Creativity and Invention: Role in the Educational Mission of Universities

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Role of Institutions of Higher Learning

• **Education**
  - to develop high quality manpower

• **Basic Research and Development**
  - to develop new knowledge

• **Applied Research and Development**
  - to develop advanced technologies

• **Develop Inventions and Intellectual Property**
Inventions Drive Technology

- All technology begins with invention
- Invention drives technology markets
  - Communications
    - Telegraph, telephone, cellular, internet
  - Information Technology
    - Computing, semiconductors, software
  - Biology
    - Vaccines, Bio-medical devices, Diagnostics
  - Energy, Environment and Water

ENORMOUS SOCIO-ECONOMIC BENEFITS
The Traditional Path

1. Extraction of natural resources
2. Heavy industry
3. Low-value mfg. and assembly
4. Low-value services
5. Innovation and high-value services
For A Technological Shortcut
You don’t have to Think Linearly!
Extraction of INTELLECTUAL resources

Invention of services

Low-value services

Innovation and high-value services

Menial labor and heavy industry

Low-value manufacturing and assembly

The Shorter Path through Inventions

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IV is the largest dedicated IP investor in the world

Investors include U.S. universities, foundations, and major global corporations

Invention Development Fund (IDF) is one of IV’s various funds and it partners with inventors
technology and IP licensing

Identify problem areas that can lead to future products, industries & companies

licensing of invention rights to companies

upfront awards and profit-sharing with inventors

agreement with IDF

INTELLECTUAL VENTURES
ENERGY — Inputs Needed

- Coal gasification technology – Thermal power
  - Plant efficiency improvements
  - Cleaner processing

- Solar power – working towards grid parity and meeting the NSM 20 GW goal by 2020
  - Solar PV cell / module / BOS efficiency improvements
  - Solar thermal concentrator technologies

- Power utilization efficiency
  - Centralized power transmission – loss reduction
  - Energy-efficient materials of building construction
  - Fuel-efficiency – Automobiles / heavy machinery / pumps
Biomass Approach to Reduce or Replace Fossil Fuels

The Problem

• Cellulosic ethanol is a non-food disruptive, renewable replacement for fossil fuels. Capital costs for commercial plants, however, remain high. Advanced low-cost biomass pretreatment technologies that distribute capital costs across the biorefinery value chain will allow a more rapid introduction of cellulosic fuels and products to the marketplace.

The Opportunity

• The bioethanol market expected to grow from $70B today, to approx. $170B by 2021. Cellulosic biorefinery technology will impact a wide range of industries. In addition to transportation fuel, cellulosic derived sugars may be utilized to manufacture renewable plastics, detergents, cosmetics, pharmaceuticals and other products.
Biomass Commoditization

Invention Areas of Interest

- Intellectual Ventures is seeking data driven biomass pretreatment technologies based on fungal/enzymatic and ionic liquid processes.
- Efficient low to medium scale processes producing a stable, cellulose enriched, biomass commodity
- Ionic liquid solvents that do not require drying of the biomass
- Ionic liquid, or other liquefaction technologies, that provide cellulose enriched, low-viscosity liquid
- Enzymatic processes ensuring complete mixing
- Improved pretreatment process monitoring and control technologies
Opportunity: Bio-Refinery

**Feedstocks**
- **Pilot Plants**
  - Wheat Straw
  - Iogen Biorefinery Partners
  - Wood chips
    - Waste from furniture manufacturer.
    - Blue Fire Ethanol Inc.
- Other Potential Feedstocks
  - Switch grass
  - Corn stover
  - Food processing wastes
  - Yard waste
  - Many others

**Separation of cellulose, hemicellulose and lignin.**

**Cellulose and hemicellulose converted to mixed C5/C6 sugars**

**Bioethanol Primary product**

Opportunity exist for diverting some of the mixed sugar stream for use in producing high value added products. See RFI 110104.

Lignin is a by-product, often burned for process energy. Lignin has varying properties such as polydispersity, solubility, extent of crosslinking, etc. Greater variation in properties from mixed biomass sources.

**OPPORTUNITY:**
Lignin is a complex aromatic compound and represents an opportunity as a feedstock for high value added products that provide improved economic benefit as compared to burning for process energy.
Value Chain and End Markets

Food disruptive feedstocks
- Corn kernels, sugarcane, soybeans, etc.

Biomass cellulosic feedstocks
- Corn stover, bagasse, wood chips, switchgrass, municipal waste

Oils
- Oils are expressed from soybeans, corn, castor beans, etc.

Sugars
- C5, C6 and C12

Chemical Building Blocks
- Solvents, polymers, surfactants, amines, emulsifiers, plasticizers, resins

Biofuels $75 bn (2011)
- Biodiesel $6 bn
- Ethanol $69 bn

Biofuels $190 bn (2021)
- Biodiesel $20 bn
- Ethanol $170 bn
- Butanol $?? bn

Other Potential Products (2011)*
- Detergents $56 bn
- Cosmetics $170 bn
- Pharmaceuticals $643 bn
- Packaging $142 bn
- Coatings $90 bn
- Textiles $450 bn

*Currently other potential products listed are primarily manufactured using petroleum derived chemical building blocks, hence, bio-derived products will likely capture only a fraction of these markets.
# Technology unmet needs

## Unmet Needs (materials & Structures)

- Robust Enzymes (pH, Temp etc.,)
- Enzymes (Allosteric too) and their combinations
- Ion-chelating agents
- Restructuring (debonding) (reduction in cellulase binding capacity)
- ILs: Temp, Water, control
- Localized activation (ILs, Enzymes)

## Unmet Needs (Process)

- Low temperature
- Large scale production
- ESP: MnP; Laccases, ILs,
- Localized breakdown
- Non toxic
- Non-corrosive
- Low cost
- Low environmental impact manufacturing process

## Activators, Accelerators, Mediators, Cleavers, Effectors, Catalysts
WATER — Inputs needed

- Cost-effective desalination technologies
- Low-cost point-of-use filtration systems (Tata’s Svach)
- Technologies to reduce use
  - e.g., Elimination of water in dyeing processes
- Technologies to recycle water efficiently
  - Rain Water Harvesting – standardization of methods / materials optimization by geography / climate / soil type
  - Ground water remediation
  - Grey water recycling
  - Industrial use of sea water
Removing Oil from Oil-Water mix: Hydrophobic, porous, superabsorbent polymer

**FEATURES**
- Selectively adsorb oil from oil-water mixture
- Takes almost diesel 12x its weight at Room temperature
- Leaves water completely oil free
- Releases 50-60 % of diesel by simple hand squeezing
- Can be re-used multiple times without loss of functionality
- Stable up to 500°C

E.g., Recovery of diesel oil from water
Supercapacitor for water purification

Features:

- Recovers 90% of the input water after purification
- Desalinate sea water using 1V power supply
- Regeneration by reversing polarity
- Removes inorganic arsenic species (arsenate, arsenite)
- Desalination efficiency of 70% for sodium, 67% for magnesium and 73% for calcium — tested upto 20 cycles

Simultaneous removal of multiple elements
Automotive Inventions

**Materials:** Ultra lightweight, better strength, tagging/tracking & recycling

- Coolants
- Environment Control
- Air purification

**Counterfeit**

**Magnetic materials**

**Physical Sensors:** temperature, humidity, Oxygen, stress/strain

**Catalysts**

**Energy Harvesting**

**Cleaning agents/solvents**

**Chemical Sensors/sequestration:** odor, VOC, PAH, Gas sensors

**Adhesives**

**Battery:** Super capacitors

**Coatings Functional:** (hydrophobic, phylic, Scratch proof)

**Interiors:** Bromine free flame retardants, Dyes, anti-bacterial

**Air Separators**

**Lighting/ Interior-Exterior**

**High Temperature Adhesives**

*Italicics – in works*
the food chain: from plough to plate

Farm
- Nano-fertilizers
- Controlled-release Products

Quality
- Mobile and instant read-out of grain characteristics to determine quality and price

Preservation
- Oxygen scavenging
- Spray-on preservation
- Food preservation enzyme
- Protein stabilizer

Packaging
- Antimicrobial coatings
- Biodegradable copolymer
- Freshness indicator
- Colorimetric contamination detection
Counterfeit prevention

Market Drivers
• Fake currency
• 2011 Auto counterfeit parts US$45B
• Similar issues in other industries

USPs
• Can be coated on any surface
• Cost < US$0.10
• Different molecules and mesoflower structures could be manipulated to provide 10-20 distinct spectral signatures

Invention: SERS tag-functionalyzed, silica-protected, mesoflower
technology transfer

1. a-prototype
   - demonstration of the principal innovation
   - focuses on characterizing the key innovation or effect
   - prototype often does not consider system level requirements

2. b-prototype
   - refinement of the a-prototype
   - highlights the innovation or effect but in more optimized form
   - prototype considers system level requirements although not fully optimized

3. engineering sample
   - sample attempts to meet every feature of product specification
   - production-ready
   - revisions based on customer input

4. production

invention development

customer / product
The Earth Needs Inventions

- Energy generation and distribution
- Water management
- Healthcare
- Food and resource management
- Ecological balance
- Addressing the digital divide
- Waste management
- Counter-terrorism
Create an IPR Environment

- Sustain & grow creative ideas in an ethical environment
- Provide capital to invest in IP creation
- Translate the ideas into products, processes & services
- Develop comprehensive IP commercialization frameworks

*This requires an appreciation for and an awareness of Intellectual Property-related issues*
10 countries, >400 institutions

Approx. 4000 inventors
Invent for the Benefit of Mankind

Ignite a Million Minds in Academic Institutions