

Report on The First Arkansas Conference on Nanotechnology and Healthcare

1. National Picture - Nanotechnology is the Nation's manufacturing technology of the 21st century. It has captured billions of dollars of federal investment because of its potentially broad effects on all parts of commerce. It is already used in consumer products such as sunscreens and stain-resistant clothing. But its potential is especially well suited to have a tremendous impact on healthcare. This is because nanotechnology involves the realm of nanometers, or billionths of a meter in size. This is the same scale on which all living cells operate. While cells are large in comparison (micrometer size), viruses range in size from 20 nanometers to 200 nanometers and antibodies roughly the size 20 to 40 nanometers. With nanoscale materials, we have the *challenge* to construct vehicles that are much smaller than a human cell so that they can deliver medication to sizes ranging from cells to bacteria to viruses.

2. Vision - In the mist of this new era of materials Arkansas is blessed with students and scientists that are leaders at nanotechnology who are learning about cancer, biology, and applying tools of nanotech for detecting and treating and ultimately preventing cancer and other medical problems like infections and cardiovascular disease. The state is also fortunate to have one of the best medical centers for researching and treating cancer. It's a really exciting time to be in Arkansas and an opportunity to mobilize the talent in Arkansas to meet this challenge. It was on the basis of this possibility that the Winthrop Rockefeller Trust supported the first "Conference on Nanotechnology and Healthcare". The proposed idea was to bring together and bridge expertise in the state in nanotechnology and healthcare especially expertise on cancer. It was designed to be the first of two conferences and the potential beginning of a long term "Series of Gordon Conferences". It was also designed to organize a state-wide effort toward competing for a federally supported research "Center for Nanotechnology and Healthcare".

3. Outcome - We are proud to report that first "Conference on Nanotechnology and Healthcare" held on January 7th to 10th at the Winthrop Rockefeller Institute on Petit Jean Mountain, made great progress toward this goal. The conference brought together the leading researchers in Arkansas and bridged state-wide talent in science and engineering at the nanoscale with talent in the medical sciences forming a state-wide force to impact the support and quality of Health Care in Arkansas and the Nation. The conference supported faculty and students throughout the state of Arkansas, by providing housing and meals for about 60 attendees (including students) from academics, industry, and government. The University of Arkansas at Fayetteville (UAF), Little Rock (UALR), and Pine Bluff (UAPB), Arkansas State University (ASU) and Arkansas Tech (AT), the Arkansas National Center for Toxicology Research (NCTR), as well as institutions outside the state contributed and lead presentations.

Conference presentations (see attached outline of presentations) pointed to advances in nanotechnology in Arkansas that are creating a wealth of opportunities for the development of new, improved medical diagnostic products and techniques. Nanoparticle formulations of superparamagnetic iron oxide, gadolinium, perfluorocarbon and specialty polymers will broaden *in vivo* imaging capabilities by enabling the detection of tumors, plaque, genetic defects and other disease states at much earlier stages and with lower, safer concentrations of contrast agents. Several medical supplies and devices will emerge as key applications for nanotechnology. Nanomaterials are already gaining significant demand as active ingredients of burn and wound dressings. In the long term, advances in nanotechnology are expected to lead to the introduction of new, improved medical supply and device coatings as well as a new, diverse



Fig.1 Students gave poster presentations on their research effort that gave them experience through a long discussion

group of medical implants. However, the greatest short-term impact of nanotechnology in health care in Arkansas will likely be in therapies and diagnostics for cancer and central nervous system disorders.

Speakers also discussed new, improved cancer drug delivery systems based on nanostructures, new imaging techniques and corresponding instrumentation, and the development of tissue structures. Quantum dots that emit bright light in a color range that varies with their size are now frequently used to study tumors and locate proteins that researchers want to study. By attaching antibodies that prefer to bind with specific types of cells to dots of different sizes, the researchers can get a multicolored image showing the location and concentration of many elements inside a tissue sample. Nanoparticles also help researchers overcome obstacles in gene therapy, which seeks to treat genetically inherited diseases like cystic fibrosis by implanting healthy genes to do the work of damaged ones. They may also be used to deliver heat or medication to cancer cells to kill them. For example, coated iron oxide nanoparticles coupled with a compound that is a nutrient for tumor cells are ingested. When an external magnetic field causes the particles to vibrate rapidly, the tumor cells are killed and then flushed from the body by its natural scavenger cells, according to research results. Within a couple of years, scientists hope to use nanotechnology to detect the location of viruses in the body. The process would involve injecting magnetic nanoparticles into the bloodstream and would potentially allow more precise virus treatments to be developed. It's an area that promises to make drug delivery, diagnosis and treatment of diseases like cancer more efficient by enabling therapies to target only harmful cells. Interestingly, nanoparticles may be able to pass the blood-brain barrier, allowing for better therapies for a host of neurological ailments.

Moreover, the need for new or improved medicines in several therapeutic areas will lead to the increasing use of nanotechnology in pharmaceutical applications. For example, protein- and peptide-based compounds for cancer, diabetes, infectious diseases and organ transplant acceptance will increase dramatically. In fact, over the long term, pharmaceutical applications for nanotechnology will extend into most therapeutic processes and delivery systems. Eventually, nanotechnologies may enable tissue regeneration, where scientists could grow artificial skin or new organs, and gene therapy. However, some speakers pointed out that toxicity consideration will likely delay the commercialization of targeted drug delivery systems, tissue regenerators, and other breakthrough products.

The final session of the conference focused on the potential market. For example, a panel discussed a recent study on *Nanotechnology in Health Care* by The Freedomia Group, Inc., a Cleveland-based market research firm who predicted that 2009 will see a \$6.5 billion dollar market for nanotechnology and healthcare. Moreover, by 2020 broad progress is expected to result in the demand for nanotechnology health care products to exceed \$100 billion – all of which points to the potential impact this conference will have on the economic future of Arkansas.

4. Future Plans – Building on this initial success we have moved forward to (a) planning the Second state-wide Conference on Nanotechnology and Healthcare. We have also (b) organized a strong group of researchers to go after a National Institute of Health Center built around the nucleus of researchers that have formed a state-wide force on nanotechnology and healthcare. Moreover, (c) this spring we are submitting an NSF proposal on the subject of training graduate students in this area of research. Finally, (d) we will engage the Arkansas Medical School's effort in Cancer Research in all of our efforts as we build bridges between both areas of expertise.



Fig.2. Activities includes social events such as a wine and food class and a game of “Who Wants to be a Nanoscientists?” at dinner, so that researchers would have an opportunity for personnel connections.

Program Outline for the First Nanotechnology and Healthcare Conference - 2009

WEDNESDAY JANUARY 7, 2009

ARRIVAL all Afternoon and Evening

6:00 - 7:30 PM Buffet Dinner

7:30 - 9:00 PM Informal Mixer (Beer, Wine, Coffee, Tea, etc.)

THURSDAY JANUARY 8, 2009

THURSDAY MORNING

7:30 – 8:20 - Breakfast

8:20 – 9:00 AM - Greg Salamo, Director of the Arkansas Institute for Nanoscale Material Science and Engineering
Opening Remarks – Conference Vision and Goals

9:00-9:50 AM - Peter Emanuel, Director of the Winthrop P. Rockefeller Cancer Institute
Cancer Center Mission, Short and Long Term Goals, Role for Nanomedicine, Overall vision for the Cancer Institute

9:50 – 10:00 AM - Short Break (Coffee, Tea, and Water, Available Throughout the Conference)

10:00 AM to 11:05 AM Detection and Imaging Strategies I

Nanotechnology – A Unique Solution for Challenging Disease Diagnoses: *In Vivo*, Novel, Non-Invasive Lymph Test Ekaterina Galanzha, Evgeny Shashkov & Vladimir Zharov; Phillips Classic Laser & Nanomedicine Laboratories, University of Arkansas for Medical Science.

Molecular imaging of neuroendocrine networks controlling stress responses and social behavior in an avian model organism. Alexander Jurkevich and Wayne J. Kuenzel. Center of Excellence for Poultry Science, University of Arkansas, Fayetteville.

Detection of Circulation Tumor Cells: Status and Perspective using Nanotechnology for Early Cancer Diagnosis and Metastasis Prevention Ahmed Safar¹ & Vladimir Zharov²; ¹Division of Hematology/Oncology, University of Arkansas for Medical Sciences, Little Rock, AR ² Phillips Classic Laser & Nanomedicine Laboratories, University of Arkansas for Medical Sciences, Little Rock, AR

11:05 – 11:25AM Break and Refreshments

11:25 AM to 12:30 PM Detection and Imaging Strategies II

Nanotechnology and organic electronics in medicine and for point-of-care patient health monitoring in real time, Vijay K. Varadan, University of Arkansas, Electrical Engineering.

Light Scattering Study of the Interaction of Fibroblast Growth Factor (FGF) and its Receptor
Pallavi Sharma,* Dakshinamurthy Rajalingam†, T. K. S. Kumar,† and Surendra Singh*; *Physics Department, and †Department of Chemistry and Biochemistry, University of Arkansas, Fayetteville, AR 72701

Detection and Bio-Distribution of Inhaled Carbon Nanotubes in Lungs by Raman Spectroscopy
Taylor Ingle¹, Enkeleda Dervishi² Kenton Leigh¹, Alexandru S. Biris², and Roger Buchanan¹,
¹Molecular BioSciences, Arkansas State University; Center for Nanotechnology, ²University of Arkansas at Little Rock

12:30 to 1:30 PM Lunch

1:30-2:30 PM Imaging and Targeting for Nanotechnology

Molecular Imaging in Animals and Patients using MRI, PET/CT - Michael J. Borrelli, Ph.D., Professor and Director of Research, Department of Radiology, University of Arkansas for Medical Sciences

Radiation Oncology- State of the art in treatment and research- Nanomedicine Targeting - Peter M. Corry, Ph.D., Distinguished Professor, Vice Chairman, Department of Radiation Oncology, College of Medicine, University of Arkansas for Medical Sciences.

Microscopy for Nanotech - Alex Biris, Nanotechnology Center and Applied Science Department, University of Arkansas at Little Rock, Little Rock

2:30- 2:40 PM Short Break (Coffee, Tea, and Water, Available Throughout the Conference)

2:40 - 4:10 PM Novel Nanoscale Materials for HealthCare I.

Enhanced Mechanical and Biological Properties of Nanocrystalline Hydroxyapatite Coating for Dental/Orthopedic Implants Huinan Liu¹, Wenping Jiang¹, Ajay Malshe¹, Jiping Cheng², Dinesh Agrawal², Clark M. Stanford; ¹NanoMech LLC, 535 W Research Center Blvd, Fayetteville, AR 72701. ²Materials Research Institute, Penn State University, University Park, PA 16802; ³Dows Institute for Dental, University of Iowa, Iowa City, Iowa 52242.

Labeling Nanoparticles for Biomedical Imaging, Marc Berridge, UAMS Department of Radiology,

Advanced Functional Nanomaterials for the Thermal Ablation of Cancer Cells and Tumors, Yang Xu¹, MeenaMahmood¹, Zhongrui Li¹, Enkeleda Dervishi¹, Steve Trigwell², Nawab Ali¹, Viney Saini¹, Alexandru R Biris⁴, Dan Lupu⁴, Vladimir P Zharov³, Vasyl P. Kunets⁵, Gregory J. Salamo⁵, Alexandru S Biris^{1,*}; ¹ Nanotechnology Center and Applied Science Department, University of Arkansas at Little Rock, Little Rock, AR; ² NASA, Electrostatics and Surface Physics Laboratory, ASRC Aerospace, Kennedy Space Center, FL; ³ Philips Classic Laser Laboratories, University of Arkansas for Medical Sciences, Little Rock, AR; ⁴ National Institute for Research and Development of Isotopic and Molecular Technologies, Cluj Napoca, Romania; ⁵ University of Arkansas, Physics Department, Fayetteville, AR

Multicolor nanoparticles as molecular photoacoustic super-contrast agents for in vivo advanced sentinel lymph node mapping, multispectral lymphography, and metastasis assessment,

Ekaterina Galanzha¹, Mimi Kokoska², Evgeny Shashkov¹, Shawn Allen¹, Suzanne Klimberg³, Jin-Woo Kim⁴, Laura Hutchins⁵, Alexandru Biris⁶ & Vladimir Zharov¹; Phillips Classic Laser & Nanomedicine Laboratories, University of Arkansas for Medical Sciences, Little Rock, Arkansas; Richard L. Roudebush VA Medical Center and Indiana University School of Medicine, Indianapolis, Indiana; Department of Breast Surgical Oncology, University of Arkansas for Medical Sciences, Little Rock, Arkansas; Department of Biological and Agricultural Engineering, University of Arkansas, Fayetteville, Arkansas; Division of Hematology/Oncology, University of Arkansas for Medical Sciences, Little Rock, Arkansas; Nanotechnology Center, University of Arkansas at Little Rock, Little Rock, Arkansas

4:10 – 4:30 PM Break and Refreshments

4:30 - 6:00 PM Drug Delivery Techniques I.

Nanoparticle-bound tumor necrosis factor for selective thermal sensitization of solid tumors: systemic and local delivery strategies, Robert J Griffin and Gal Shafirstein University of Arkansas for Medical Sciences, Departments of Radiation Oncology and Otolaryngology; University of Arkansas for Medical Sciences, Departments of ¹Radiation Oncology and ²Otolaryngology

Arginine Interactions with Lipid Bilayers, Roger E. Koeppel II*, Denise V. Greathouse and Vitaly V. Vostrikov; Department of Chemistry and Biochemistry, University of Arkansas, Fayetteville, Arkansas 72701

Microbubble-Mediated Ultrasonic Sonophoresis And Sonoporation For Targeting Drug And Nanotherapeutic Delivery, Michael J. Borrelli¹, Gregory J. Salamo², Steve Tung³, and Alexandru S. Biris⁴, ¹UAMS Department of Radiology, 4301 West Markham, Little Rock, AR 72205, ²Department of Physics, PHYS 225, University of Arkansas, Fayetteville, AR 72701. ³Department of Mechanical Engineering, MEEG 214 University of Arkansas, Fayetteville, AR 72701, ⁴UALR Nanotechnology Center, ETAS 151, Little Rock, AR, 72701.

Selective Nanophotothermolysis of Cancer Targeted by Gold Nanoparticles with Super-Narrow Plasmon Resonances, Mark Viegas, Student, College of Medicine, University of Arkansas for Medical Sciences E-mail: mgviegas@uams.edu Thomas Kelly, UAMS: Department of Pathology Puneet Bharill and Robert Reis UAMS: Departments of Medicine, Pharmacology, and Biochemistry/Molecular Biology Evgeny Shashkov, Ekaterina Galanzha, Vladimir Zharov UAMS: Philips Classic Laser & Nanomedicine Laboratories

6:00 PM-7:30 PM Dinner

7:30 PM – 9:00 PM Mixer (Beer, Wine, Coffee, Tea, etc.) and Posters

Anginex increases the permeability of planar lipid bilayers, Matthew Naglak, Eric Krueger, Rachel Lee, *Robert Griffin, Greg Salamo, Ralph Henry, Daniel Folega, University of Arkansas, Fayetteville. Poster

Use of nanomaterials in the study of protein interactions in targeting to membrane-localized transporters, Robyn Goforth¹, Nathaniel Lewis¹, Naomi Marty¹, Alicia Kight¹, Dakshinamurthy Rajalingam², Thallapuranam Krishnaswamy Suresh Kumar², Ralph Henry¹; ¹Department of Biological Sciences and ²Department of Chemistry and Biochemistry, University of Arkansas, Fayetteville, AR 72701

Quartz Crystal Microbalance for Investigating Biomolecule Interactions Eric Krueger, Naomi Marty, Robyn Goforth, Daniel Fologea, Ralph Henry, Greg Salamo, University of Arkansas, Fayetteville.

Nanointegrated Tissue Printing for Regenerative Biomedicine, Ajay P. Malshe, University of Arkansas
Wei Sun, Drexel University

Uptake and Release of Drugs and Nanoparticles from Liposomes, Rachel Lee, Matthew Naglak, Ralph Henry, Gregory Salamo, and Daniel Fologea, University of Arkansas - Fayetteville

FRIDAY JANUARY 9, 2009

7:30 – 8:20 - Breakfast

8:20 - 9:00 AM David A. Brant, NSF Biomaterials Program Director,
Nanobiotechnology and the NSF Biomaterials Program

9:00 – 9:10AM Short Break (Coffee, Tea, and Water, Available Throughout the Conference)

9:10 – 10:30 Neural Science

Interactions of Nanomaterials and Neurons: Potential Applications and Concerns 1Malathi Srivatsan, 1Mahadevappa P. Badanavalu, 1Justin Yancey, 2Jining Xie, 2Linfeng Chen, 2Phillip T. Hankins, 2Hargsoon Yoon and 2Vijay K. Varadan¹ Arkansas State University, Jonesboro, AR 72401, USA and University of Arkansas, Fayetteville, AR 72205, USA

Protein Folding in Anisotropic Three Dimensional Landscapes Eitan Gross, Department of Physics, University of Arkansas, Fayetteville, AR

Neuron Regeneration and Multiplexed Biochemical Sensing on Nanowire-Membrane F. Chen¹, S. Ali², Z. R. Tian^{1*} ¹Chemistry/Biochemistry, University of Arkansas, Fayetteville, AR 72701, ²Neurochemistry Laboratory, National Center for Toxicological Research, Food and Drug Administration, Jefferson, AR 72079-9502

Development of Neural Probes with Au/IrO₂ Nanowire Electrodes and Neural Recordings In-Vivo Hargsoon Yoon, Phillip Hankins, Sechang Oh, and Vijay K. Varadan, Innovative Nano/Bio, Devices and Systems Lab, University of Arkansas, Fayetteville, AR, 72701 USA

10:30 – 10:50 AM Break and Refreshments

10:50 - 11:50 Drug Delivery Techniques II.

Boron Nitride Nanotubes (BNNTs) used as an Immunotargetable Reagent for Boron Neutron Capture Therapy (BNCT) :(a novel approach to targeted cancer therapy) Dan Buzatu and Jon Wilkes, FDA National Center for Toxicological Research

Nanomedicine with Advanced Nanoparticles: From Bench to Bedside Vladimir Zharov, Philips Classic Laser & Nanomedicine Laboratories, University of Arkansas for Medical Sciences

Superparamagnetic-Nanoparticles for Targeted Delivery of Therapeutics to the Inner Ear

Kenneth Dormer, Ph.D., Department of Physiology, University of Oklahoma Health Sciences Center

Brian Grady, Ph.D., School of Chemical, Biological and Materials Engineering, University of Oklahoma

David Bourne, Ph.D., Department of Pharmaceutical Sciences, College of Pharmacy, University of Oklahoma, Isaac Rutel, Ph.D., Department of Radiological Sciences. College of Allied Health,

University of Oklahoma Health Sciences Center, Xinsheng Gao, M.D., Ph.D., Kejian Chen, M.D.,

Ph.D., Kelsey Wang, M.S. and Richard Kopke, M.D., Hough Ear Institute, Oklahoma City

11:50 - 12:30 Toxicology

Comparative Biodistribution of Coated and Uncoated Nano- and Micron-Sized Titanium Dioxide Following Intradermal Administration in Mice. Neera V. Gopee, Christy Cozart, Paul H. Siitonen, Cynthia S. Smith², Nigel J. Walker², and Paul C. Howard, National Center for Toxicological Research and National Toxicology Program Center for Phototoxicology, FDA, Jefferson, AR, and ²National Toxicology Program, National Institute for Environmental Health Sciences, Research Triangle Park, NC.

Copper Nanoparticles Exert Size and Concentration Dependent Toxicity on Somatosensory Neurons of Rat, 1Mahadevappa P. Badanavalu., 1Sahitya C. Pandanaboina, 2Syed F. Ali , 3Saber M. Hussain 1*Malathi Srivatsan; 1Department of Biological Sciences, Arkansas State University, Jonesboro, AR; 2National Center for Toxicological Research/FDA, Jefferson, AR; 3Human Effectiveness Directorate, Air Force Res. Laboratory, Wright-Patterson AFB, Dayton, OH.

12:30 – 1:30 LUNCH

1:30 – 3:30 AFTERNOON FUN ACTIVITIES

Cooking, Geological Trailing, Eagle Watching

3:30 – 5:30 AFTERNOON FUN ACTIVITIES

Wine, Geological Trailing, Eagle Watching

6:00 PM-7:30 PM Dinner and Panel Discussion by Healthcare Community on Interest in Nanotechnology

7:30 PM – 9:00 PM Mixer (Beer, Wine, Coffee, Tea, etc.) Same posters and Late Papers as Poster

SATURDAY JANUARY 10, 2009

7:30 – 8:20 - Breakfast

8:20 – 9:20 AM Novel Sensors

The rectification properties of voltage controlled nanochannels Daniel Fologea, Eric Krueger, Rachell Lee, Mathew Naglak, Ralph Henry, Yuriy Mazur, Gregory Salamo

Nanomedical Approach to Single Pathogens *in vivo*: From Bench to Preclinical Studies

Ekaterina Galanzha,¹ Evgeny Shashkov,¹ Emre Vural,¹ Kelly Mercer,² Mark Smeltzer,³ & Vladimir Zharov;¹ Philips Classic Laser & Nanomedicine Laboratories, University of Arkansas for Medical Sciences; ² Arkansas Biosciences Institute, University of Arkansas for Medical Sciences; ³ Department of Microbiology and Immunology, University of Arkansas for Medical Sciences

Bio-sensors using flexible, organic ion sensitive field effect transistor with Ionophores and nanowire structures Authors: Taeksoo Ji, Pratyush Rai, Soyoun Jung, and Vijay K. Varadan; University of Arkansas, Electrical Engineering, Fayetteville, AR

9:20 – 9:30AM Short Break (Coffee, Tea, and Water, Available Throughout the Conference)

9:30 - 10:50 Novel Materials for HealthCare II

Nanoparticle Spray Deposition System for Functionally Graded Bioactive Coatings for Biomedical Applications, Wenping Jiang¹, Justin Lowrey¹, and Ajay P. Malshe^{1,2} ¹ NanoMech, LLC, Fayetteville, AR 72703 ² Department of Mechanical Engineering, the University of Arkansas, Fayetteville, AR 72703

Delivery and Visualization of Advanced Functional Nanomaterials for Bio-Medical Applications, Meena Mahmood, Yang Xu, Alokita Karmakar, Zhongrui Li, Ashley Fijley, Viney Saini, Nawab Ali, Fumiya Watanabe, Alexandru S. Biris; University of Arkansas at Little Rock, Applied Science Department, UALR Nanotechnology Center, Little Rock, AR 72204; Ekaterina I. Galanzha, Vladimir P. Zharov Philips Classic Laser Laboratories, University of Arkansas for Medical Sciences, Little Rock, AR, 72205

Peptoids for Biomedical Applications, Shannon Servoss, University of Arkansas – Fayetteville

Design of liposome-encased quantum dots for drug delivery and release applications, Daniel Fologea², Azemat Jamshidi-Parsian¹, Michael J. Borrelli¹, Xiaogang Peng², Ralph Henry², Greg Salamo², Robert J. Griffin, PhD¹; ¹University of Arkansas for Medical Sciences, Little Rock, AR, USA, ²University of Arkansas, Fayetteville, AR

10:50 – 11:10 AM Break and Refreshments

11:10 - 12:00 PM "QUO VADIMUS: Bio-Nano Business and Academic Partnership for Economic Development"- Ajay P. Malshe, Ph.D., 21st Century Endowed Chair Professor of Materials, Manufacturing and Integrated Systems, Director, Materials and Manufacturing Research Laboratories (MMRL), Mechanical Engineering, University of Arkansas, and NanoMech.

12:00 12:30 PM Greg Salamo, Director of the Arkansas Institute for Nanoscale Material Science and Engineering - Closing Remarks – Conference Vision and Goals.