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**Shandong University -Virginia Tech
Symposium on Bat Biophysics &
Bio-inspired Technology
August 14-18, 2010**

**Session on
“Innovation Concepts”**

August 15, 2010

**Chair Zuo-tang Liang,
Shandong University**



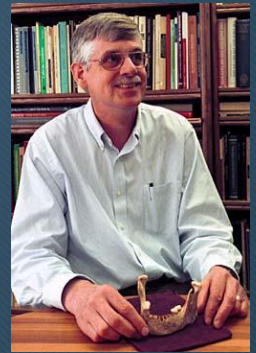
Innovation concepts

Human Spark

- Neanderthals and modern humans evolved from the same ancestors.
- Neanderthals left Africa and spread to Europe where they lived for about 200, 000 years before they became extinct.
- Those left behind successfully evolved to modern humans and occupied the planet.



DO YOU KNOW WHY?



Innovation

“Just as energy is the basis of life itself, and ideas the source of innovation, so is innovation the vital spark of all human change, improvement and progress.”

Ted Levitt; Marketing Guru, Harvard Business School

1. Invention vs. Innovation

Invention vs. Innovation

INVENTION

- an idea made manifest
- the creation/embodiment of something new
- the first occurrence of an idea for a new product or process
- *is the conversion of cash into ideas*

INNOVATION

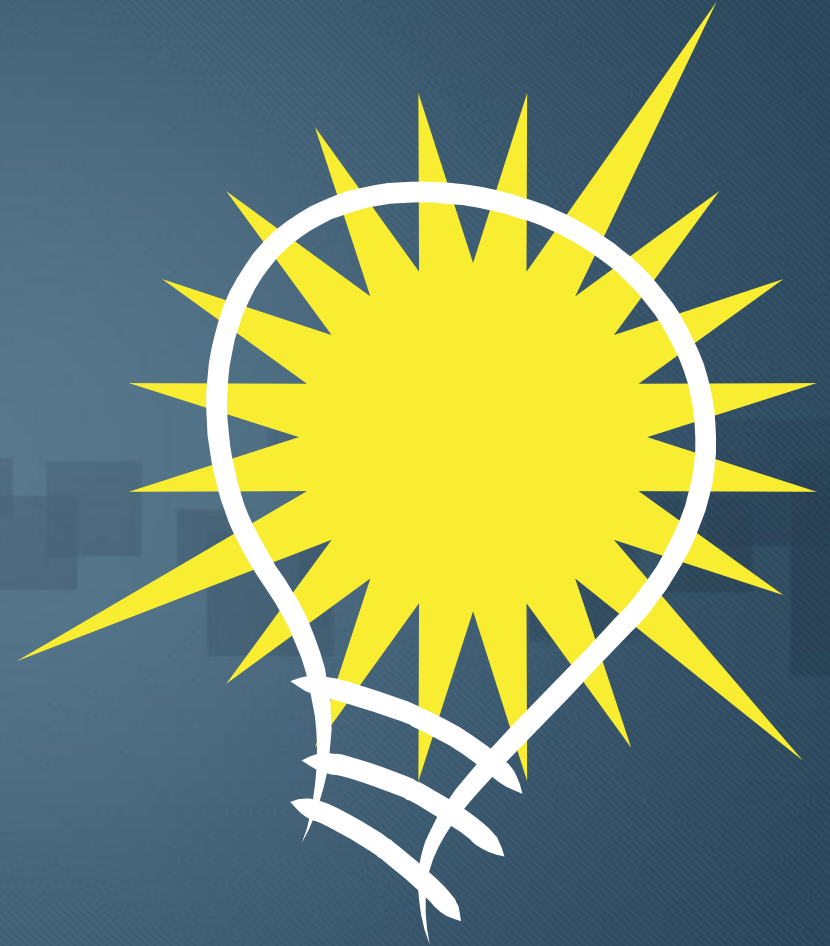
- an idea applied successfully in practice
- is the conversion of ideas into cash

(Etymological origin of word INNOVATION – creation of something new)

Invention vs. Innovation

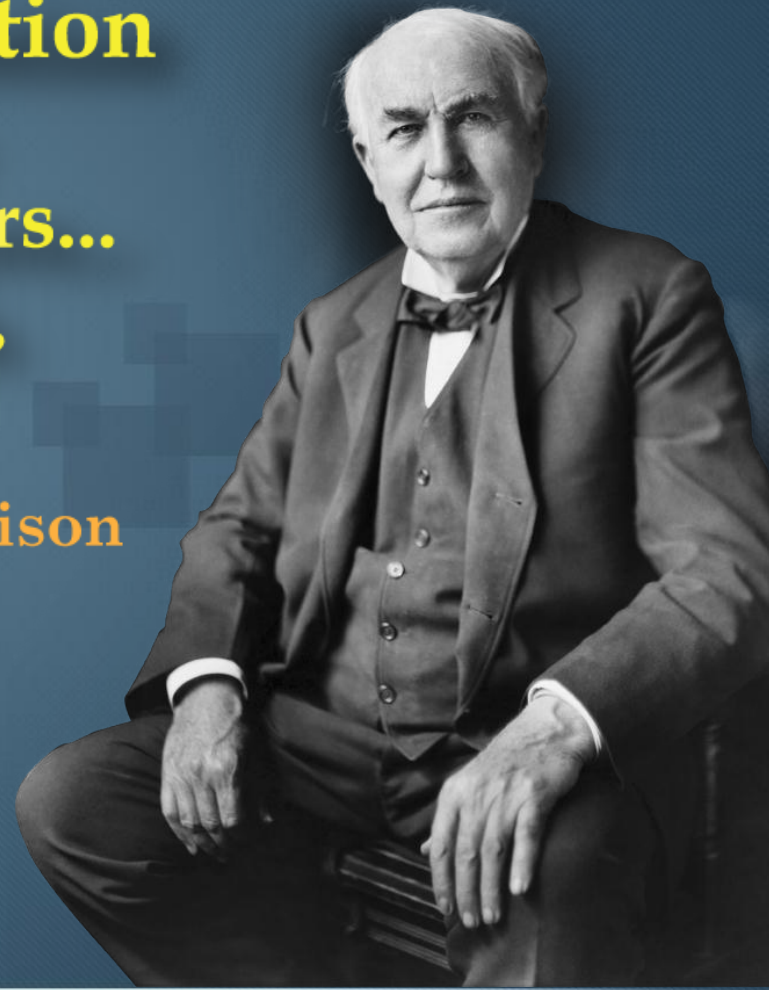
Innovators produce, market and profit from their innovations

Inventors may or may not profit from their inventions



“ I never perfected an invention
that I did not think about in terms of the
service it might give others...
I find out what the world needs,
then I proceed to invent. ”

– Thomas Edison



2. Sources of Innovation

Sources of Innovation

➤ Inventor(s) –driven

- Recent research suggests that the most successful innovation occurs at the boundaries/interfaces

➤ End- User –Driven

- Need-based
- Increasingly assuming more importance

Sources of Innovation

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Recent research suggests that the most successful innovation occurs at the boundaries/interfaces

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3. Linear vs. disruptive Innovation

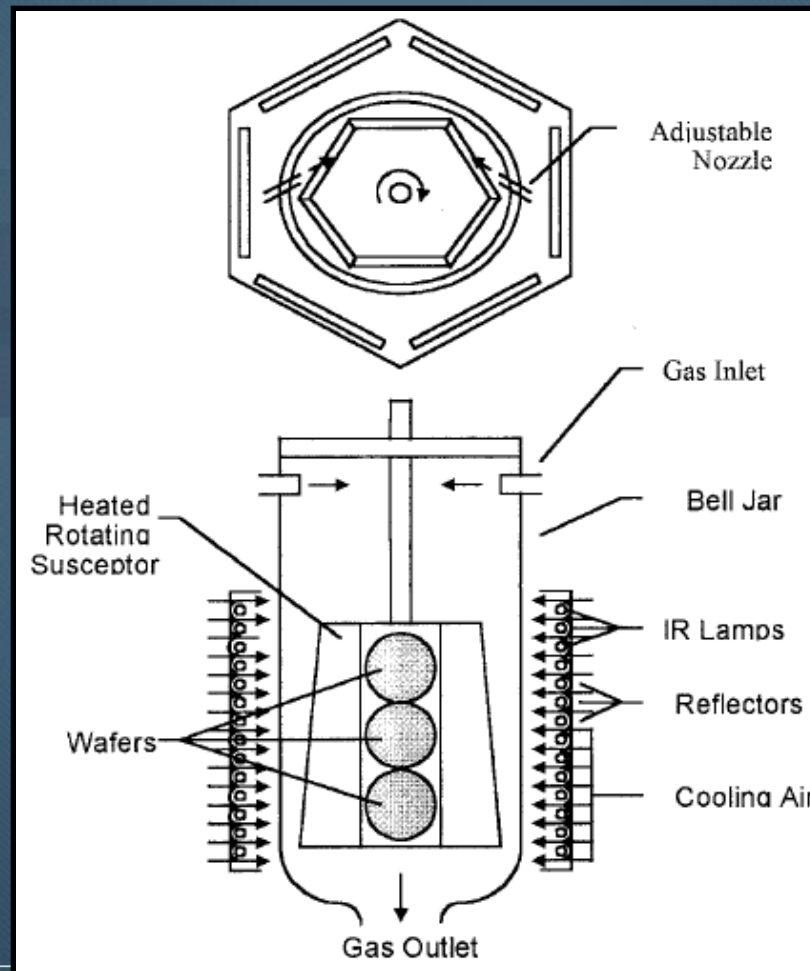
3. Linear vs Disruptive Innovation

□ Linear

- Incremental
Ex: Cost reduction

➤ Barrel reactor silicon epitaxy

CVD: Barrel Reactor



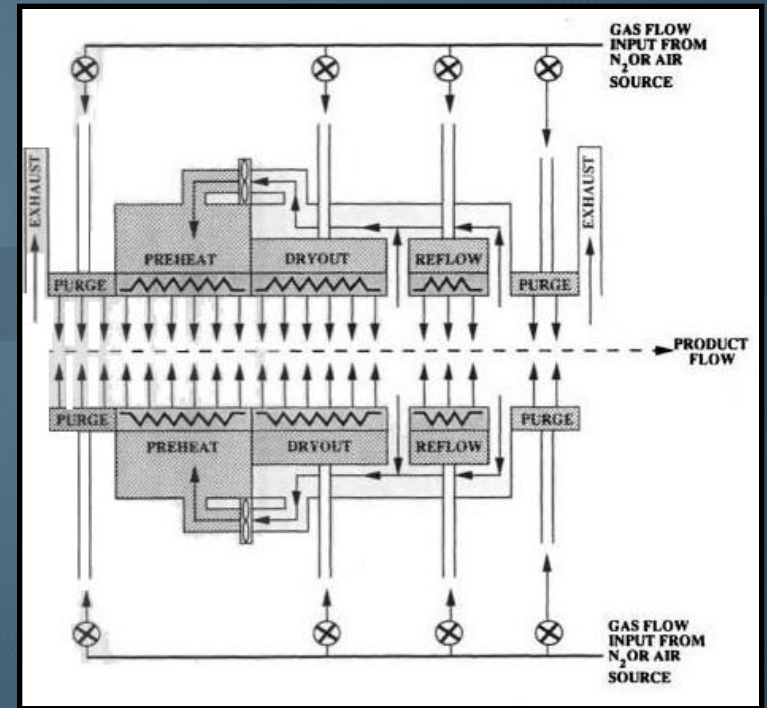
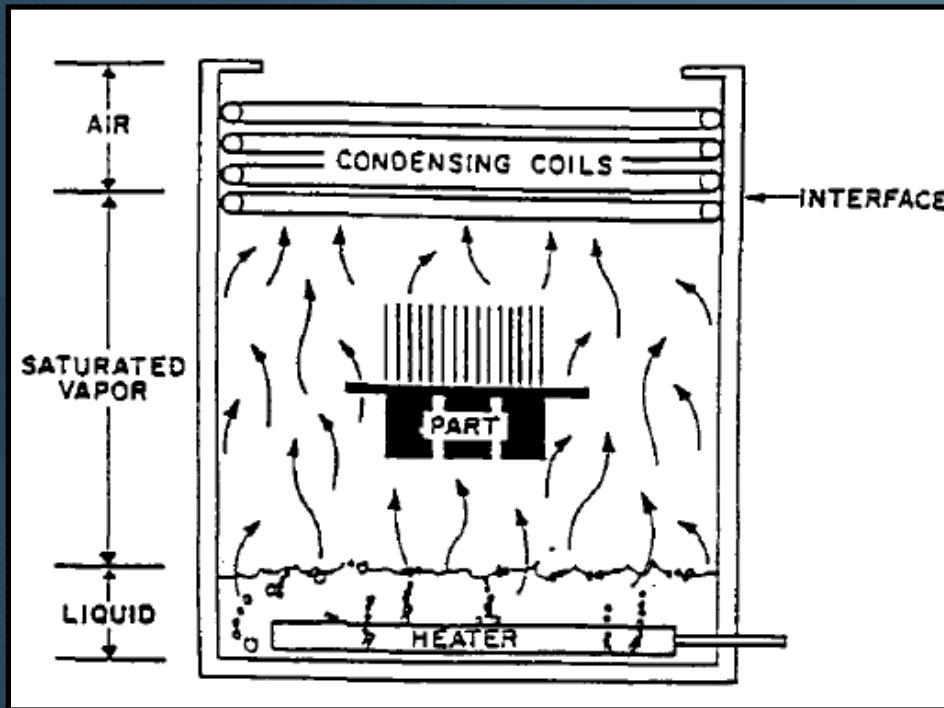
3. Linear vs. Disruptive Innovation

□ Disruptive

- Game-changer
- EX: Digital vs analog watches

➤ **Condensation Soldering vs IR soldering**

Condensation and IR Reflow Soldering



3. Linear vs. Disruptive Innovation

➤ Disruptive

- Game-changer
- EX: Digital vs analog watches

Condensation Soldering vs IR soldering

➤ The Black Swan

Disruptive Innovation and a Black Swan

A **Black Swan** is an event that has three characteristics;

- it is an outlier
- it carries an extreme impact
- it has retrospective predictability.



"The Black Swan", by Nassim Nicholas Taleb

- Our world is dominated by Black Swans.
 - the internet
 - the computer
 - the laser

All three were unplanned, unpredicted, and unappreciated upon their discovery, and remained unappreciated well after initial use.

Disruptive Innovation

A powerful exercise for disruptive innovation

WHAT WILL MAKE YOU
UNEMPLOYABLE IN 7 YEARS?



Or

WHAT WILL MAKE YOU IRRELEVANT
IN 7 YEARS?

4. Promoting innovation

Promoting Innovation

- promoting interdisciplinary research



Buds of creativity bloom at intersections

- encourage risk-taking

- Celebrate successes and failures

- constantly examine existing paradigms

- Look for the next **Black Swan**

Promoting Innovation

Additional ingredients for success

- Technical competency
- Resources
- Recognition

Innovation Concepts

1. Invention vs. Innovation
 2. Sources of Innovation
 3. Linear vs. disruptive innovation
 4. Promoting innovation
- **ICTAS as an agent of Innovation**



ICTAS

INSTITUTE *for* CRITICAL TECHNOLOGY
and APPLIED SCIENCE *Virginia Tech*

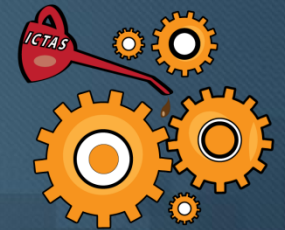
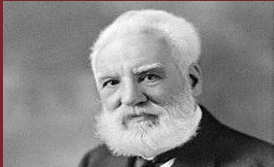
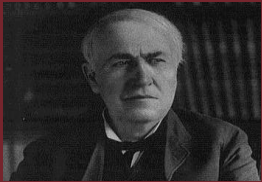
VISION

*To be among the top-ranked global institutes in transformative technologies for
a sustainable future*

MISSION

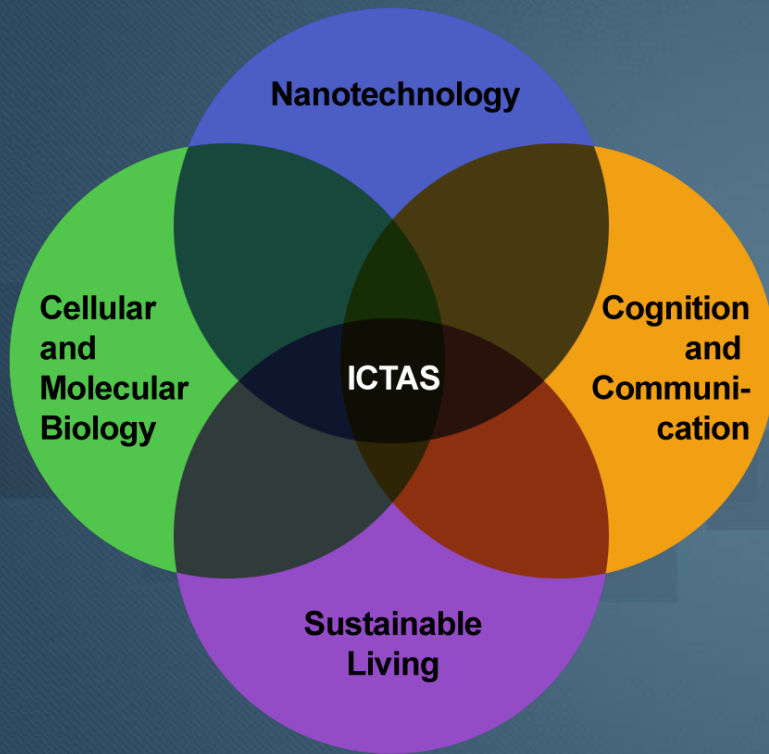
To stimulate, catalyze and promote interdisciplinary / trans-disciplinary research at the intersection of science, engineering, biology and social sciences.

critical emerging areas
transformative thinking



NBIC Tetrahedron

Defining Research Thrusts



ICTAS research is at the NBIC interfaces with a focus on A SUSTAINABLE FUTURE

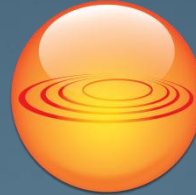
“The most incomprehensible thing about the world is that it is at all comprehensible.”

Albert Einstein

ICTAS *Thrust Areas*



Nanoscale Science and Engineering



Sustainable Water



Nano-Bio Interface



Cognition & Communication



Sustainable Energy



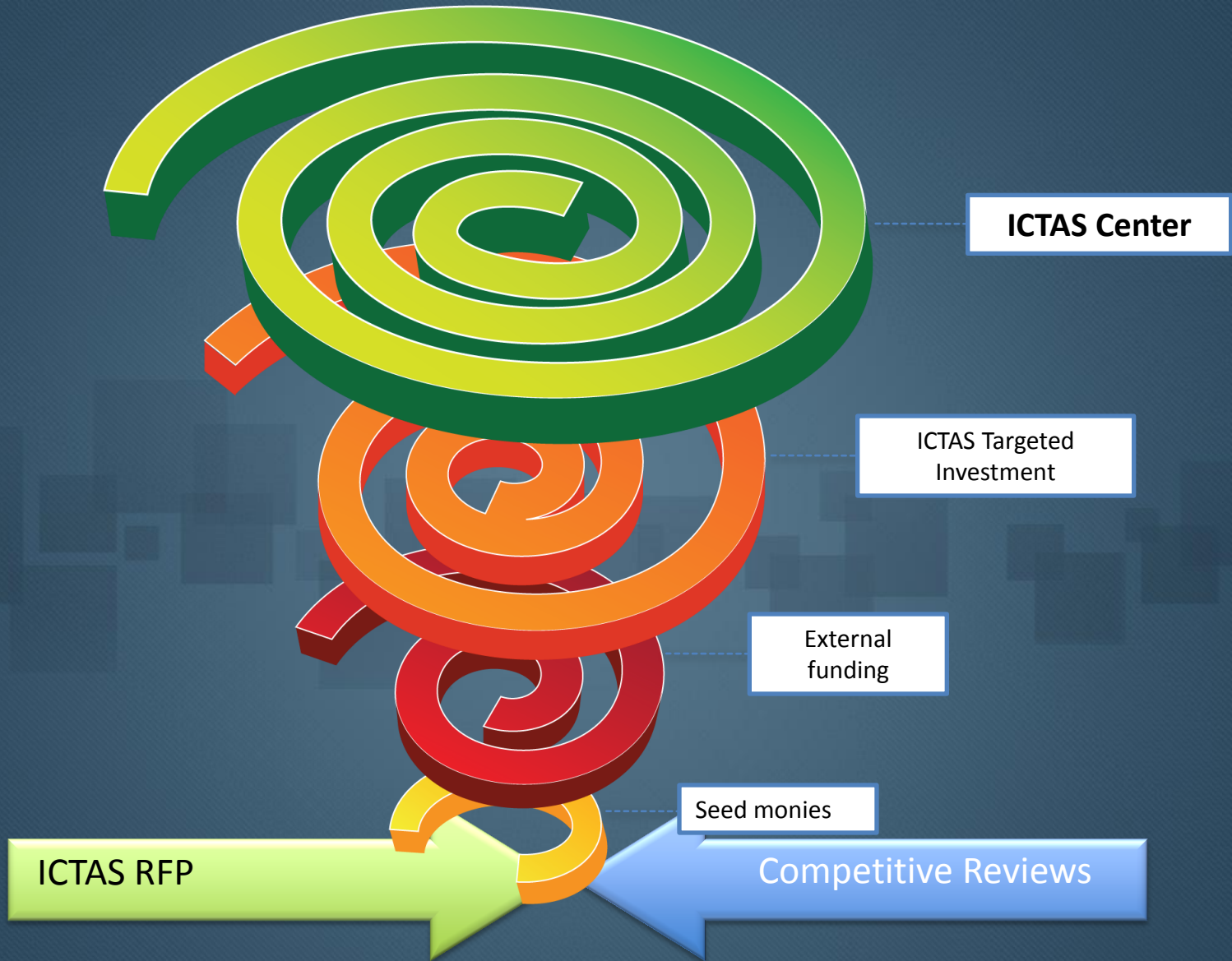
Emerging Research



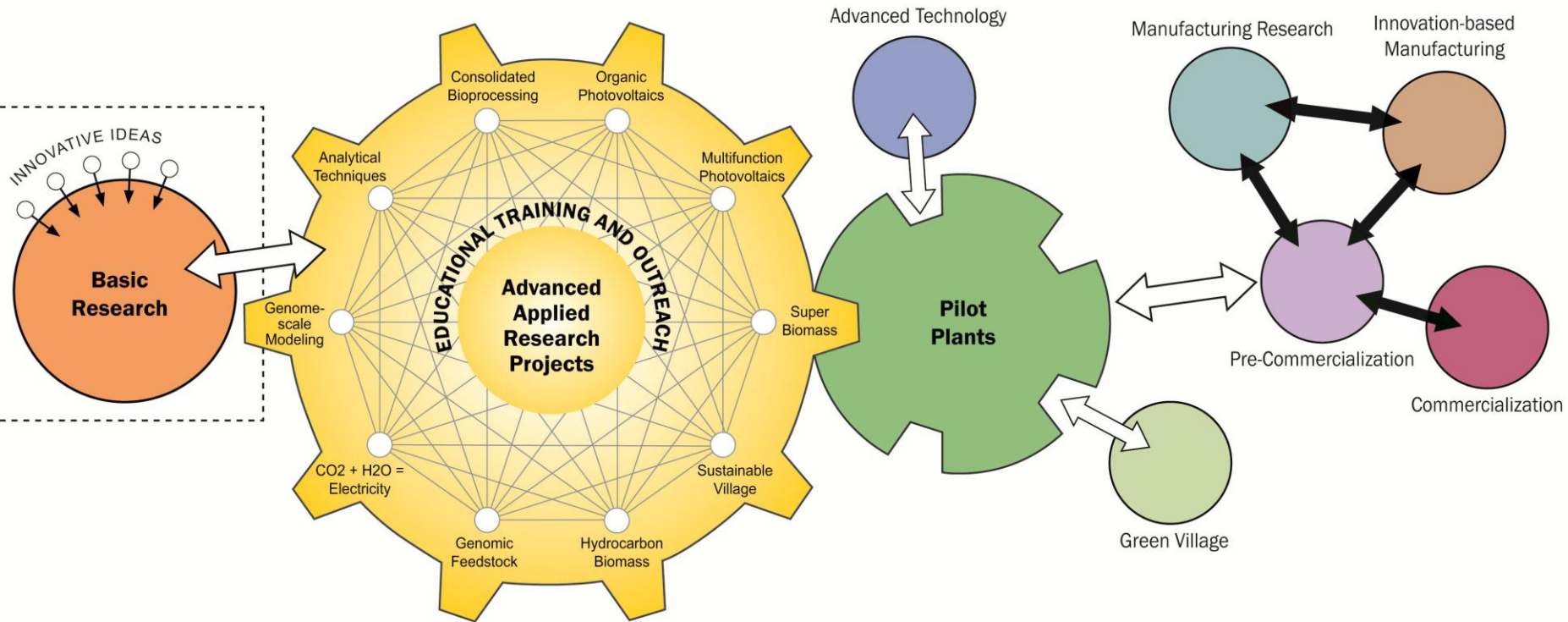
Renewable Materials



National Security



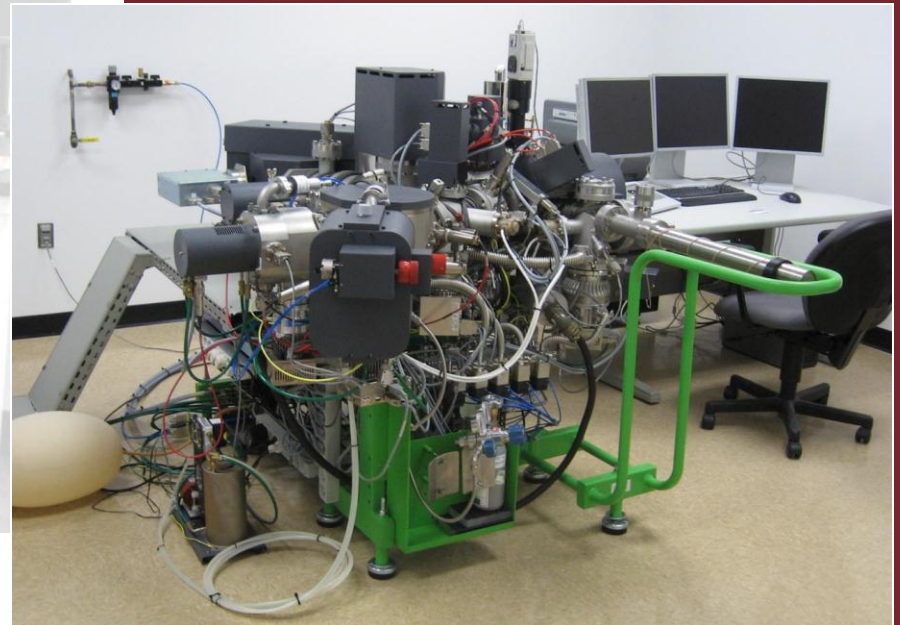
SUN2Fuels Hub

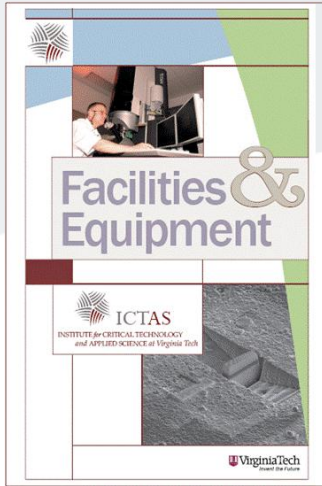


Laboratories and Collaborative Space

• <http://www.ictas.vt.edu/ncfl>

NCFL Director Bill Reynolds





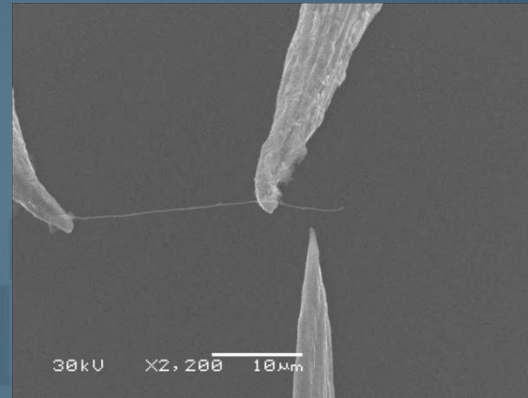
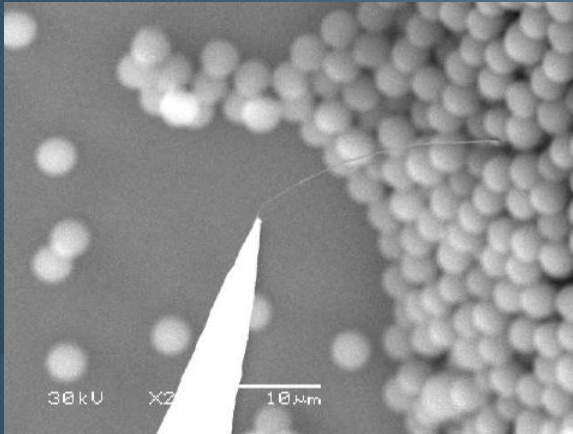
FEI Helios 600 NanoLab

- **Field-emission SEM: LEO (Zeiss) 1550**
- **Focused Ion Beam: FEI Helios 600 NanoLab**
- **Environmental SEM FEI: Quanta 600 FEG**
- **Transmission Electron Microscope : FEI Titan 300**
- **Secondary Ion Mass Spectrometer: Cameca IMS 7f GEO**
- **XPS PHI Quantera SXM: Scanning Photoelectron Spectrometer Microprobe**
- **Confocal laser scanning microscope: Zeiss LSM 510 NLO + VIS**
- **BioAFM, TriboIndenter, AFM : NanoMAN**



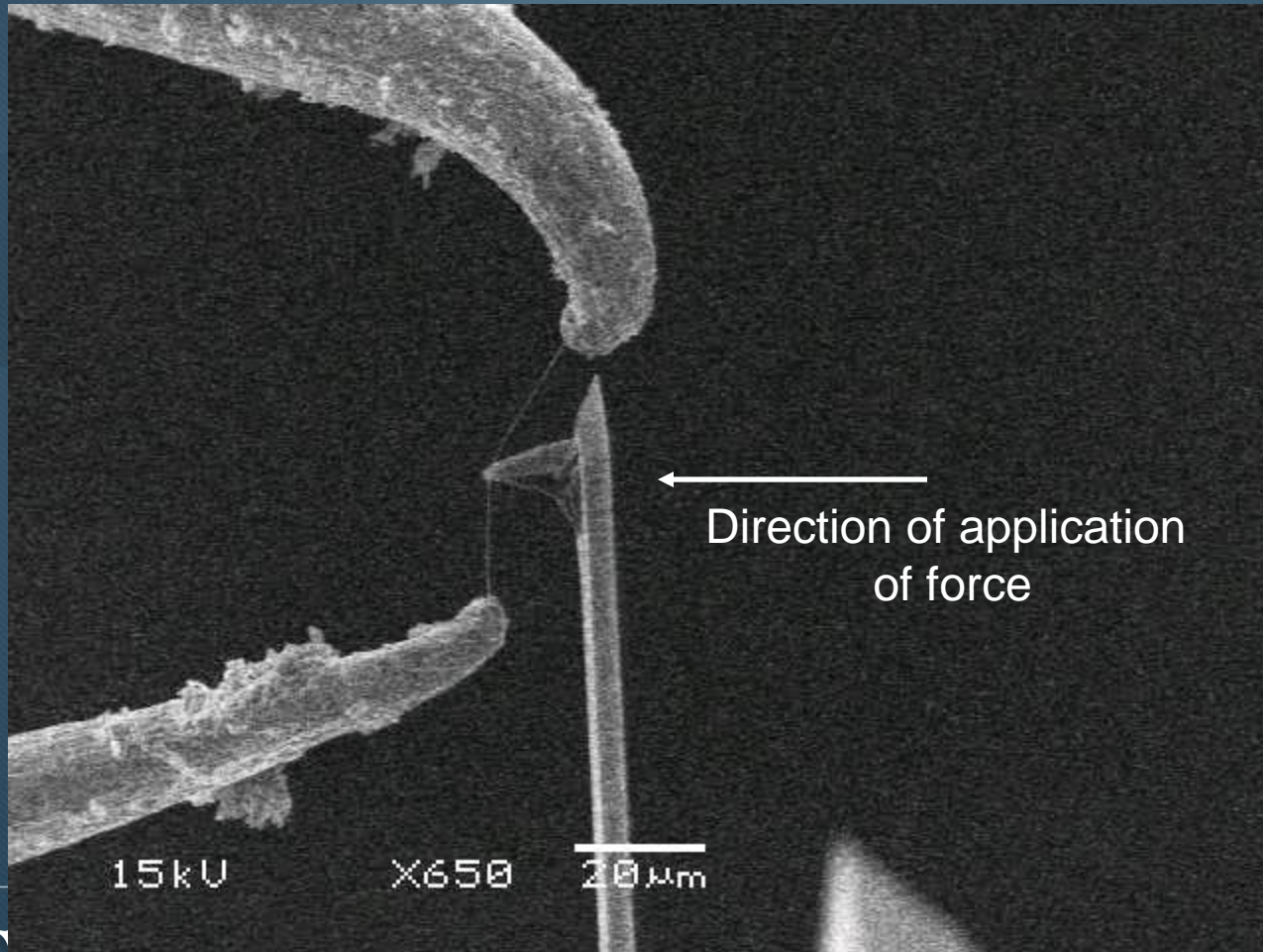
FEI Titan 300

Nanoscale Fabrication: NT/Sphere Device



Mechanical Characterization

(B) Mechanical Testing



ICTAS Laboratories

ICTAS-NCFL: The Nanoscale Characterization and Fabrication Lab opened in the Corporate Research Center in July 2007.

ICTAS-HQ: The institute headquarters and home to the School of Biomedical Engineering and Sciences opened on Stanger Street in March 2009.

ICTAS-LSP The facility in the Life Sciences Precinct is under construction and will open at the end of this year.

ICTAS-NCR: ICTAS will utilize 7,000 ft² in the new facility near Washington.



ICTAS *Thrust Areas Populated*

Nanoscale Science and Engineering	Environmental Nanoscience and Technology Nanomaterials including carbonaceous materials Nanosensors
Nano-Bio Interface	Targeted Delivery of Nano-medicine Cellular Engineering Microsystems Non-invasive Sensing and Diagnosis Inflammation Bio-Imaging
Sustainable Energy	Fuel Cells Organic Photovoltaics Biologically Derived Fuels Energy Harvesting Clean Coal Energy
Renewable Materials	Bio-based Materials: Design and Processing
Sustainable Water	Water Infrastructure Management Sustainable Ecosystems and Urban Infrastructure Water & Health
Cognition and Communication	Cognitive Radio Networks Autonomous Secure Communications Human Computer Interface
Homeland Security	Naval Surface Warfare Center Dahlgren Division (NSWCDD) DARPA, NASA
Emerging Research	Complex Network Systems Accelerating Scientific Discovery through Data Mining Personal Health Informatics Humanoid Hospital

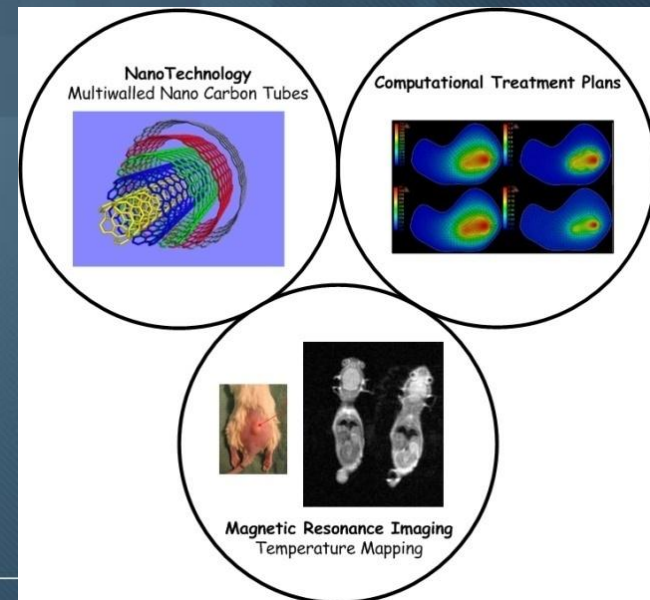
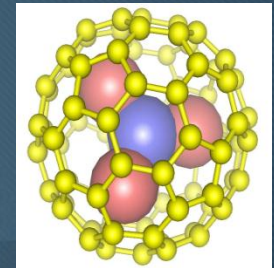


Nanoscale Science and Engineering

- Continues to grow in scholarship and external funding- beyond Environmental Nanoscience and Technology
 - \$7.05 million new research funding related to NSE (21 awards: NSF, NIH, DoD, VCOM, AFOSR, other).
 - IMI: International Multifunctional Materials Research Institute (IMMRI)
 - New Center for Sustainable NT (SUN)
 - Nanofibers
 - **Nanomanufacturing : Discussion with Aneesh Chopra/ Dr Kota**
 - **Innovation-based manufacturing**

Novel nanomaterials for engineering and medical applications

- New material discovered by Prof. Harry Dorn of Chemistry, 1994
 - Metal encapsulated in a fullerene cage
 - More discoveries followed
 - Many applications in bio-imaging, energy, optoelectronics
- Grants:
 - \$6m from NIH and NSF; 2005-09
 - \$200,000 from the Commonwealth Technology Research Fund (CTRF), March 2008
- Has spurred new collaborative research
 - Novel nanostructures (peapods and nanohorns) as improved imaging agents and therapeutic enhancers (hyperthermia, drug delivery)





Sustainable Water

- **One of the eight thrust areas, with three sub-areas**
 - Sustainable Water Infrastructure Management (SWIM)
 - Pipe restoration, rehabilitation, renewal
 - Water and Health
 - Pathogens, Water treatment, Aesthetics
 - Sustainable Ecosystems and Urban Infrastructure
 - Stormwater runoff/recovery, nutrient cycling, natural systems

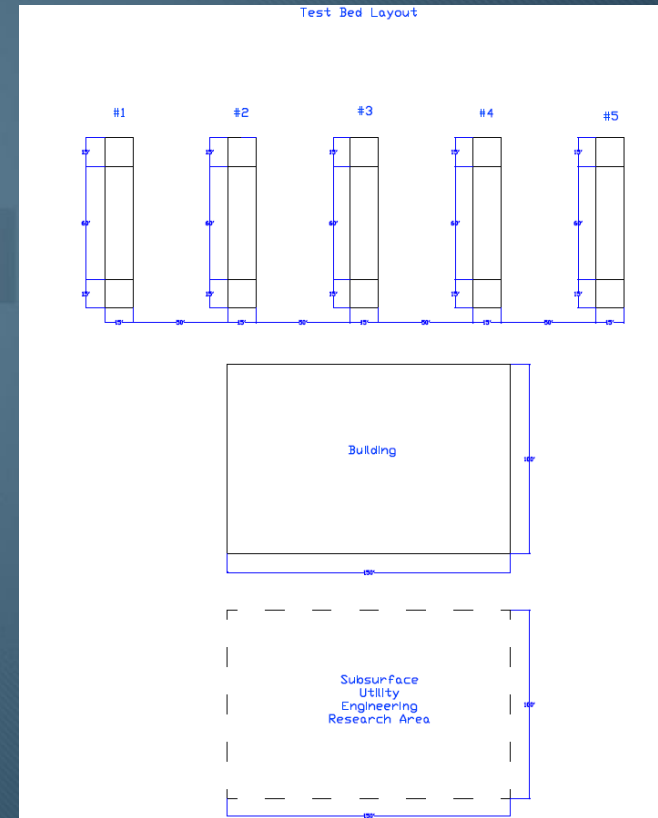
PROPOSALS:

- **NIST/EPA “SMART PIPE” FACILITY \$10-15 million**
- **NSF EFRI “SUSTAINABLE WATER BUILDINGS” \$2 million**
- **NSF IGERT (2011) *DESAL Water: ACES- Discovering Environmental and Sustainable Alternatives for Water: Aesthetic, Community and Engineering Solution***

Smart Pipe Test-Bed Facility

NIST External Construction Grant Proposal (to submit April 26, 2010): \$10-15 million with \$2-3.0 million cost share

- A platform for conducting controlled-condition research on the benefits of using innovative technologies (e.g., new measurement sensors) to **assess the condition of pipe infrastructure systems and to rehabilitate aging water and wastewater pipelines.**





New Energy Sources *for a Sustainable Future*

Research in energy cells, photovoltaics, and other technology areas lead the way to sustainability for future generations.

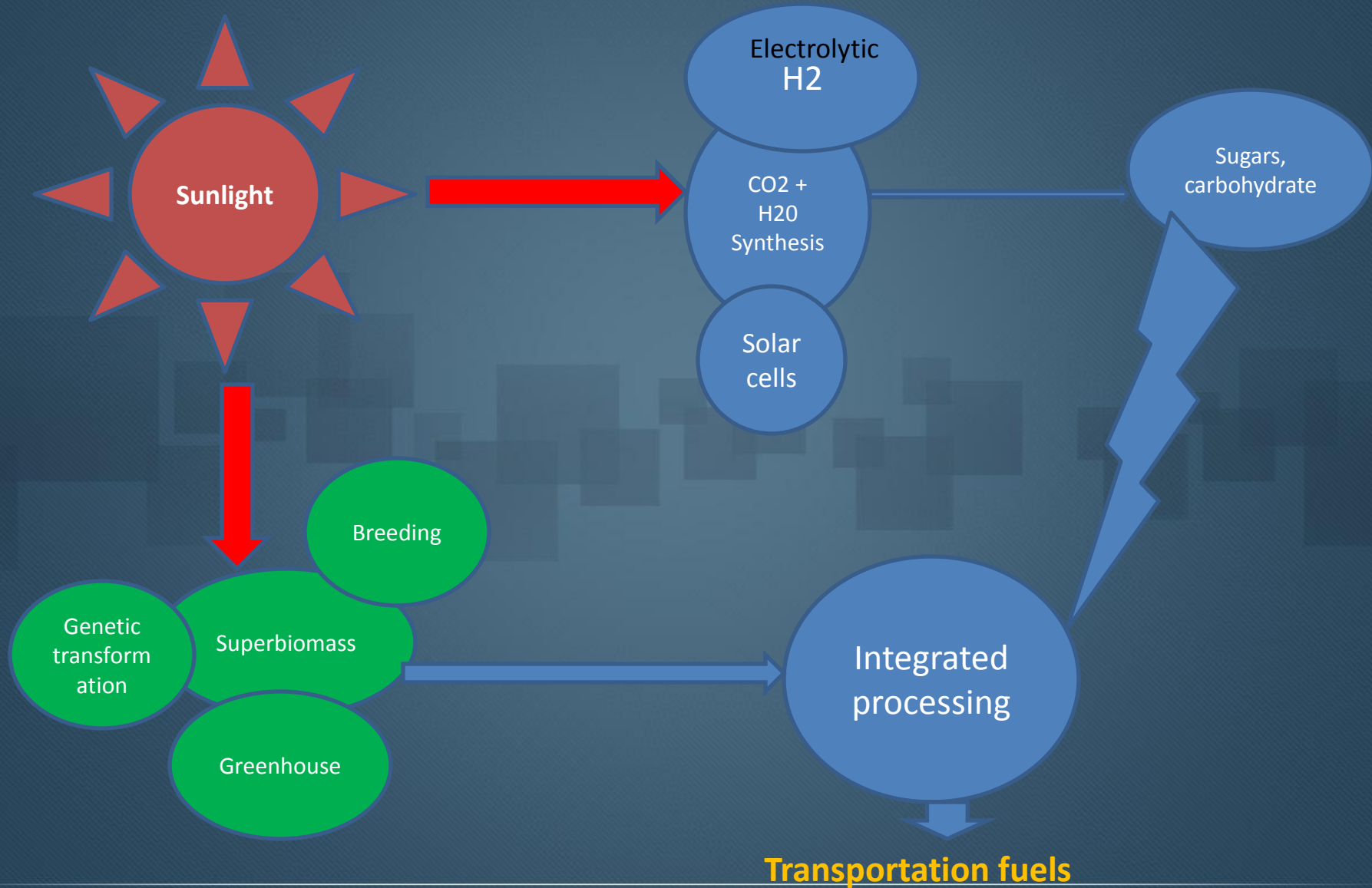


Sustainable Energy

Southeastern Regional SUN2 Biofuels Hub

- A major effort, VT Lead University ; \$125 m over 5 years
- Partners: ORNL, Columbia U., SUNY-Syracuse, Baylor U., U. of Delaware , CIT, BASF, Applied Materials, Inc., Luna nanoWorks...
- P.I. : Dr. Foster Aglevor; Roop L. Mahajan: Chair, External Advisory Committee
- 33 Faculty from COE, COS, VBI, CALS, IALR, CNR
- Significant help from PAG, OSP, ICTAS Team, Burruss Hall

Sun2Fuels Process Pathways





Sustainable Energy

E-RIC (Energy Regional Innovation Cluster)

- **Another major effort; \$129 m over 5 years**
- **Two potential partners**
 - CCI/ PSU led teams; politics
 - VT as a core university with PSU/CMU/UT/ IBM.....
 - **P. I. : Professor John Burns**
 - Faculty from COS, COE, College of Architecture, College of Arts & Humanities

Nuclear Energy Hub: Led by ORNL; VT as a user-institute



Nano-Bio Interface: VT Center for Inflammation

- A theme area under ICTAS; Expanded to a VT Center, with support from Fralin

Integrative team

- Experimental biologists; Computational and engineering scientists; Chemists
Clinicians (Cardiologists, neurologists, infectious disease experts)

Core Areas

- Mechanism of irreversible and chronic inflammation
- Computational simulation and prediction of inflammation network
- Target identification and chemical intervention of inflammation
- Translational studies of human atherosclerosis, infection and neurological inflammation

Key grant support

- Collective funding from NIH totaling \$2.5 million annually
- Additional grant application from NIH, NSF totaling \$2.5 million annually

Collaborative networks

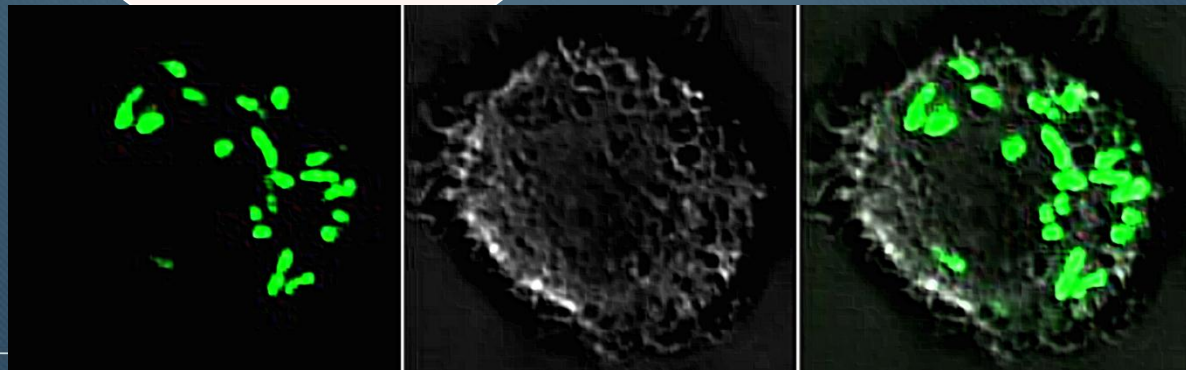
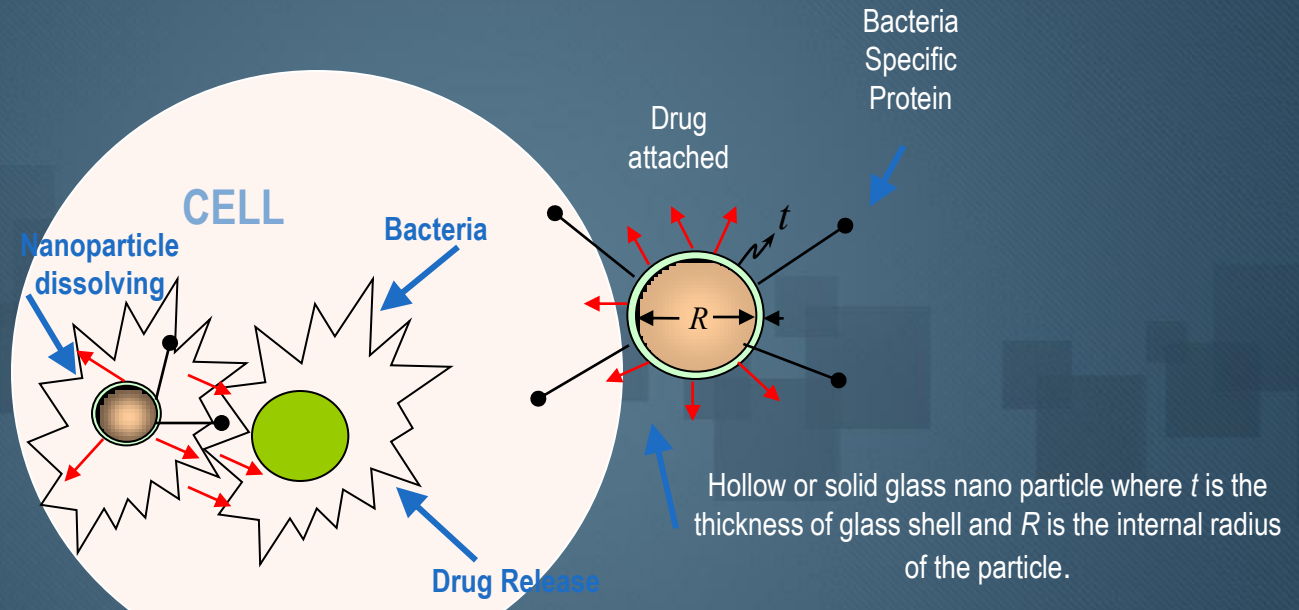
- Wake Forest, **Georgetown**, NIEHS, Carilion Clinic, Celgene, Amgen, BD Bioscience

Nano-Bio Interface

Targeted delivery of nano-medicine

Targeted drug delivery for the treatment of infections due to intracellular pathogens

- Work is currently underway into all aspects in a systematic manner with encouraging results
- Will define the ideal system which can be used for the control of intracellular bacterial infections like *Tuberculosis*, *Brucellosis* and *Salmonellosis* with targeted drug delivery system using nanoparticles



Macrophage cells infected with *Brucella* expressing green fluorescence protein. Confocal image of J774 A.1 cells

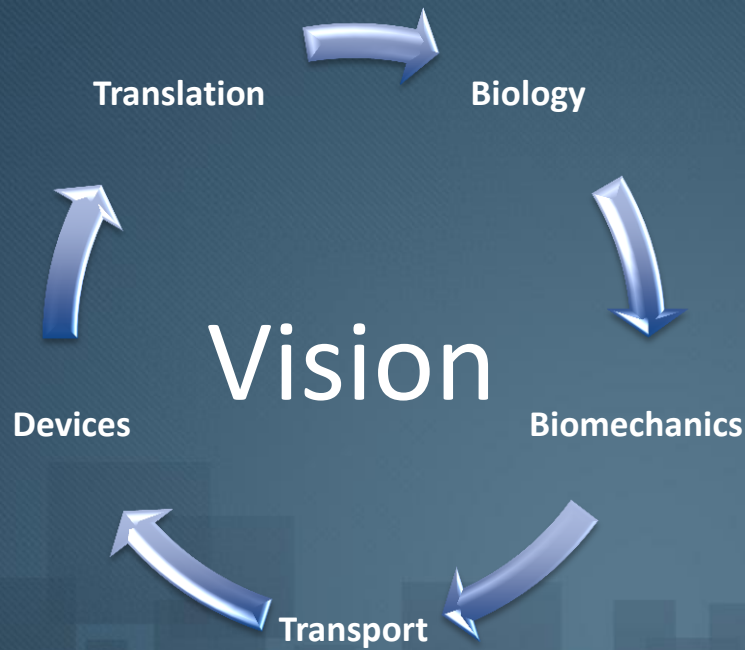
ICTAS M-BEDS

- yet another example of spiral growth

Multiscale Bio-Engineered Developed and Systems

Background

- ✓ MBEDS is the grandchild of several ICTAS and COE initiatives:
 - ✓ CEMS/CarDia ICTAS theme areas
 - ✓ NSF IGERT: MultiSTEPS
 - ✓ NSF-EFRI: Complex Microsystem Networks
Inspired by Internal Insect Physiology



*ICTAS-MBEDS envisions to realize **novel biomedical devices** or **systems** that serve as enabling or platform technologies for the efficient and effective diagnosis and treatment of acute or chronic diseases.*

MBEDS will bridge the “bench-to-bed” gap by developing a framework that will enable technology translation to clinical practice.

MBEDS will be a “grassroots” initiative that will be shaped by and contribute to the research aspirations, desires, and goals of its stakeholders.

M-BEDS Role within ICTAS

- ✓ MBEDS will exist at the intersection of engineering, physics and biology, cutting and connecting across ICTAS theme and thrust initiatives within the “nano-bio interface”, biomedical engineering and sciences and physics of disease.

ICTAS Bio-Based Materials Center

- Formally established as an ICTAS Center
 - Added 6 new faculty members
 - Awarded first round of interdisciplinary research grants; each student will be mentored by at least two center faculty members in different disciplines to facilitate interdisciplinary learning
 - Proposed new graduate certificate in Bio-based Materials Science
 - Hosted first annual Bio-based Materials Symposium
 - Entire BBMC faculty won the only USDA Educational Center grant awarded (\$0.5M, 4 yrs)



Cognition and Communication

VT-Cornet Status

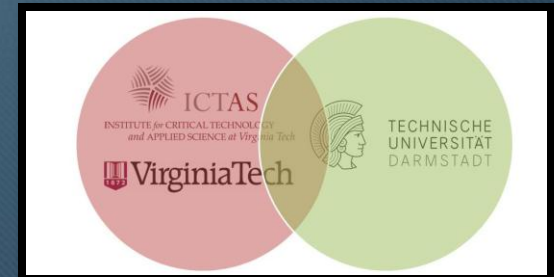
- 48 high performance servers are installed in a server room and accessible from outside
- Currently have 10 RF nodes, full 48 RF needs by summer

VT-CORNET to be connected to NEW MOBILE TESTBED

- Can study interoperability between mobile and fixed cognitive radio and to enhance the capability of VT-CORNET.
- A unique and premier infrastructure

Expansion to advanced security

- Potential collaboration with TUD
 - Security of data, services , imbedded systems
- Ted & Karyn Hume Center for National Security & Technology



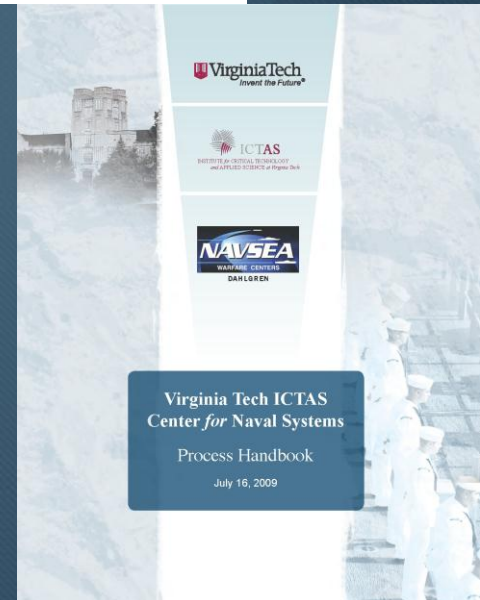
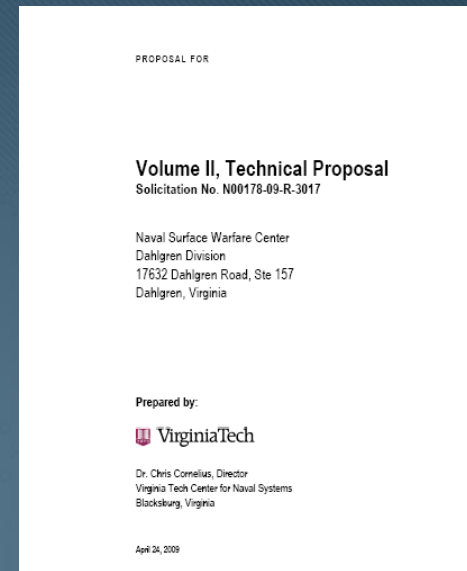
Ted & Karyn Hume Center for **National Security and Technology**

- **Mission:** To create a capability and framework that provides a sustainable pipeline of science and technology leaders for the Intelligence Community
- Key role and investment by ICTAS
- Interim Director: Dr. Jeff Reed
- \$5 million over 10 years, first installment of \$2 million received
- Center announcement to the IDEA group in DC on April 8 by President Steger



Dahlgren Initiative

- Sole-Source IDIQ awarded, June 2009 (Indefinite Delivery Indefinite Quantity, 5yr, \$7.5M)
- CRADA (Cooperative Research and Development Agreement) signed, August 2009
- **Tasks Awarded June through December 2009 ~ \$4M**
- **Increase of IDIQ Ceiling to \$11.25M**
- Another IDIQ in progress with APL:
 - Expected contract : \$1.5 m





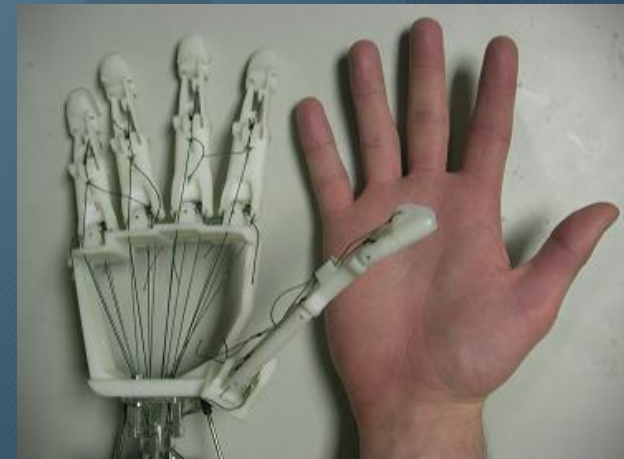
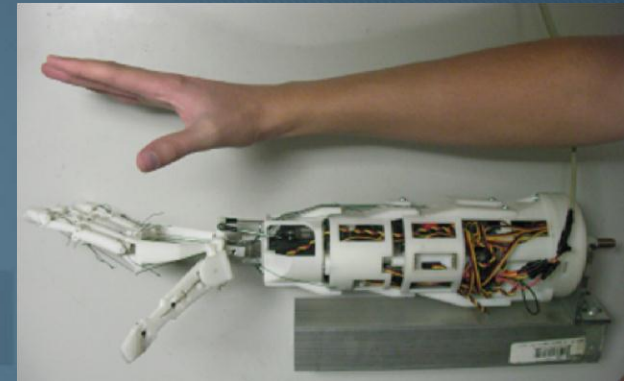
Incubator/ Emerging Technologies: *Humanoid Hospital*

GOAL:

Develop fully functional human-like patients (robots) tailored to mimic any specific or combined state of the healthy/diseased body.

Example of research in progress: Dexterous Humanoid Hand

	Robot	Human (male)
Hand Size	180 x 90 x 50 (mm)	189 x 84 x 48 (mm)
Forearm Size	315 x 100 x 85 (mm)	275 x 88 x 75 (mm)
Hand Weight	0.09 kg	0.4 kg
Forearm Weight	0.96 kg	1.113 kg
Degrees of freedom	23	24
Joint ranges of motion	70, 90, 90 (degrees)	90, 100, 110 (degrees)
Grasp Speed	0.35 sec	0.15 sec
Typing Speed	20 words/minute	33 words/minute





Incubator/ Emerging Technologies: *Discovery Analytics*

Mission: Extract interesting/actionable knowledge from exabyte-scale data

Current targeted activities with rich application contexts

- Mining data from massive sensor networks
 - Data centers, neuroscience
- “Storytelling” for unstructured data exploration
 - Cyber-intelligence
- Probabilistic graphical models
 - Protein design, electronic medical records

A highly successful research program

Ideal candidate for NCR



Incubator/ Emerging Technologies:

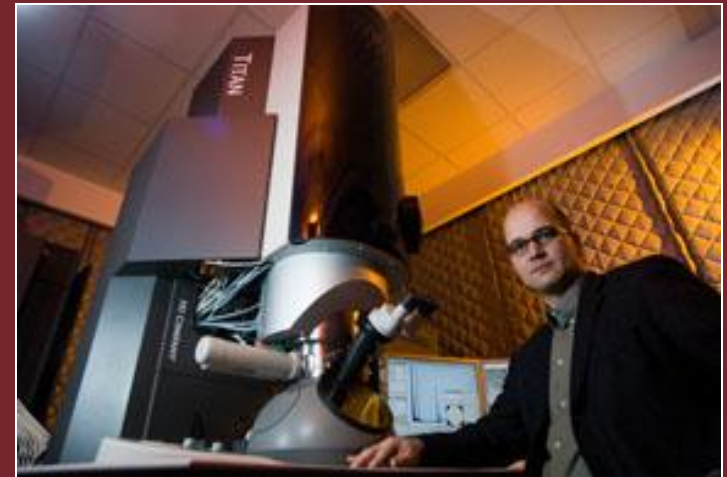
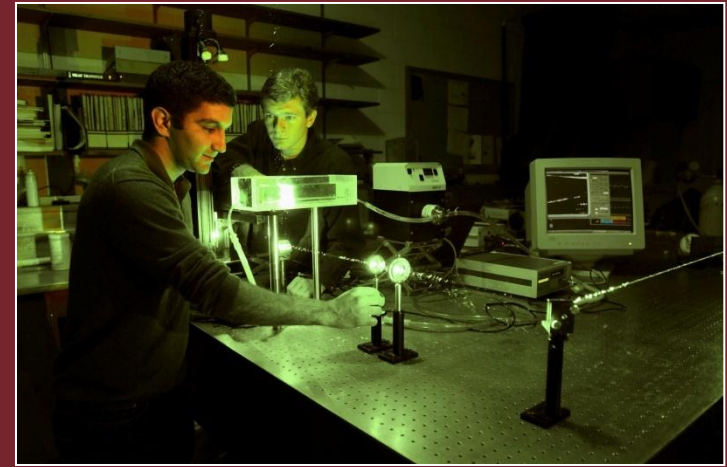
VT Center for Ethics and Scholarship Integrity

A campus-wide Collaborative Center

- ICTAS, ISCE, Graduate School, Fralin, Philosophy Dept, OVPR
- The Center will serve as a university-wide structure:
 - to coordinate efforts throughout the university to enhance our knowledge and understanding of ethics and scholarly integrity
 - to foster research identifying ethical issues and concerns throughout the discovery process and addressing ethical issues in the advancement of new knowledge and practices
 - to help educate faculty, staff and students about ethics and scholarly integrity
- Executive Committee in place; seed monies, charter under development

Students and Faculty

- **ICTAS Doctoral Scholars**
- **New Faculty Hires**
- **ICTAS Faculty Fellows**



Doctoral Scholars 2010-2014

COE (3)

- 1.School of Biomedical Engineering and Sciences (SBES), pending
- 2.Aeronautic and Ocean Engineering (AOE), pending
- 3.Civil and Environmental Engineering (CEE), pending

COS (3)

- 1.Mathematics, declined
- 2.GeoSciences, pending
- 3.Mathematics, pending
- 4.Biological Sciences, pending

CALS (2)

- 1.Plant Pathology and Weed Science, declined
- 2.Biological Systems Engineering, pending
- 3.Plant Pathology and Weed Science, pending

CNS (1)

- 1.Wood Science and Forest Products, **ACCEPTED**

CVM (1)

1. **ACCEPTED**

ICTAS Doctoral Scholar Program:

Four-year summary

	COE	COS	CNR	CALS	CVM	Total
Class of 2007	3	3	2	2	1	11
Class of 2008	3	2	1	2	1	9
Class of 2009	2	3	0	1	0	6
Class of 2010	3	3	1	2	1	10
Total	11	11	4	7	3	36

Learning Domain: Other Graduate Student Initiatives

IGERT programs

PI: Gerardo W. Flintsch (CEE): Uncovering network Interdependencies and Synergies (UNIS)

P.I. Mark Stremier (ESM): Multi-STEPS

PI Tamal Bose (ECE), USDOE *proposal*, \$30,000

PI Robert Moore (Chemistry), IGERT *award*, \$30,000/yr. for 3 years

PI Jeff Kuhn (Biology), IGERT *proposal*, \$30,000/yr. for 3 years, space in NCFL

PI Tamim Younos, NSF IGERT *proposal*, Roop will chair the internal advisory panel.

Learning Domain: Other Graduate Student Initiatives

26th Annual Graduate Student Assembly Research Symposium: \$3500 in support

Participation in Graduate Student Appreciation Week

Undergraduate Student Initiatives

- Staff participation in the university search committee charged with selection of a *Director for Undergraduate Research*
- Research Experience for Undergraduates (REU), NSF Award, P.I.: I. Puri
- NCFL faculty plan to submit an NCFL-based REU
- Summer internships at NCFL; considering AY internships

Outreach and engagement

ICTAS Newsletter twice annually, SBES newsletter once annually



The newsletter of the Institute for Critical Technology and Applied Science at Virginia Tech

The newsletter of the Institute of Critical Technology and Applied Science at Virginia Tech

INSIDE
1 Item
2 Item

INSIDE

- 1 Cover Story
- 2 Dean's Corner: Ann Craig
- 3 Director's Corner: The Way of the Thing of the Order of the Phoenix
- 4 Faculty Focus: Sarah Masen
- 5 Research Focus: Sarah Masen
- 6 Student Spotlight: Sarah Masen
- 7 Technology Spotlight: Edible Phones
- 8 ICTAS in the News: Contract with the Moon Men

continued on page xx

Outreach and engagement

2-page flyers for initiatives underway at ICTAS, 22 in circulation

The ICTAS Water Group

An ICTAS Focus Area

Need for Research
Water is critical to life. With anticipated changes in weather patterns coupled with aging infrastructure and overuse of water resources, a time will come when water is valued as much as petroleum.


Virginia Tech (VT) has unique capabilities in the water and watersheds areas. The Occoquan Watershed Monitoring Laboratory (OWML) is a major environmental engineering field facility of the VT Civil & Environmental Engineering Department, and is located in the National Capital Region (NCR) in the City of Manassas. Investigators have conducted water quality research on this major drinking water source for the northern Virginia area since 1972. The Occoquan water supply system is the largest indirect potable reuse (of wastewater) system in the U.S.

Research in water and watershed sciences at VT has a long history and considerable expertise across five colleges and fifteen departments. Research ranges from detailed disciplinary studies to broad interdisciplinary projects. VT water research has been centered on basic science and engineering, but also has been extended to interdisciplinary studies and knowledge of watershed management and water and land policy.

Strategic Approach
In the area of infrastructure major initiatives are underway. The most important of these is providing information for the citizens of Washington DC regarding the presence of lead in the water distribution system, along with solutions to solve this problem. More and more cities are recognizing the problem of contamination and leach and odors associated with the distribution of water and Virginia Tech is positioned to be the leading research team in this area.

The interdisciplinary WATER group within ICTAS will focus on water issues with the goal of ensuring that we have adequate water supplies to all citizens. This will be carried out by focusing on three core areas:

- Managing and protecting urban water
- Providing safe and reliable infrastructure for the collection and conveyance of wastewater and stormwater and by providing safe and reliable water distribution systems within urban areas.
- Managing and protecting urban water
- Providing the best effective treatment of drinking water



ICTAS The Institute for Critical Technology and Applied Science at Virginia Tech supports and promotes cutting edge research at the intersection of engineering, science and medicine. Please visit www.ictas.vt.edu.

Sustainable Energy

An ICTAS Thrust Area

Growing demands for energy, rising energy prices, growing concerns about fossil-fuel emissions, and increasing dependence on energy imports from politically unstable countries are positioning the world for a major paradigm shift in how energy is produced, distributed, converted, and used. Alternatives must be found for petroleum, which currently supplies 95 percent of U.S. transportation energy needs and which is increasingly expensive. These alternatives must meet our needs for long-term availability, reasonable cost, and limited environmental impact. For electricity generation, a variety of renewable alternatives exist including solar, wind, and biofuels, but currently none can compete on a purely economic basis with more established technologies such as coal and nuclear.

The path forward to a more sustainable energy future will require new energy sources such as biologically derived liquid fuels, hydrogen from renewable sources, and solar power. New energy conversion systems such as fuel cells will be essential to increase the efficiency of transportation and electricity generation thus reducing the burden on emerging sustainable resources and minimizing the use of conventional fuels during the transition. Advances will also be required in the development of new engineered feedstock crops and advanced conversion pathways, either thermochemical or biochemical, to realize the goal of meeting transportation needs with sustainable carbon neutral biofuels. The large-scale implementation of solar power will require continued cost reduction through new technologies such as organic solar cells and through advances in manufacturing processes. Finally, the transition to a sustainable future will require new integrative technologies including grid management and power conditioning and new design approaches that balance economic, environmental and security concerns.


Technology to meet society's energy needs - renewably and responsibly.

Mission
The mission of the Sustainable Energy Solutions (SES) focus area is to advance science and technology to achieve reliable energy systems with long-term availability, reduced environmental impact, and lower cost. Our areas of interest include renewable energy resources (e.g. solar and biomass), cleaner more efficient energy conversion systems (e.g. fuel cells), and source-to-application integration for achieving improved energy sustainability.

Accomplishments

- Developed and transferred to industry techniques for characterizing the properties and predicting the durability of membranes in proton exchange membrane fuel cells.
- Developed and patented novel high performance proton exchange membrane (PEM) fuel cell materials.
- Developed new processing approaches for improving the performance of existing PEM materials and novel PEM fuel cell architectures for portable power.
- Developed high temperature glass seal materials for use in solid oxide fuel cells.
- Developed processes, currently being extended to pilot scale for the conversion of biomass to bio-ols and syngas for green diesel production.
- Developed a novel high-yield sugar-to-hydrogen conversion process that enables sugar to be used as a high-energy density hydrogen carrier.
- Developed metal-free dimeric molecules with properties that theoretically yield a two-fold increase in organic solar cell performance.

SES researchers including Dr. Fuchen Zhang are working on more efficient processes for producing fuels from biomass. Researchers are also working on bio food sources (e.g. corn stalks, pistachio in field).



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Fuel Cell Research

A DIVISION OF ICTAS SUSTAINABLE ENERGY

An ICTAS Focus Area

The Need for Research
As global energy use continues to grow, there is a vital need for the development of more efficient means for using our energy resources. Fuel cells systems can help meet this need by converting chemical energy to electricity more efficiently than comparably sized conventional systems. In vehicle applications, fuel cell systems can more than double the tank-to-wheels efficiency for typical drive cycles, and in stationary applications, studies show that the incorporation of high temperature fuel cells can lead to conversion efficiencies exceeding 70 percent. Fuel cells also promise to perform better than batteries in long term portable power applications such as consumer electronics and unmanned aerial vehicles. The ICTAS Fuel Cell Research Group is making important contributions in each of these areas with active research programs in polymer electrolyte membrane (PEM) fuel cells for transportation systems, solid oxide fuel cell systems for stationary applications, and direct methanol fuel cell systems for portable power applications.

Fuel to electricity...efficiently and affordably.

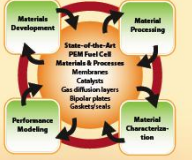
Technical Approach
At its core, a fuel cell is comprised of a relatively limited number of components - electrolyte, catalyst, diffusion layer, collector plates and seals - with the functionality embedded in the materials. In a larger sense a fuel cell system combines this core with ancillary components to accomplish the direct conversion of fuel to electricity. The Fuel Cell Research Group contributes to the advancement of each of these components and to the optimization of the entire system through the efforts of our team members who are world leaders in materials development, materials processing, materials characterization, and performance modeling. Currently our focus includes:

- Synthesis and processing of ion conducting polymers for polymer electrolyte membrane (PEM) fuel cells that have improved performance and reduced cost.
- Development of a fundamental understanding, an engineering framework, and supporting property data that allows the assessment and improvement of the durability of PEM membrane electrode assemblies.

Modeling of transport processes and measurement of transport properties in porous electrodes and diffusion media

Synthesis, design, and optimization of low and high temperature fuel cell systems to improve performance and reduce cost.

Development of glass seal materials for solid oxide fuel cells and electrolyzers.



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Outreach and engagement

Seminar Series



Bill Reynolds
Virginia Tech



Roop Mahajan
Virginia Tech



Claudia Cardona
Luna Innovations



Masoud Agah
Virginia Tech



Carolyn Elfland
UNC Chapel Hill



Hrishikesh Panchawagh
Eastman Kodak



W.S. Sampath
Colorado State U.



Skip Garner
Virginia Tech



Jeffrey Nelson
Sandia National Labs

Outreach and engagement

A New Seminar Series to start later this month

“The Black Swan and Disruptive Technology”:

An informal discussion of the future

Where ? Café X located in the main ICTAS building.

Objectives

Create an environment for engineers, scientists, and humanists to come together to move *beyond the predictable and incremental advances* in the current technologies to the *disruptive technologies* of the future.

Features:

No tyranny of power point

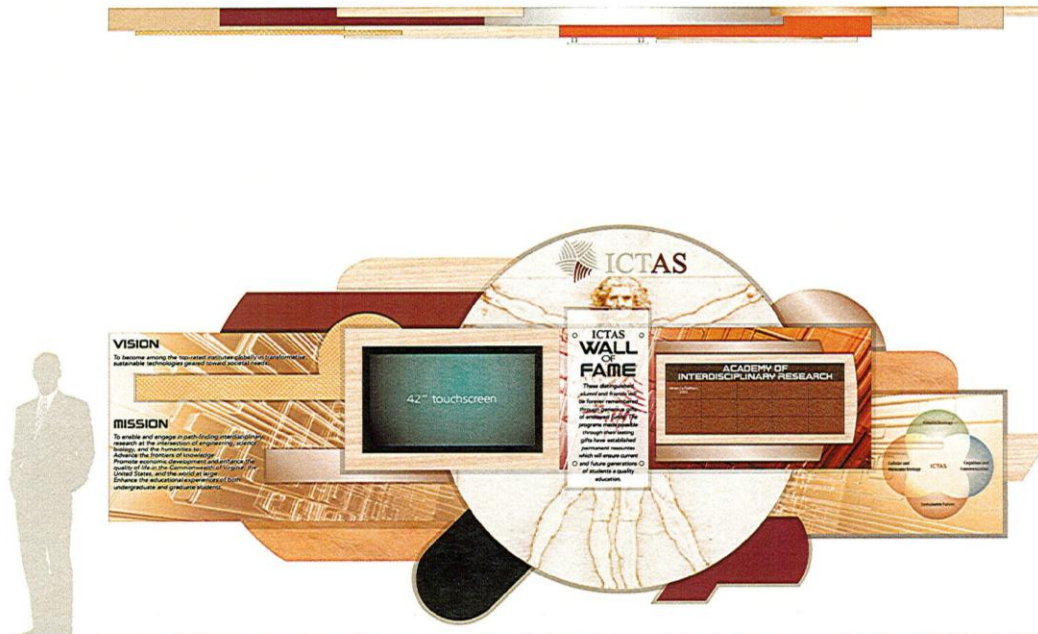
Focus on one general area with invitees from outside the field

Outreach and engagement Website

Between Feb. 23 and March 25, 2010, Google website analytics logged the following for ICTAS website:

- 6,188 page views
- Helps give a boost to other organizations affiliated with ICTAS
- Top page after homepage: research
- A user's average time on a page: 1:05

The screenshot shows the ICTAS website homepage with a dark red header. The header includes the Virginia Tech logo (1872) and the text "Invent the Future" on the left, and "Institute for Critical Technology and Applied Science" on the right. Below the header is a navigation bar with links: Home, About Us, Research and Discovery, Facilities, Education, Outreach, Downloads, and a highlighted "NCFL" button. The main content area features a large white box with the headline "ICTAS Building gets a new accent" and a "more info" button. Below this are two seminar series: "Seminar Series: Elfland" and "Seminar Series: Panchawagh". A large abstract sculpture is visible in the background. Below the seminars is a "ICTAS highlights" section with three items: "ICTAS Awards Announced", "ICTAS Co-Sponsoring a Water Seminar Series", and "Photo Tour of New Facilities". To the right is an "ICTAS News Feed" section with two items: "Tiny antenna could find its way into every home" and "CAREER launchers". At the bottom right, there is a "Scientific Report released" section. The footer of the website is not visible in the screenshot.



FOR CONCEPT ONLY

Virginia Tech / ICTAS

Date: 3.31.10 / all / #71890 / Overall Size: 211.125" x 88.5" x 6.75"



Outreach and engagement

Scientific Report



Outreach & Engagement - National Labs

Oak Ridge National Laboratory (ORNL)

- Discussions underway to strengthen the relationship, as previously established in Oak Ridge Association of Universities (ORAU) agreement with Virginia Tech
- Two User Access projects active on nanobiotechnology
- Talks underway to embed a graduate student in Center for Nanoscale Materials Science (CNMS) labs

National Institute of Standards and Technology (NIST)

- Strengthening collaborative discussions in area of Sustainable Water research (*e.g.*, Smart Pipe Test-Bed Facility)
- Multiple visits to Gaithersburg and Boulder, NIST staffers visiting Blacksburg for conferences and further discussion

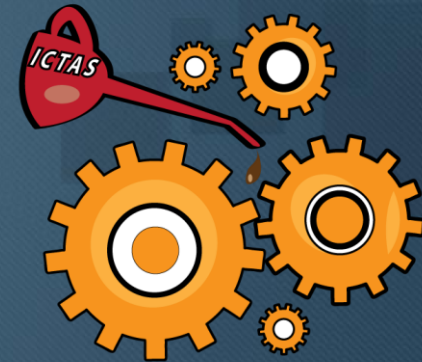
Outreach & Engagement- Research Day

- ICTAS Research Day scheduled for **September 28, 2010**
- Dr. Anthony Atala from Wake Forest University / SBES is a confirmed keynote speaker
- Aneesh Chopra (invited), Vinod Khosla (on list), Regina Dugan (on list)
- Tours, student poster session with competition, and other activities are being planned
- Participants will be invited from a large list of key players in the federal agencies (DOD, NIH, NSF, ARPA-E, DARPA, etc.), as well as VT faculty, students

ICTAS –An agent of Innovation



- ❑ **Interdisciplinary research**
 - Recall “Buds of creativity bloom at intersections”
 - ❑ **Identify/ Recognize need**
 - NBIC for sustainable growth
 - Thrust areas
 - ❑ **Match need with technical expertise**
 - Interdisciplinary teams; 227 faculty
 - ❑ **Provide resources**
 - NCFL, Collaborative space, financial resources
 - ❑ **Promote transformative thinking**
 - The Black Swan Seminar Series
- *Results have far exceeded our expectations*



Proposals/awards/expenditures

- steady increase

