



Second Annual Nanotechnology Symposium

2009

*Advances in Nanotechnology
and Applications*

**NEW: Workshops in Nanotechnology
for Educators and Students**

**October 9 & 10, 2009
Louisville, Kentucky, USA**

Presented By:

 **Sullivan
University**
College of Pharmacy

C.E.N.T.E.R.A.
Center for Nanotechnology:
Education, Research, & Applications

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Welcome Message

October 9, 2009



Dear Friends and Colleagues,

Sullivan University College of Pharmacy would like to welcome you to the city of Louisville, and personally to our Second Annual Nanotechnology Symposium! We have received a record of papers and presentations, as well as the participation of very distinguished scientists and academicians. We all are very aware about the place that nanotechnology will have at the brink of the twenty first century. Sullivan University College of Pharmacy is committed to the education, research, and promotion of nanoscience. We have created a Center for Nanotechnology: Education, Research, and Applications (CENTERA) to fulfill this mission and also — most important — to provide awareness and education to a workforce of the future. This will help to shape a strong foundation for developing industry in Louisville and the Commonwealth of Kentucky.

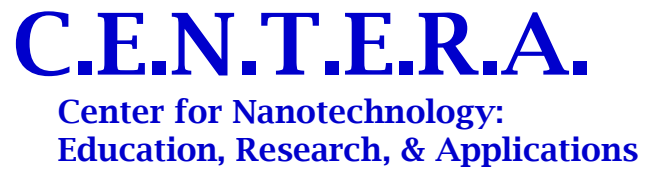
I would like to personally thank you for coming to join us for these two days filled with discoveries, renewed friendship, and also networking with other colleagues in the country. Dear Friends and Colleagues, I hope you will enjoy the Symposium and also don't forget to take the time to visit all the cultural richness that our city of Louisville has to offer. Should you have any suggestions for improvement, please feel free to send those to my attention.

Warmest Regards,

A handwritten signature in black ink that reads "Hieu T. Tran, Pharm.D." with a stylized flourish at the end.

Hieu T. Tran, Pharm.D.
Founding Dean and Professor
College of Pharmacy
Sullivan University
htran@sullivan.edu

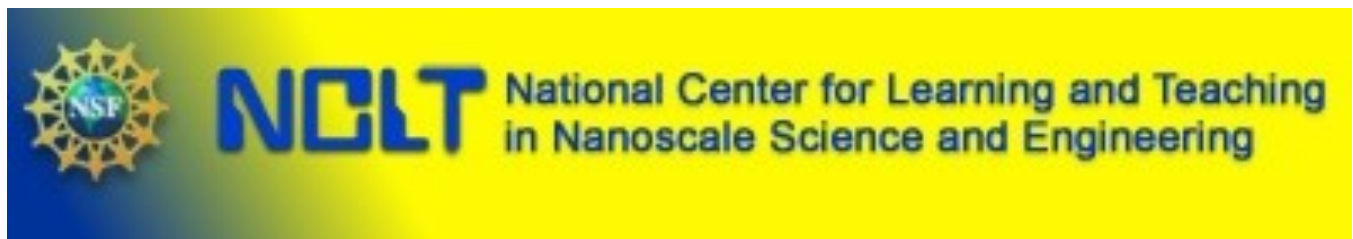
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NIH Nanomedicine Development Center:

Phi29 DNA-Packaging Motor for Nanomedicine



NIH Roadmap FOR MEDICAL RESEARCH



Organizing Committee

Dr. Hieu Tran

Founding Dean
Professor, Department of Clinical and Administrative Sciences

Dr. Yashwant Pathak

Assistant Dean of Research
Professor, Department of Pharmaceutical Sciences

Allison Koch

Event Coordinator
Administrative Assistant to the Assistant Dean of Research

Lindsay Koch

Administrative Assistant to the Chair of the Department of Clinical and Administrative Sciences

Paige Sherid

Administrative Assistant to the Assistant Dean of Student Affairs

Rhonda Frazier

Administrative Assistant to the Director of Program Assessment

Sara Wade

Executive Assistant to the Dean
Human Resources Coordinator

Yolanda Long

Administrative Assistant to the Assistant Dean of Experiential Education

Award Selection Committee

Dr. Miriam Ansong

Director, Drug Information Center
Assistant Professor, Department of Clinical and Administrative Sciences

Dr. Girish Kotwal

Professor, Department of Pharmaceutical Sciences

Dr. Yashwant Pathak

Assistant Dean of Research
Professor, Department of Pharmaceutical Sciences

Dr. Wasana Sumanasekera

Assistant Professor, Department of Pharmaceutical Sciences

Dr. Hieu Tran

Founding Dean
Professor, Department of Clinical and Administrative Sciences

Dr. Raghunandan Yendapally

Assistant Professor, Department of Pharmaceutical Sciences

Session Chairs and Co-Chairs

Dr. Abeer Al-Ghananeem

Associate Professor, Department of Pharmaceutical Sciences
Sullivan University College of Pharmacy
Vice President of Scientific Affairs, US WorldMeds, LLC
Louisville, Kentucky

Dr. Maria Lourdes Ceballos-Coronel

Associate Professor, Department of Pharmaceutical Sciences
Sullivan University College of Pharmacy
Louisville, Kentucky

Dr. Vladamir Dobrokhotov

Assistant Professor of Nanoscience, Department of Physics and Astronomy
Western Kentucky University
Bowling Green, Kentucky

Dr. Peixuan Guo

Director of one of the eight NIH Nanomedicine Development Centers
Dane and Mary Louise Miller Endowed Chair in Biomedical Engineering, University of Cincinnati
Cincinnati, Ohio

Dr. Girish Kotwal

President, Kotwal Bioconsulting, LLC
CEO, InflaMed Inc.
Louisville, Kentucky

Dr. Gopal Pillai

Chair and Professor, Department of Pharmaceutical Sciences
Sullivan University College of Pharmacy
Louisville, Kentucky

Dr. Judy Senior

Adjunct Professor, College of Pharmacy
Western University of Health Sciences
Pomona, California

Dr. Gamini Sumanasekera

Associate Director, IAM-RE, Associate Professor of Physics
University of Louisville
Louisville, Kentucky

Dr. Jasjit Suri

Fellow AIMBE, Eigen Inc.
Grass Valley, California

Dr. Kevin Walsh

Samuel T. Fife Professor of Electrical and Computer Engineering
Founding Director of the UofL Micro/Nanotechnology Center University of Louisville
Louisville, Kentucky

Workshops in Nanotechnology

NCLT, the National Center for Learning and Teaching, is the first national center for nanoscale science and engineering education in the United States. The Center's primary focus is on **learning and teaching through inquiry and design of nanoscale materials and applications**. Through collaborative efforts, the Center members are developing curricular activities based on the latest nanoconcept research from the laboratories and bringing them into the classrooms! The goal is to use nanoconcepts to foster greater student appreciation of the existing science and mathematics courses they are taking, so that they will enjoy exposure to the cutting-edge technology that is already impacting society and everyday products. The workshops will feature two modules recently developed: 1) the importance of surface area increases at the nanoscale and 2) the interaction of light with nanoscale materials.

Workshop 1: Introduction to the Nanoscale

As an introduction to the nanoworld, the inquiry-based curricular activities are designed to (1) give students a feel for just how small the nanoscale is, (2) give student practice in communicating nanoscale quantities and relating them to the familiar macroscale, and (3) illustrate the first and foremost property that increases in importance at the nanoscale, viz., surface area. Students are engaged in various hands-on activities to investigate the effects of changing surface area with size/shape of different forms of sugar, polymers, and models. The activities culminate in a card game that further reinforces the foundational knowledge of size, scale, and surface area relationships at the nanoscale.

Workshop 2: Manipulating Light in the Nanoworld

In this module, students explore size-dependent properties of nanoscale materials through their interaction with light. A home-made spectroscope is used to examine light emission of macroscopic and nanoscale light sources, in which the size determines spectral output (i.e., the color of light produced), whereas macroscopic sources do not. The interactions of light with micro and nanoscale structures (such as soap films and bird feathers) also result in the production of color due to interference effects. The activities culminate in students designing their own, artificial opals, made from nanoscale sized spheres.

Note: NCLT is the host of the NanoEd Resource Portal—a central repository for the collection and dissemination of Nanoscale Science and Engineering Education (NSEE) materials. For more information on program offerings and resources for teachers, go to www.nclt.us.

Workshop Presenters

Dr. Matthew Hsu oversees all aspects of the Materials World Module's development. Dr. Hsu received his Ph.D. in Materials Science and Engineering at Northwestern University and his B.S. in Chemical Engineering from UC Berkeley. He works with regional teachers as well as field test teachers across the US and Mexico to share the excitement of cutting-edge science and technology.

Dr. Sarah Dugan received her Ph.D. in Physics from Northwestern University. She is currently a research associate at NCLT working on lessons and activities for grades 7-12. She has presented several teacher workshops based on activities developed though NCLT. Dr. Dugan is also a co-instructor for the nano section of the Engineering Design and Communication course at Northwestern, guiding undergraduates in the design of games and activities for middle school classes.



Program for October 9 & 10, 2009

FRIDAY OCTOBER 9, 2009

Nanotechnology Symposium
Advances in Nanotechnology and Applications

- 8:30 a.m. — 9:30 a.m. **Registration and Continental Breakfast**
- 9:30 a.m. — 9:32 a.m. **Introduction**
Yashwant Pathak
Assistant Dean of Research
Director of CENTERA
Professor, Department of Pharmaceutical Sciences
Sullivan University College of Pharmacy
Louisville, Kentucky
- 9:32 a.m. — 9:35 a.m. **Welcome Remarks**
Hieu T. Tran
Founding Dean and Professor
Sullivan University College of Pharmacy
Louisville, Kentucky
- 9:35 a.m. — 9:40 a.m. **Initial Remarks and Inauguration**
A.R. Sullivan
Chancellor
Sullivan University System
Louisville, Kentucky
- 9:40 a.m. — 9:50 a.m. **Awards, Recognition**
Yashwant Pathak
- 9:50 a.m. — 10:05 a.m. **Inaugural Address**
Lee Warren
Vice President of Commercial Operations, US WorldMeds, LLC
Louisville, Kentucky
- 10:05 a.m. — 11:00 a.m. **Keynote Address I**
RNA Nanotechnology and Nanomedicine
Peixuan Guo
Director of one of the eight NIH Nanomedicine Development Centers
Dane Mary Louise Miller Endowed Chair in Biomedical Engineering
University of Cincinnati
Cincinnati, Ohio
- 11:00 a.m. — 11:30 a.m. **Keynote Address II**
What I Have Learned From Nanotechnology
John DiLoreto
NanoReg, Founder
Gaithersburg, Maryland
- 11:30 a.m. — 11:40 a.m. **Break**

FRIDAY OCTOBER 9, 2009

Session I

Nanoparticulate Drug Delivery Systems

Chair: Dr. Jasjit Suri
Co-Chair: Dr. Kevin Walsh

11:40 a.m. — 12:00 p.m. **LHRH-Mediated Drug Delivery for Ovarian Cancer Treatment**

Sarah E. Norberto, Sham S. Kakar
Department of Physiology and Biophysics, University of Louisville
James Graham Brown Cancer Center
Louisville, Kentucky

12:00 p.m. — 12:20 p.m. **Macrophage Targeting of Amphotericin B Bearing Emulsomes for the Treatment of Visceral Leishmaniasis: A Nanocarrier Approach**

Swati Gupta¹, Anuradha Dube², Suresh P. Vyas³
1. Nanomedicine Research Center
ISF College of Pharmacy, Department of Pharmaceutics
Moga, India
2. Division of Parasitology, Central Drug Research Institute
Lucknow, India
3. Drug Delivery Research Laboratory
Department of Pharmaceutical Sciences
Dr. Hari Singh Gour Vishwavidyalaya
Sagar, India

12:20 p.m. — 12:40 p.m. **Targeted Enteric Delivery by pH Sensitive Chitosan Nanoparticle**

Kiran Sonaje¹, Hsing-Wen Sung¹, Michael T. Tseng²
1. Department of Chemical Engineering
National Tsing Hua University
Hsinchu, Taiwan
2. Department of Anatomical Sciences and Neurobiology
University of Louisville
Louisville, Kentucky

12:40 p.m. — 1:00 p.m. **Use of Nanotechnology in Breast Cancer Therapy: Verge on a Possible Panacea**

Wasana Sumanasekera, Erin Billingsley, Crystal Bishop, Yashwant Pathak, Hieu Tran
Sullivan University College of Pharmacy
Louisville, Kentucky

1:00 p.m. — 2:00 p.m. **Lunch**

FRIDAY OCTOBER 9, 2009

Session II
RNA Nanotechnology

Chair: Dr. Peixuan Guo
Co-Chair: Dr. Abeer Al-Ghananeem

- 2:00 p.m. — 2:20 p.m. **Fingerprinting of DNA and RNA Using the Nano-Channels of Bacteriophage Phi29 DNA Packaging Nano-Motor**
Farzin Haque, Jing Peng, Jia Geng, Chris Stites, Peixuan Guo
College of Engineering and College of Medicine
Department of Biomedical Engineering, University of Cincinnati
Cincinnati, Ohio
- 2:20 p.m. — 2:40 p.m. **Channel Conductance and dsDNA Translocation Through Phi29 Motor Nano-Channels Integrated in Liposomes and Lipid Membrane**
Peng Jing, David Wendell, Farzin Haque, Jia Geng, Feng Xiao, Ying Cai, Carlo Montemagno, Peixuan Guo
College of Engineering and College of Medicine
Department of Biomedical Engineering, University of Cincinnati
Cincinnati, Ohio
- 2:40 p.m. — 3:00 p.m. **Dual-Channel Single-Molecule Imaging of pRNA on Phi29 DNA-Packaging Motor**
Hui Zhang, Dan Shu, Roman Petrenko, Taejin Lee, Feng Xiao, Chad Schwartz, Chun-Li Chang, Cagri Savran, Jarek Meller, Peixuan Guo
College of Engineering and College of Medicine
Department of Biomedical Engineering, University of Cincinnati
Cincinnati, Ohio
- 3:00 p.m. — 3:20 p.m. **Automated Analysis of DNA Fingerprinting Using the Nano-Channels of Bacteriophage Phi29 DNA Packaging Motor**
Chris Stites, Peixuan Guo
College of Engineering and College of Medicine
Department of Biomedical Engineering, University of Cincinnati
Cincinnati, Ohio

FRIDAY OCTOBER 9, 2009

Session II (Cont'd)
RNA Nanotechnology

- 3:20 p.m. — 3:40 p.m. **Evaluation of Specific Delivery of Chimeric Phi29 pRNA/siRNA Nanoparticles to Multiple Tumor Cells**
Jing Liu^{1,2}, Li Li¹, Zhijuan Dia¹, Peixuan Guo², Guanxin Shen¹
1. Huazhong University of Science and Technology
Wuhan, China
2. University of Cincinnati
Cincinnati, Ohio
- 3:40 p.m. — 4:00 p.m. **Bottom-up Assembly of Massive Sheets of Single Layer Patterned Arrays Using Reengineered Phi29 Nano Motor Connector**
Feng Xiao¹, Jinchuan Sun², Oana Coban¹, Peter Schoen³, Joseph Che-Yen Wang⁴, R. Holland Cheng⁴, Peixuan Guo¹
1. Department of Biomedical Engineering, University of Cincinnati
Cincinnati, Ohio
2. University of North Carolina at Chapel Hill
Chapel Hill, North Carolina
3. Radboud University
Nijmegen, Netherlands
4. University of California, Davis
Davis, California

FRIDAY OCTOBER 9, 2009

Session III (Poster)
Nanotechnology and Related Research

4:00 p.m. — 4:30 p.m. **Hybrid Nanostructures for Detection of Explosives**
Landon Oakes, Vladamir Dobrokhotov
Department of Physics and Astronomy, Western Kentucky University
Bowling Green, Kentucky

Delivery of Herbal Extract Using Nanotechnology
Long M. G. Bui¹, Hieu T. Tran², Yashwant V. Pathak², Uyen M. Le²
1. Faculty of Pharmacy, University of Medicine and Pharmacy
Ho Chi Minh City, Viet Nam
2. Sullivan University College of Pharmacy
Louisville, Kentucky

Manipulation of Light in the Nanoworld
Matthew Hsu, Sarah Dugan, Robert Chang
National Center for Learning and Teaching (NCLT) in Nanoscale
Science and Engineering
Evanston, Illinois

Introduction to the Nanoscale Module
Matthew Hsu, Sarah Dugan, Robert Chang
National Center for Learning and Teaching (NCLT) in Nanoscale
Science and Engineering
Evanston, Illinois

Nanotechnology Module
Matthew Hsu, Sarah Dugan, Robert Chang
National Center for Learning and Teaching (NCLT) in Nanoscale
Science and Engineering
Evanston, Illinois

Proposed Courses in Nanotechnology at CENTERA
Yashwant Pathak, Hieu Tran
Sullivan University College of Pharmacy
Louisville, Kentucky

4:00 p.m. — 4:30 p.m. **Coffee and Refreshments Served**

FRIDAY OCTOBER 9, 2009

Session IV
Nano Education

Chair: Dr. Gamini Sumanasekera
Co-Chair: Dr. Maria Lourdes Coronel

4:30 p.m. — 4:50 p.m. **Introduction to Nanotechnology: An “Elementary”
Education Program**

Mark Budnik, David Beck
Valparaiso University
Valparaiso, Indiana

4:50 p.m. — 5:10 p.m. **Research Funding Opportunities in Kentucky**

Mahendra K. Jain
Kentucky Science and Technology Corporation
Lexington, Kentucky

5:10 p.m. — 5:30 p.m. ***KY nanoNET: A Statewide Integrative Micro/Nano
Initiative for Collaborative Research, Education and
Outreach***

Kevin Walsh¹, Robert Keynton², Shamus McNamara¹, Mark Crain³,
Joseph Lake³, Thomas Roussel², Ana Kieswetter¹, Curtis McKenna³

1. Department of Electrical and Computer Engineering
University of Louisville
Louisville, Kentucky

2. Department of Bioengineering, University of Louisville
Louisville, Kentucky

3. Micro/NanoTechnology Center (MNTC), University of Louisville
Louisville, Kentucky

SATURDAY OCTOBER 10, 2009

Nanotechnology Symposium
Advances in Nanotechnology and Applications

- 9:00 a.m. — 9:30 a.m. **Continental Breakfast**
- 9:30 a.m. — 9:40 a.m. **Introduction**
Raghunandan Yendapally
Assistant Professor, Department of Pharmaceutical Sciences
Sullivan University College of Pharmacy
Louisville, Kentucky
- 9:40 a.m. — 10:10 a.m. **Keynote Address III**
Drug Development of Nanoparticulate
Bio-Pharmaceuticals
Judy Senior
Adjunct Professor, College of Pharmacy
Western University of Health Sciences
Pomona, California
- 10:10 a.m. — 10:40 a.m. **Keynote Address IV**
Nanostructured Solar Cell Devices
Vijay Singh
University of Louisville
Louisville, Kentucky
- 10:40 a.m. — 10:50 a.m. **Break**
-

Workshops in Nanotechnology

- 9:30 a.m. — 10:00 a.m. **Registration and Continental Breakfast**
- 10:00 a.m. — 10:50 a.m. **Workshop I**
Introduction to the Nanoscale
- 10:40 a.m. — 11:00 a.m. **Break**
- 11:00 a.m. — 12:50 p.m. **Workshop I Continuation**
Introduction to the Nanoscale
- 12:50 p.m. — 1:45 p.m. **Lunch**
- 1:45 p.m. — 4:00 p.m. **Workshop II**
Manipulating Light in the Nanoworld

SATURDAY OCTOBER 10, 2009

Session V

Nanoparticulate Drug Delivery Systems

Chair: Dr. Judy Senior
Co-Chair: Dr. Girish Kotwal

- 10:50 a.m. — 11:10 a.m. **Nanoniosomes of a Chelating Agent for Treatment of Iron Overload**
G. K. Pillai, Cindy Bhagwandin
School of Pharmacy, University of the West Indies
St. Augustine, Trinidad, West Indies
- 11:10 a.m. — 11:30 a.m. **Nanoparticulate Delivery Systems for Drug Targeting to the Brain Through Intranasal Drug Delivery**
Abeer Al-Ghananeem
Department of Pharmaceutical Sciences
College of Pharmacy, University of Kentucky
Lexington, Kentucky
- 11:30 a.m. — 11:50 a.m. **Cancer Therapies in Molecular Paradigm – A Review**
Jasjit Suri¹, Priya N. Werahera², Yashwant V. Pathak³
1. Fellow AIMBE, Eigen Inc.
Grass Valley, California
2. University of Colorado Denver, AMC Campus
Denver, Colorado
3. Sullivan University College of Pharmacy
Louisville, Kentucky
- 11:50 a.m. — 12:10 p.m. ***In Planta* “Green Engineering” of Variable Sizes and Exotic Shapes of Gold Nanoparticles: An Integrative Eco-Friendly Approach**
Daniel L. Starnes, Ajay Jain, Jahnavi R. Kancharla, Shivendra V. Sahi
Western Kentucky University, Department of Biology
Bowling Green, Kentucky
- 12:10 p.m. — 12:30 p.m. **Development and Optimization of Brain Targeted Tempol Loaded Nanoparticles for Parkinson’s Disease**
Ruchi Bhatia, Nicholas Miladore, Deepak Bhatia, Werner Geldenhuys, Richard Carroll, Vijay Sutariya
Department of Pharmaceutical Sciences
Northeastern Ohio Universities Colleges of Medicine and Pharmacy
Rootstown, Ohio

SATURDAY OCTOBER 10, 2009

Session V (Cont'd)
Nanoparticulate Drug Delivery Systems

12:30 p.m. — 12:50 p.m. **Nanocurcumin Treatment Protects Neuronal Cells from Cellular Damage and Neurodegeneration Caused by the Reactive Oxygen Species (ROS)**

Debomoy K. Lahiri¹, Balmiki Ray¹, Savita Bisht², Anirban Maitra²

1. Department of Psychiatry, Institute of Psychiatric Research

Indiana University School of Medicine

Indianapolis, Indiana

2. Department of Pathology

John's Hopkins University School of Medicine

Baltimore, Maryland

12:50 p.m. — 2:00 p.m. **Lunch**

SATURDAY OCTOBER 10, 2009

Session VI

Manufacturing and Mechanical Properties of Nano Systems

Chair: Dr. Gopal Pillai

Co-Chair: Dr. Vladamir Dobrokhotov

2:00 p.m. – 2:20 p.m. **Endohedral Fullerenes and Their Implication in Technology**

Kaliappan Muthukumar^{1,3}, Anna Stròzecka², Bert Voigtländer², J. Andreas Larsson¹

1. Tyndall National Institute, Lee Maltings, Prospect Row
Cork, Ireland

2. Institut for Bio- und Nanosysteme
Forschungszentrum Jülich
Jülich, Germany

3. Department of Chemical and Materials Engineering
University of Cincinnati
Cincinnati, Ohio

2:20 p.m. – 2:40 p.m. **Bi-Specific Anti-HER-2 Immunonanoparticles: Design and Targeting to Breast Cancer Cells *in Vitro***

Senthilkumar M¹, Ritu Dhankar², N. Mahadevan¹

1. Nanomedicine Research Center, Department of Pharmaceutics
Rajendra Institute of Technology and Sciences, Institute of Pharmacy
Haryana, India

2. Department of Pharmaceutics, ISF College of Pharmacy
Moga, India

2:40 p.m. – 3:00 p.m. **Parylene Nanospheres, Nanotubes and Nanocoatings for Medical Applications**

Rakesh Kumar

Vice President of Technology, Specialty Coating Systems
Indianapolis, Indiana

3:00 p.m. – 3:20 p.m. **Thermoelectric Properties of Large Area Graphene**

Andriy Sherehiy, Anton Sidorov, Ruwantha Jayasinghe, Gamini Sumanasekera

Department of Physics, University of Louisville
Louisville, Kentucky

SATURDAY OCTOBER 10, 2009

Session VI (Cont'd)

Manufacturing and Mechanical Properties of Nano Systems

3:20 p.m. — 3:40 p.m. **Graphene Nanoribbons From Graphite Surface Dislocation Bands**

Ruwantha Jayasinghe, Anton N. Sidorov, Andriy Sherehi, P. J. Ouseph, Gamini Sumanasekera
Department of Physics, University of Louisville
Louisville, Kentucky

3:40 p.m. — 4:00 p.m. **Controlling of the Single-Walled Carbon Nanotubes (SWNT) Growth with High Yield Metallic Conductivity**

Tereza M. Paronyan¹, Gamini U. Sumanasekera¹, Avetik R. Harutyunyan²

1. Department of Physics and Astronomy, University of Louisville
Louisville, Kentucky

2. Honda Research Institute USA Inc.
Columbus, Ohio



Collection of Abstracts

KEYNOTE ADDRESS

RNA Nanotechnology and Nanomedicine

Peixuan Guo, Dan Shu, Yi Shu, Jing Liu, Feng Xiao

Department of Biomedical Engineering, University of Cincinnati
Cincinnati, Ohio

RNA is particularly useful in nanotechnology based on the amazing diversity in function and versatility in structure. RNA can be designed and manipulated with both a level of simplicity characteristic of DNA and a versatile flexibility in structure and function similar to that of proteins. Typically, RNA contains a large variety of single-stranded stem-loops for intra- and/or inter-molecular interactions. These loops can serve as mounting dovetails, and thus, external linking dowels might not be needed in fabrication and assembly. RNA is a polymer made up of four different nucleotides. Thus, in a 100-nucleotide RNA polymer, as many as 10^{60} ($=4^{100}$) different RNA molecules can be generated. The pRNA of bacteriophage phi29 DNA packaging motor assembles into dimers, trimers, and hexamers via hand-in-hand interactions between two right and left interlocking loops. siRNA, ribozyme, RNA aptamers, and anti-sense RNA have been incorporated into phi29 RNA nanoparticles in various medical applications including gene silencing and the detection of cell receptors or biomarkers. Many techniques for the construction and analysis of these RNA nanoparticles have been utilized for medical applications of phi29 pRNA. These include phylogenetic analysis, SELEX, self-assembly, photoaffinity crosslinking, complementary modification, chemical modification and chemical modification interference, cryo-AFM, computer modeling, genetic analysis by truncation, insertion, deletion and mutation, and footprinting. The unique feature of two interlocking loops makes phi29 pRNA a promising tool for bottom-up assembly in nanomachine fabrication, pathogen detection, and therapeutics delivery. The polyvalent pRNA nanoparticles can deliver up to six kinds of therapeutics to specific cells at a time. Incubation of the synthetic RNA nanoparticles containing receptor-binding aptamers or ligands resulted in cell binding and cell entry of the incorporated siRNA, ribozyme, or drugs, subsequently modulating programmed cell death. The delivery efficiency and therapeutic effect were confirmed in animal trials. 3-D design, circular permutation, folding energy alteration, and nucleotide modification of RNA were applied to generate stable RNA nanoparticles with low toxicity and to make chimeric RNA complexes resistant to RNase digestion and processed into siRNA by Dicer after delivery. Using such protein-free nanoparticles as therapeutic reagents would extend in vivo half-life, avoid nonspecific cell entry and antibody induction, thus allowing repeated treatment of chronic diseases including cancers, viral infections, and genetic ailments.

Related publications from this lab:

1. Guo, et al, 1998. Inter-RNA Interaction of phage phi29 pRNA to Form a Hexameric Complex for DNA Transportation. *Mol. Cell* 2:149-155.
2. Shu D, Huang L, Hoeplich S & Guo P. 2003. Construction of phi29 DNA-packaging RNA monomers, dimers and trimers with variable sizes and shapes as potential parts for nano-devices. *J Nanosci Nanotech*, 3: 295.
3. Shu D, Moll D, Deng Z, Mao C, and Guo P. 2004. Bottom-up assembly of RNA arrays and superstructures as potential parts in nanotechnology. *Nano Lett*. 4: 1717.
4. Guo P. RNA Nanotechnology: Engineering, 2005. Assembly and Applications in Detection, Gene Delivery and Therapy. *J Nanosci Nanotech*. 5: 1964 6.
5. Khaled A, Guo S, Li F, & Guo P. 2005. Controllable Self-Assembly of Nanoparticles for Specific Delivery of Multiple Therapeutic Molecules to Cancer Cells Using RNA Nanotechnology. *Nano Letters* 5: 1797
6. Guo S, Khaled A, Tschammer N, Guo P. 2005. Specific Delivery of Therapeutic RNAs to Cancer Cells via the Dimerization Mechanism of phi29 Motor pRNA. *Human Gene Ther*. 16: 1097

KEYNOTE ADDRESS

What I Have Learned From Nanotechnology

John DiLoreto

Founder, NanoReg
Gaithersburg, Maryland

Nanotechnology has the ability to change our lives in ways we can't imagine. Consumer products enhanced by the incorporation of nanomaterials are entering the marketplace at a rapid pace. A great deal of research has led us to a number of discoveries that only a few short years ago would have been considered science fiction. Nanotechnology is teaching us about many things and the process of discovery takes us down paths with no lights or signs to guide us. Sometimes what we learn is not what we were looking for.

NANOPARTICULATE DRUG DELIVERY SYSTEMS

LHRH-Mediated Drug Delivery for Ovarian Cancer Treatment

Sarah E. Norberto, Sham S. Kakar

Department of Physiology and Biophysics, University of Louisville
James Graham Brown Cancer Center
Louisville, Kentucky

Chemotherapy, while common and effective, is always accompanied by a myriad of side effects due to cytotoxicity induced in normal, healthy cells of the body. In order to better treat patients and spare their normal body functions from these consequences, it is necessary to develop a treatment that is targeted directly to cancer cells and which will not affect non-cancerous tissues. Targeted therapy has become increasingly popular in the last few years. One common method is to target biomarkers expressed on cancer cells but not expressed on normal cells. Luteinizing hormone releasing hormone (LHRH) receptor is one example. This receptor is overexpressed on the surface of cancer cells in a number of endocrine cancers, including breast, ovarian, and endometrial cancers. We exploited this differential expression of the LHRH receptor as a target for a novel therapy. In addition, we have proposed the use of gold nanoparticles as successful drug carriers to prolong the circulation time and slow delivery of chemotherapeutic agents in the body. We conjugated gold nanoparticles with doxorubicin, a common chemotherapeutic agent, and D-Trp⁶[LHRH], an analog of the LHRH peptide to target the cancer cells. Treatment of various ovarian cancer cell lines that express high levels of high affinity LHRH receptors with doxorubicin-nanoparticle-LHRH conjugates resulted in significant cell death. In contrast, treatment of cells that do not express LHRH receptor, showed no effect. The dosage requirement to achieve 90% cell death was found to be 200 fold less compared to free doxorubicin. Treatment of ovarian cancer cells with unconjugated gold nanoparticles or gold nanoparticles conjugated only with doxorubicin did not result in cell death at comparable concentrations. Our *in vivo* studies showed specific targeting of ovarian cancer cells by suppressing tumor growth and metastasis, suggesting novelty of our technology and its potential application in treatment of ovarian cancer. This work was supported by grants from DOD, NCI and OTT (SSK).

NANOPARTICULATE DRUG DELIVERY SYSTEMS

Macrophage Targeting of Amphotericin B Bearing Emulsomes for the Treatment of Visceral Leishmaniasis: A Nanocarrier Approach

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The control of visceral leishmaniasis or kala-azar (VL), a major tropical parasitic disease caused by *Leishmania donovani*, remains a challenging problem because the available chemotherapeutics such as amphotericin B (AmB) have serious side effects and require long-term treatment. Therefore AmB was formulated in tristearin-based emulsomes (nanosize lipid particles) stabilized by soya phosphatidylcholine (PC), as a new delivery system for macrophage targeting for the treatment of VL. Emulsomes were modified by coating them with macrophage-specific ligand (*O*-palmitoyl mannan, OPM). The surface modified emulsomes and their plain counterparts were characterised for size, shape and entrapment efficiency. The antileishmanial activity of AmB-deoxycholate (AmB-Doc) and emulsome entrapped AmB was tested *in vitro* in *Leishmania donovani* infected macrophage-amastigote system (J774A.1 cells), which showed higher efficacy of OPM grafted AmB emulsomes (TSEs-OPM) over plain AmB emulsomes (TSEs) and AmB-Doc. Fluorescence microscopy study showed significant localization of fluorescein loaded TSEs and TSEs-OPM inside the liver and spleen cells of golden hamsters. The *in vivo* antileishmanial activity of the AmB (0.5mg/kg) was tested in AmB-Doc, TSEs and TSEs-OPM forms against VL in *L. donovani* infected hamsters. Formulation TSEs-OPM eliminated intracellular amastigotes of *L. donovani* within splenic macrophages more efficiently ($70.1 \pm 4.8\%$ parasite inhibition) than the formulation TSEs ($47.4 \pm 3.4\%$ parasite inhibition) or AmB-Doc ($33.6 \pm 2.9\%$ parasite inhibition). The proposed formulations, TSEs and TSEs-OPM showed excellent potential for passive and active intramacrophage targeting respectively and the approach could be a successful alternative to the currently available drug regimens of VL and systemic fungal infections.

NANOPARTICULATE DRUG DELIVERY SYSTEMS

Targeted Enteric Delivery by pH Sensitive Chitosan Nanoparticle

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The harshly acidic environment in the stomach presents obstacle for enteric delivery of macromolecules. We have developed a pH sensitive chitosan nanoparticle for targeted delivery of compounds including insulin. Upon entering duodenum, the chitosan nanoparticle disintegrates and releases the encapsulated content. Central to the success of this nano-platform is the transient, reversible opening of the mucosal tight junction. In this presentation, we will share in vitro and in vivo data supporting the utility of our chitosan based targeted delivery system.

NANOPARTICULATE DRUG DELIVERY SYSTEMS

Use of Nanotechnology in Breast Cancer Therapy: Verge on a Possible Panacea

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Hieu Tran**

Sullivan University College of Pharmacy
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The diagnosis of breast cancer to any woman is a devastating reality to be exposed to, yet it is still a common cancer that science fights today. Even with acute awareness rooted in educational programs and the practitioner's diligence of prevention, women still find themselves at risk and even more distressing, losing the battle. Conventional breast cancer therapy includes hormone therapy, immunotherapy, and systemic chemotherapy. Selective Estrogen Receptor Modulators (e.g. Tamoxifen), monoclonal antibodies raised against Human Epidermal Growth factor receptor 2 (e.g. Herceptin / anti -Her2 / trastuzumab), are the current treatment of choice for the estrogen receptor (ER) and Her2 positive breast cancers. ER and Her2 negative breast cancers are treated with systemic chemotherapy, which carries unwanted devastating side effects. With the advent of nanotechnology, science has possibly found the optimal portal to launch a new attack that just changed the outlook for the future of treating breast cancer. Nanotechnology has several applications in breast cancer therapy. Several formulations of nano - liposomal Doxorubicin have already been successfully used in the breast cancer therapy. Nanotechnology can also be utilized in gene therapy to treat breast cancers. Second and third generation nano vectors are currently being developed to specifically target biological molecules on the surface of breast cancer cells. Many different types of nano delivery systems including nanotubes, nanowires, and nanocrystals have been implicated in breast cancer research. By exploring new avenues that nanotechnology can provide to breast cancer therapy, nanotechnology may in fact become the panacea by which scientists, practitioners, and patients are hoping for.

RNA NANOTECHNOLOGY

Fingerprinting of DNA and RNA Using the Nano-Channels of Bacteriophage Phi29 DNA Packaging Nano-Motor

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Living systems contain a wide variety of nanomachines and highly-ordered structures of macromolecules that could serve as modules, tool boxes, or building blocks in nanotechnology. The ingenious design of the bacteriophage phi29 DNA packaging motor with an elegant and elaborate channel has inspired its application for single molecule detection and sensing. The central component of the phi29 motor is the connector composed of twelve copies of the protein gp10, which form a dodecamer channel. The connector after incorporation into a lipid bilayer can serve as a detector for extremely sensitive, reliable, and precise sensing and fingerprinting of ions and macromolecules at the single molecule level (*Nature Nanotechnology*, in press). Double stranded and single stranded DNA can be electrophoretically driven through the channel in a concentration and voltage dependent manner. Information about the structure, length and conformational dynamics can then be deduced by their characteristic dwell times during translocation and by their relative percentage in current blockades. This protein nanopore system with explicit engineering capability has potential technological applications such as rapid DNA sequencing, gene therapy and controlled drug delivery.

Channel Conductance and dsDNA Translocation Through Phi29 Motor Nano-Channels Integrated in Liposomes and Lipid Membrane

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Bacteriophage phi29 of *Bacillus subtilis* is a double stranded DNA phage that encapsulates its genome into a procapsid through an entropically unfavorable process accomplished by an ATP driven DNA packaging motor. The core component of the motor is the connector, showing as a dodecamer of the protein gp-10. Connector contains a channel that allows the 19.3 kb genome DNA, covalently attached to a viral protein gp-3, to enter the capsid during maturation and exit during infection. In this work, phi29 connector was inserted into planar bilayer membrane to form channels by means of connector reconstituted liposomes. Similar to the properties of some well-studied transmembrane proteins, such as alpha-haemolysin, the channels formed by the connector protein were stable under experimental conditions. By means of electrophysiological measurements, we approximated its cross sectional area was at least 5 fold larger than that of alpha-haemolysin based on single pore conductance measurement. The measured conductance of a single connector channel was 4.8 nS in 1 M KCl. To characterize the nano-sized phi29 connector channels spanning across the bilayer membrane, we further performed ds-DNA translocation experiments. Q-RT-PCR was used to characterize the translocation rate of DNA. Using electrophysiological measurements, we characterized the dwell time and current blockades induced by DNA translocation through phi29 connector channels. This engineered and membrane-adapted phage connector is expected to have interesting applications in nanotechnology and nanomedicine, such as MEMS sensing, microreactors, gene delivery, drug loading, and DNA sequencing. The work reported here represents a system for further physical and chemical characterization of DNA translocation passing the motor channel in viral DNA packaging.

Dual-Channel Single-Molecule Imaging of pRNA on Phi29 DNA-Packaging Motor

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Bacteriophage phi29 DNA-packaging motor is geared by six packaging RNAs (pRNA). The pRNA molecules have been reported to serve as building blocks in RNA nanotechnology, and as vehicles for specific delivery of therapeutics to treat cancers and viral infections. The understanding of the 3D structure of pRNA and its location and positioning on the motor are both fundamentally and practically important. A customized single-molecule dual-color imaging system has been constructed to study the structures of pRNA molecules. The system is the combination of a low-temperature (-80 °C) sensitive electron multiplied CCD camera and the prism-type total internal reflection mechanism. A laser combiner was introduced to facilitate simultaneous dual-channel imaging. It has been applied to study the structure, stoichiometry, distance and function of the phi29 DNA packaging motor. Single molecule photobleaching combined with binomial distribution analysis clarified the stoichiometry of pRNA on the motor and elucidated the mechanism of pRNA hexamer assembly. The feasibility of the single-molecule imaging system was demonstrated in studies of single-molecule FRET. Distance rulers made of dual-labeled dsDNA and RNA/DNA hybrids were used to evaluate the system by determining the distance between one FRET pair. The single-molecule FRET was also applied to the reconstructed the 3D structure of phi29 motor pRNA monomers and pRNA dimers. Ten pRNA monomers labeled with single donor or acceptor fluorophore at various locations were constructed, and eight partner pairs were assembled into dimers. FRET signals were detected for six dimers and utilized to assess the distance between each donor/acceptor pair. The results provide the distance constraints for 3D computer modeling of phi29 DNA packaging motor. We have also re-engineered the energy conversion protein, gp16, of phi29 motor for single fluorophore labeling to facilitate the single molecule studies of motor mechanism. The potential applications of single-molecule high-resolution imaging with photobleaching (SHRIMP) and single molecule high resolution with co-localization (SHREC) approaches to the study of the phi29 nanomotor were also investigated.

Automated Analysis of DNA Fingerprinting Using the Nano-Channels of Bacteriophage Phi29 DNA Packaging Motor

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Translocation of biopolymers such as DNA is an important theme in living systems. The connector channel of the phi 29 DNA-packaging motor is an intriguing element in this category. We demonstrated that the lipid-embedded connector channel has the ability to translocate double stranded and single stranded DNA under an applied voltage (*Nature Nanotechnology*, in press). Herein, we developed an automated system using MATLAB for detailed analysis of DNA translocating through the protein nanopore using a set of parameters. Individual pore-blockade events are first distinguished from noise events with high confidence. The characteristic depths and duration of the current blockade events are then determined to distinguish varying lengths and conformational structure of DNA. The automated single molecule DNA analysis has the potential for future high throughput analysis of various biopolymers as well as DNA sequencing applications.

Evaluation of Specific Delivery Chimeric Phi29 pRNA/siRNA Nanoparticles to Multiple Tumor Cells

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The pRNA (packaging RNA) of bacteriophage phi29 DNA packaging motor has been reported to have novel applications in nanotechnology and nanomedicine. The unique ability of pRNA to form dimers, trimers, hexamers and patterned superstructures via the interaction of two reengineered interlocking loops makes it a promising polyvalent vehicle to load siRNA and other therapeutic molecules and be applied as a therapeutic nanoparticle in tumor therapy. In this study, several tumor cell lines were used to evaluate the previously reported pRNA nanotechnology for specific siRNA delivery and for the silencing of targeted genes. It was found that MCF-7 and HeLa cells, out of twenty-five tested tumor cell lines, expressed high levels of folate receptors and exhibited specific binding of the FITC-folate-pRNA nanoparticles, while the others expressed low levels and thus, for these, delivery was not feasible using folate as a targeting agent. Folate receptor positive tumor cells were then incubated with the chimeric pRNA dimer harboring both the folate-pRNA and the chimeric pRNA/siRNA (survivin). Knock down effects of survivin expression in these tumor cells were detected at the mRNA level by real time-PCR and at the protein level by western blot. Apoptosis was detected by flow cytometry analysis with dual staining of annexinV-FITC and PI. The data suggest that the chimeric pRNA nanoparticles containing folate-pRNA and pRNA/siRNA (survivin) could be specifically taken up by tumor cells through folate receptor-mediated endocytosis, resulting in significant inhibition of both transcription and expression of survivin in tumor cells and triggering cell apoptosis. Using such protein-free nanoparticles as therapeutic reagents would not only allow specific gene delivery and extend the in vivo retaining time but also allow long-term administration of therapeutic particles, therefore avoiding the induction of antibodies caused by repeated treatment for chronic diseases.

Bottom-up Assembly of Massive Sheets of Single Layer Patterned Arrays Using Reengineered Phi29 Nano Motor Connector

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The bottom-up assembly of patterned arrays is an exciting and important area in current nanotechnology. Arrays can be engineered to serve as components in chips for a virtually inexhaustible list of applications, ranging from disease diagnosis to ultrahigh-density data storage. Recently, we showed that phi29 motor connector could serve as membrane channels for translocation of dsDNA and signature small molecules (*Nature Nanotechnology*, in press). Previously it has also been reported that connectors formed elegant multilayer tetragonal arrays. However, multilayer protein arrays are of limited use for nano-applications which demand nano replica or coating technologies. The ability to produce a single layer array of biological structures with high replication fidelity represents a significant advance in the area of nanomimetics. To facilitate the assembly of a single layer and prevent the continuous growth of multiple layers, a short streptavidin binding peptide was introduced either into the N- or C- terminus of gp10, located at the narrow and wide end of the connector, respectively. Thin layers of biotinylated lipid mixtures were used to direct the assembly of single layer patterned arrays. The reengineered dodecamer connector was pre-incubated with streptavidin before the lipids were spread. Massive sheets of array were grown *in situ* on lipid monolayers at the air-water interface and then transferred on carbon coated TEM grids. Uniform, clean and highly-ordered arrays were constructed as shown by EM. Hydrophilic bare mica was used as an alternative surface for the assembly and adsorption of single layer patterned array as confirmed by AFM imaging.

NANOTECHNOLOGY AND RELATED RESEARCH (POSTER)

Hybrid Nanostructures for Detection of Explosives

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The ability to sense the environment is of critical importance for a broad array of applications ranging from ecosystem health, hazardous materials avoidance/chemical warfare to medical applications. We are investigating the use of self-assembled monolayer (SAM)-functionalized nanoparticle-decorated nanosprings as a novel design for sensing vapors associated with explosives. This research is based on a fundamentally new concept of sensing by hybrid 3-D nanostructures that will contribute to our abilities to create reliable sensors for detection of vapors associated with explosives. The common requirements for any sensor application are sensitivity, selectivity, refreshability, repeatability, low cost of manufacture, and ease of use. The project goal is to answer these needs through the use of mats of functionalized metal nanoparticle-coated nanosprings as a novel type of low-cost nanomaterials-based gas sensor. Preliminary experiments have shown a significant change in the electrical properties of gold nanoparticle coated semiconductor nanowires when they are exposed to various gases. The advantage of this approach is that very dilute quantities of airborne explosive products can be accumulated over a few seconds to a few minutes onto our high surface area nanospring electrodes. This will facilitate electronic detection, which in contrast to optical detection methods reduces false positive signals, reduces detector sizes and complexity.

NANOTECHNOLOGY AND RELATED RESEARCH (POSTER)

Delivery of Herbal Extract Using Nanotechnology

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Herbal medicine has been increasingly used on the world wide health care aspect. However, like pharmaceutical drugs, herbal extracts have a lot of problems such as poor bioavailability and limited stability. Several approaches, including fabricating of derivatives and salt forms or designing drug carriers, have been applied to overcome these disadvantages. Nanotechnology interests a lot of scientists in creating delivery systems for herbal extracts. Liposomes and polymeric systems have been applied in improving the bioavailability and stability of curcumin, lycopene, and other Chinese herbs. This review presents recent applications of nanoparticulate systems in the delivery of herbal extracts that are potential for the development of plant-based therapeutics.

NANOTECHNOLOGY AND RELATED RESEARCH (POSTER)

Manipulation of Light in the Nanoworld

Matthew Hsu, Sarah Dugan, Robert Chang

National Center for Learning and Teaching (NCLT) in Nanoscale Science and Engineering
Evanston, Illinois

"Manipulation of Light in the Nanoworld" extends the standard topics of wavelength, diffraction, and interference into the nanoscale by introducing students to the concept of photonic crystals. Hands-on activities present macro and microscale diffraction and interference effects in an engaging way. Computer simulations that parallel some of these hand-on activities allow students to observe the changes in these effects as objects move from the micro to the nanoscale. Eventually, the students use a computer simulation of a photonic band gap to predict the behavior of photonic crystals (an artificial opal structure) they actually make and test.

Introduction to the Nanoscale Module

Matthew Hsu, Sarah Dugan, Robert Chang

National Center for Learning and Teaching (NCLT) in Nanoscale Science and Engineering
Evanston, Illinois

As an introduction to the nanoworld, a series of inquiry-based curricular activities were developed to (1) give students a feel for just how small the nanoscale is, (2) give student practice in communicating nanoscale quantities and relating them to the familiar macroscale, and (3) illustrate the first and foremost property that increases in importance at the nanoscale, viz., surface area. Through the various hands-on activities students investigate the effects of changing surface area with size/shape of different forms of materials familiar to the students. The activities culminate in a card game that further reinforces the foundational knowledge of size, scale, and surface area relationships at the nanoscale.

Nanotechnology Module

Matthew Hsu, Sarah Dugan, Robert Chang

National Center for Learning and Teaching (NCLT) in Nanoscale Science and Engineering
Evanston, Illinois

The Nanotechnology Module teaches students about the interesting science that happens at the nanoscale, the tools used by scientists to study objects so small, and the potential applications of discoveries made in nanotechnology. The module introduces the concept of nanometer, asking "Just how small is a nanometer?" and "How does the size of something determine its physical and chemical properties?" Students simulate a nanolithography technique used to create a nanoscale materials and look at the challenges of signal amplification that one faces when working with nanoscale objects. They are then challenged in the culminating design project to design, build, test, and evaluate a working model of an atomic force microscope (AFM) to "see" various 3D objects.

NANOTECHNOLOGY AND RELATED RESEARCH (POSTER)

Proposed Courses in Nanotechnology at CENTERA

Yashwant Pathak, Hieu Tran

Sullivan University College of Pharmacy
Louisville, Kentucky

The Sullivan University College of Pharmacy has already established involvement with nanotechnology through its annual Nanotechnology Symposium. We would like to propose further involvement in nanotechnology, as it is an ever-growing focus, relevant to numerous subjects. Scientists globally recognize the importance of nanotechnology, and involving our future researchers and educators in the field sooner rather than later.

This center will educate those within the Kentuckiana region about the nanotechnology, its ever-growing importance, and its significance within our community.

NANO EDUCATION

Introduction to Nanotechnology: An “Elementary” Education Program

Mark Budnik, David Beck

Valparaiso University

Valparaiso, Indiana

Instructors at all levels of education are asked to introduce leading-edge concepts to their students. Our College of Engineering developed twelve hours of training material on nanotechnology for approximately 55 fourth and fifth grade students. To make such material accessible to young children, we developed a series of analogy-based lessons, which focused on our state's fourth and fifth grade Science and Mathematics Standards. Our local school system offered the program in two-hour sessions over six Saturday mornings. The curriculum for the program was developed by a professor in our College of Engineering who has research and pedagogical interests in the field of nanotechnology. The professor recruited four undergraduate engineering students who were motivated to learn about nanotechnology and interested in sharing this knowledge with young students. The assistant superintendent of our community schools arranged the program's logistics, such as publicizing the program, reserving classroom space, and registering students. Our teaching techniques varied and included movies, stories, demonstrations, and projects. We provided a tangible macroscopic analogy for every nanotechnology topic we covered. For example:

Nanotechnology Topic

Semiconductor Physics
Transistors
Digital Logic
Quantization of Energy and Matter
1-, 2-, and 3-D Objects
Quantum Wells
Ohm's Law
Memristors
Scanning Electron Microscopes

Analogy

Spiders and Spider Webs
Magnets
“Choose Your Own Adventure” Stories
Legos Building Blocks
Lego creations imitating 1-, 2- and 3-D Objects
Parking Garages
Water, Pipes, and Pumps
Plumbing Fixtures
Topographical Maps

The students met approximately 90% of the objectives we set for the course. Following the course, 67% of the students and parents returned a feedback form. On a scale of one (worst) to five (best), the students rated the course at 4.79. When asked if they would refer the program to a friend, all of the parents responded with a 5.

NANO EDUCATION

Research Funding Opportunities in Kentucky

Mahendra K. Jain

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Lexington, Kentucky

For ideas to take root and grow, researchers must prove their concept through a well planned research work. Funds are needed to catalyze the efforts that are necessary to take a brilliant idea from a conceptual form to the lab bench to obtain supporting data. Several risky but innovative ideas are not carried out in the absence of funding. The Commonwealth of Kentucky offers funds to the scientific community in the state for research and technology development in emerging and established area of research. The State invests in such ideas in very early-stage that doesn't interest others to fund such ideas. The State provides research funds to both university researchers and small tech businesses to stimulate innovations in the belief that such investments will lead to revolutionary technologies resulting in new start up businesses for job creation and economic development. Several state-initiated funding programs available in Kentucky will be discussed along with select federal programs for both universities and small businesses.

NANO EDUCATION

KY nanoNET: A Statewide Integrative Micro/Nano Initiative for Collaborative Research, Education and Outreach

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The “*KY nanoNET (KYNN) Initiative*” is a 5-yr NSF program for the development of a statewide infrastructure network and support system for the specific advancement of micro/nanotechnology in Kentucky and the many fields that utilize this pervasive technology. The *KY nanoNET Initiative* contains 3 distinct efforts: 1) development of a comprehensive web-based regional network (i.e. the *KY nanoNET*) to better coordinate the many existing micro/nano labs and resources scattered throughout the Commonwealth, similar to what the NSF-sponsored NNIN and nanoHUB initiatives do on a national level, 2) development of a “portal-based shared software program” (i.e. KRUNCH - **K**entucky **R**esearch **U**sers of **N**ano **C**ADtools **H**ub) as a key component of the *KY nanoNET* which will allow researchers across the state access to a wide variety of expensive commercial TCAD tools for general micro/nano/MEMS research/education, and 3) development of a centralized physical core facility (i.e. KORE - **K**entucky **O**ptical **R**E-sources) for the generation of custom photomasks to effectively serve the needs of all micro/nano researchers/educators in Kentucky. In addition to these 3 strategic initiatives are complementary outreach and economic development efforts. Details of the KYNN and its anticipated impact on nano-scale research and education in the state of Kentucky will be presented.

KEYNOTE ADDRESS

Drug Development of Nanoparticulate Bio-Pharmaceuticals

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Nanoparticulate biopharmaceutical products intended for clinical use in the US must fulfill a raft of regulatory requirements regardless of whether the active agent (drug component) has been previously approved for clinical use. For novel agents, the path can be complicated by the need to evaluate both the biopharma drug component and the nanoparticulate carrier system itself.

While the overall drug development work to support regulatory submissions follows well-worn pathways, every potential drug product will also require a case-sensitive scientific approach to ensure a clinical drug candidate has the potential to make it over the regulatory hurdles.

Another consideration is ensuring that any show-stopping toxicities or other complications are discovered as early as possible in the drug development process to avoid conducting costly studies prematurely.

Thus the drug development of nanoparticulate systems presents a special case versus single therapeutic agents whether a biopharmaceutical or small molecular drug product in the absence of a carrier system.

This presentation will focus on two important areas:

- ◆ Typical stages of the drug development process using as an example, a marketed nanoparticulate injectable system.
- ◆ Examples of ways where a scientific approach to the drug development process can provide solutions to the challenges that arise at all stages of the drug development process and propel a promising therapeutic agent-containing nanoparticulate system through preclinical testing and safely into the clinic.

KEYNOTE ADDRESS

Nanostructured Solar Cell Devices

Vijay Singh

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Nanowires of copper indium diselenide (CIS), cadmium telluride (CdTe), cadmium sulfide (CdS) and copper phthalocyanine (CuPc) are of interest for the development of photovoltaic (PV) devices of high efficiency that can be produced inexpensively. Enhanced performance is obtained by in nanowire (NW) device designs by, exploiting the quantum confinement effects to tailor the energy band gap of semiconductors to optimal values and, by having electron-hole pairs (or excitons in organic semiconductors) travel only a few nm before they are broken up and electrons and holes are separated and propelled in opposite directions.

Porous alumina templates were used to produce nanowires of CIS, CdS, CdTe and CuPc by electrodeposition into the nanopores. Schottky diodes were formed on each of these nanowires and materials and electro-optical characterizations were performed. Electrical and materials parameters were extracted. Results of these characterizations and analysis will be described.

NANOPARTICULATE DRUG DELIVERY SYSTEMS

Nanoniosomes of a Chelating Agent for Treatment of Iron Overload

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This preliminary study explores the feasibility of employing nanocapsules prepared from nonionic surfactant vesicles (niosomes) as a carrier for an iron-chelating agent, desferal, to enhance iron excretion from the body. The methodology consisted of creating an iron overload model in an experimental animal with repeated injections of iron dextran followed by measurement of iron excretion pattern in the urine and feces of control and test animals by atomic absorption spectrophotometry. Niosomes were prepared with span 60: cholesterol:dicetyl phosphate (47.5:47.5:5.5) by the lipid hydration method with an aqueous solution of desferal. The niosome suspension was probe-sonicated and the unilamellar vesicles were separated by gelfiltration chromatography on sephadex G-50. Percent encapsulation was determined by disruption of the vesicles and estimation of the drug. The stability of the niosomes was determined by the degree of leakage of desferal from the vesicles at room temperature and also at 4°C. The niosomal preparation was administered subcutaneously to iron-overloaded rat kept in metabolic cages, urine and feces collected and analyzed for iron content. Sections of liver, heart, kidney of control and test animals were stained with Perl stain followed by microscopic examination to grade the extent of iron accumulation.

NANOPARTICULATE DRUG DELIVERY SYSTEMS

Nanoparticulate Delivery Systems for Drug Targeting to the Brain Through Intranasal Drug Delivery

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The development of new drugs is expensive and time-consuming. Many drugs are not being effectively and efficiently delivered using conventional drug delivery approaches to brain. Transport of drugs from systemic circulation into the central nervous system (CNS) is restricted by the blood-brain barrier (BBB) and blood-cerebrospinal fluid (CSF) barrier. Most charged, hydrophilic, water soluble substances and/or large therapeutic agents are inhibited or prevented from entering the brain by the BBB

An alternative to developing new drugs is to focus on delivering drugs of potential therapeutic value to the target site. Intranasal (IN) administration of therapeutic agents has been an area of great interest and targeting brain/CNS via the nasal administration of drugs was studied and reported in the literature. The direct anatomical connection exists between the nasal cavity and the CNS makes it possible to deliver some substances into the CNS by circumventing the BBB instead of penetrating it, which provides the basis for the development of therapeutic agents for IN administration. Drugs administered by the intranasal route not only circumvent the BBB but also avoid the hepatic first-pass effect. Thus, direct transport of drugs to the CNS circumventing the BBB following intranasal administration provides a unique feature and a better option to in the target drug delivery and treatment of CNS diseases.

This presentation reviews the background of nasal nanoparticulates drug delivery with special references to the pharmaceutical consideration for nasal drug administration.

Applications of nasal administration of nanoparticles for the delivery of therapeutic agents will be discussed. Furthermore, new classes of functionalized mucoadhesive nanoparticles, the characterization and safety aspects of nasal drug products as well as the opportunities presented by nasal drug delivery will be discussed.

NANOPARTICULATE DRUG DELIVERY SYSTEMS

Cancer Therapies in Molecular Paradigm — A Review

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Primary objective of cancer therapy is to save life or improve or maintain the quality of life whenever possible. Cancer therapies can be invasive, minimally invasive or non-invasive. Depending upon the organ being treated and the stage of the disease, there is a need to customize therapy for each patient. The emerging technologies allow us to accurately diagnose and offer promising therapeutic options based on grade and stage of the disease. This talk presents a strong review of the cutting edge technologies for cancer treatment, drug delivery, monitoring response to therapy for several organs specific carcinomas including kidney, liver, prostate, pancreas, atherosclerosis, thyroids, breast, fibroids, etc. These treatments show a very promising paradigm for molecular and nano infrastructures covering the fields such as the bio-imaging in live sciences, biomedical engineering and biomedical devices and continuous ability to keep pace with fast evolving treatment methodologies. Examples will be presented extending from minimally invasive to non-invasive surgeries, diving into molecular nature of the diseases.

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NANOPARTICULATE DRUG DELIVERY SYSTEMS

In Planta “Green Engineering” of Variable Sizes and Exotic Shapes of Gold Nanoparticles: An Integrative Eco-Friendly Approach

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Manipulating matter at the nanoscale creates materials endowed with unique optoelectronic and physicochemical attributes. Among the noble metals, the properties of gold in "nano" form could further be monitored by manipulating their shapes and sizes. Gold nanoparticles find several applications in electronics, medicine and environmental reclamation. Emphasis has been on the “green synthesis” of nanogold to mitigate the hazardous implications stemmed from conventional nanogold synthesis. In our earlier study we had demonstrated the *in planta* reduction of KAuCl_4 by *Sesbania* into 80-85% elemental monodisperse gold nanoparticles endowed with *in situ* catalytic functions. In this study we show that gold nanoparticles could not only be “green synthesized” but could also be “green engineered” by manipulating different growth parameters (light, temperature, pH of the nutrient medium) and nutrient composition. For instance, low pH triggered the formation of nanotriangles in *Medicago sativa*, whereas depriving the nutrient medium of phosphate and/or sucrose resulted in some exotic shapes of gold nanoparticles in *Arabidopsis thaliana*.

NANOPARTICULATE DRUG DELIVERY SYSTEMS

Development and Optimization of Brain Targeted Tempol Loaded Nanoparticles for Parkinson's Disease

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Many antioxidants have been successfully tested to prevent neurodegeneration *in vitro* but failed to show significant results *in vivo* for Parkinson's disease (PD) as a consequence of insufficient concentration in the brain. We propose that the targeted delivery of Tempol to the brain using nanoparticles could be an effective treatment for PD. The major challenge with antioxidant therapy for PD is selective drug delivery to the brain. Tempol is a hydrophilic drug and requires high dosing concentration to penetrate the brain to effective levels while the lipophilic nanoparticles containing Tempol could easily permeate through the BBB. The biodegradable nanoparticles were prepared using pegylated poly-lactide-co-glycolide-mallemide (PLGA-PEG-maleimide) by nanoprecipitation method with PLGA as polymer, pluronic P85 as surfactant, and acetone as solvent. PLGA-PEG-maleimide polymer was synthesized by conjugating PLGA-COOH and NH₂-PEG-maleimide in presence of N,N-diisopropylethylamine. The confirmation of reaction was done by NMR spectroscopy. Mitochondrial specific antibody (MCO2) and transferrin receptor specific antibody (OX26) were conjugated to the PLGA-PEG-maleimide nanoparticles after thiolating the antibodies. The nanoparticles showed particle size suitable for BBB permeation (particle size 200-300nm). The nanoparticles were used for cellular uptake studies in rat glioma cells (RG2 cell lines) using fluorescence microscopy and found that these nanoparticles showed significantly higher uptake in RG2 cell lines and the cellular uptake is probably due to endocytosis. The drug loaded nanoparticles did not indicate the substrate property of p-glycoprotein (p-gp) measured by Human PGP-ATPase assay and will not be effluxed by p-gp present in blood brain barrier. We are proposing PEG-nanoparticles which are less susceptible to be taken up by the RES in the blood stream after intravenous administration. Tempol loaded nanoparticles are suitable for further neuroprotection study in a Parkinsonian mouse model and could be a potential treatment for PD.

Nanocurcumin Treatment Protects Neuronal Cells from Cellular Damage and Neurodegeneration Caused by the Reactive Oxygen Species (ROS)

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Background: Curcumin is one of the ingredients of turmeric, which is a common culinary component in the Indian and Asian countries. Curcumin is extracted from the plant named *Curcuma longa*. Researchers have previously shown anti-inflammatory and anti-cancer properties of curcumin, however, its beneficial role in brain disorders has not been fully explored. However, one of the major hindrances of curcumin as a therapeutic agent is its poor aqueous solubility and low bioavailability. To address this problem, a polymeric nanoparticle encapsulated formulation of curcumin (Nanocurcumin) has recently been developed to increase its solubility in aqueous media (Bisht *et al.*, 2007). Deposition of the amyloid beta peptide (A β)- loaded neuritic plaque and associated reactive oxygen species (ROS)- mediated neuroinflammation is one of the major hallmarks of Alzheimer's disease (AD). Our goal is to investigate preventive and curative role of nanocurcumin in neuro-inflammation associated with AD.

Objectives: Our aim was to demonstrate the effect of nanocurcumin in preventing or rescuing neuronal cells from ROS mediated insults. We have also independently studied the effect of nanocurcumin treatment on synaptic proteins in neuronal cells.

Experimental Design: We have used neuronally differentiated human SK-N-SH cells for our experiments. Cells were treated with 200 μ M of H₂O₂ and co-treated with either vehicle or different doses (500nM and 1 μ M) of nanocurcumin. Following 48 hours, cell viability (CTG), cellular toxicity (LDH) assays and phase contrast images were performed after 48 hours of treatment. Further, differentiated SK-N-SH cells were treated with a 500 μ M of nanocurcumin for 48 hours without the presence of ROS. After harvesting, the cell lysate was analyzed for one of the synaptic proteins SNAP25 by western immunoblotting.

Results: We observed that i) ROS treatment alone significantly damaged the cells and caused neuronal loss which were reflected by CTG, LDH assays, ii) both the doses of nanocurcumin protect neuronally differentiated cells from ROS mediated insults and restore cellular integrity, iii) there was a significant increase in SNAP25 protein in differentiated cells when treated with nanocurcumin without the presence of ROS.

Conclusion: The results suggest that nanocurcumin can potentially slow down neuronal loss associated with AD by preventing ROS mediated damage. Further experiments with nanocurcumin in protecting neuronal cells against A β mediated insults are in progress. Since nanocurcumin is readily soluble in aqueous media, it may have increased bioavailability and better therapeutic potentials than curcumin. Taken together our results are suggestive of strong therapeutic potential for nanocurcumin.

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MANUFACTURING AND MECHANICAL PROPERTIES OF NANO SYSTEMS

Endohedral Fullerenes and Their Implication in Technology

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One of the fascinating aspects of nanotechnology is the miniaturization of devices, where single molecules are investigated to be used as electric components. Endohedral fullerenes which encapsulate an atom(s) or a molecule have many interesting physical and chemical properties with potential applications both in technology and in biomedical sciences [1][2]. A combined theoretical and experimental characterization of endohedral fullerenes has enabled to understand many of their structural and electronic properties and will be overviewed followed by our recent investigation with the conductance measurements of single C_{60} and $Ce_2@C_{80-I_h}$, established by controlled contact using scanning tunneling microscopy [3]-[5]. The measurements indicate that the endohedral species has almost, five times less conductance than the empty cage and will be explained by the analysis of electronic structure of these two molecules bonded to Cu(111) by density functional theory computations.

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MANUFACTURING AND MECHANICAL PROPERTIES OF NANO SYSTEMS

Bi-Specific Anti-HER-2 Immunonanoparticles: Design and Targeting to Breast Cancer Cells *in Vitro*

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In the present study we developed bi-specific anti-HER-2 (Human epidermal growth factor receptor) immunonanoparticles (INPs) loaded with Docetaxel (DTX) (antineoplastic agent) for breast cancer therapy. Targeting directed by an anti HER-2 antibody which endows long circulating immunonanoparticles with the capability of carrying their drug load inside the target cancer cell will add a new dimension to the technology of nanoparticles drug delivery. HER-2 monoclonal antibody (mAb) was attached covalently to the surface of long circulating PEGylated PLGA (Poly Lactide-co-Glycolide) nanoparticles. Biodegradable PLGA was conjugated with PEG (Poly ethylene glycol) via amide linkage by coupling chemistry and confirmed by ¹H NMR, FT-IR and Gel permeation chromatography. DTX loaded nanoparticles (NPs) were prepared and characterized. NPs, with a smooth spherical shape and near 100nm size were prepared and characterized for their size, DEX, surface charge, and surface morphology. The mAb (monoclonal antibody) was conjugated with amine group present in the NPs surface using MBS reagent and the presence of mAb on the NPs surface was determined by BCA protein assay. The integrity of attached mAb was confirmed using SDS-page analysis. The *in vitro* release behavior of DTX was investigated in PBS (pH 7.4) and the release rate was exhibited a biphasic pattern that is characterized by an initial burst, followed by a slower sustained release. *In vitro* cell uptake and cytotoxicity studies were evaluated by using SK-BR-3 cell line. Anti-HER-2 INPs efficiently bind to and internalize in HER2-overexpressing cells *in vitro*, resulting in intracellular drug delivery. Thus, anti-HER2 INPs represent an efficient and feasible strategy to achieve targeted intracellular delivery of therapeutic agents.

MANUFACTURING AND MECHANICAL PROPERTIES OF NANO SYSTEMS

Parylene Nanospheres, Nanotubes, and Nanocoatings for Medical Applications

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Parylenes (p-xylylenes), organic vapor phase polymers, have continuously been finding numerous applications in the protection and reliability enhancement of many nano and micro devices in the medical and electronic fields. Recently Parylenes have drawn considerable interests as a structural material for nano and micro technologies because of their exceptional properties such as stress-free truly conformal deposition, chemical inertness, low dielectric constant, biocompatibility, and optical transparency. During the past several years, Parylene polymers have been considered an integral part of micro devices by many biomedical engineering researchers as devices are made of Parylene through MEMs technology. In advancing Parylenes applications further through the above work, Parylene hollow-nanospheres and nanotubes were successfully developed, which opened variety of new applications in the medical areas. Examples include, but not limited to control release of drug delivery systems, sensors and separation technology (gases, particle filtration, bacteria, etc.)

This paper describes the methods to obtain parylene hollow nanospheres and nanotubes, and their potential applications along with application of Parylene coatings on nanostructured substrates for functionality and reliability enhancement. Various types of spheres and particles with different functionality were also explored. The above structures are derived from the concept of hollow nanospheres and include non-tubular and non-fiber like substances, filled or coated internally and externally that may have different functions; attachment of functional groups that may be single or multiple layers, and coatings that may be metal or non metals.

The results of above work conclude that Parylene nanostructured materials can be obtained, as non woven, from 10 nm to 125 microns in size with excellent electrical insulation, low dielectric constant (<3), thermal stability up to 450°C and excellent capability to withstand chemical, mechanical, and electrical stresses. Several new commercial applications that will have significant impact in medical, electronics, and other areas can now be developed.

MANUFACTURING AND MECHANICAL PROPERTIES OF NANO SYSTEMS

Thermoelectric Properties of Large Area Graphene

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Graphene is the newest member in the all-carbon family with exotic properties. In this study, the charge transfer effect of large area graphene was studied by *in situ* monitoring of the Thermoelectric power (S). The large area of the graphene allows one to connect two miniature thermocouples and a resistive heater for easy measurement of S without the use of extensive micro fabrication tools. Graphene samples were synthesized by (i) Chemical vapor deposition technique followed by transferring to the SiO₂ substrate (ii) epitaxial growth on SiC substrates (both Si-face (000-1) and C-face (0001)). The samples were characterized by Raman spectroscopy and atomic force microscopy. Additionally absorption/desorption properties were measured for O₂, NH₃, N₂H₄, and N₂O. The changes in S correlate very well with the relative position of the Fermi level with respect to the equilibrium chemical potential of the ambient.

MANUFACTURING AND MECHANICAL PROPERTIES OF NANO SYSTEMS

Graphene Nanoribbons From Graphite Surface Dislocation Bands

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We have developed a novel technique to produce long and narrow graphene ribbons with smooth edges. This technique is free of any chemical treatments and involves a combination of two steps: (i) creation of surface dislocation ribbons by high velocity clusters impacting graphite surface and (ii) electrostatic transferring of the ribbons to a desired substrate. The width of the ribbons can be controlled by varying the impact velocity and the direction of the jet stream. The electrical transport properties were investigated on the ribbons in field effect transistor configuration. The observed p-type behavior observed under ambient conditions was found to be reversed upon annealing at 180 °C in a vacuum of 10^{-7} Torr. Charge transfer effects were observed when the degassed graphene was exposed to O₂, NO₂ and NH₃.

MANUFACTURING AND MECHANICAL PROPERTIES OF NANO SYSTEMS

Controlling of the Single-Walled Carbon Nanotubes (SWNT) Growth with High Yield Metallic Conductivity

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Single-walled carbon nanotubes (SWCNTs) can be classified as either metallic or semiconducting depending on their conductivity, which is determined by their chirality. Existing synthesis methods cannot controllably grow nanotubes with a specific type of conductivity. By varying the synthesis conditions of the catalyst with the combination of oxidative and reductive species, we alter the fraction of carbon tubes with metallic conductivity from 1/3 of the population to a maximum of 91%. Raman analysis and electrical transport measurements have been carried out to confirm high percentage of the metallic nanotubes. Ultra high transparency up to 97% with high conductivity has been observed on the thin SWNT films grown on the quartz supporting materials.



ABOUT SULLIVAN UNIVERSITY COLLEGE OF PHARMACY:

Sullivan University has been preparing students for careers for more than 45 years. The College of Pharmacy is the most recent addition to the University, where the first classes began July 7, 2008. The College of Pharmacy offers an accelerated program, allowing students to earn their Doctor of Pharmacy degree in three years (after 2 years of pre-requisite courses) rather than the typical four professional years. The College currently consists of two departments, Clinical and Administrative Sciences and Pharmaceutical Sciences. The College of Pharmacy program is under the leadership of the Founding Dean Hieu T. Tran, Pharm.D., who joined Sullivan University October 10, 2006 to launch the new College of Pharmacy in Louisville, KY. All faculty members and administrators were hand-picked from across the country to ensure that the College of Pharmacy provides its students quality and meaningful learning experiences.

Restaurant List

Note: All directions are based on taking a right out of the main parking lot. The light (Bakery on your Right, Heine Brothers on your left) is Bardstown Road. Heading left on Bardstown Road will take you toward the Highlands.

The Highlands is a rather popular and historic area of Louisville, with multiple restaurants, bars, and hang outs — if you're looking for entertainment it is a great place to be!

Winston's Restaurant

Address: 3101 Bardstown Road

Phone: (502) 456-0980

Directions: Go straight through light to main Sullivan Campus

Buckhead Bar and Grill

Address: 3008 Bardstown Road

Phone: (502) 456-6680

Directions: Before arriving at light, take Left into Parking Lot by Heine Brothers

Chili's Grill and Bar

Address: 3623 Bardstown Road

Phone: (502) 301-8888

Directions: Right on Bardstown Road, 1 mile up on Left (Near Arby's)

Tumbleweed:

Address: 3602 Bardstown Road

Phone: (502) 454-2727

Directions: Right on Bardstown Road, 1 mile on up on right

John E's Restaurant and Lounge

Address: 3708 Bardstown Road

Phone: (502) 456-1111

Directions: Turn Right on Gardiner Lane, Right on Bardstown Road, 1.2 miles on left

Steak 'n Shake:

Address: 3232 Bardstown Road

Phone: (502) 456-2670

Directions: Turn Right on Gardiner Lane, Right on Bardstown Road, .3 miles on right

Mr. Gatti's Pizza

Address: 3319 Bardstown Road

Phone: (502) 451-0540

Directions: Turn Right on Gardiner Lane, Right on Bardstown Road, .3 miles on left

Bristol Bar and Grille

Address: 1321 Bardstown Road

Phone: (502) 456-1702

Directions: Turn Right on Gardiner Lane, Left on Bardstown Road, 2.3 miles on right

Continued on next page...

Restaurant List Continued

Mark's Feed Store

Address: 1514 Bardstown Road

Phone: (502) 458-1570

Directions: Left on Bardstown Road, 2.5 miles on left

Kashmir Indian Restaurant

Address: 1285 Bardstown Road

Phone: (502) 473-8765

Directions: Left on Bardstown Road, 3 miles on right

Just Fresh Bakery

Address: 1255 Bardstown Road

Phone: (502) 451-2324

Directions: Left on Bardstown Road, 3.1 miles on right

De La Torre's Restaurant

Address: 1606 Bardstown Road

Phone: (502) 456-4955

Directions: Left on Bardstown Road, 2.3 miles on right

Sapporo Japanese Steakhouse

Address: 1706 Bardstown Road

Phone: (502) 479-5550

Directions: Left on Bardstown Road, 2.5 miles on right

Seviche: A Latin Restaurant

Address: 1538 Bardstown Road

Phone: (502) 473-8560

Directions: Left on Bardstown Road, 2.5 miles on right

Quick Service Restauarants

Directions: Turn Right on Gardiner Lane, Right on Bardstown Road

Sonic Drive-In

Taco Bell

Pizza Hut

Penn Station

Arby's

Wendy's

Kentucky Fried Chicken

Popeye's Chicken and Biscuits

White Castle

Subway (Inside WalMart)

Dairy Queen (turn left at Thornton's light)

Captain D's Seafood

