuing this research in collaboration with Hubert Dinse, a professor with Ruhr University in Bochum, Germany. This project is supported by a three-year, $750,000 grant from the Human Frontiers Science Program, an organization dedicated to bringing together scientists with expertise in different fields and from different parts of the world.

Another aspect of research involves development of new and improvement of existing techniques that allow rapid imaging of the brain structures with high resolution and with minimal invasiveness and to employ these techniques to further our understanding of the representation of the sensory world in the mammalian brain. For example, one project explores the possibility to map multiple cortical features concurrently.

Valery Kalatsky

Short Biography
Professor Valery Kalatsky received a Ph.D. in physics from Texas A&M University in 1999, and M.S. (1994) and B.S. (1994) in applied physics and mathematics from Moscow Institute of Physics and Technology. He is a recipient of an Alfred P. Sloan Foundation fellowship in neuroscience (2005). His primary research interests include neuroimaging, brain mapping, optical imaging of intrinsic signals, neuro-biology, representations of information in sensory modalities (vision, hearing, somatosensation) in mammalian neocortex, and reorganization of these representations during development and in adulthood.

Selected Publications
Bone Replacement
at University of Houston Cullen College of Engineering

Bone replacement is a major treatment for those chronic and acute musculoskeletal diseases as well as some fractures. Traditional replacements, including bone tissue from the same patient or cadaver, and permanent biomaterials, such as metals and ceramics, are hindered by problems like limited availability, disease transmission, immune response, wear and infection.

Synthetic biodegradable polymers are widely utilized in the fabrication of scaffolds for bone tissue engineering. However, this class of materials generally exhibits inferior mechanical properties when used as scaffolds of high porosity for guided bone growth under load bearing conditions. Injectable, biodegradable biomaterials with sufficient mechanical strength are necessary to fabricate scaffolds for bone replacement. Professor Ramanan Krishnamoorti has found that the addition of tiny quantities (e.g., 0.02%-1%) of nanoparticles such as carbon nanotubes and the natural tooth mineral hydroxyapatite can produce nanocomposite bone replacement materials with superior mechanical and degradation characteristics.

Single-walled carbon nanotubes (SWNTs) are widely regarded as optimal reinforcing fillers and may be combined with biodegradable polymers to provide novel materials for tissue engineering applications. A major challenge in mechanical reinforcement via SWNTs is to overcome the strong inter-tube aggregation, resulting from van der Waals interactions and π – π stacking, to prevent the formation of large bundles of SWNTs. Using functionalyzed nanotubes and surfactant compatibilization routes, they have obtained better dispersion of these nanotubes than unmodified SWNTs in an in situ crosslinkable and degradable fumarate based polymer. Nanocomposites with 0.1 wt% functionalyzed nanotubes resulted in a three-fold the pure polymer networks. Furthermore, these nanocomposites demonstrate good cytocompatibility, making them promising candidate materials used for a mini-invasive surgery or guided tissue growth in tissue engineering.

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Short Biography
Professor Ramanan Krishnamoorti received his B.Tech from IIT Madras and his Ph.D. from Princeton University, and pursued postdoctoral studies at Caltech and Cornell. In addition to teaching and research, Dr. Krishnamoorti serves as the college’s associate dean for research. He is the recipient of a 1999-2004 NSF CAREER Award, a 2000 Cullen College of Engineering Junior Faculty Research Award, and the 2001 UH Award for Excellence in Research and Scholarship.

Selected Publications
Many types of cancer have been treated by radiation therapy in recent years. The treatment objective is to achieve tumor control by planning a significant total dose of radiation to the cancerous region to sterilize the tumor without damaging the surrounding healthy tissues. The dose of radiation must be constrained to avoid healthy organs because an overdose may lead to medical complications.

Our research goal is to develop a fully automated and optimized Intensity Modulated Radiation Therapy (IMRT) planning system for treating cancer patients. Since most optimization models for IMRT planning are computationally intractable, we aim to develop new computational algorithms for solving mixed integer non-linear programming (MINLP) models that can substantially speed up the solution process so that clinicians can use the most precise optimization tools in the hospital.

Our preliminary experiments have shown very promising results. We were able to reduce the computation time from one week to 15 minutes without losing the treatment plan quality. With this new optimization tool, physicians can develop robust treatment plans for cancer patients within a fraction of the time that was required in the past.

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Short Biography
Professor Gino Lim obtained his M.S. and Ph.D. degrees in Industrial Engineering from the University of Wisconsin – Madison. He is the founding director of Systems Optimization of Computing Laboratory (SOCL) in the UH Department of Industrial Engineering. He received the Pierskalla Best Paper Award from The Institute for Operations Research and the Management Sciences (INFORMS) for his research on brain cancer treatment using Gamma Knife. He is the current chair of the Bonder Scholarship committee of INFORMS and a recipient of the Moving Spirit Award from INFORMS in 2006. He received an Outstanding Teacher Award from the UH Cullen College of Engineering in 2007 and Outstanding Teacher Awards from the IE department in 2005 and 2006.

Selected Publications
Thermal Response of Heart Tissue

at University of Houston Cullen College of Engineering

The Texas Heart Institute, in cooperation with the Heat Transfer and Phase Change Laboratory of the Department of Mechanical Engineering, is studying the thermal response of heart tissue to the acute cessation of coronary blood flow.

The research seeks to establish a link between ischemia and the temperature of the heart that may lead to a new early detection mechanism for heart disease. In experiments performed on swine, blood flow in a single coronary artery is blocked.

The temperature of a part of the heart muscle fed by that artery is monitored along with the pumping work produced at that location. Microthermocouple probes constructed by a UH graduate student and implanted by surgeons at the Texas Heart Institute are used to measure tissue temperature. An example of these probes is shown in the figure (upper right).

An ultrasound probe developed at the Baylor College of Medicine is used to measure the local work rate. The graph shows an example response to a five-minute occlusion. The tissue temperature rises slightly as the work produced per heat beat drops.

This response indicates that the pumping efficiency of the muscle is dropping rapidly at the onset of the occlusion. When blood flow is restored, the temperature falls and the magnitude of the pump work is restored.

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Short Biography
Professor Keith Hollingsworth received his B.S. and M.S. from North Carolina State University, and Ph.D. from Stanford University. He is the recipient of the highest teaching awards at both the College and University levels, and the El Paso Energy Corp. Faculty Achievement Award.

Selected Publications
» Publications.
Neonatal Seizure Detection

at University of Houston Cullen College of Engineering

The identification of electrographic seizures during long-term EEG monitoring in the neonate is currently based upon visual interpretation of the graphic record, a process that is very time-consuming.

Therefore, the major objective of this project is the development of techniques for the reliable automated detection of electrographic seizures in the neonatal EEG.

We utilize a multi-stage, hybrid approach to detection that employs a combination of signal processing, pattern recognition, neural networks, and expert rules.

Through the successive stages of the detection process, multichannel neonatal EEG data containing all types of background activity and artifacts is analyzed to detect and classify electrographic seizures.

The system has been tested on data recorded from infants in the Clinical Research Center for Neonatal Seizures, The Methodist Hospital, Houston, Texas, in collaboration with physicians from the Baylor College of Medicine.

We expect that the information we gain from the research will lead to the development of a practical seizure detection system and further our long-term goals of reduced expense in the reading and interpretation of neonatal EEGs.

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Short Biography
Professor John R. Glover received B.A. and M.E.E. degrees in electrical engineering from Rice University, and a Ph.D. degree in electrical engineering from Stanford University, where he was a National Science Foundation Fellow. In 1981 he received the Outstanding Transactions Paper Award from the IEEE Education Society. His current research interest is in the area of intelligent signal interpretation, particularly as applied to biomedical signals.

Selected Publications
As many as 15 million Americans are estimated to have unruptured cerebral aneurysms, which are ballooning weak spots in the wall of a blood vessel in the brain. We are currently working with doctors at The Methodist Hospital Research Institute and the Baylor College of Medicine on new techniques to identify brain aneurysms before they rupture or cause strokes.

Our research focuses on developing computational models to predict the location of aneurysm formation, writing sophisticated algorithms for flow visualization to help doctors better understand the flow dynamics inside the aneurysm and performing simulations to analyze the effectiveness of a certain surgical interventions such as stent placement. This involves the application of computational hemodynamics (computer simulations of blood flow) to the prevention, diagnosis and treatment of cerebral aneurysms.

The initial objective of this study is to clarify the cause-and-effect linkages between hemodynamic factors (such as wall shear stress and dynamic pressure) and physiological responses leading to aneurysm formation. First, the arterial environment before aneurysm formation is approximated and simulations are performed on an artificially “smoothed” arterial segment. Second, the flow features in this “pre-aneurysm” environment are compared with those in an artery with a fully-formed aneurysm. Third, based on these comparative results, a model has been developed that should help doctors better predict the susceptibility of an arterial segment to aneurysm formation.

The second part of the research deals with developing algorithms for flow visualization inside the aneurysm. Realistic, unambiguous, and appealing visualizations are necessary to fully understand the complexity of blood flow in healthy and diseased arteries. The visualization challenges posed by intricate steady and unsteady flows are undertaken with the use of novel techniques to interpret computational fluid dynamical (CFD) data from three-dimensional (3D) numerical simulations with two-dimensional (2D) and 3D still images and animations. The visualizations required to understand this fluid dynamical behavior should prove useful in both academic and clinical settings and provide better insight in the design and placement of stents, coils, and various other interventional flow diverting devices.

This research is being pursued in collaboration with Dr. Goetz Benndorf, an Interventional Neuroradiologist, and Dr. Christof Karmonik, Research Scientist from the Department of Radiology at The Methodist Hospital Research Institute, and both Adjunct Professors of Mechanical Engineering at the University of Houston.

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**Short Biography**
Professor Ralph W. Metcalfe received his B.S. in Mathematics from the University of Washington, and his M.S. and Ph.D. in Applied Mathematics from M.I.T. He is currently Professor of Mechanical Engineering, Biomedical Engineering, and Mathematics at the University of Houston. In 2004, he was named deputy director for the U.H. Biomedical Engineering Program. His primary research interests include Computational Hemodynamics (computer simulations of blood flow) applied to the study of cerebral aneurysms and atherosclerotic lesions.

**Publications**
Bacterial expression of extracellular polymeric substances (EPS) facilitates their adhesion and biofilm formation. Fouling caused by biofilms reduces performance efficiency of several technological systems including membranes employed for water and wastewater purification.

The overall goal of this project is to investigate bacterial secretion of extracellular proteins and polysaccharides and their control by using bismuth dimercaptopropanol (BisBAL).

In collaboration with scientists at the Pacific Northwest National Laboratory, we are rigorously characterizing free and bound EPS components using FTIR spectroscopy and atomic force microscopy.

Results to date have shown that one possible mechanism of biofilm reduction by BisBAL to be the inhibition of polysaccharide O-acetylation.

Additionally, we have demonstrated that EPS play a major role in biofouling and reducing the effectiveness of hydrodynamic backwashing during microfiltration of Brevundimonas diminuta suspensions suggesting that "chemically enhanced" backwashes incorporating EPS-disrupting substances may result in reducing fouling and improving performance.

This research is funded by an NSF CAREER award and the Texas Hazardous Waste Research Center.

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Short Biography
Shankar Chellam obtained his M.S. and Ph.D. degrees in Environmental Engineering from Rice University, and was awarded the American Water Works Association's Larson Aquatic Research Award for his doctoral research. Dr. Chellam chaired the American Water Works Association's Membrane Technology Research Committee from 1998 - 2001, and is the recipient of a 2002-2007 NSF CAREER award for membrane research. He received the UH Cullen College of Engineering's Junior Faculty Research Award and Outstanding Teacher Award in 2003, 2004 and 2007 respectively.

Selected Publications
Filtration Membranes

at University of Houston Cullen College of Engineering

Filtration membranes are used to remove microorganisms and particles from drinking water and in the pharmaceutical, biotechnology, and food industries. Current manufacturing techniques produce wide pore size distributions, including some pores much larger than the average. The presence of these large pores risks microbial contamination of the product.

The long-range goal of this research, which is funded by the Texas Advanced Technology and Texas Advanced Research Programs, is to develop water treatment membranes capable of ultra-high fluxes. The principal objectives of our research are (1) to fabricate polymeric microfiltration and ultrafiltration membranes possessing near-ideal characteristics, such as pores having uniform size, cross section, and spacing, and (2) to demonstrate that these filters will result in substantially higher fluxes compared to equivalent track-etched membranes that represent the current state-of-the-art for commercially available membranes. We are employing a novel manufacturing process, aperture array lithography, to fabricate such micro- and ultrafilters with target pore diameters in the range 1μm to 50nm.

Related aspects of this work include validation of these novel membranes using bacteria as well as elucidating bacterial fouling mechanisms at the onset of filtration. Results to date indicate that bacteria simultaneously deposit directly on the membrane and on each other during the early stages of filtration, which has been quantitatively modeled using the intermediate blocking law.

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Selected Publications

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Short Biography
Professor Paul Ruchhoeft earned his B.S. and Ph.D. in electrical engineering from UT-Austin and UH, respectively. He joined the UH faculty in 2000 as a research assistant professor and became an assistant professor in 2001. He was recently promoted to associate professor with tenure. His research is on nanoscale printing using energetic helium ions and atoms. He has authored numerous papers in these areas and was the 2004 recipient of the Cullen College of Engineering Junior Faculty Research Award.
Microfiltration membranes are highly effective for turbidity, bacteria, and protozoa removal. However, they are not efficient barriers for viruses, which are typically smaller than membrane pores.

We are investigating coagulation pretreatment methods to increase virus removal, while simultaneously reducing membrane fouling.

Chemical coagulation using iron chloride was shown to achieve >99.99% removal of viruses (MS2 bacteriophages) from the feed water with an iron dosage of 10 mg/L.

Also, the negatively charged viruses first appear to adsorb onto the positively charged iron oxyhydroxide, FeOOH(s), floc particles prior to their subsequent removal by the membrane.

A very important aspect of this research is that we are investigating an innovative electrocoagulation process where iron coagulant species are generated by electrolytic oxidation of an anode. Results to date demonstrate that ferrous iron is produced electrochemically, which is then oxidized in situ to ferric iron.

We are commencing the study of aluminum electrodes since we expect that employing aluminum anodes will generate Al3+ during electrocoagulation, producing Al(OH)3 precipitates capable of destabilizing natural colloids and improving membrane performance when used as a pretreatment process.

This research has been funded by the Texas Advanced Technology Program, NSF CAREER program, and the United States Department of Interior (through the Bureau of Reclamation).

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Shankar Chellam obtained his M.S. and Ph.D. degrees in Environmental Engineering from Rice University, and was awarded the American Water Works Association's Larson Aquatic Research Award for his doctoral research. Dr. Chellam chaired the American Water Works Association's Membrane Technology Research Committee from 1998 - 2001, and is the recipient of a 2002-2007 NSF CAREER award for membrane research. He received the UH Cullen College of Engineering's Junior Faculty Research Award in 2003, 2004 and 2007 respectively.

**Selected Publications**


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**Short Biography**
Dennis Clifford hold a B.S. in Chemical Engineering from Michigan Technological University, a M.S.E. both Environmental and Chemical Engineering from the University of Michigan, and a Ph.D. in Environmental Engineering, also from the University of Michigan. He joined the Cullen College of Engineering in 1976 and has served as the Civil and Environmental Engineering department chair, a visiting associate professor at Rice University and a guest professor at the Engler-Bunte Institute, Water Chemistry Section at the University of Karlsruhe in Germany. His research impacts the areas of water filtration and treatment.
Antibiotic Development

at University of Houston Cullen College of Engineering

Bacterial resistance to antibiotics has reached alarming proportions. Scientific publications as well the popular press have recently issued repeated warnings on bacterial wars, new plagues, worldwide calamities, new apocalypses, requiem for the magic bullets, and return to the pre-antibiotic era.

There is a dire need both to preserve the effectiveness of existing antibiotics and to rapidly develop new ones. In this project, jointly with Dr. Vincent Tam (UH College of Pharmacy), we are partly addressing this need by developing methods usable for the rational design of dosing regimens capable of suppressing the emergence of bacterial resistance to antibiotics.

These methods can be used in a clinical setting to prolong the effectiveness of existing antibiotics, as well as by the pharmaceutical industry to develop new ones.

Effective dosing regimens for levofloxacin against Pseudomonas aeruginosa correspond to \( \frac{D}{K_{s}} > 1 \).

Hollow-fiber in vitro experimental infection model

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Short Biography
Professor Michael Nikolaou received a Ph.D. from UCLA in 1989 and a Diploma from the National Technical University, Athens, Greece in 1984, both in chemical engineering. His research interests are in computer-aided systems engineering, with applications in various fields. Over 15 Ph.D. students from his group have moved on to successful careers in industry and academia.

Selected Publications
» Publications...

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Short Biography
Professor Vincent H. Tam received a Pharm.D. from the Albany College of Pharmacy and a B.Sc. (Pharm) from the National University of Singapore, followed by Post-Doctoral Training at Detroit Receiving Hospital (Infectious Diseases Pharmacy Residency) and Albany Medical College (Clinical Pharmacology/Infectious Diseases Fellowship). He is a Board Certified Pharmacotherapy Specialist (with added qualifications in Infectious Diseases). His academic research interests are in pharmacokinetics and pharmacodynamics of antimicrobials, mathematical modeling and simulation of biological processes, and mechanisms of bacterial resistance.
Understanding the pharmacokinetic and pharmacodynamic behavior of drugs is critical in their efficient use. The interactions between the drugs and lipid membranes is one of the key elements in the in vivo behavior of such drugs and vital to tailor the pharmacokinetic and pharmacodynamic characteristics of the drugs.

Non-steroidal anti-inflammatory drugs (NSAIDs and e.g., Aspirin and Ibuprofen) mainly used for their pain and fever reducing action also cause well known side effect called gastrointestinal (GI) toxicity with chronic usage. NSAID-Phosphocholine lipid complexes are purported to be safer alternatives wherein NSAIDs are pre-associated with lipid vesicles (figure below) and preliminary laboratory based tests indicate a potential decrease in GI toxicity. However, the interactions between NSAIDs and lipid membranes are not completely elucidated.

The Krishnamoorti group’s focus is to understand the interactions between various NSAIDs and lipid membranes at a molecular level using both experiments and simulations. Macro measure experiments like differential scanning calorimetry clearly indicate that the drugs partition into the bilayer. Using molecular dynamics simulations we are systematically addressing the various aspects like thermodynamics, diffusion, concentration effects etc. of these drugs in lipid membranes. Some of the results clearly provide deeper insight which is difficult to obtain in experiments. This also helped the group design various neutron scattering experiments in a way that will systematically address and complement our simulations results. Their preliminary round of small angle neutron scattering, neutron reflectivity and neutron spin echo experiments clearly corroborate both macro and molecular level effects of these drugs on lipid vesicles and the membranes.

The group collaborates with Len Lichtenberger & Vasanthi Jayaraman (UTHSC) and Rob Raphael (Rice).

**Short Biography**
Professor Ramanan Krishnamoorti received his B.Tech from IIT Madras and his Ph.D. from Princeton University, and pursued postdoctoral studies at Caltech and Cornell. In addition to teaching and research, Dr. Krishnamoorti serves as the college’s associate dean for research. He is the recipient of a 1999-2004 NSF CAREER Award, a 2000 Cullen College of Engineering Junior Faculty Research Award, and the 2001 UH Award for Excellence in Research and Scholarship.
Unfortunately, a portion of the materials marketed as products of a successful nanotechnology industry will ultimately find their way into our environment. As environmental engineers and scientists, we are interested in evaluating the possible effects of nanoparticles on microorganisms present ubiquitously in the environment. This has considerable implications for possible technological applications as well as ecological impacts transmitted through such microorganisms. Bacteria are at the base of ecosystems and their perturbation may have unforeseen consequences for the entire food web and nutrient cycling. Viruses such as bacteriophages may play an important role in the ecology of bacterial populations and as vectors for the transport and transmission of genetic information. This aspect of our research directly responds to calls for reliable data on nanoparticle behavior in aqueous environments that have come from environmental advocacy groups and the emerging nanochemistry industry.

On-going research in my laboratories addresses the effects of fullerene-based nanoparticles on bacterial viruses (bacteriophages) and their bacterial hosts. Our primary goal is to lay the basis for assessing the impacts of these nanoparticles on microbes that are the foundation of all ecosystems, are often the bases for food webs, and are main agents of biogeochemical cycles. Specifically, we are evaluating the hypotheses that reactive oxygen species (ROS) production by nanoparticles alter phage capsid proteins or RNA/DNA, and bacterial cell lipids that may be susceptible to oxidative stress. This research also provides insights into understanding how nanomaterials can be used in engineering applications such as disinfection and biofouling control.

This research is funded by the National Science Foundation.

Enhanced inactivation of the MS2 bacteriophage upon exposure to fullerol and UV-A radiation or sunlight.

Fullerol nanoparticles association with the T7 bacterial virus

Short Biography

Shankar Chellam obtained his M.S. and Ph.D. degrees in Environmental Engineering from Rice University, and was awarded the American Water Works Association’s Larson Aquatic Research Award for his doctoral research. Dr. Chellam chaired the American Water Works Association’s Membrane Technology Research Committee from 1998 - 2001, and is the recipient of a 2002-2007 NSF CAREER award for membrane research. He received the UH Cullen College of Engineering’s Junior Faculty Research Award and Outstanding Teacher Award in 2003, 2004 and 2007 respectively.

Selected Publications

The research activities of Biomedical Optics Laboratory concentrate on the development of new methods and techniques for functional imaging and biosensing of tissues and cells. Some of the research projects include:

**Noninvasive functional and structural imaging of embryonic development:** The overall objective of this project is to develop a novel method for noninvasive functional and structural imaging of developing heart and vascular system of embryos by using Optical Coherence Tomography (OCT) technique.

**OCT-based Drug Diffusion Biosensor and Early Diagnostics:** We are developing novel methods for noninvasive functional imaging of tissues and assessment of drug diffusion in epithelial tissues. This could facilitate expansion of novel therapeutic agents and drug-delivery techniques and enhance the overall understanding of topical drug delivery. Preliminary studies also suggest that this imaging method could potentially be applied for early diagnostics of cardiovascular diseases.

**OCT-based Biometric System:** Spoofing of biometric fingerprint devices is a common problem nowadays. We are developing novel noninvasive OCT-based Biometric System that would be able reliably identify presence of artificial materials commonly used for spoofing fingerprint devices.

**Noninvasive detection and assessment of gas emboli and DCS:** Noninvasive functional imaging, monitoring and quantification of microbubbles forming in blood and tissues upon rapid changes in barometric pressure are extremely important for effective therapy and diagnostics of several diseases as well as for several imaging and drug delivery projects. We are developing Phase-Sensitive Swept Source OCT (PhS-SSOCT) technique for real-time, sensitive, accurate, and noninvasive imaging, monitoring, and quantification of microbubbles in skin.

**Nano-Biosensor:** This research is devoted to development of a new imaging tool for real-time monitoring and sensing of proteins and neuronal activity with high-resolution spectroscopy of active nanostructures such as Quantum Dots (QDs).

The research activities are currently supported by Wallace Coulter Foundation and Office of Naval Research.

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**Short Biography**
Professor Kirill V. Larin received MS degree in Laser Physics and Mathematics in 1995 from Saratov State University, Russia. In 1997, he received Young Investigator award from Russian President Boris Yeltsin. He received his Ph.D. degree in Biomedical Engineering from the University of Texas Medical Branch in 2002.

**Selected Publications**
Sickle cell anemia was the first disease whose molecular basis was identified as a point mutation in both β-chains of hemoglobin. The mutated protein (sickle cell hemoglobin or HbS) forms 14-member fibers when the protein is in its T-conformation in deoxy-state. The fibers stretch the erythrocyte membrane, which damages it and increases its permeability and adhesion to the endothelial walls. The fibers also render the red cells rigid. These consequences of HbS polymerization result in obstruction of the blood flow, an excruciatingly painful event, which leads to tissue necrosis and, eventually, to death of the patient. The formation of HbS fibers, also called polymerization, is the primary pathogenic event of sickle cell anemia: if polymerization is prevented or slowed down, sickle cell crises do not occur even in individuals homozygous for HbS. Thus, insight into the mechanisms of HbS polymerization and the search for means to slow it down or prevent it are pathways in the search for a cure for this debilitating disease. While more than 200 molecules have been proposed, which bind to hemoglobin and prevent its polymerization, none of them have lead to a treatment applicable in the clinic: since the hemoglobin concentration is the red blood cells is ~ 5 millimolar, all found additives were found to be toxic at the concentrations, needed for binding.

In search of additives, which could be active at significantly lower concentrations, we probed the physico-chemical mechanisms of polymerization of sickle cell hemoglobin. We found that the first stage in polymerization, the nucleation of new fibers, follows a two-step mechanism, whereby the fiber nucleus forms within a dense liquid cluster of hemoglobin. While these dense liquid clusters are crucial for the fiber nucleation, they are metastable and exist due to a fine balance between attraction and repulsion in the mean force potential of interaction between the hemoglobin molecules. Thus, the properties and the volume of the dense liquid clusters can be regulated by fine-tuning of the intermolecular interactions.

We are currently probing for molecules which might be present in the erythrocyte cytosol of sickle cell patients and which may regulate the amount of dense liquid in it. In this way, these molecules may enhance or suppress the rate of nucleation of sickle cell hemoglobin polymers and control the pathophysiology of sickle cell anemia.