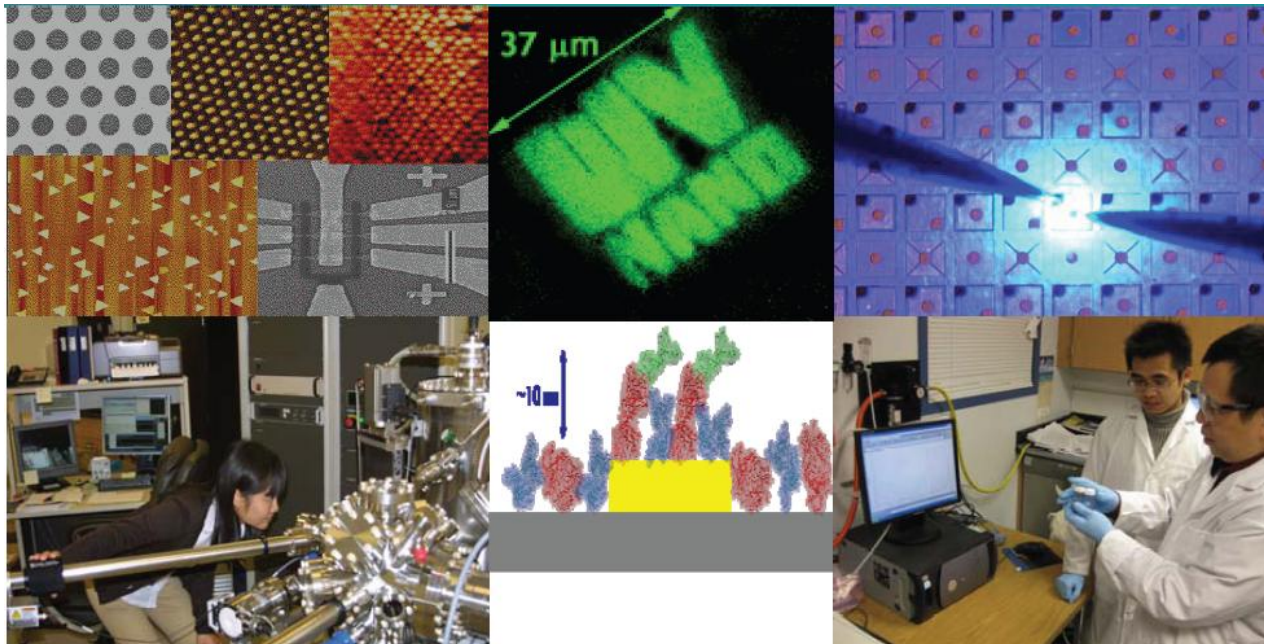
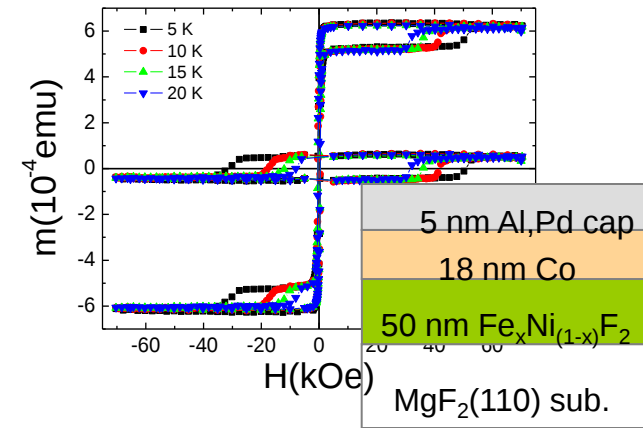


WVNano: Bionanotechnology for Public Security and Environmental Safety

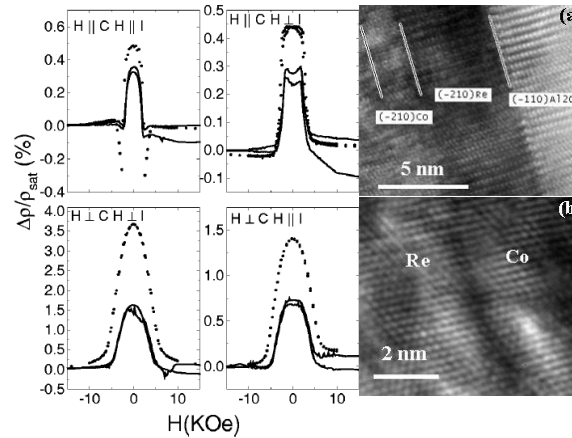


David Lederman
Interim Director, WVNano (8/1/2008 – 10/31/2010)
Professor of Physics
West Virginia University

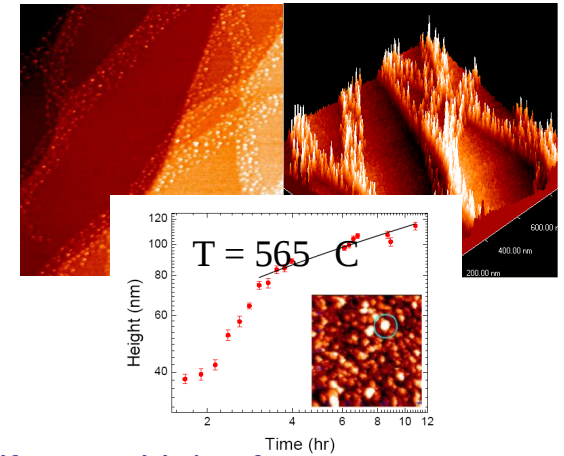
DL Areas of Interest



Exchange bias

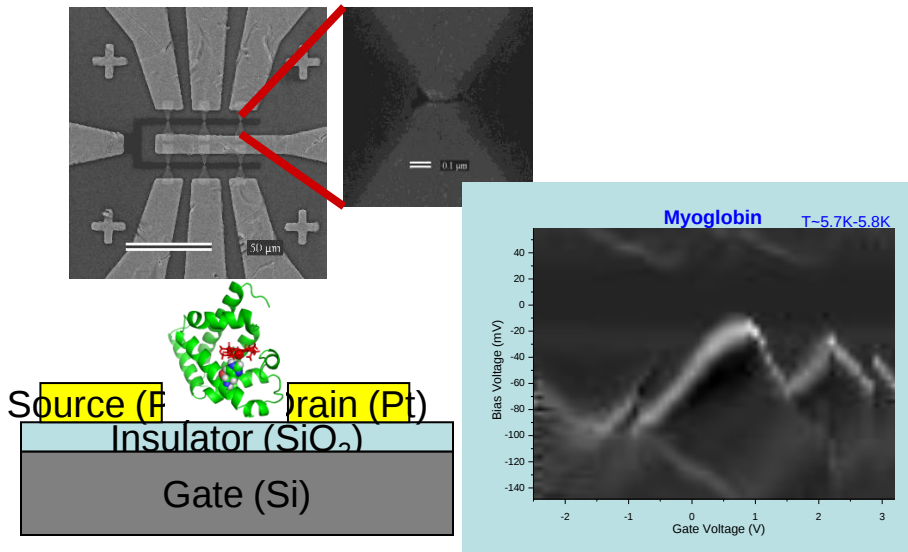


GMR in anisotropic structures



Self-assembly/surface dynamics/hydrogen absorption

Magnetic Nanostructures and Interfaces



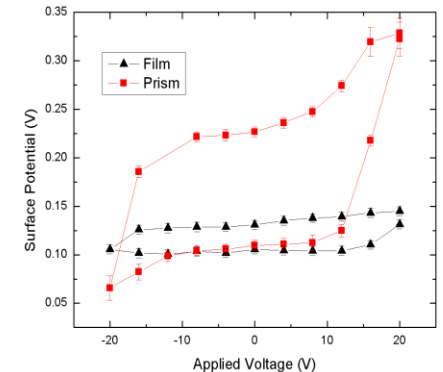
Myoglobin Single Electron Transistor



Biomolecular Electronics

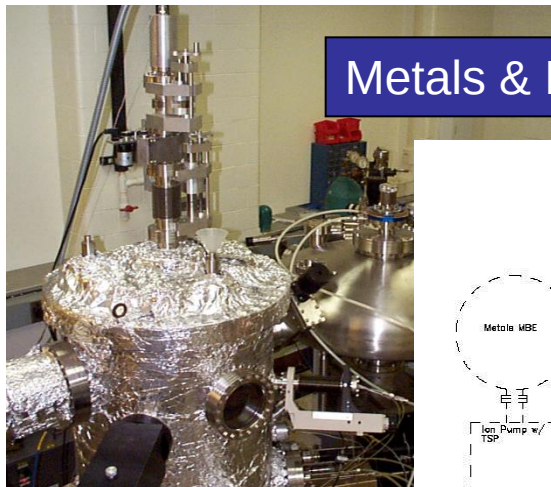


YMnO_3/GaN

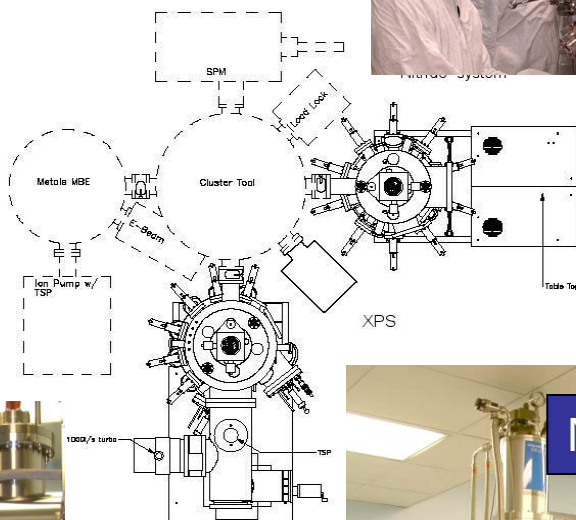


Hybrid Multifunctional Heterostructures

Metals & Fluorides



In-situ scanning probe microscopy and characterization



Multifunctional Materials Growth Cluster Tool

Combining Magnetic, Semiconducting and Ferroelectric Materials at the Nanoscale for New Functionality

Oxides



Nitrides





What is WVNano?

- Initiative established in 2004 to enable and accelerate interdisciplinary research in nanotechnology at West Virginia University
- Received \$9M NSF – EPSCoR grant in 2006 for “Biomolecular Identification” program; matched by \$9M from state of WV & WVU
- Initiative elevated to State-wide status in 2007
- WVNano includes comprehensive research, outreach, and education programs at all levels
- Currently funded by new NSF- EPSCoR grant + state and institutional commitments (~\$15M/5 years at WVU, \$12M for other institutions) + investigator grants
- Has strong support at State and University levels
- Now includes 25 faculty members at WVU, 5 at MU





Accomplishments 2006-2010

- Twelve new faculty of diverse backgrounds (10 @ WVU, 2 @ MU)
- Developed strong interdisciplinary research efforts
 - ~77 publications
 - ~\$7.3M in new grants (aside from NSF-EPSCoR) from NSF, NIH, DOE
 - Grad students & postdocs trained
- Established regional, national, and international collaborations
 - National labs (e.g., NIOSH, NETL, NIST)
 - Institutions in China and South America
 - Collaborative agreement with IC Inova Japan (\$2.5M)
- Sustainable shared facilities
 - Support existing and new research efforts of universities
 - Available to industrial and national lab partners

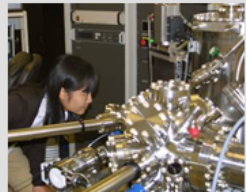
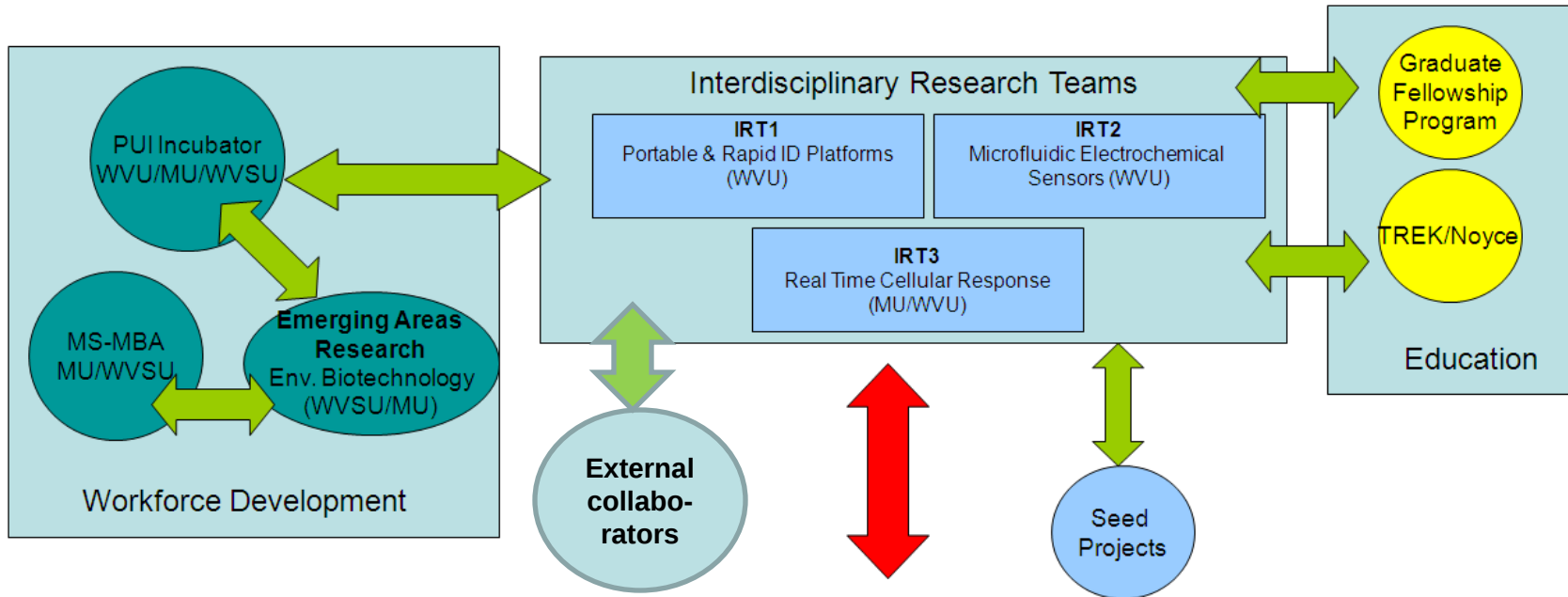


Goals and Objectives

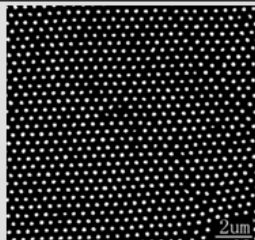
- Overall Goal
 - To develop a nationally and internationally recognized nanotechnology research center that addresses fundamental science and engineering problems related to environmental health, security and energy
- Objectives
 - Build on existing expertise and collaborations to create new platforms for integrated sensor devices
 - Genomic and proteomic identification for biometric and environmental applications
 - Environmental sensing via bioelectronic nanosensors
 - Environmental cell-based sensing
 - Create new shared facility infrastructure to enable proposed research and education activities
 - Bioengineering research facility
 - High performance computing facility
 - Build on existing education & outreach programs and broaden impact through graduate fellowships and teacher training



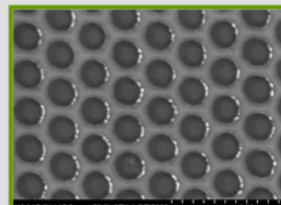
WVNano Current Activities



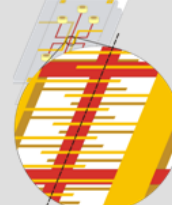
Shared Facilities



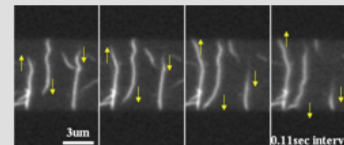
Electronic Recognition



Photonic Recognition



Microfluidic Transport



Nanokinematic Transport



Undergraduate Research Programs



WV Nano Activities

1. Application-inspired fundamental research
2. Equipment infrastructure to support research (shared facilities)
3. Graduate education
4. Outreach



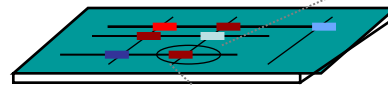


WV Nano Research

- Interdisciplinary research teams (IRTs)
 - IRT 1: Portable and rapid molecular recognition platforms
 - IRT 2: Field-deployable sensors for toxin detection
 - IRT 3: Cellular sensing devices
- Seed projects (externally reviewed)
 - Seed 1: Electric cell-substrate impedance sensor for quantitative toxicology
 - Seed 2: Nanoscale selection for rapid analyses of steroids in plasma

Integrated systems for
security, health, and
energy of societal impact

Integrated Recognition System

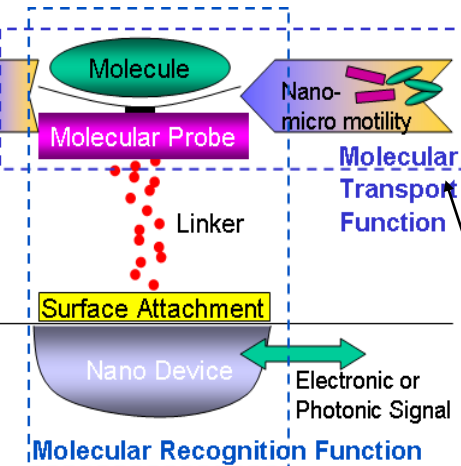


Co-integration of
recognition and
transport

Test bed Standard Cell

Discovery linking materials,
devices, and proteomics
inspired by needed
recognition and transport
functions

Interdisciplinary Research Groups



- 1.) Nanokinematics
- 2.) Nano/microfluidics
- 3.) Electronic Transduction
- 4.) Photonic Transduction

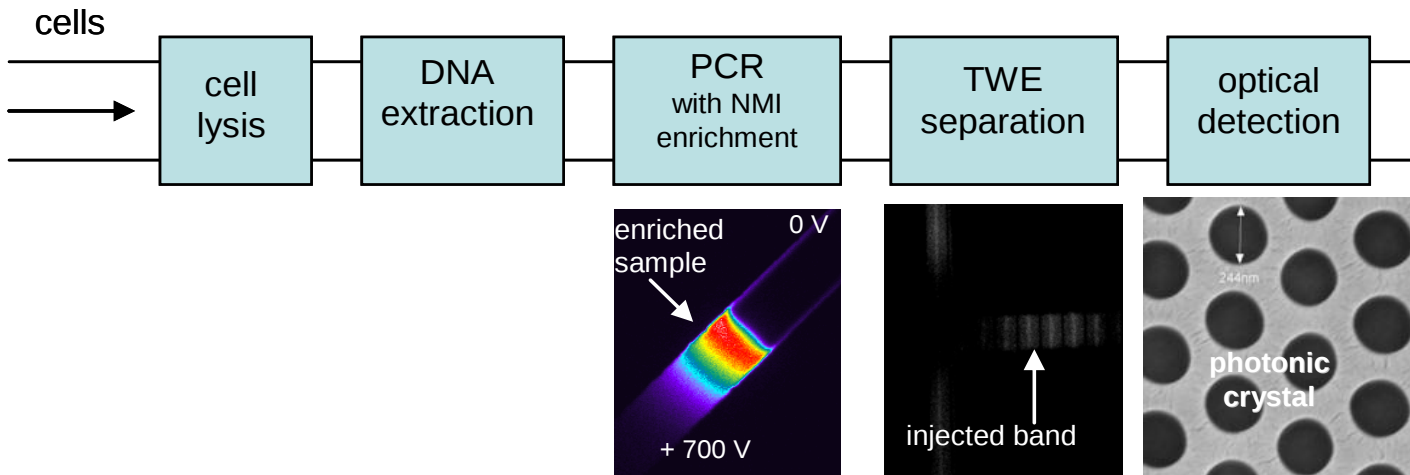
Faculty core research in
materials, devices, biology
and proteomics

IRT1

Portable and Rapid Molecular Recognition Platforms

Team Leader: Larry Hornak (EE)

Team Members: Aaron Timperman (ERDC-CERL), Jeremy Dawson (EE), Slawomir Lukomski (Microbiology), Lloyd Carroll (Chemistry), Boyd Edwards (Physics), Letha Sooter (Pharmacy), Yuxin Liu (EE)



Motivation and Challenges

Lab-on-a-Chip System-Level Challenges:

- Widespread need for devices that perform rapid and field-portable detection and identification of molecular signatures (pathogenic bacteria, human DNA etc.)
 - Existing efforts focused on miniaturizing bench-top DNA analysis procedures (label-based)
 - J. Palmer, Annual Biometrics & Forensics Summit, San Diego, CA, (2010)
 - K.M. Horseman, J.M. Bienvenue, K.R. Blaiser, and J.P. Landers, J Forensic Sci, 52(4), 784, (2007)
 - Current methods (i.e. US FBI CODIS procedures) may not be best for biometrics (i.e. rapid) approaches
- Co-integration of multi-function components is a major hurdle to system-level operability and cost-effectiveness
 - Challenging for both monolithic and modular systems

Processing/Functionality Challenges:

- Maintaining signal integrity/quality in integrated systems
- Differentiation of strains of bacteria that reproduce clonally (e.g. anthrax) is nontrivial
- Identification of emerging, unknown threats is difficult
 - Can at least classify genomically (although sometimes very little genomic difference between pathogenic and benign species)

HUMAN ACTIVITY



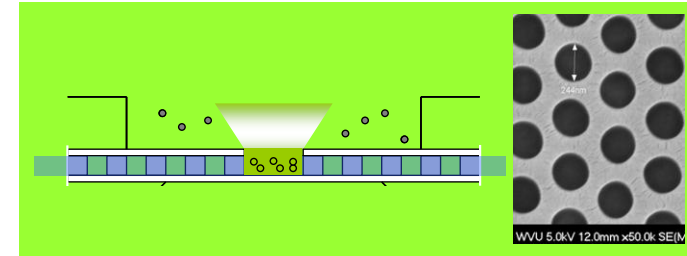
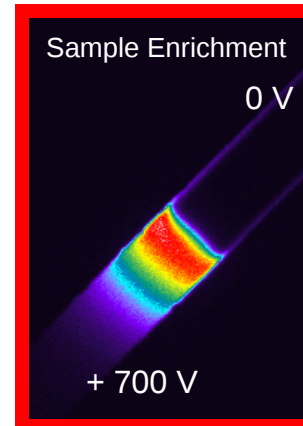
MOLECULAR BIOMETRICS

- Human identification
- Chemical forensics
- Access control

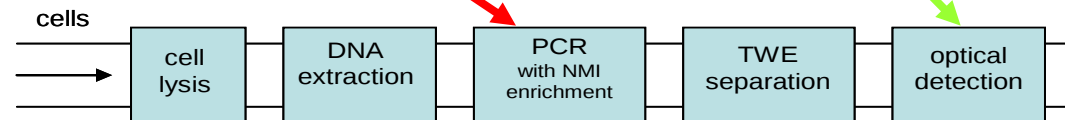
Activity Goals

- ‘Design-for-integration’ system/component development

- Wetware: fluid dynamics to minimize sample band broadening and dilution, buffer solutions from different processes
- Hardware: material requirements for different modules, multi-domain system integration (micro/nano, opto/fluidic), efficient signal extraction with high SNR and low LoD

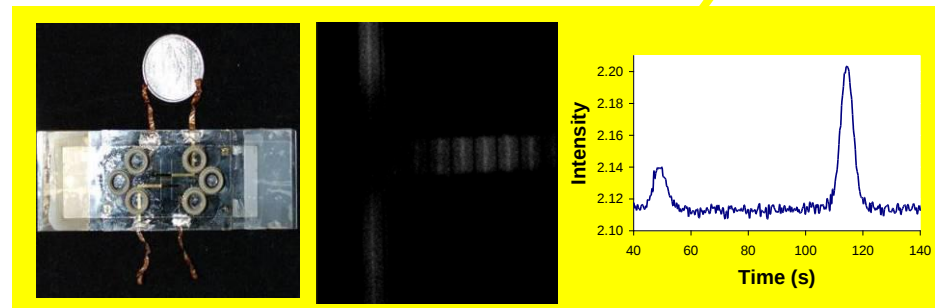


optical detection



- Refine microfluidic modules for DNA processing and protein ID

- DNA: extraction, PCR, transverse wave electrophoresis (TWE), optical detection
- Protein: cleavage of surface proteins, minimize non-specific adsorption, selective recognition



Results of Current Activities

- Application of primary-sequence and sequence-length polymorphism of collagen-like genes for pathogen detection and strain fingerprinting

- Successful results for multiple strains of *B. Anthracis** and *Aspergillus fumigatus*

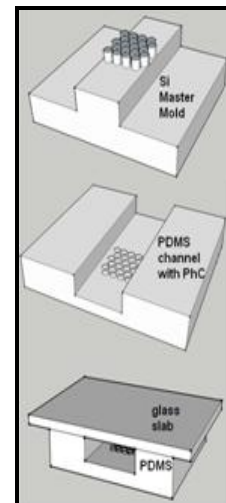
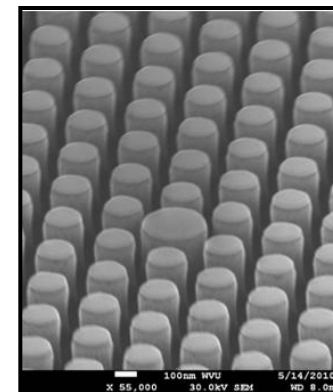
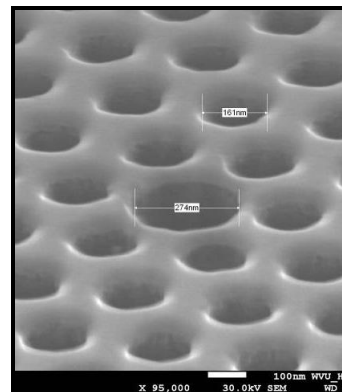
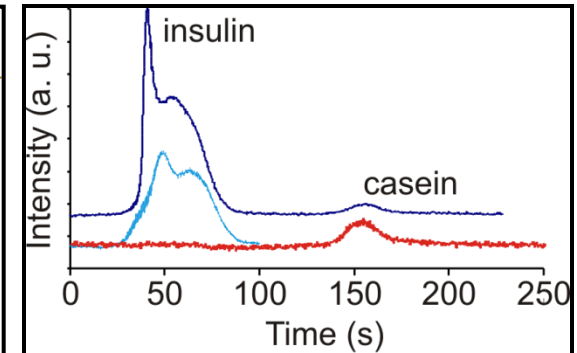
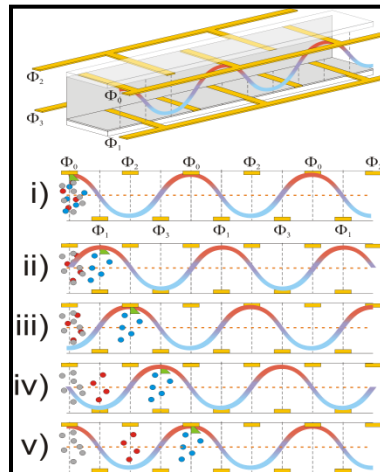
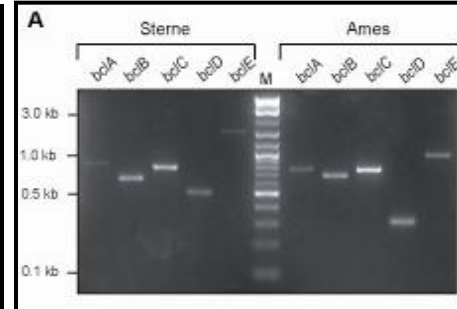
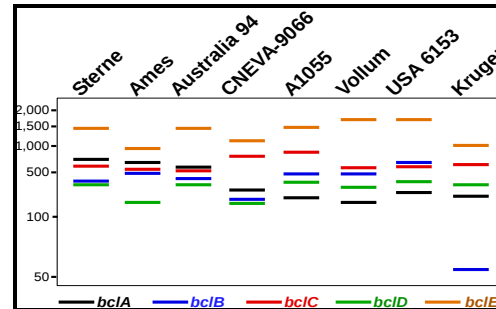
*APPLIED AND ENVIRONMENTAL MICROBIOLOGY, Nov. 2009, p. 7163–7172

- Initial testing of separation capability of traveling wave electrophoresis

- Separation of insulin and casein in TWE (upper trace) with amplitude of 0.5V and frequency of 2 Hz. Each of the proteins were also run separately under the same conditions (cyan and red traces). The shoulder at the insulin peak indicates a resolvable impurity in the sample.

- Achieved routine fabrication of photonic crystal structures in Si (IR) and GaN (visible) and initiated experimental measurement of fluorescence enhancement in defect regions

- Thin-film Si PhC and IR QD label
- Developing process for molded polymer PhCs





Future Plans

- *Main Goal:* Further integration of building blocks into functional subsystems

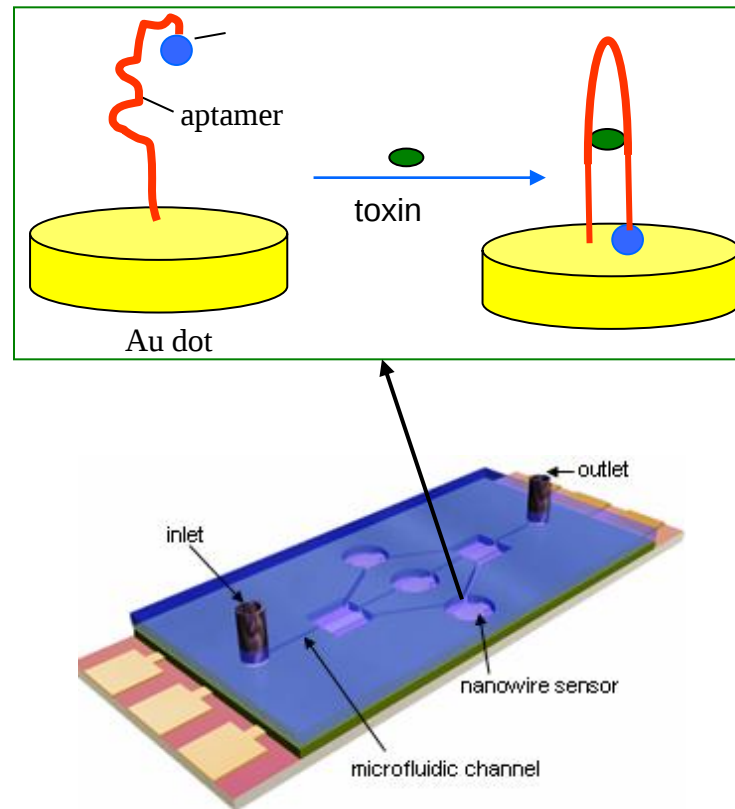
Near-Term Activities	Faculty
PCR-Based Detection and Fingerprinting PCR Design: 1. Selection of targets/amplicons (amps) in Humans to be used in POCs. a) Amp #, DNA type/source, Amp size, Amp type: SNPs mini/microsatellite 2. Selection of bacterial targets: Burkholderia mallei/ pseudomallei – DoD warfighter health, Aspergillus (black mold) - NIOSH. PCR Testing: 1. Testing via conventional PCR in thermal cycler 2. Testing in light cycler 3. Separation by agarose gel electrophoresis	Slawomir Lukomski (Microbiology) & Letha Sooter (Pharmacy)
Rapid PCR with nanofluidic/ microfluidic interface (NMI) concentrators 1. Study migration of reactants to enable control. 2. Construct Device with 2 NMIs 3. Develop Temp control for PCR incorporation	Lisa Holland (Chemistry) & Aaron Timperman (ARL)
Rapid DNA separation with traveling wave electrophoresis (TWE) 1. Fab and test 8 array device 2. Demo directional control, enrichment. 3. Dev. theoretical approach to charge dispersion effects	Lloyd Carroll (Chemistry) & Boyd Edwards (Physics)
Photonic crystals (PhC) for sensitive and integrated fluorescence detection 1. Characterize PhC Fluorescence enhancement 2. Develop labeling for use appropriate for DNA process 3. Integrate and test PhCs with microfluidic delivery system. 4. Test Proof of Concept	Jeremy Dawson (EE) & Yuxin Liu (EE)

IRT2

Field-deployable sensors for toxin detection

Team Leaders: Nick Wu (Mech. Eng.), Pete Gannett (Pharmacy)

Team Members: Yuxin Liu (EE), Letha Sooter (Pharmacy), David Lederman (Physics)



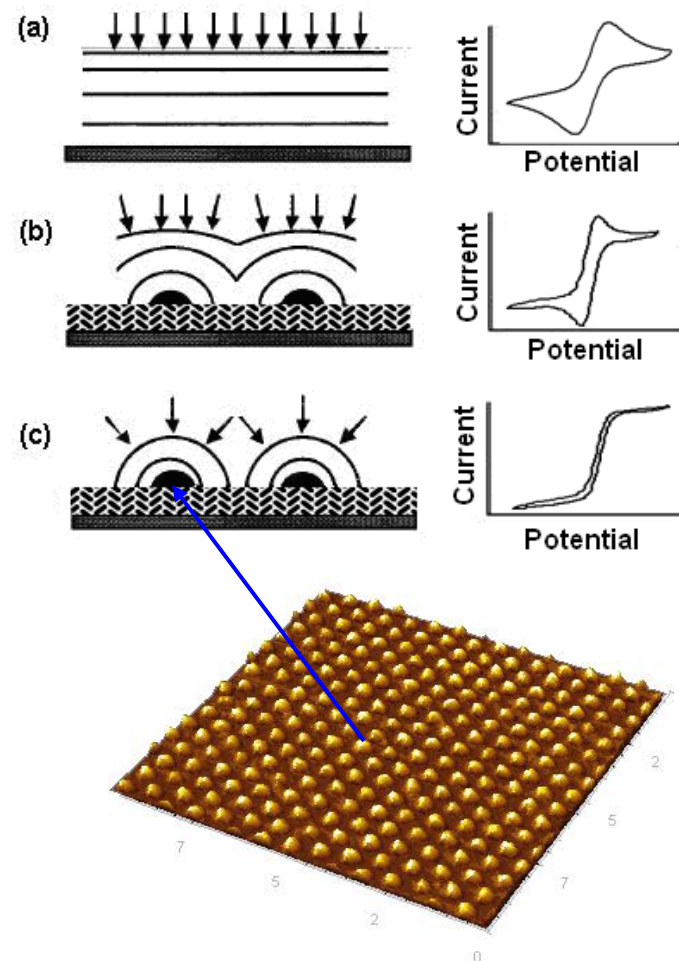
Motivation (Background & Challenges)

- West Virginia is a leading coal producer. The state's economy is also driven by metal manufacturing, agriculture and forest production.
- Heavy metals, pesticides/herbicides are uptaken by human through the food chain or drinking water.
- The allowable levels set by WHO:
 Hg: 6 $\mu\text{g/L}$ (6 ppb), Pb: 10 $\mu\text{g/L}$, As: 10 $\mu\text{g/L}$,
 Pesticides in ground water: $\sim 0.1 \mu\text{g/L}$
- Currently lab-based analytical technique:
 expensive, labor-intensive, time-consuming, large sample volume,
 not for on-site, real-time detection.



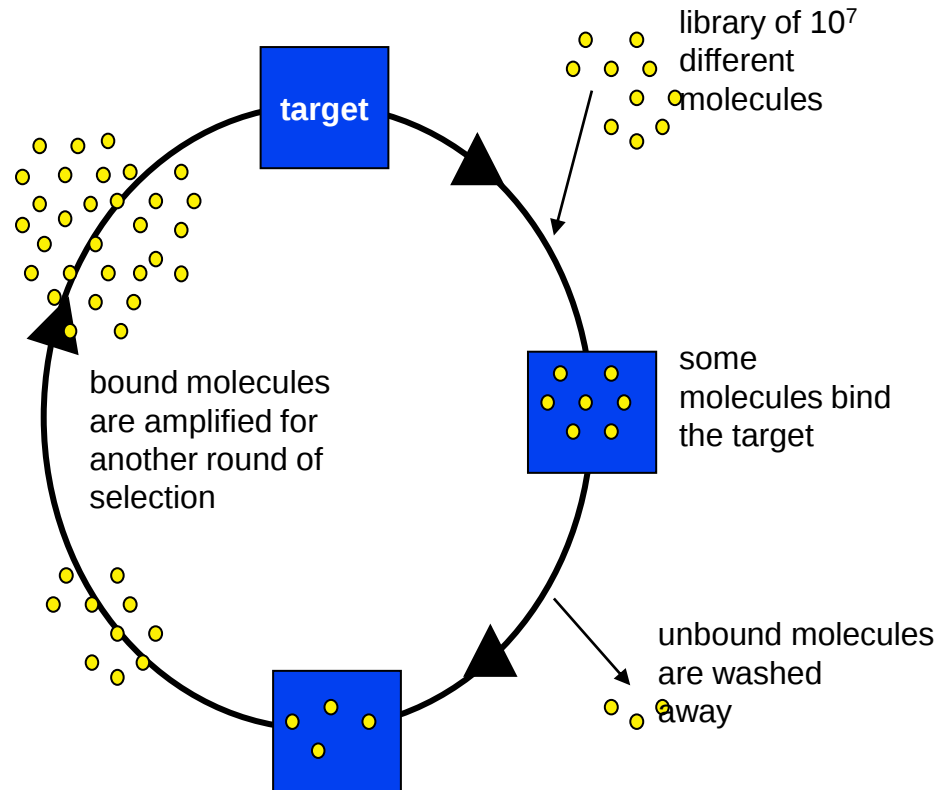
Goals

- Develop approaches to fabricate large-area nanoelectrode arrays (NEAs)
- Develop novel methods for identification of aptamers (Molecular Recognition Element – MRE)
- Integrate aptamers into NEA based sensors on microfluidic chip
- Utilize other biological molecules (P450s) as MRE



DNA Aptamer Selection for binding toxins

- DNA aptamer against ATP, and Pb^{2+} deoxyribozyme cleavase.
- Ready to sequence prostate cancer specific scFv's after two rounds of positive and negative selection.
- New DNA pool obtained so that toxin selections may proceed.

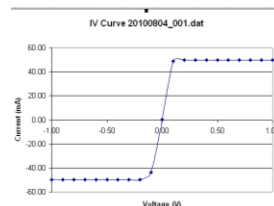


Multifunctional bonded P450 Enzymes

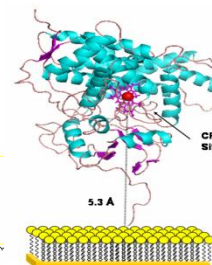
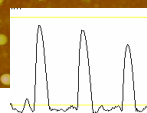
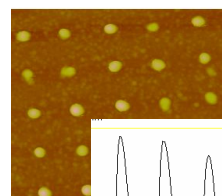
Sensors, Bioreactors, and Electron Transfer

- Bonding P450 enzyme to gold
 - Via amide linkage
 - To nanopillars, nanodots, and nanowells
- Yields binding, enzyme kinetics, metabolite – agree with solution results
- Nanodot and nanowells for sensors and high throughput screens (HTS)
- Nanopillars for electron transfer and spin-state
- Immobilized enzymes
 - Improved reproducibility, sensitivity, and speed of measurements
 - Facilitate basic electron transfer mechanism research
 - Novel uses (quantum computing)

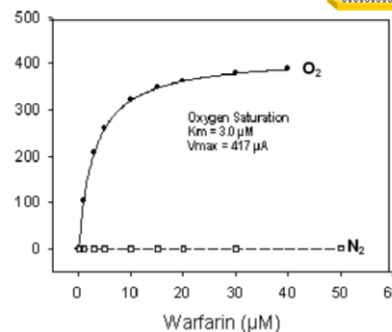
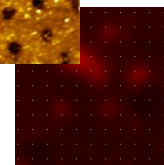
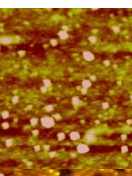
Electron Transfer



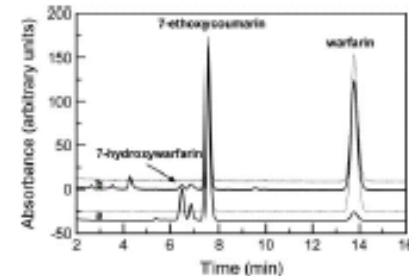
Pillars



Wells



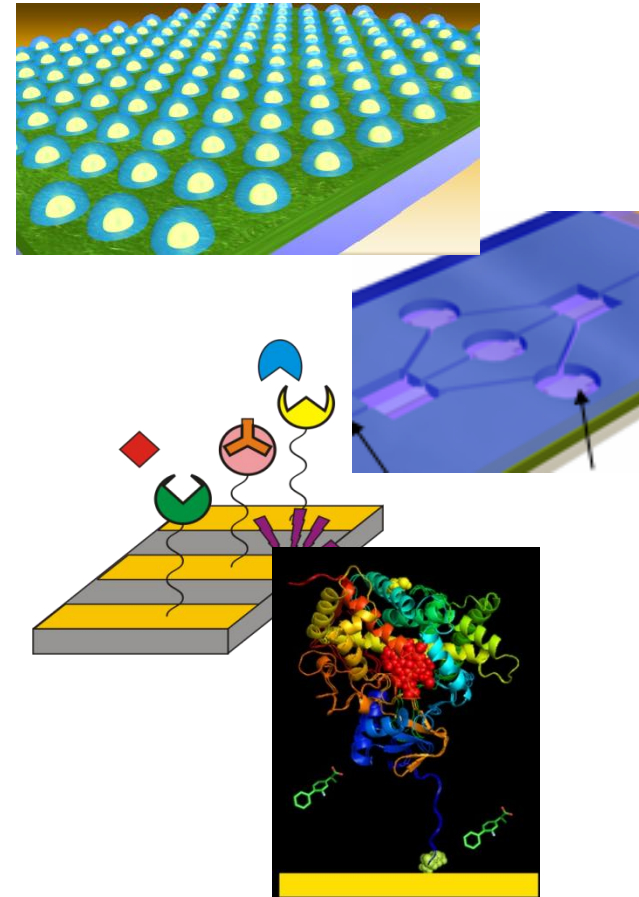
Binding & Kinetics



Metabolites

Future Plans

- NEA geometry optimization and device integration.
- Microfluidics for analyte isolation (e.g., blood purification).
- Optimize novel aptamer selection (CE based) with experimental and computational methods
- Develop system for use with biomolecules other than aptamers (e.g., enzymes/drug candidate screening)

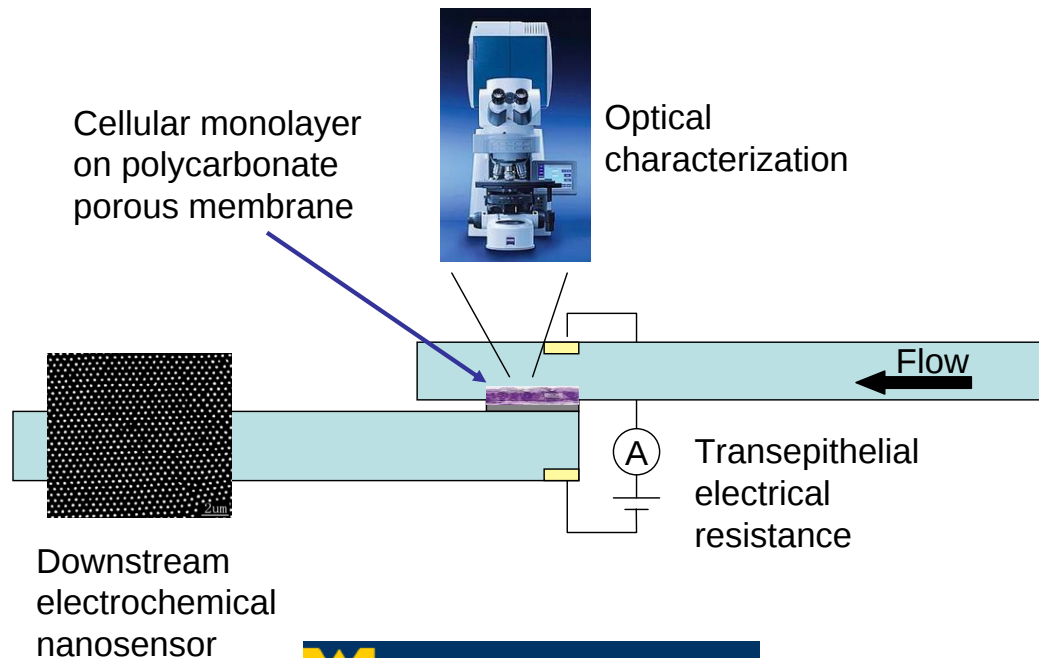


IRT3

***Ex Vivo* and *In Vitro* Biomimetics for Cellular Response Monitoring**

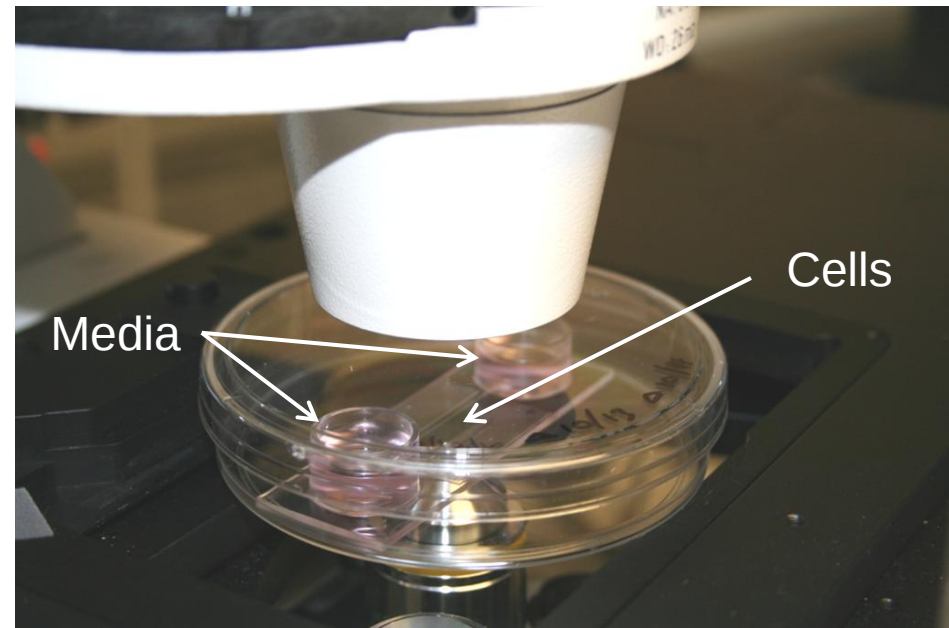
Team Leaders: Yon Rojanasakul (WVU-Pharmacy), Elmer Price (MU-Biology)

Team Members: Yuxin Liu (WVU-EE), Nick Wu (WVU-MAE), Feruz Ganikhanov (Physics)



Background and Motivation

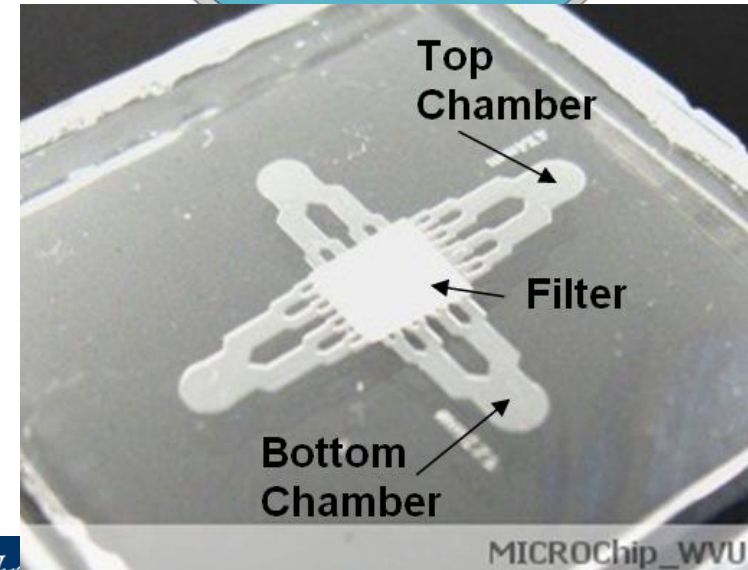
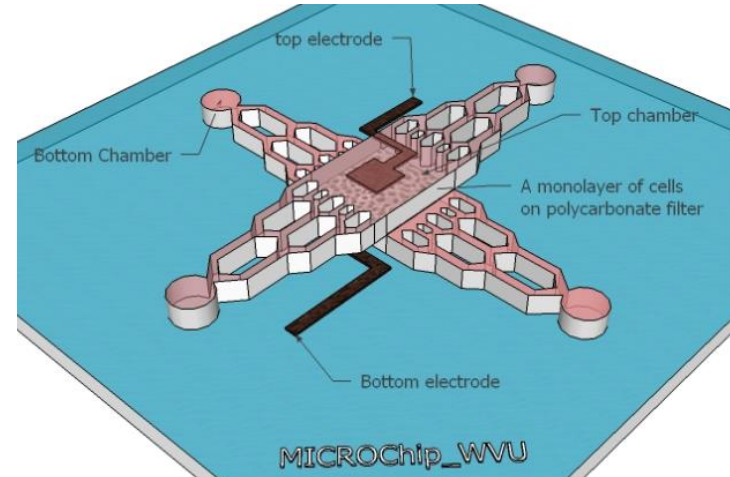
- Endothelial cells line all blood vessels and are both the first line of defense and the first tissue to show dysfunction in vascular disease
- To date, it is not possible to assess endothelial function during early stages of disease
- Endothelial cell function can also be used as a cell-based assay to detect toxins and other chemicals



“Macro” flow chamber seeded with endothelial cells, mounted in a live-cell imaging microscope

Microfluidic System for Transmembrane Electrical Resistance Measurement

- Two vertically aligned PDMS microfluidic channels
- A porous membrane on which cells are cultured for impedance measurement
- Two electrodes on opposite sides in immediate proximity



Advantages of Microfluidic System

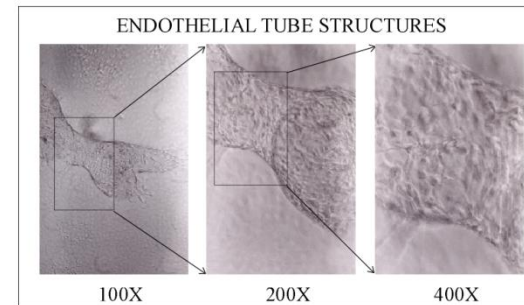
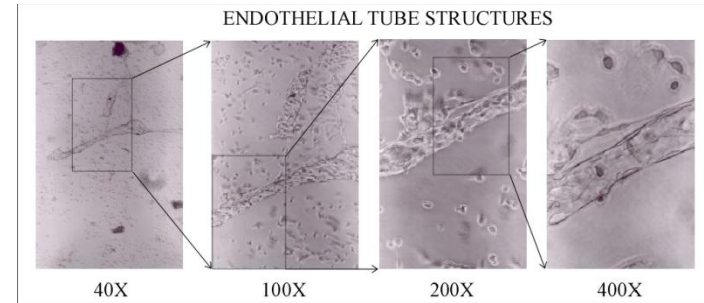
- Hybrid microfluidic device
 - ✓ Integrates traditional cell culture membrane with microfluidic chamber
 - ✓ Permits healthy cell growth over long periods of time
 - ✓ Measure resistance over a small surface area of cells in real time
 - ✓ Recording electrodes are close to the cell monolayer for reliable measurement

Future Work - WVU

- Short-term
 - ✓ Test the device and culture epithelial cells inside the microfluidic chamber for up to 7 days
 - ✓ Integrate two electrodes with the device
 - ✓ Measure impedance across the filter and cell monolayer
- Long-term
 - ✓ Integrate optical and downstream sensors for analysis of cells that naturally grow *in vivo* as monolayers
 - ✓ Study cell functions and biological responses to nanoparticles and toxicants

Current activities – Marshall

- Endothelial cell function involves the detection of NO (nitric oxide)
 - Endothelial cells can also be induced to grow as tubes, reminiscent of blood vessels
 - Flow and various pharmacological agonists induce NO production
 - Toxins or other agents, if deleterious to endothelial function, will result in reductions in NO production



Tube-like (capillary?) structures formed by cultured endothelial cells



Future Work - Marshall

- Optimize culture and assay conditions using a “macro” chamber; developing microfluidics chamber
- Challenge is development of nanosensor for NO produced by the cells in the microfluidic device
- We will also adapt other cell types in this cell-based assay, such as epithelial cells (cells that are found in the airways and GI tract)



Seed 1: Electric Cell-substrate Impedance Sensor for Quantitative Toxicology

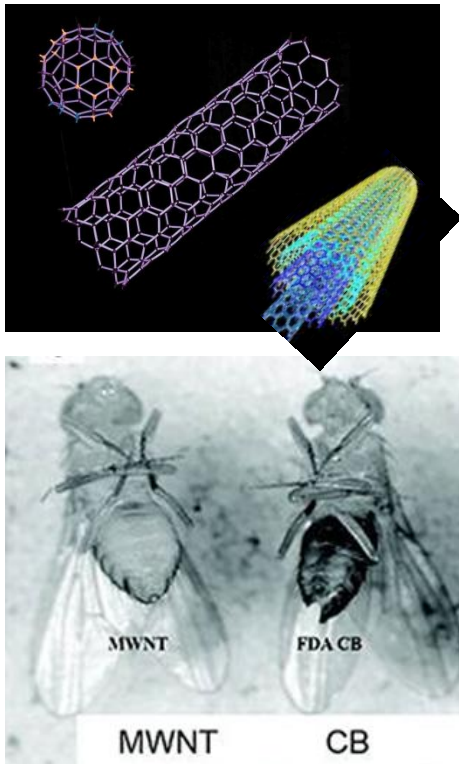
Cerasela Dinu (Chem. E.) and Yon Rojanasakul (Pharmacy)

- ECIS
 - Non-destructive technique
 - Monitors electrically cell impedance without affecting behavior
 - May be validated by optical microscopy, classical toxicology, and genomic studies



Seed 1 Background

The biological impacts of nanomaterials and their bio- kinetics are dependent on size, chemical composition, surface structure, solubility, shape, and aggregation. These parameters can modify cellular uptake, protein binding, translocation from portal of entry to the target site, and the possibility of causing tissue injury.

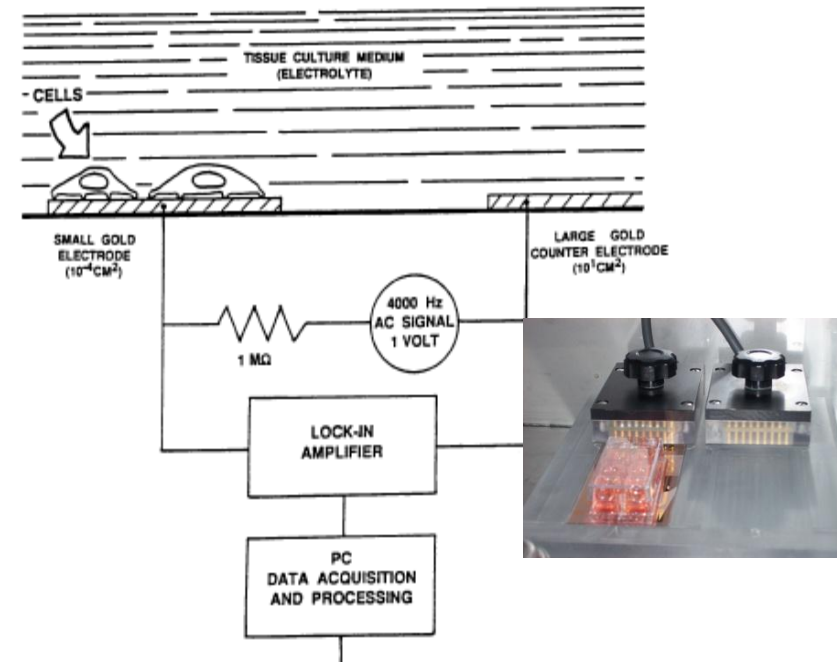


Carbon nanotubes:

- Inhalation exposure likely during production and processing
- Degrade slowly: stay in the body for a long time
- High affinity for DNA
- ***Similar toxicity to asbestos fibers?!***

Electric Cell-Impedance Sensing (ECIS)

- Apply an oscillating electric field to cells cultured on interdigitated gold electrodes *in situ*. Cell response can be observed as a resistance, capacitance, phase.
- Measured cell response (cell morphology and behavior) is a function of time, frequency, sampling rate, the “stimulant”, media composition. Monitor the changes as a function of frequency in real-time and with high sensitivity.



Giaever I. Proc. Natl. Acad. Sci. 1991

Future Plans

Correlate the morphologically changes in response to nanotubes with metabolic changes.

Questions :

- What are the cell signatures?
- Can we develop [rapid signature diagnostics](#)?
- What are the differential expression profiles?

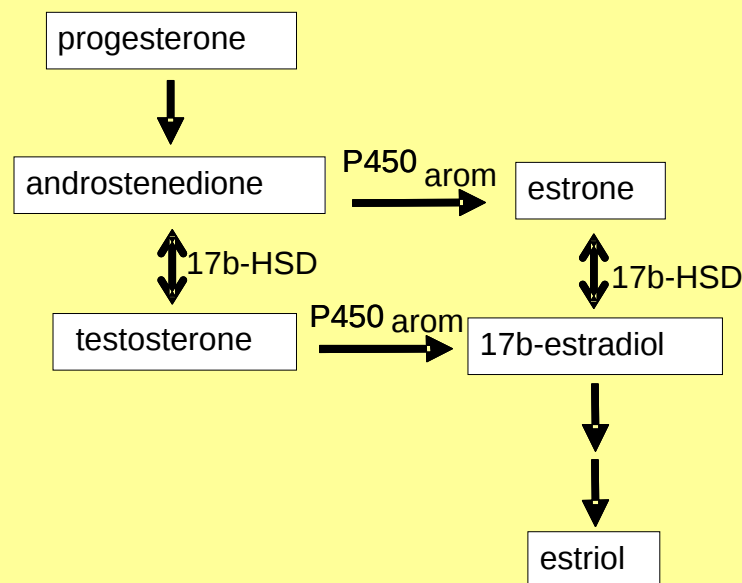
- Genetic damage of carbon nanotubes and similarities to chrysotile asbestos suggests caution should be used during the production and processing of carbon nanotubes.
- Further research is in progress to examine mechanism of incorporation of carbon nanotubes as well as in vivo response.

Seed 2: Nanoscale selection for rapid analyses of steroids in plasma

Letha Sooter (Pharmacy) and Lisa Holland (Chemistry)

- Chemicals in personal care products and pharmaceuticals are released into the water supply and disrupt the endocrine systems of humans and animals.
- Disruption is implicated in feminization and infertility. In humans it is also implicated in estrogen sensitive cancers.
- When the endocrine system is disrupted the profile of steroids circulating in plasma changes
- There is no rapid and portable method to monitor multiple steroids circulating in plasma

Steroid Hormones Signal Many Processes and are Interrelated



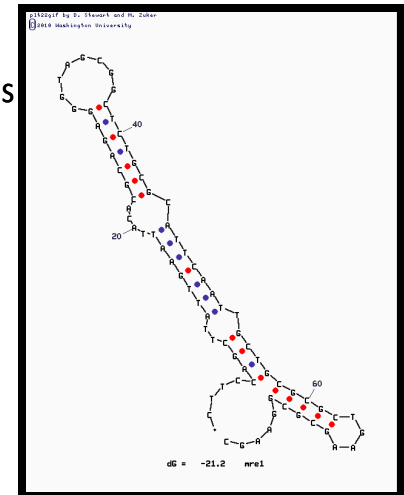
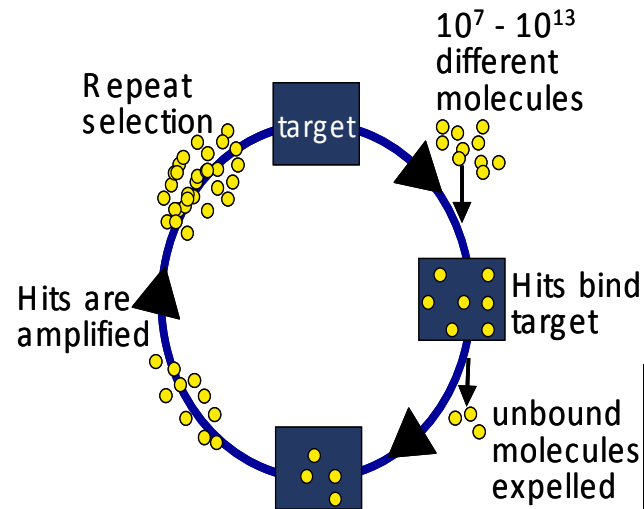
Seed 2 Goals

- DNA sequences are selected using directed evolution using a method called SELEX (Prof. Sooter, WVU-Pharmacy).
- These unique DNA sequences capture steroids in plasma and are selectively loaded into a device that separates, detects and quantifies multiple steroids (Prof. Holland, WVU-Chem and Dr. Fintschenko, Director New Technology, LabSmith).



Current Activities

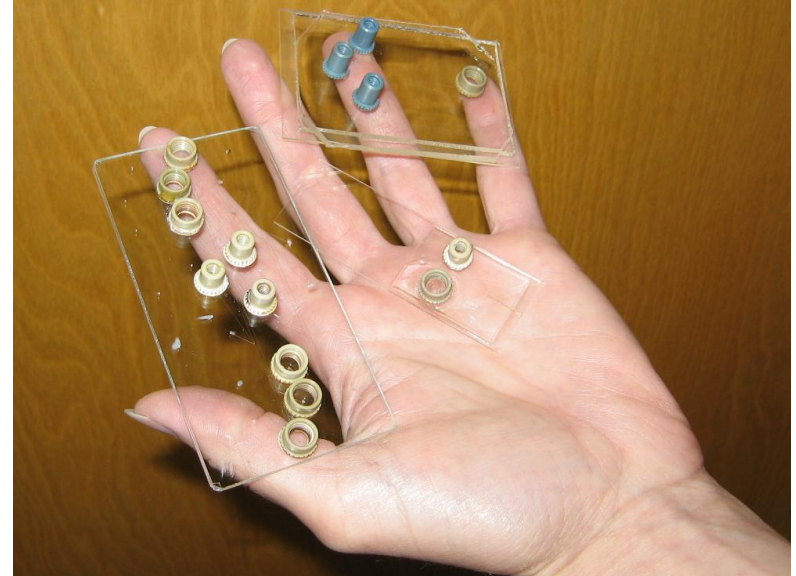
- DNA Aptamer
 - Structure determined with mfold software¹
 - Steroid capture
 - Aptamer loading into capillary channel
 - Separation of multiple steroids
- ideal for portable measurement



¹Mfold web server for nucleic acid folding and hybridization prediction. *Nucleic Acids Res.* **31 (13)**, 3406-15, (2003)

Future Plans

- Portable devices to profile multiple steroids in environmental and clinical samples





Infrastructure

- Device fabrication and characterization shared facilities
- High performance computing facilities



WVNano Shared Facilities

Kolin Brown, Shared Facilities Coordinator

- Established in January 2007
- Blending funding support
 - WVU Research Corporation
 - WVU Colleges
 - WV Higher Education Policy Commission
 - User Fees
- Also supported by NSF until 6/2010



Mission

“To manage West Virginia University’s resources of specialized laboratories and equipment, making them available to researchers to further WV research, education and economic development.”





Shared Facilities Goals

- To be a progressive research learning environment where students gain research skills and experience
- To create, manage and maintain a knowledge base of user experience and research
- To provide resources for qualified scientist in WV to increase research funding and improve economic development
- To support WVNano in its goal to become a nationally recognized Nanotechnology Research Center



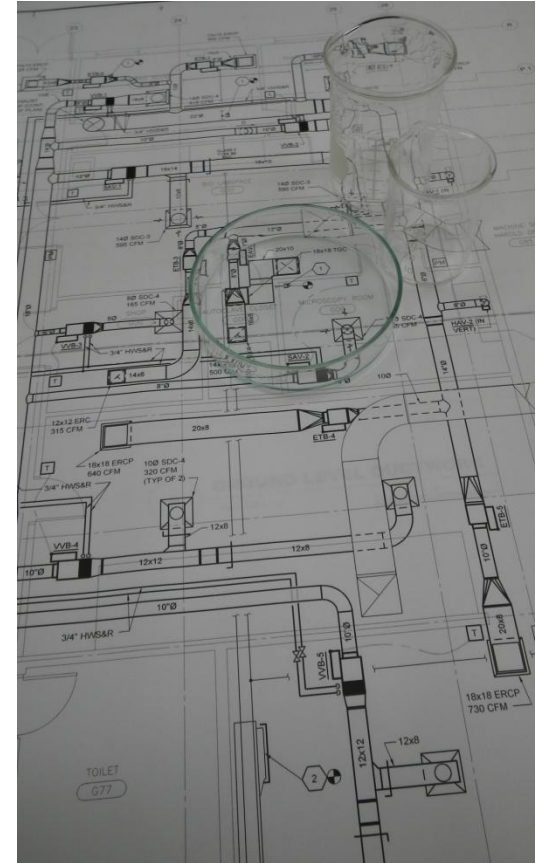
Characterization and Fabrication Facilities

- Collection of existing and newly purchased tools
- Material characterization tools
 - XRD, XPS, SEM, FTIR, AFM, VSM, Raman microscopy, ellipsometry
- TEM Laboratory
- Microfabrication
 - 3,300 square foot cleanroom
 - E-beam lithography, photolithography, chemical processing, RIE, metallization, dielectric deposition, thermal processing and packaging tools
- Four technicians
 - Maintain equipment
 - **Train users**



Bioengineering Research Facility

- Funding by NSF for two new bionanotechnology labs from July 1, 2010 to June 31, 2014
- Main BRF
 - Bottom-up directed surface immobilization of biomolecular
 - Cell culture
 - Nano/microfluidic fabrication integration with surface functionalization
- Cleanroom satellite BRF
 - Protein purification tools
 - Cell in culture sustainability





Sample research enabled by WV Nano Shared Facilities:

Nanoscale microwave oscillators and local sources of spin waves

Physics Dept., West Virginia University, USA: **Sergei Urazhdin**, Phil Tabor

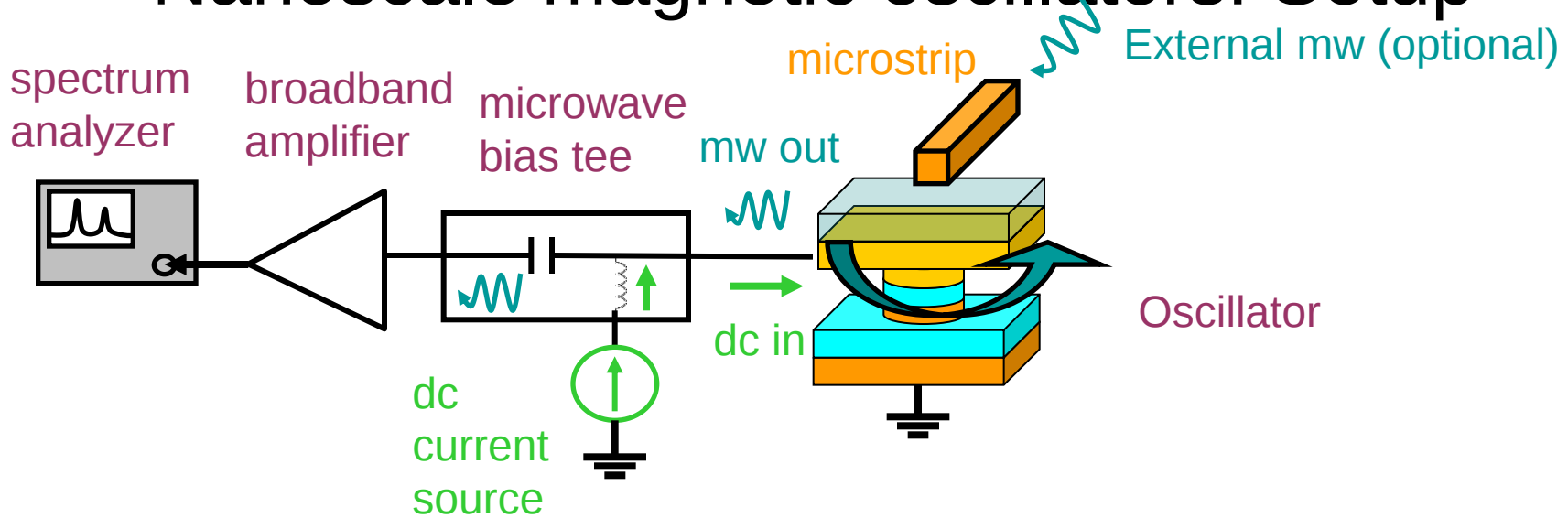
Oakland University, USA: Andrei Slavin, Vasyl Tiberkevych

U. Muenster, Germany: Sergej Demokritov, Vlad Demidov

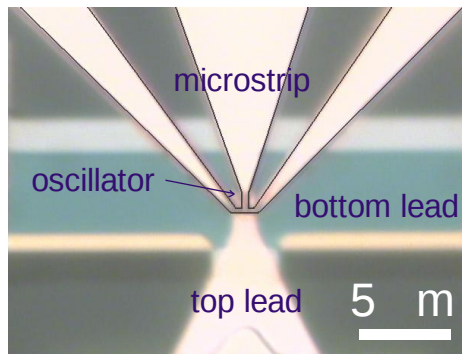
Supported by:



Nanoscale magnetic oscillators: Setup



- Spin-Torque nano-oscillator (STNO) includes two nanopatterned magnetic layers: one polarizes the electric current, the other oscillates due to the spin torque exerted by the spin-polarized current
- (optional) external microwave field applied through a microstrip: enables studies of response of nanodevice to external perturbations

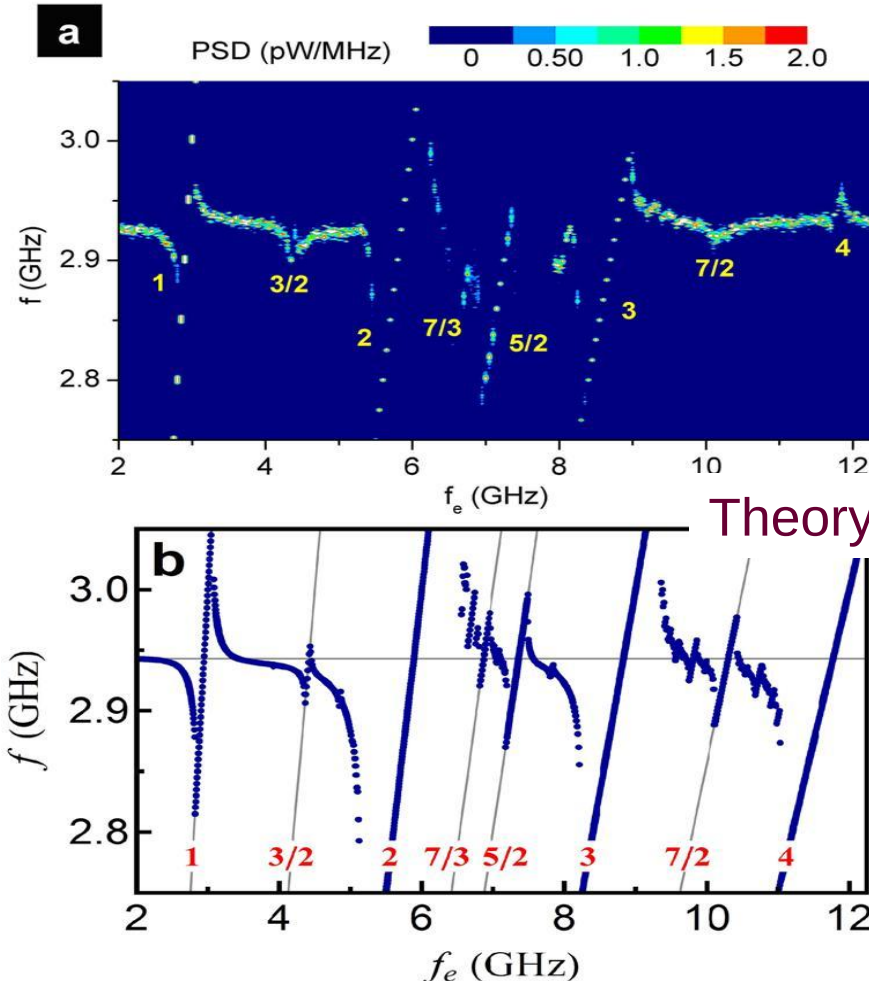


Device fabrication:

- Sapphire substrate with leads patterned into microstrips
- 1 step of photolithography
- 6 steps of e-beam lithography

Fractional synchronization of STNO to microwave field*

Experiment

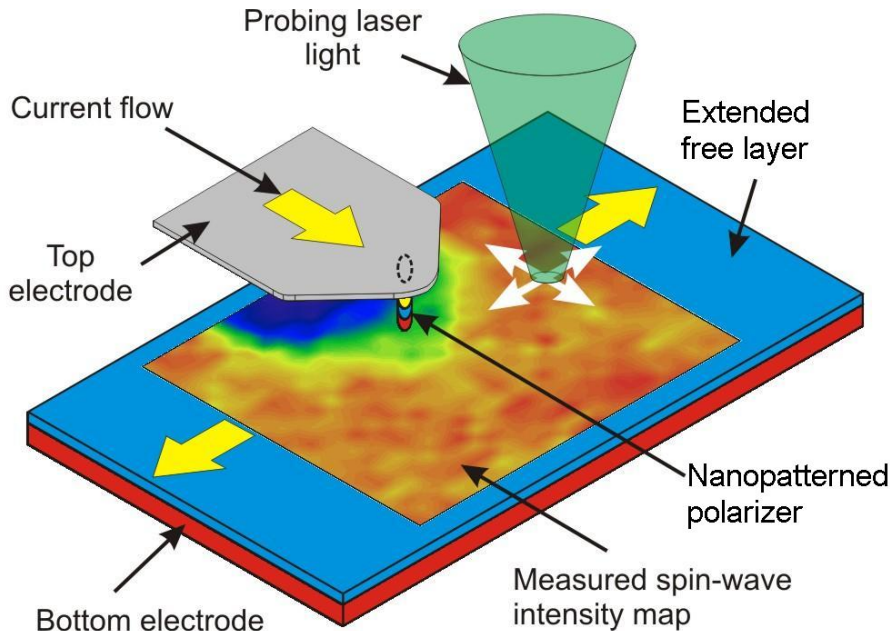


- The natural (auto) oscillation frequency is $f_0 \sim 2.94$ GHz
- External microwave field is applied over a large range of frequency f_e
- Series of dots following linear dependencies are different synchronization regimes characterized by certain relations $r = f_e/f_0$ as labeled
- Theoretical analysis shows that measurements of fractional (non-integer r) synchronization enables one to restore the information about the magnetic oscillation orbit

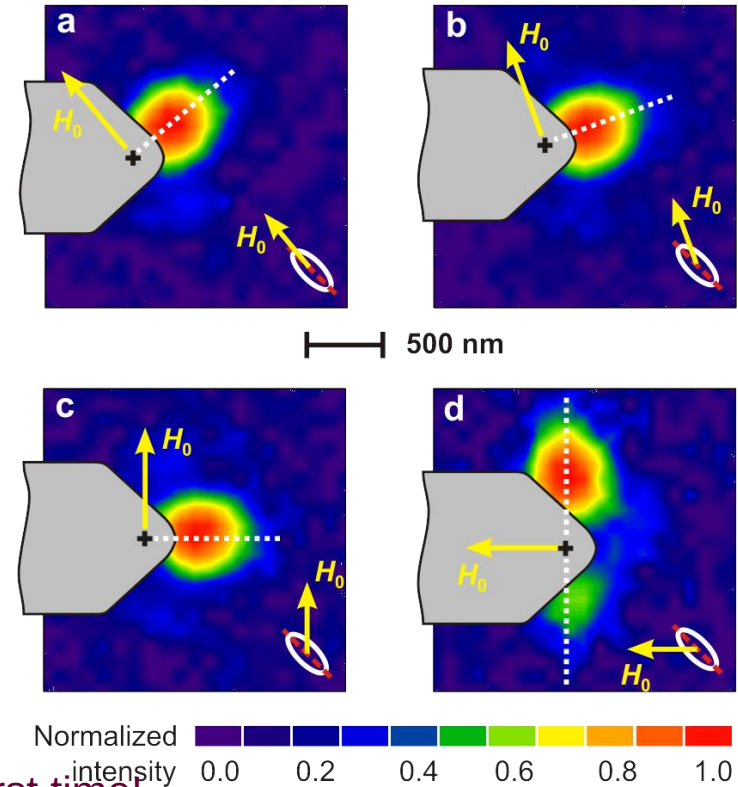
*PRL **105**, 104101 (2010)

Brillouin light spectroscopy (BLS) of spin waves generated by STNO*

Setup



BLS microscopy of spin waves



- Spin waves emitted by STNO are observed for the first time!
- Emission always occurs perpendicular to the magnetic field
- Analysis shows that directional emission is caused by the anisotropic dispersion of spin waves. It is expected to be a general property of ANY system with anisotropic dispersion

Shared High Performance Computing Facility

James Lewis (Physics)

- Goal: establish high-performance computing shared facilities to support all WVU and WVNano researchers
- Coordinated with WVU Office of Information Technology and WVU VP for Research
- Two additional grants from NSF





Activities

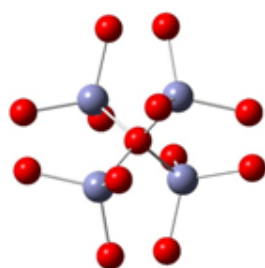
- Build infrastructure – expand to at least 720 nodes with 10 Gb/s data access
- Monthly HPC Workshop Series – train WVU researchers about HPC hardware and software
- Summer Institutes – engage PUI faculty in computational research
- Remote operation of characterization equipment



Sunlight Conversion of CO₂ to Useable Products

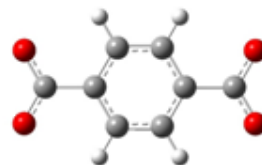
Photoactive Organic-Inorganic Porous Materials

James Lewis (Physics) and Michael Shi (Chemistry)

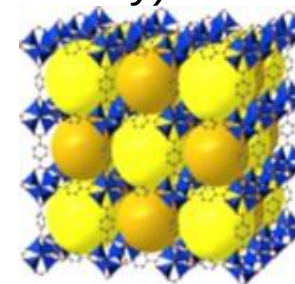


metal oxide cluster

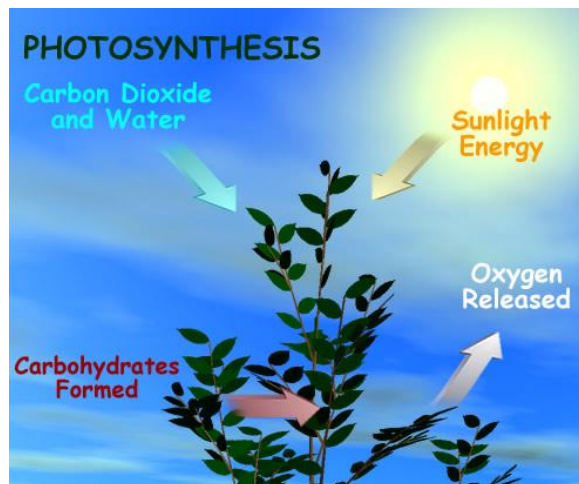
+



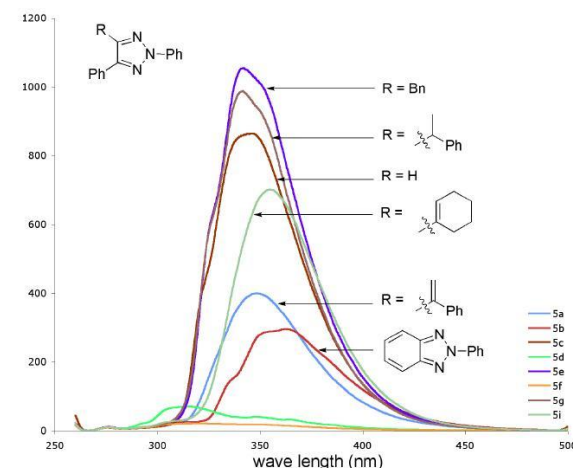
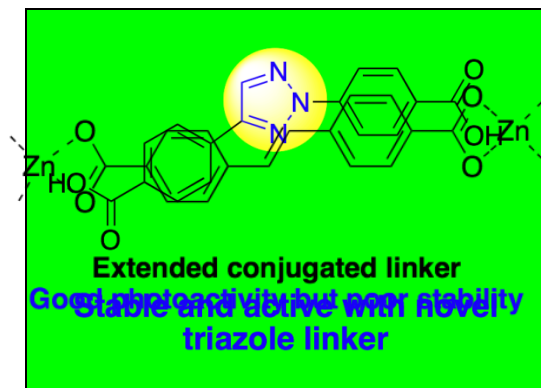
organic "linker"



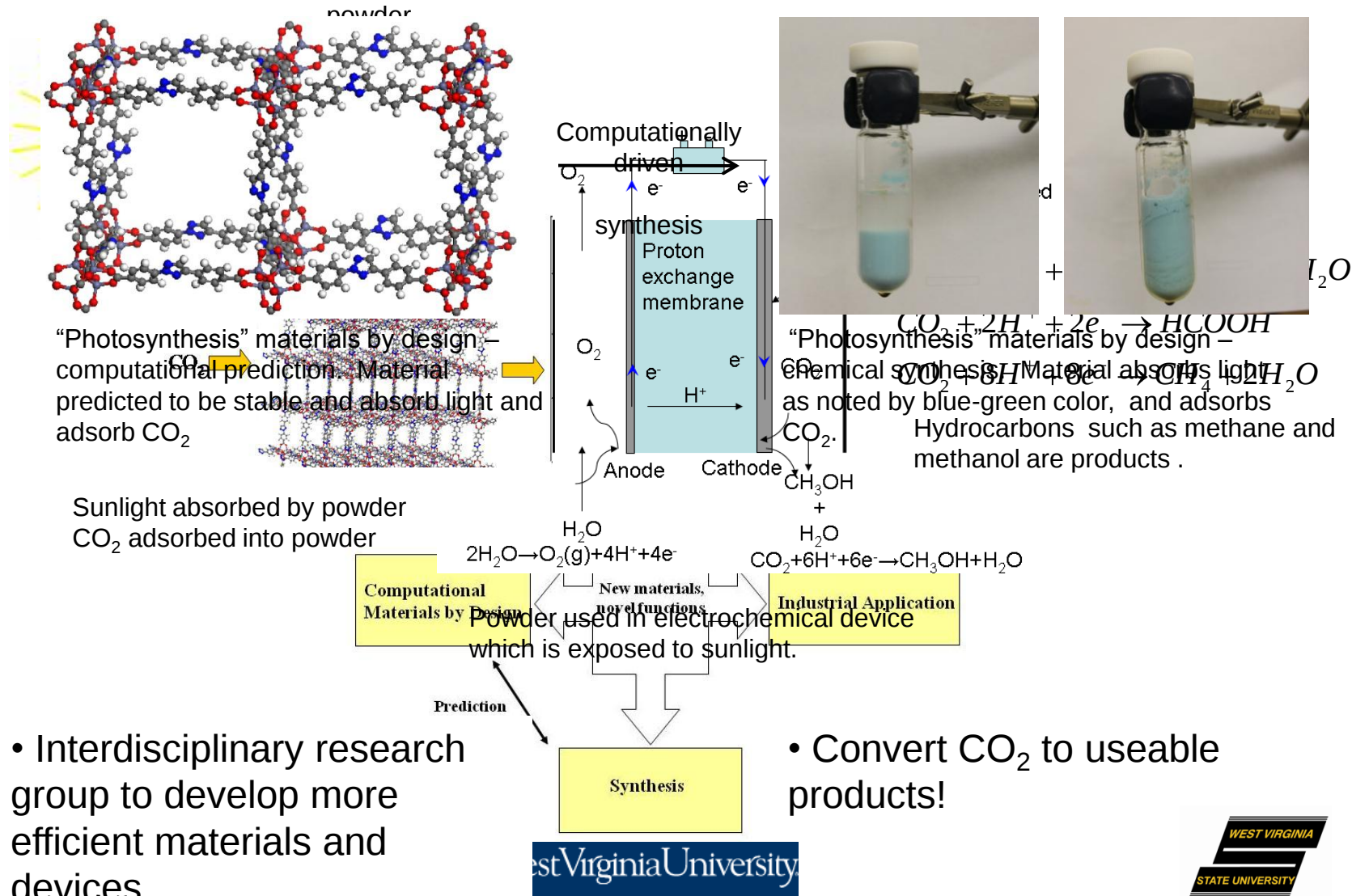
porous framework
supramolecular polymer structure



Simple linker in MOF construction
Good stability but poor photoabsorption

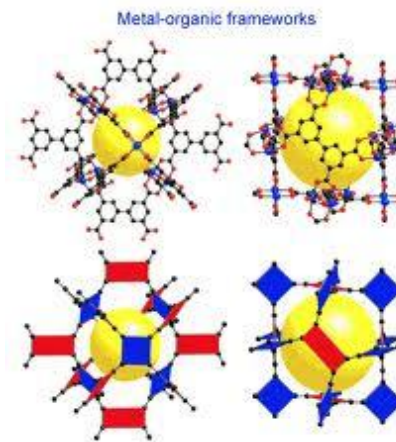
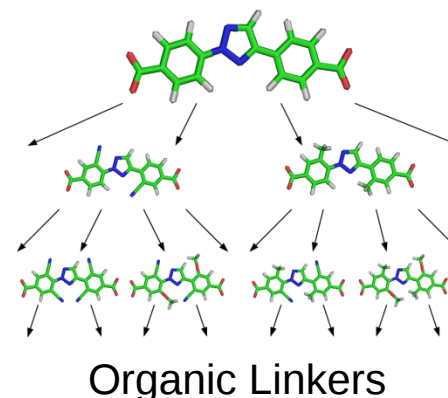


Application Driven CO₂ Sunlight Conversion



Designing Organic-Inorganic Porous Materials

- Applications in carbon capture
- Research challenge:
Combinations of organic linkers numbers into the billions, too expensive and too time-consuming to synthesize
- Use data-mining and tree-searching algorithms to *discover* optimal candidates
- *Computational* driven synthesis routes





Graduate Education

- WVNano Graduate Fellowship Program
- Supported by NSF and WVU VP for Research





Graduate Fellowship Program

Lisa Holland (Chemistry), Pete Gannett (Pharmacy), Parviz Famouri (EE), Eva Toth (Education)

- Graduate fellows enroll in unique coursework to learn ethics and interdisciplinary scientific communication.
- Presentations, proposal writing, engage in ethics debate
- Each fellow has access to WVNano faculty mentors and receives close mentorship from the WVNano graduate education faculty



WV Nano Graduate Research Fellowship Program

- Year 1 coursework: classes in discipline, technical communication, professionalism, ethics, entrepreneurship
- Year 1-2 travel to meetings: local/national/international travel, complete 1-week business academy program
- Year 2-5 Interdisciplinary research, protection of intellectual property
business internships



Results

- Access to IRT research
 - Fellows meet with IRT groups and group leaders
 - Fellows assigned WVNano research mentors (participants)
 - materials and supplies for independent research
 - Fellows eligible to apply for NIH and NSF research fellowships



Future Plans

- Protection of intellectual property developed during graduate studies
- Bionanotechnology is transferred into small business
- Fellow transitions into small business through WVU business incubation





Outreach Activities

- Teacher research experience (NSF-EPSCoR)
- Learning assistant program (NSF-EPSCoR)
- Undergraduate research program (NSF-REU)



Teacher Research Experience for the Advancement of Knowledge (TREK)

Jeffrey Carver (Education-WVU), Eva Toth (Education-WVU), Betsy Ratcliff (Chemistry-WVU), Tina Cartwright (Education-MU)

- Eight week paid research experience for 16 teachers and one student each
- Increased teacher content knowledge and practice improves student performance in science



(Darling-Hammond & Youngs, 2004)



TREK Goals

- Increase teacher knowledge and practice
 - Nano/biotechnology content knowledge
 - Research process skills
 - Nature of science understanding
 - Reflective teaching practice
- Increase recruitment and retention in science & education
 - Students with better backgrounds in science are more likely to pursue science
 - More students in science leads to more students in science education





Current Activities

- Currently engaged in a planning period
 - Major recruitment conducted at the West Virginia Science Teachers Association annual meeting (Oct. 21-23, 2010).
 - Mailings and direct contact to schools will follow.
- First cohort begins June 15, 2011
- A sequence of three graduate courses includes:
 - Standards-based educational planning
 - Action research based implementation
 - Ethical issues in scientific research and teaching



Future Plans

- Teachers currently being recruited for cohort one of four
- Increase the number of teachers with knowledge of and ability to teach Nano/biotechnology concepts
- Increase the number of high school students with knowledge of and interest in pursuing science or science education

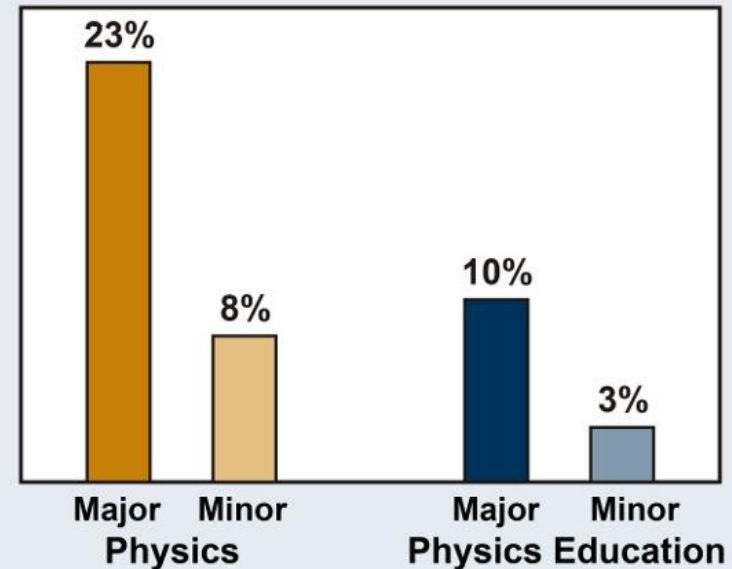


Learning Assistant Program

Paul Miller (Physics-WVU), Eva Toth (Education-WVU), Betsy Ratcliff (Chemistry-WVU), Tina Cartwright (Education-MU)

- Physics education is a challenge, particularly in West Virginia
- University of Colorado at Boulder and the University of Arkansas have both demonstrated student learning gains in physics, increased majors, and improved science teacher recruitment

Figure 14. Percent of Physics Teachers with a Physics Degree

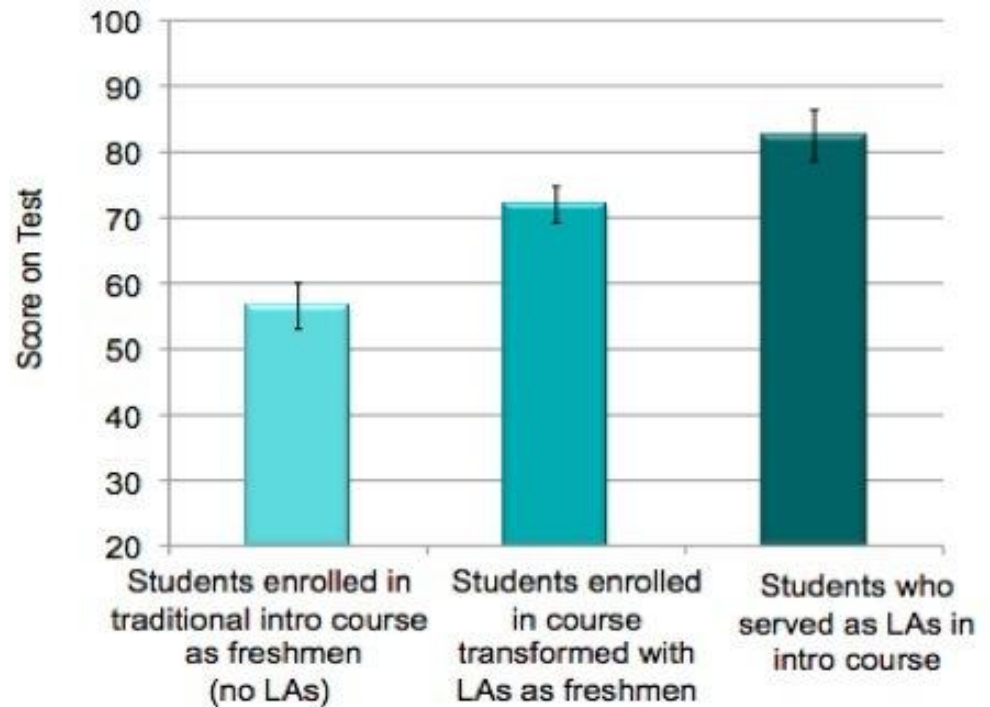


AIP Statistical Research Center: 2004-05 High School Physics Survey

LA Program Goals

- Use Learning Assistants (exemplary STEM students) to enhance instruction and recruit some of these students to K-12 teaching careers.
- Adapt program to needs of West Virginia students; reproduce gains seen in other places.

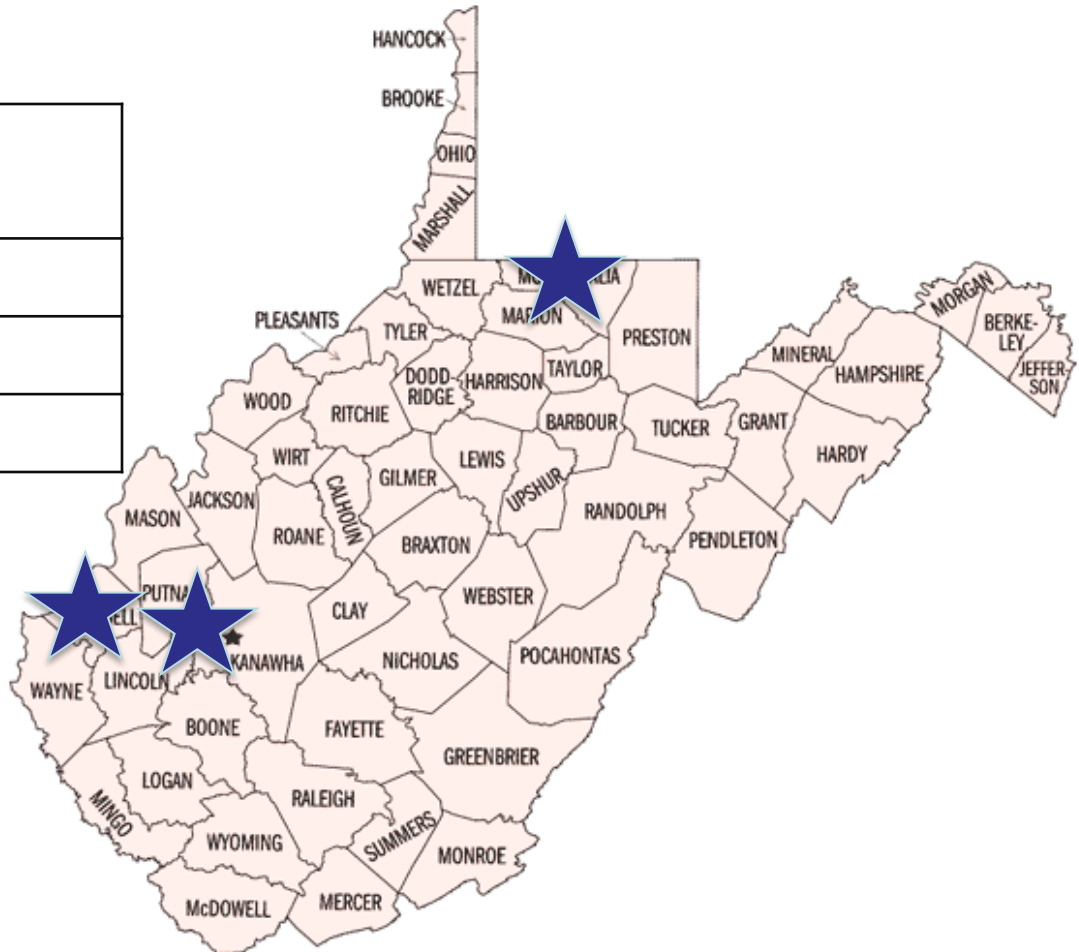
Data: UC Boulder



LA Program: Planning Year

Beginning Fall 2011:

Institution	# of LAs per semester
WVU	5
Marshall	15
WVSU	2



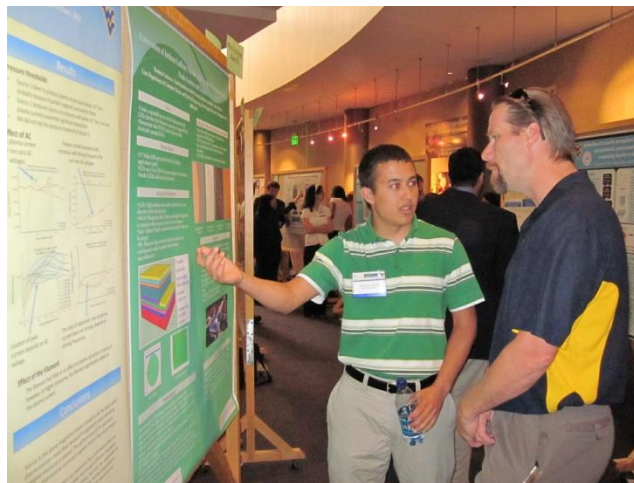
Undergraduate Research in Nanoscience: Increase Quality and Quantity of the Scientific Workforce

Michelle Richards-Babb (Chemistry), David Lederman (Physics)

- Nanoscience products pervade the consumer marketplace (PEN, 2008)
- By 2015, 0.8-0.9 million nanotechnology workers needed in US alone (Roco, 2003)
- General public largely uninformed: in 2008, 77% of adults (n=1505) and 66% of B.S./B.A. holding adults (n=259) had heard little about nanotechnology (NSB, 2010)
- Increase participation of women, URM, and persons from Appalachia in graduate-level STEM disciplines to expand the STEM workforce



2010 WVNano REU Participant, Autumn Bullard, EE major from Norfolk State U. showing graduate student mentor Christian White her microchip electrophoresis setup. Autumn received best poster award at culminating symposium.



2010 WVNano REU Participant, Dominic Gutierrez, ME major from American River College discussing his research with Dr. Lloyd Carroll (WVU Chemistry faculty) during the culminating poster symposium.

Provide Authentic Research and Training Experiences

Equip participants with the confidence needed to continue their careers in STEM in graduate school and beyond via:

- (i) Immersion in authentic cutting edge nanoscience research
- (ii) Training that fosters scientific career development and includes
 - communication skills(oral/poster prepn/present.)
 - scientific ethics
 - safety/cleanroom/scientific instrument. training
 - exposure to grad. school in STEM via a grad. school roundtable
 - graduate school peer advice
 - laboratory notebooks, library skills, grantwriting
- (iii) Career mentoring through presentations by invited speakers (academia, industry, govt.) and tours of national laboratories



Visiting speaker Dr. Ron Clawson, from ATK Mission Systems, and Dr. Mark Hoover of NIOSH during career mentoring seminar for STEM undergraduates.



2009 REU Participants during a trip to NIST.



Undergraduate Research: Projects and Project Outcomes

WV Nano offers two summer undergraduate research sites that provide authentic research and training experiences:

(i) Summer Undergraduate Research Experience (SURE)

- administered 2007-2010
- 120+ STEM students, mainly from WV, participated
- 17 researched internationally at Jilin University

(ii) Research Experiences for Undergraduates (REU)

- administered 2007-2010
- 42 STEM students, primarily from PUI within Appalachia, participated
- demographics: 48% women, 33% URM (Af-Am/Hispanic), 21% first generation, and 40% from Appalachia

Students equipped with these experiences have the confidence to continue their careers in STEM beyond undergraduate and into graduate school.

"I had no aspirations of going to graduate school...I know now I would not be in graduate school today if I had not attended the REU program. I am so grateful for the REU program and very appreciative of the doors it has opened for me."

(2007 REU, female participant now in her third year of graduate school in chemistry)

"Before the REU program I was not considering grad school, but now I am seriously considering going because I have seen what grad school is like and know that I can do it if I want to."

(2009 REU participant)

Of the 2007-2009 REU participants (n=32), 62% are currently attending STEM grad school and 31% plan to apply to grad school.



Future? Continue Summer Undergraduate Research Sites, Develop Research Experiences for Teachers, and Expand Science Outreach

- Renewal funding was received from NSF to continue the WVNano REU site (to 2012).
- The SURE site has been funded to 2014.
- SURE/REU activities are coordinated with other programs (Biology REU & Honors SURE site). We expect to include other summer research programs.
- A Research Experiences for Teachers (RET) site has been funded (start date 2011).
- A traveling summer science outreach program to students in grades 5-12 attending county/statewide 4-H camps will be continued and expanded in 2011.



2010 Science Outreach to grade 5-12 attendees of Monongalia County, WV, 4-H camp.
Science and laser show demonstrations were followed by a series of hands-on activities.





Geography

