Fostering Innovation and Commercialization of Green Nanotechnology for Market Leadership and Competitiveness

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OBJECTIVES

- Focus on nanotechnology (green) development
  - Enabling policy mechanisms
  - Enabling regulatory frameworks
  - Enabling R&D and innovation
  - Enabling commercialization and market development
  - Enabling technology transfer
  - Enabling safety issues
  - *Understand emerging practices and strategies for nanotechnology innovation, research commercialization, technology transfer and safety compliance in the region*

AIT
Asian Institute of Technology

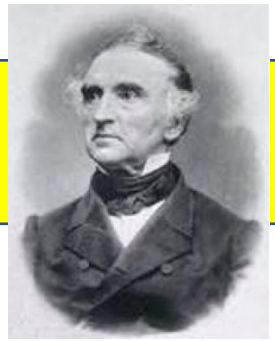
COEN@AIT

Research and Testing Laboratories

Louis Hornyak *ACADEMIC TREE*

Claude. Louis Berthollet
University of Turin
1768
Chemical Equilibria

Joseph Louis Gay-Lussac
University of Paris
1800
Water Structure/ Gas Laws

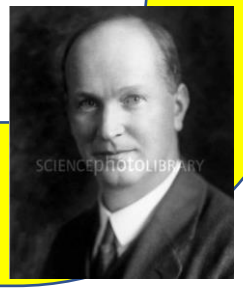


Justus von Liebig
University of Erlangen
1822
Founder of
Organic Chemistry

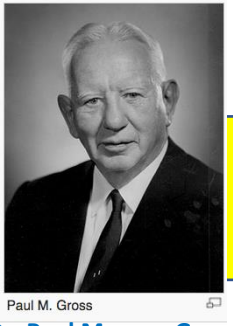
Dr. Carl Schmidt
University of Giessen
1844
Biochemical Crystallization

Wilhelm Ostwald
University of Dorpat
1875
Nobel Prize: Catalysis

Sir James Walker
University of Leipzig
1889
Electrolysis/
Carboxylic Acids



Dr. James P. Kendall
University of Edinburgh
1911
Solution Chemistry



Dr. Paul Magnus Gross
University of Columbia
1919
Fluorine Chemistry

Dr. Henry Freiser
Duke University
1944
Ionic Equilibria

Dr. Charles R. Martin
University of Arizona
1980
Template Synthesis
Electrochemistry

Dr. G. Louis Hornyak
Colorado State University
1997
Optical Nanogold

Nanotechnology Background

- Involved since 1990
- Watched its development
- The ’hype’ was (and still is) real
- Not just a buzzword
- Written several textbooks on nanotechnology
- The number of journals, large conferences, products ….. Is real
- But how is it different??

Green Nanotechnologies

"People are realizing that green engineering materials are real and gaining momentum worldwide"

"Creation of new businesses that spur new job markets are on the rise."

Green Nanotechnology?

- Most Important: ENERGY
- Most Important: CLEAN WATER
- Most Important: CLEAN AIR
- Most Important: CLEAN FOOD
- Most Important: HEALTH CARE

- *"What we breathe, what we drink, what keeps us warm and moves us, what we eat, what keeps us healthy….."* Anything else?

Fostering Innovation?

fosteringinnovation.info/?page_id=69

Fostering Innovation

- Foster is to "encourage *or promote the development of....”*

- *“In applying these principles, regulators should use flexible, adaptive, and evidence-based approaches that avoid, wherever possible, hindering innovation and trade while fulfilling responsibility to protect public health and the environment.”*

www.timharper.net/nanotech-regulation-fostering-innovation-while-protecting-public-health/

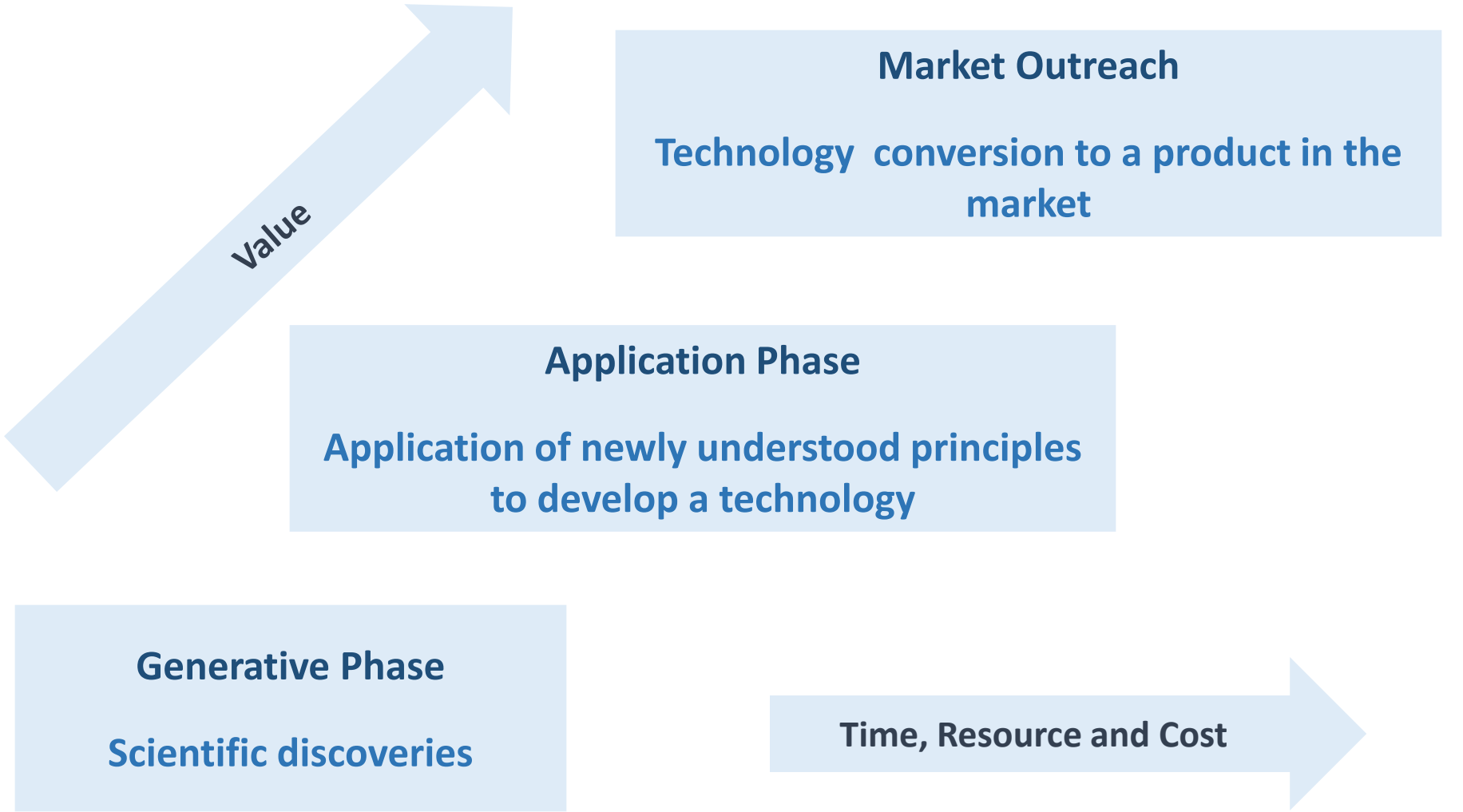
Or ….. From the UN

- *"Policy makers and regulators may consider a fine balance between accessibility and affordability in the mission of making sure that 'human development reaches everyone everywhere."*

Top-Down Approaches?

- I am not a big participant
- There are plenty of brilliant people that know how to do top-down better than me
- Everyone knows them – require good cooperation between government / business and academia
  - In the USA, for example, there is the SBIR program
  - Economic clusters and Enterprise zones
  - Nanotechnology consortiums
  - Boards of innovation
  - NGO systems
  - Etc.

Nanotechnology…Time Criticality



Prof. Siddharth Jabade, VIT, Pune 2017

Nano-reality Space … Densely Dotted… Crowded Nature of Inventions

$$R = \frac{\text{Corporate nanotech. patent applications}}{\text{Corporate nanotech. publications}}$$

R was 0.4 in 1999

Grew to 0.8 to 1.1 in 2003

…1 to 1.5 in 2006-2007

Surge in utilization of nano-concepts in produces / processes

Youtie, J., Shapira, P., and Kay, L., Anticipating developments in nanotechnology commercialization, http://stip.gatech.edu/wp-content/uploads/2010/09/commercialization-nano-2010-8final.pdf.

Fostering Nanotechnology Innovation?

- What makes this distinct from the previous case?
- What makes nanotechnology special?
- We have the same players…. Just different kinds of research
- What special policies and processes need to be created to support this burgeoning technology?

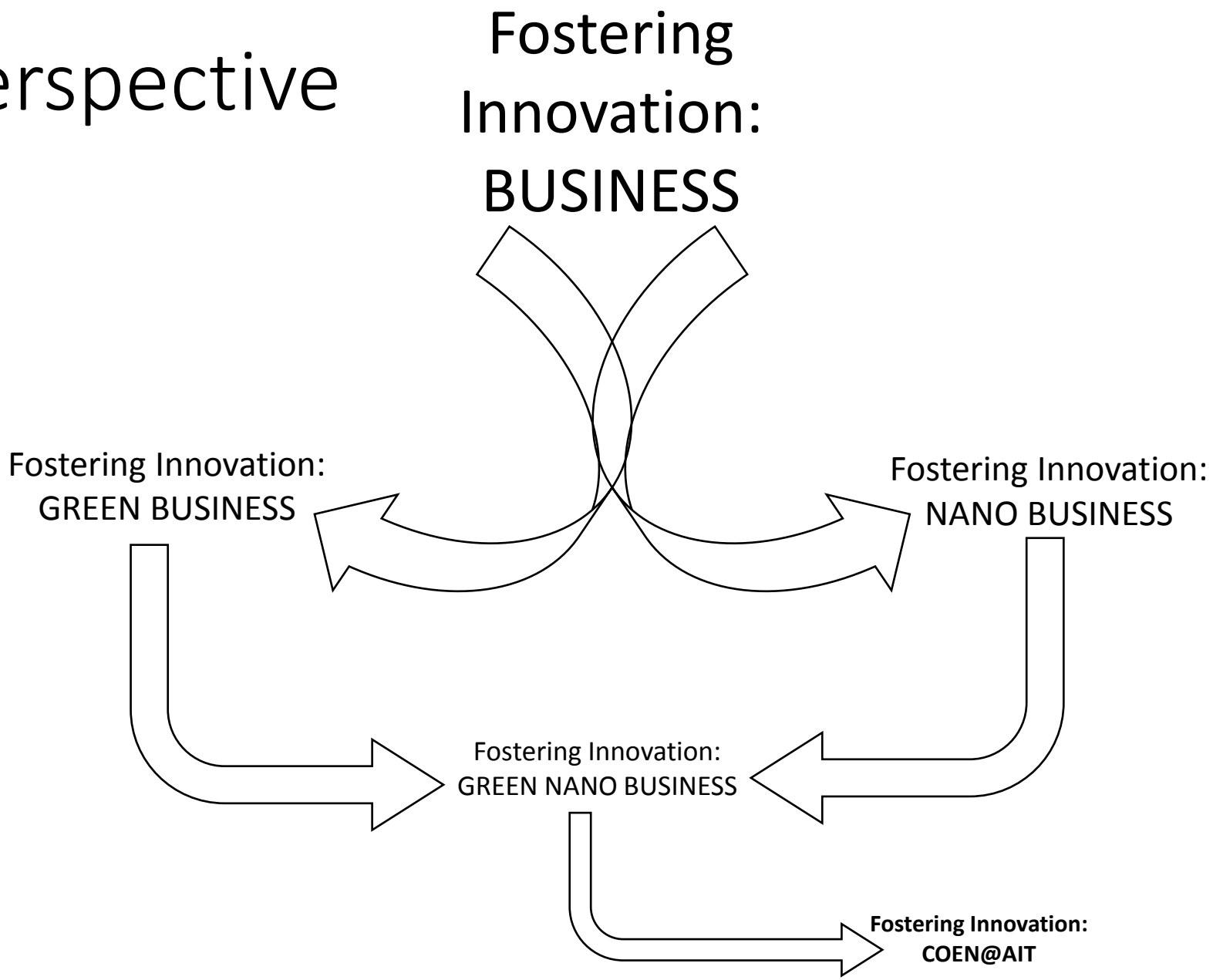
The Bottom-Up Perspective!

- Models based on Dr. Ioan Marinescu of Toledo University and Dr. Siddharth Jabade of Vishwakarma University of Pune, India

- SIMPLE PLAN ….. Seek out industry …. Have them contibute “small, reasonable amounts of funding” ….. Conduct 1 to 2 year studies

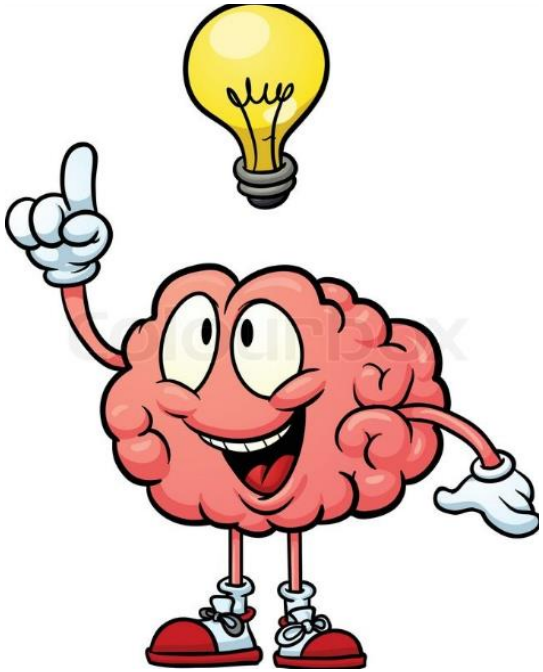
- Key ingredient? Seek out several industries

Perspective



Nano is Easy (Maybe)

- Perhaps easy because it is so diverse that cooperative relationships with industries could and should be found
- How to do it?



There is a new driver!

- On the average it takes about 30 years for a new material to be discovered in the lab and deployed in a commercial product" …. May be accelerated nowadays
- According to the America Physical Society (APS) "'Designing' new materials is relatively new territory"
- "There is a move to away from institution-driven trial and error experiments"

S. Chen, Mining Computer Simulations for New Materials, *APS News*, APS March Meeting 2017, Vol. **26**(4) www.aps.org/publications/apsnews/201704/mining.cfm

It is called SIMULATION !!
For Industry Assistance

- And it is very attractive to industry
- Companies help you buy the software (there are many amazing softwares out there now)
- You develop new materials and then predict macroscopic properties
- According to vendors (e.g. ANSYS™, Materials Studio™, AspenTech™ and COMSOL Multiphysics™), companies can save 10 times the effort and time required for experiments

How can simulation, academia and industry be linked?

- Industrial research labs are expensive — how many PH.D's can one company afford
- Yes of course, really big companies can afford to do this
- Academia has the Ph.D.'s and the experts but needs help in purchasing the software and co-processor systems and support graduate students
- With these new softwares, academia does not need more than a few Ph.D.'s to conduct simulation of highly integrated systems

COEN@AIT's Approach?

- Government funding of research is difficult to achieve
- COEN has decided that its best opportunity lies in its ability to work with industry
- But even then, how?
- Our hook is SIMULATION – Industries love it.

Focus on Our Own Experience

- The rules of engagement are simple
  - Seek out industry
  - Propose “Industry Assistance”
  - Execute Simulation / Experiment cycle
  - Develop new material / prototype
- Intellectual Property / Technology Transfer
  - No road blocks. No deal breakers
  - We understand industry’s needs
- Industry endows us with more funds / projects

How to Find Industry

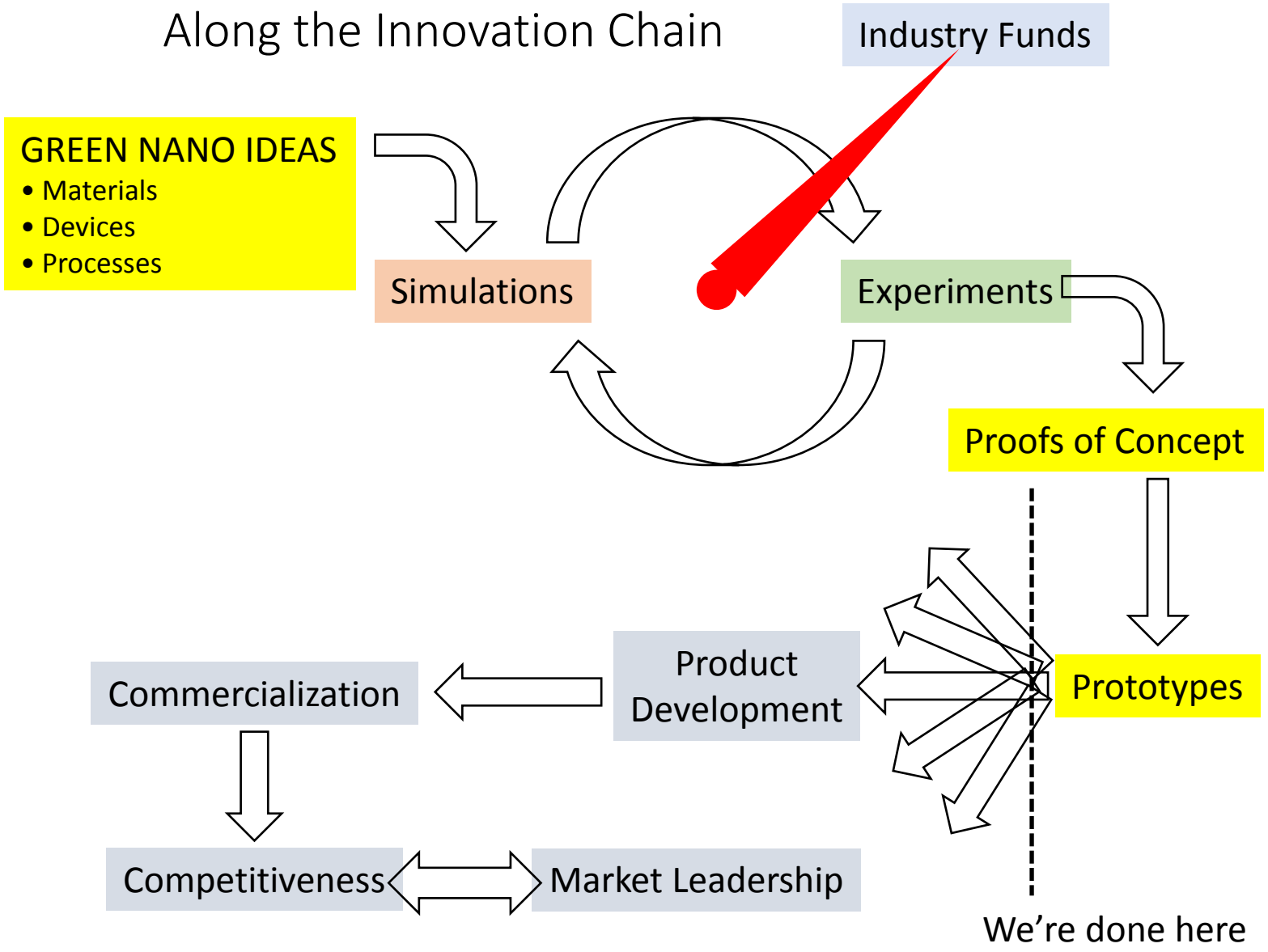
- AIT has an incredible industry portfolio
- Promote “nanotechnology events” and invite industry
- Promote smaller seminars focused on a researched topic that is surely of interest to industry
- Invite single industries for discussion
- Of course, attend exhibitions and trade shows
- There are many ways

Locking It Up

- Sign Memorandum of Agreement (MoA) that describes
  - Funding
  - Timeline (usually two to three years)
  - Expectations / deliverables
  - Non-disclosure agreements
  - Licensing and technology transfer (very simple at AIT)
- If there is added value, then the cycle can be repeated
- Deal breakers are usually big university policies and bureaucracies

Simple Cycle

Along the Innovation Chain



Industry Responsibility

- All the “blue boxes” need to interface with top-down sources and networks
- There are many ways for academic-industry partnerships to be exploited
- There is a great opportunity in ASEAN to form an international ”green-nanotechnology” partnership
- But this is all top-down kind of policies and procedures

Examples of Green Nano Innovations

- Environmental sensing
- Clean car nanotechnologies
- Cellulose nanofibers
- Battery nanotechnology
- Agricultural
- Green products
- Solar cell technology

Fostering Innovation in Green Growth, Organization for Economic Cooperation and Development, OECD Green Growth Studies, 2011

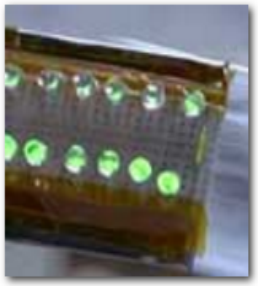
Focus on the AP/ASEAN Region

- Sustainable development and nanotechnology
- Nanotechnology and the environment
- Nanotechnology innovation, research commercialization, technology transfer and safety

- BOTH TOP-DOWN AND BOTTUM-UP METHODS NEED TO BE ESTABLISHED

Innovations? Energy

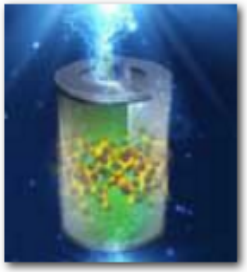
A giant leap towards inexpensive and large-scale fabrication of triboelectric nanogenerators for sustainable energy



Notwithstanding the progress in extracting renewable energy from many natural resources through nanotechnologies, some 60 research groups worldwide have now begun to develop triboelectric nanogenerators (TENGs) for harvesting energy from 'good (mechanical) vibrations' including human walking and ocean waves, which are otherwise wasted. Nanostructuring the materials in a TENG device amplifies the produced energy by increasing...

Posted: Apr 12, 2017

Improving Li-ion batteries with nanostructured conductive polymer gels



The electrode in lithium-ion (Li-ion) batteries is an integrated system in which both active materials and binder systems play critical roles in determining its final properties. In order to improve battery performance, a lot of research is focussing on the development of high-capacity active materials. However, without an efficient binder system, these novel materials can't fulfill their potentials. Researchers have now ...

Posted: Mar 28, 2017

RMIT University

This New Graphene-Based Electrode Could Boost Solar Storage by 3,000%

Hello, future.

SIGNE DEAN 16 APR 2017

Drawing inspiration from the plant world, researchers have invented a new electrode that could boost our current solar energy storage by an astonishing 3,000 percent.

sciencealert.com/new-graphene-based-electrode-could-boost-solar-energy-storage-by-3-000

Innovations? CO_2 Remediation

Transforming greenhouse gas CO2 into carbon nanotubes

In two new studies, researchers show that cement plants can have their carbon dioxide exhaust eliminated while co-producing carbon nanotubes. They demonstrate that with their C2CNT (carbon dioxide into carbon nanotubes) process, a wide portfolio of tailored carbon nanotubes, such as those with special shapes or conductivity can be made. C2CNT is a straightforward process that transforms CO2 to carbon nanotubes by molten electrolysis...

Posted: Mar 21, 2017

Application of Social Networks

- Role of multi-level social networks in developing new products: intra-cluster / inter-cluster

R.T.A.J. Leenders and W.A. Dolfsma; Social Networks for Innovation and New Product Development, *J. Product Innovation Management*, **33**(2), 123-131 (March 2016)

- Nanotechnology blogs
  - Futuretime Nanotechnology
  - Nanowerk
  - Sustainable Nano
  - Nanodot: the Original Nanotechnology Web Blog
  - Nanotech
  - Nanotechweb.org

F. Anderson, Top 5 Nanotechnology Blogs, Biolin Scientific, November 10, 2015, blog.biolinscientific.com/top-5-nanotechnology-blogs-2015

Many Thanks

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Asian and Pacific Centre for Transfer of Technology

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