TRANSLATING SCIENCE INTO TECHNOLOGY AND PRODUCTS: A VIEW FROM CSIR

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New Delhi

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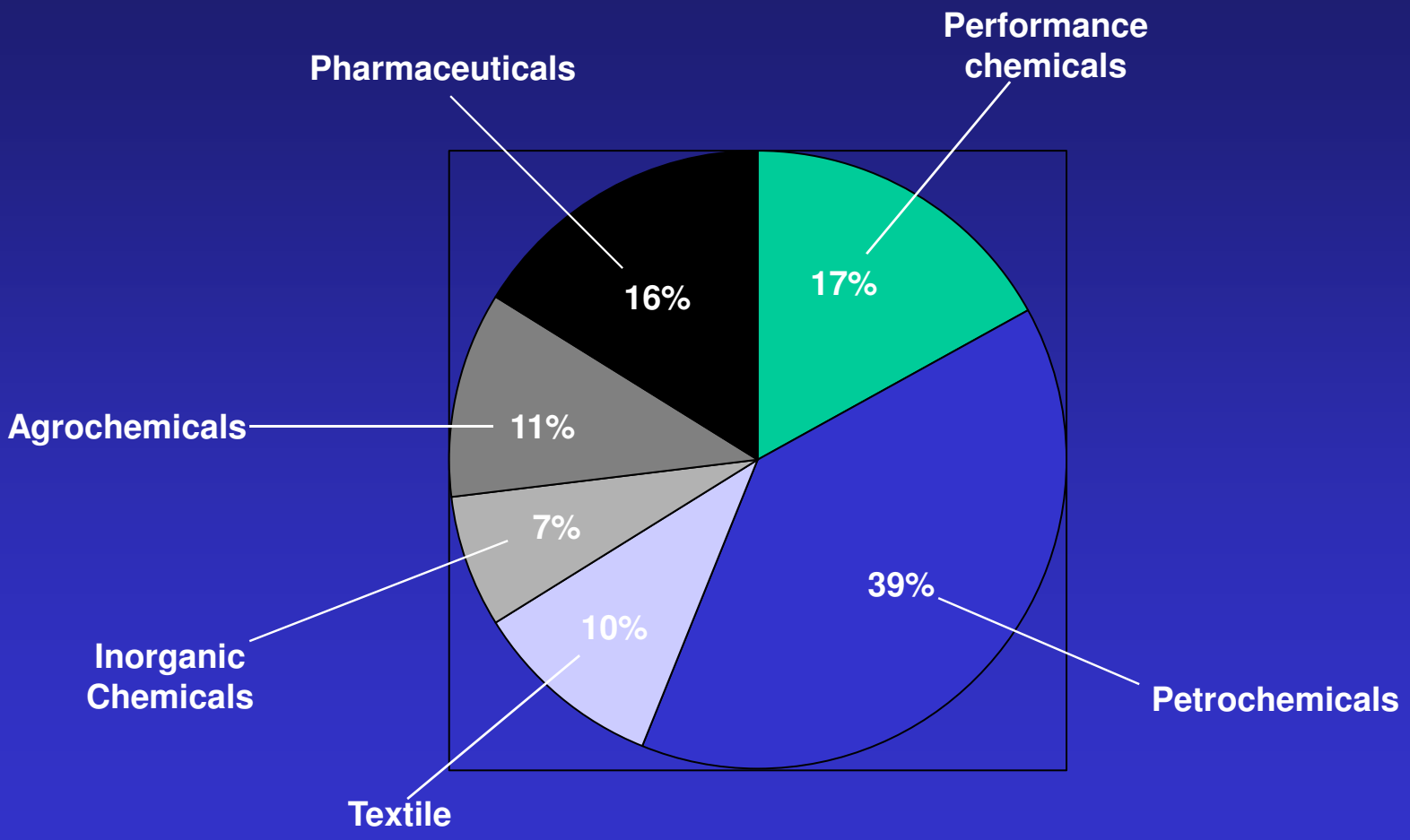
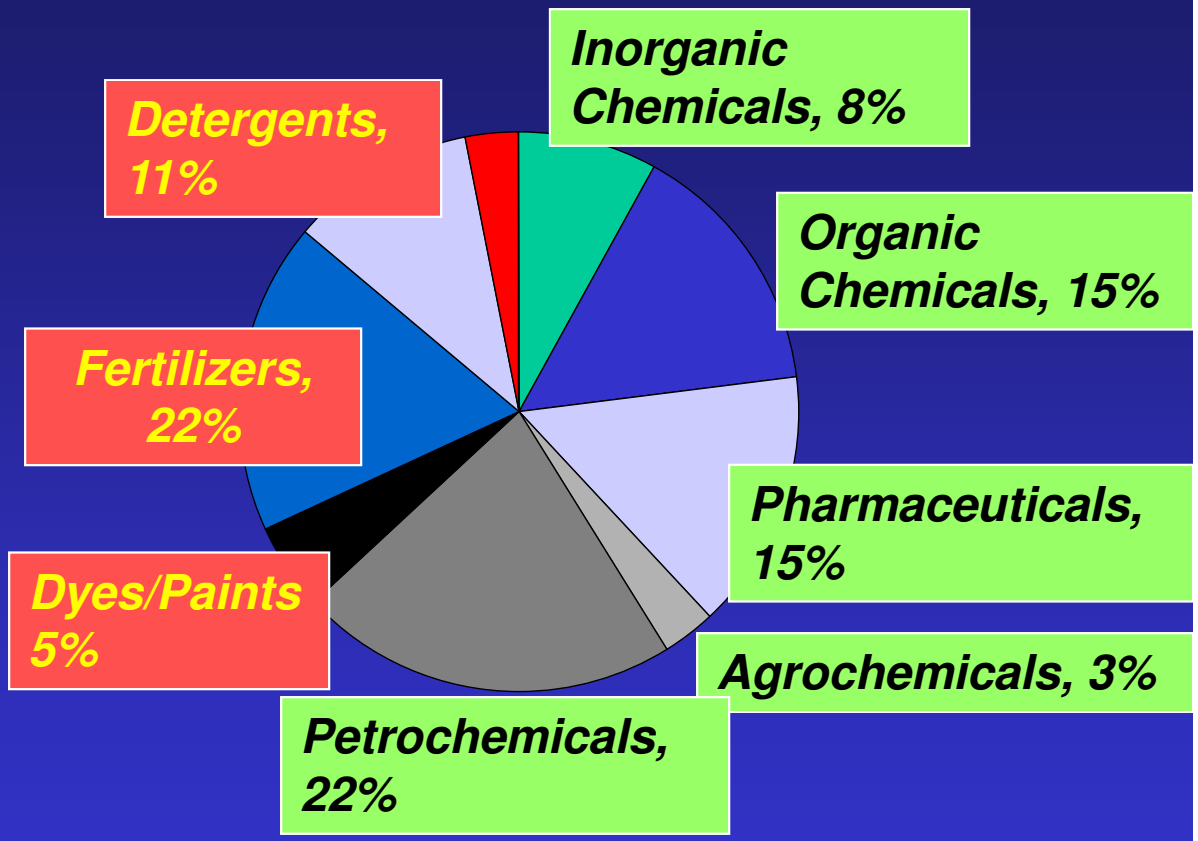
WORLD CHEMICALS MARKET

A THREE TRILLION $ INDUSTRY



INDIAN CHEMICAL INDUSTRY

- Chemical industry in India contributes to 3 % of its GDP and 14 % of its exports
- Revenues : US $ 55 billion in 2007-08 and CAGR of 11 % (2002-07)
- Projected to grow to US$ 75 billion by 2011
- Indian Chemical industry 12 th largest in the world and 3 rd largest in Asia



Commodity chemical industry is technologically mature; all innovations are incremental in nature

CHANGING TOPOGRAPHY OF CHEMICAL INDUSTRY

- **Globalization of business**
- **Shifting manufacturing geographies**
- **Growing concerns for sustainability**
- **Changing customer expectations driven by new demographics**
- **Changing work force requirements**
- **Impact of ICT**
- **Industry consolidation**

J. Mack, Speciialty Chemicals : Competitiveness in Global Markets, American Chemistry Council, Leadership Conference, Houston, USA October 2001

FORCES OF CHANGE IN THE CHEMICAL INDUSTRY

- **Unprecedented rise in fuel and raw material costs**
- **High cost of new product introductions; difficulties in identifying new growth platforms**
- **Increasing regulatory (environment, health and safety) frameworks**
- **Faster technology diffusion / commoditization of products leading to quicker price / margin erosion**
- **Supply chain is taxed by breadth of markets, products and geography**
- **Increased global segmentation in terms of technology providers , low cost producers and large domestic markets**

Merely building capacities or growth via acquisition without a specific game plan is no longer sufficient for survival

FORCES OF CHANGE IN THE CHEMICAL INDUSTRY

- *Chemical industry is a mature industry*
- *Innovations are largely incremental in nature*
- *Disruptive innovations are becoming scarcer and fewer*

GLOBAL ISSUES

- **Difficulties in identifying new growth platforms**
- **Difficulties in creating value and high entry barriers for new product introductions**
- **Globalization of economy, reduced barrier to movements of goods services**
- **Increased global segmentation in terms of technology providers , low cost producers of feed-stocks and large domestic markets**

INDIAN CHEMICAL INDUSTRY: CONCERNS

- **Branded as low cost supplier/outsourcing/contract manufacturing entity for fine and specialty chemicals**
- **Innovation deficit; few new product offerings based on proprietary knowledge / IP. Low R&D intensity with the exception of drugs and pharmaceutical sector**
- **Conventional engineering practices**
- **Poor application development skills, especially for specialties**
- **Talent deficit; chemistry and chemical engineering education no longer considered fashionable; serious issues of talent retention/flight**

Chemicals and chemical industry is not perceived as sexy as Biotechnology or IT

CHEMICAL INDUSTRY : 2020 TECHNOLOGY VISION

- **Reduce feed stocks losses to waste / byproducts by 90%**
- **Reduce energy intensity of processes by 30%**
- **Reduce emissions including CO_2 and effluents by 30%; move towards zero discharge goals**
- **Increase use of renewable resources as building block for chemicals ; combine judiciously chemical and biological processes to achieve sustainability goals**
- **Small/ modular chemical plant designs for enhanced safety and reduced quantities of inventory storage**
- **Increase the conversion of stoichiometric processes to catalytic processes; batch to continuous processes**
- **Understand better the impact of chemicals and materials on environment, safety and human health**

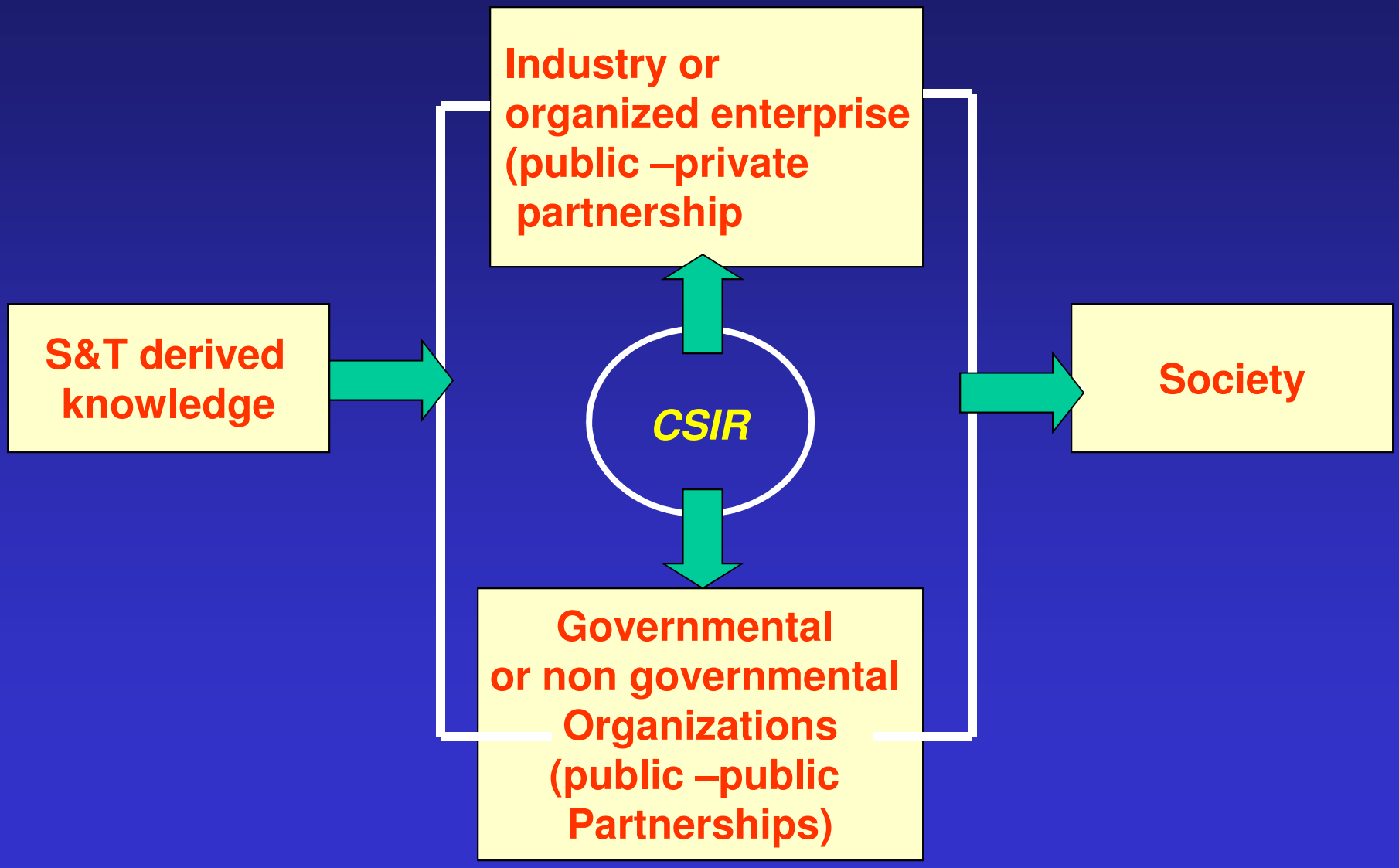
FUTURE CHALLENGES

- **Low carbon economy**
- **Sustainability (GHG, LCA, Carbon and water footprint, energy conservation and efficiency, sustainable energy, impact of human activity on ecology, environment and habitats)**
- **Distributed manufacturing**
  - **Process intensification / simplification**
  - **Smaller footprint**

RELATIONSHIP MODELS FOR REALIZING OUTCOMES

- **Conversion of knowledge into economic wealth requires partnership with industry or Government**
- **Innovative models of public / private partnerships need to be experimented with in our laboratories**
- **In a similar vein there is a need to focus on several societal missions with renewed focus on delivery to the stakeholders where active partnership with "Social Entrepreneurs" could greatly help in diffusing and replicating technologies in different strata's of society**

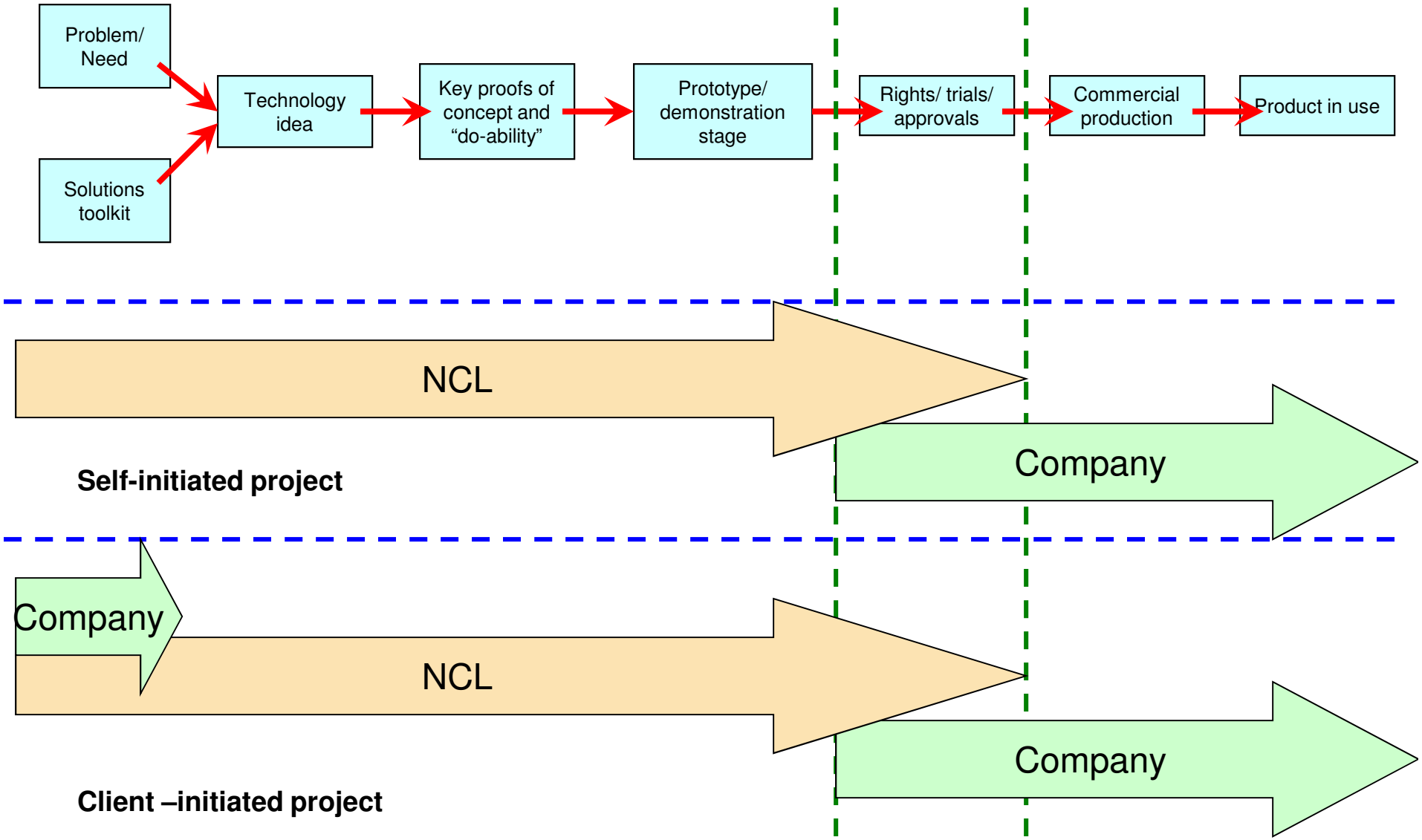
PARTNERSHIP IS ESSENTIAL FOR S&T REACH THE STAKEHOLDERS

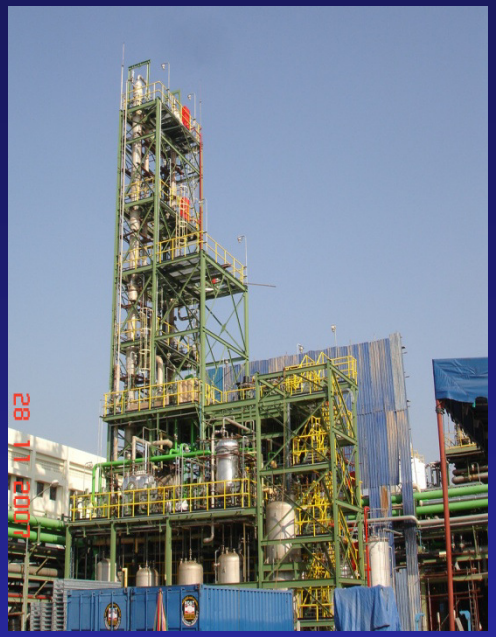


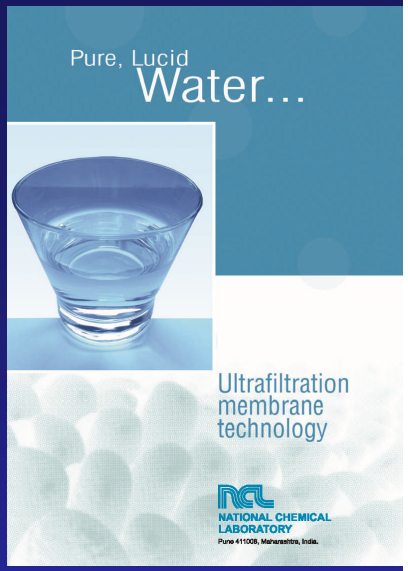
EXISTING TRANSLATIONAL MODELS

- **Sponsored / Collaborative /contract research**
- **Technical service**
- **Consultancy**
- **IP licensing**
- **In-house development of processes and products followed by licensing (with or without IP)**

Technology development & transfer: Conventional models



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PRODUCT FEATURES
BIOPORE Orbital Implants provide surgeons with porous biocompatible implants for orbital reconstruction following enucleation and evisceration procedures.
BIOPORE Surgical Implants are manufactured from linear high density polythylene. The porosity of BIOPORE Biomaterial is maintained large with average pore size larger than 100 micrometers and a pore volume in the 40-50 percent range.
The interconnecting, omni directional pore structure of the BIOPORE Biomaterial allows for rapid vascularization and soft tissue ingrowth.
RESULTS OF BIOPORE STUDY GROUP
WELCOME TO BIOPORE SURGICALS
BIOPORE surgical implants are manufactured in a wide variety of shape and sizes to meet many applications. The interconnecting open pore structure of the BIOPORE Biomaterial allows for tissue ingrowths. The porosity of the BIOPORE biomaterial is maintained large, with average pore size large than 100 micrometers and pore volume in the 50 percent range.
"Porous orbital implants have numerous minute channels, through which the orbital fibro-vascular tissues grow into the implant."
BIOPORE ORBITAL IMPLANT STUDY GROUP
Porous allograft materials such as hydroxyapatite and porous polyethylene are becoming increasingly popular as integrated orbital implants for volume replacement in an anophthalmic socket. A porous orbital implant permits fibrovascular integration with the host socket, thereby reducing the risk of extrusion, migration and infection.


5 blister strips of 10 tablets each.
S (-) Amlodipine Besilate Tablets
Asomex®-2.5
Emcure
S (-) Amlodipine Besilate Tablets
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5 blister strips of 10 tablets each.
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Batch No. : NAL.021
Mfg. Date : AUG.2002
Exp. Date : JULY 2004
Retail Price not to exceed Rs. : 19.50
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Each uncoated tablet contains :
S (-) Amlodipine Besilate equivalent to S (-) Amlodipine 2.5 mg.
Colour : Yellow Oxide of Iron
Manufactured by :
Emcure
PHARMACEUTICALS LTD.
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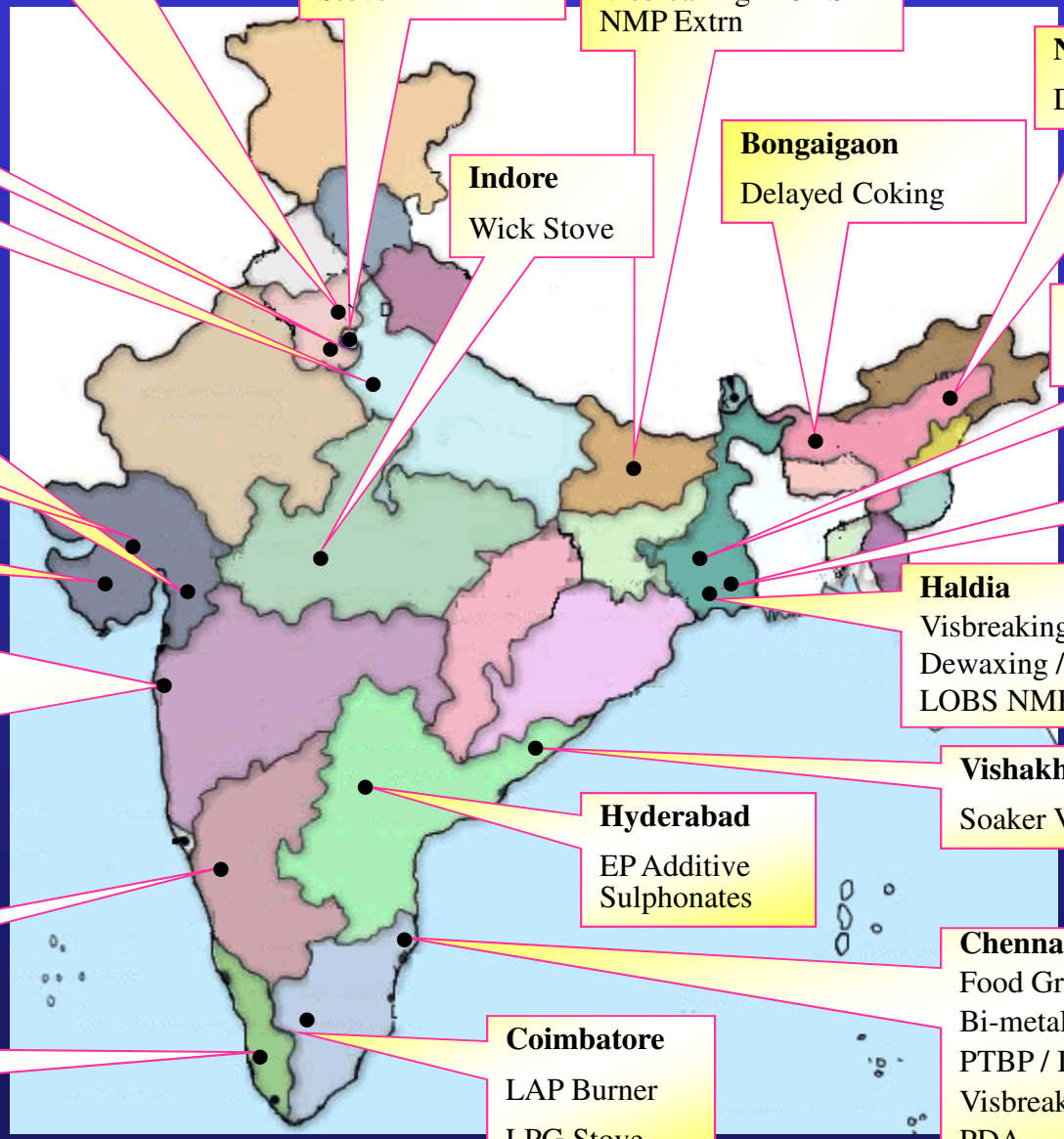
™ Trade Mark Owners.
Dosage : As directed by the Physician.
Store in a cool, dry & dark place.
Warning : To be sold by retail on the prescription of a Registered Medical Practitioner only.

IIP Technologies in Operation in India



Panipat Refinery
Soaker Visbreaking

New Delhi
LAP Burner Wick Stove

Barauni
Delayed Coking
Visbreaking LOBS
NMP Extrn

Faridabad
LAP Burner

Mathura Refinery
Visbreaking (Revamp)

Baroda
Visbreaking (Revamp)
Bi-metallic Reformer Cat
NTGG
Retrofit-kit

Indore
Wick Stove

Bongaigaon
Delayed Coking

Numaligarh
Delayed Coking

Durgapur
Ethanol Dehyd. Cat.

Ahmedabad
Sulpholane

Calcutta
LAP Burner

Rajkot
Wick Stove

Haldia
Visbreaking (Revamp)
Dewaxing / Deoiling (Revamps)
LOBS NMP Extrn

Mumbai
Bio-diesel
BT Extraction
FGH Production
Dewaxing Aid Additive
Hot Rolling Oil
PTBP / BHT
LAP Burner

Vishakhapatnam
Soaker Visbreaking

Hyderabad
EP Additive
Sulphonates

Bangalore
Impregnating Pitch

Chennai
Food Grade Hexane
Bi-metallic Reformer Cat
PTBP / BHT
Visbreaking (Revamp)
PDA

Kochi
BT Extraction
Visbreaking (Revamp)

Coimbatore
LAP Burner
LPG Stove

MODELS OF TECHNOLOGY TRANSFER : EXAMPLES FROM NCL

- *EPICHLOROHYDRIN*

  -Process chemistry developed at NCL and IP generated: IP licensed to ABG; joint development of process technology and validation of process economics with industry; industry invests in commercial development

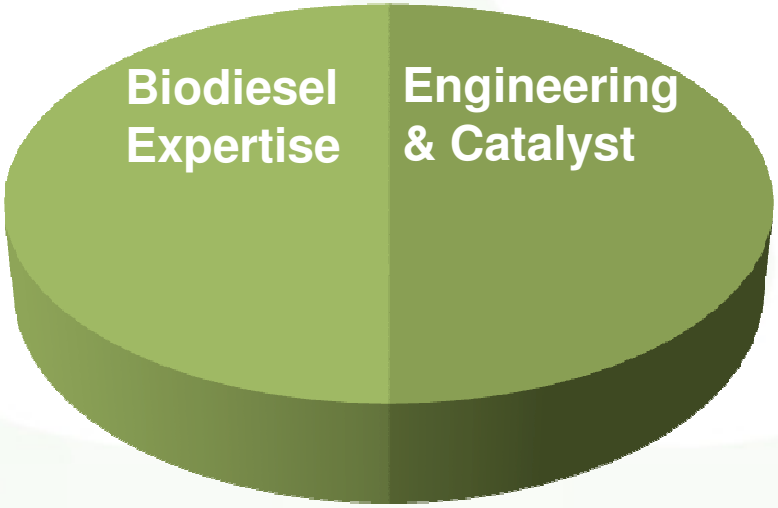
- *VALUE ADDITION TO BIOMASS IN AN INTEGRATED BIOREFINERY*

  -Process developed at NCL in a public private partnership model with industry involvement from early stages of project conceptualization ; industry invests in technology demonstration and validation

- *SOLID CATALYST FOR TRANSESTERIFICATION : BIO-DIESEL*

  - Basic chemistry discovered at NCL and IP generated : IP licensed to a start –up company, The start –up company raised finances based on the robustness of NCL IP; Technology validation by the company

Management Expertise



Strategic Partners

- One of largest catalyst producers in world
- 5,000 person, publically traded company
- Global production capacity

- Market leader for crude oil dewatering using electrostatic separation
- Co-developed novel method for separating biodiesel & glycerin

- One of the world's largest catalytic research institutes
- Government backed institute with over 200+ PhD's
- Focus on catalysis since 1980

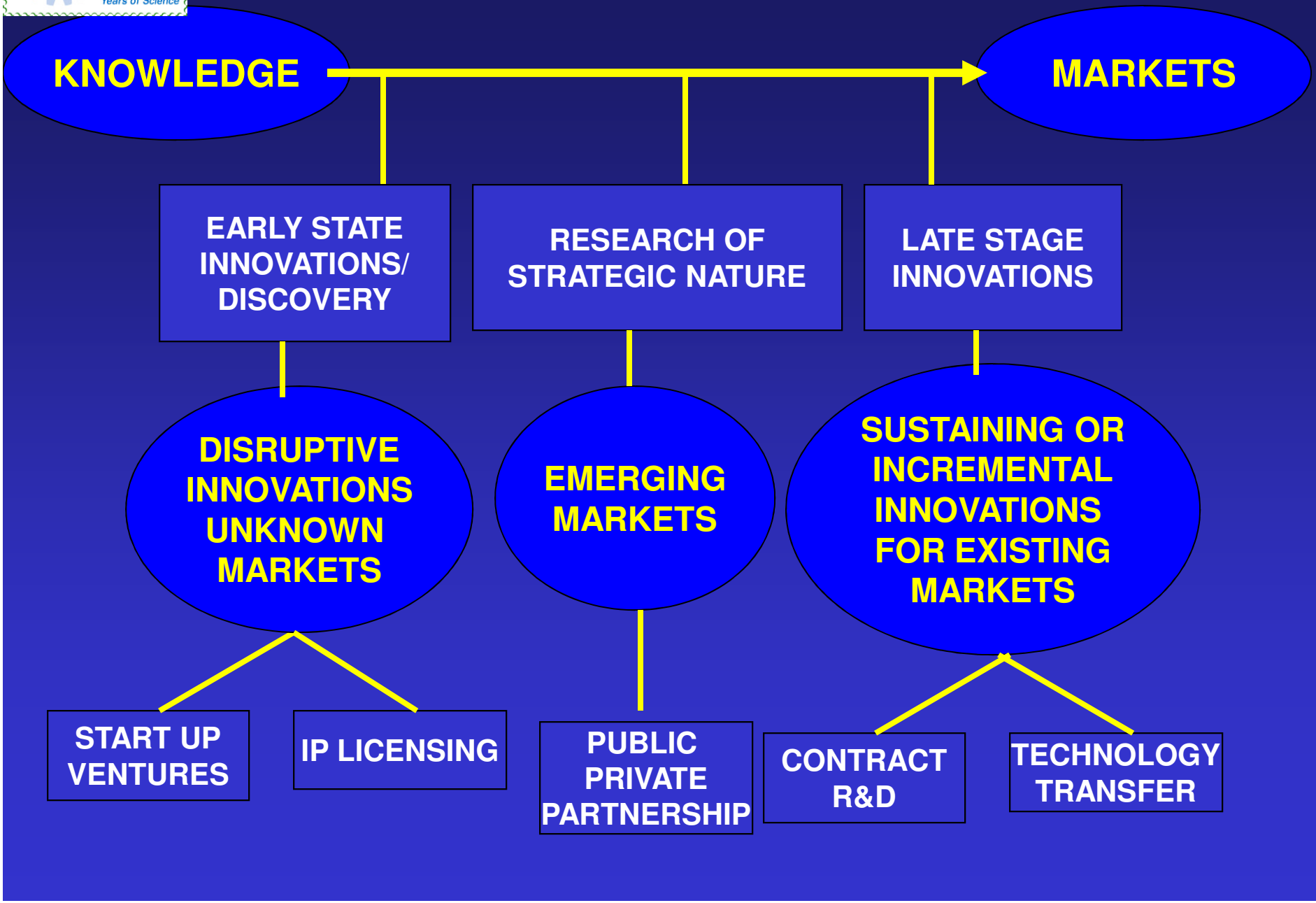
Ravi Randhava, PhD. – CTO
- Founder of Xytel – 700+ world wide process engineering company
- Focus on solid catalyst technology development

SOME USEFUL LESSONS LEARNT

- Invest in good basic / curiosity driven research leading to IPR / high quality publications
  - Intuition driven
  - New opportunities for generic patent

- Choose products / processes for development where the entry barrier is likely to be low
  - Difficult to license technologies
  - Single technology supplier items
  - Products having large transportation cost
  - Formulated or structured products

LINKING KNOWLEDGE TO MARKETS



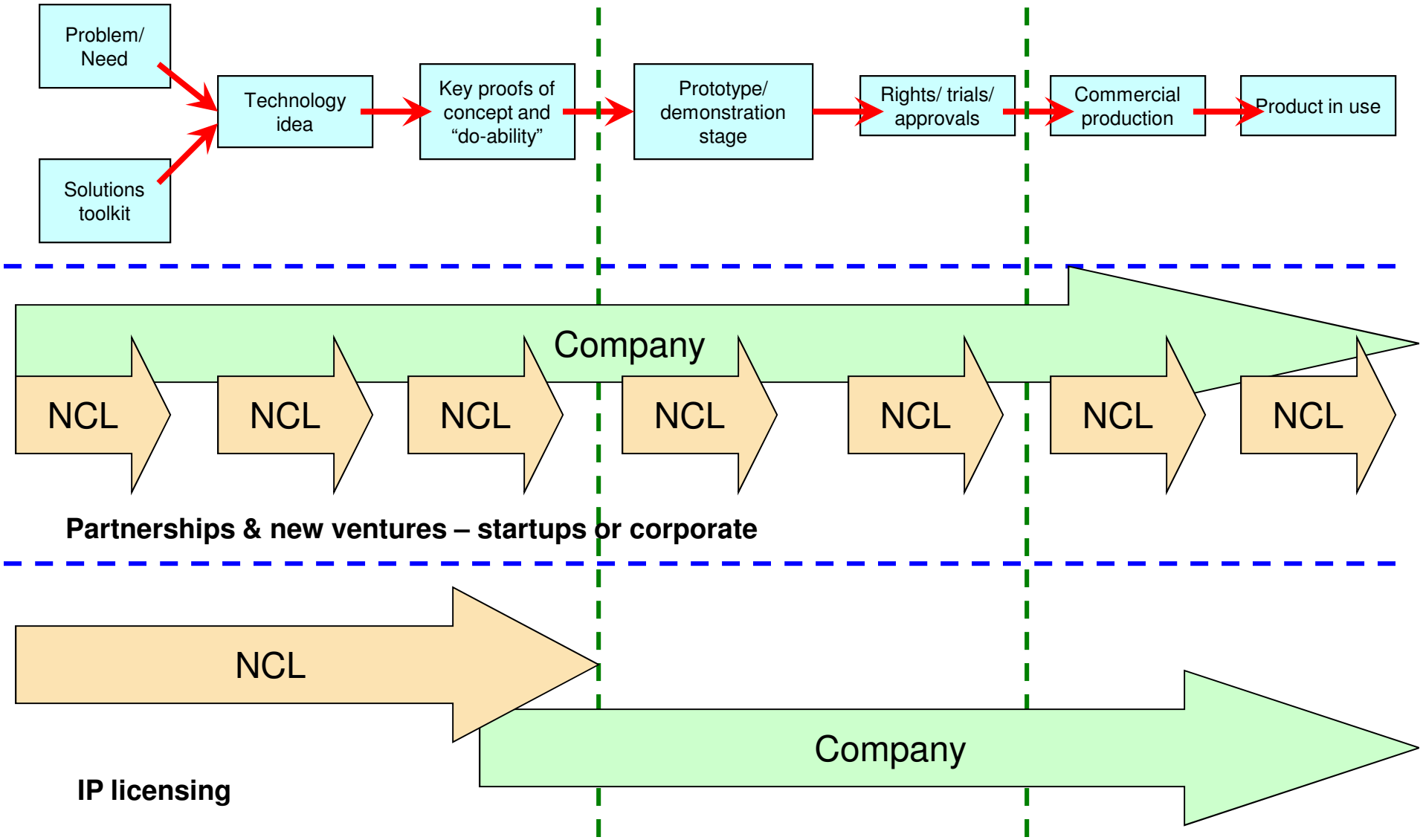
NEW INITIATIVES

- **Mission mode programmes through public-private partnership (NMITLI - New Millennium Initiative for Technology Leadership for India) (~ 35 projects, 167 public and 55 private sector partners, expenditure Rs ~200 crores)**

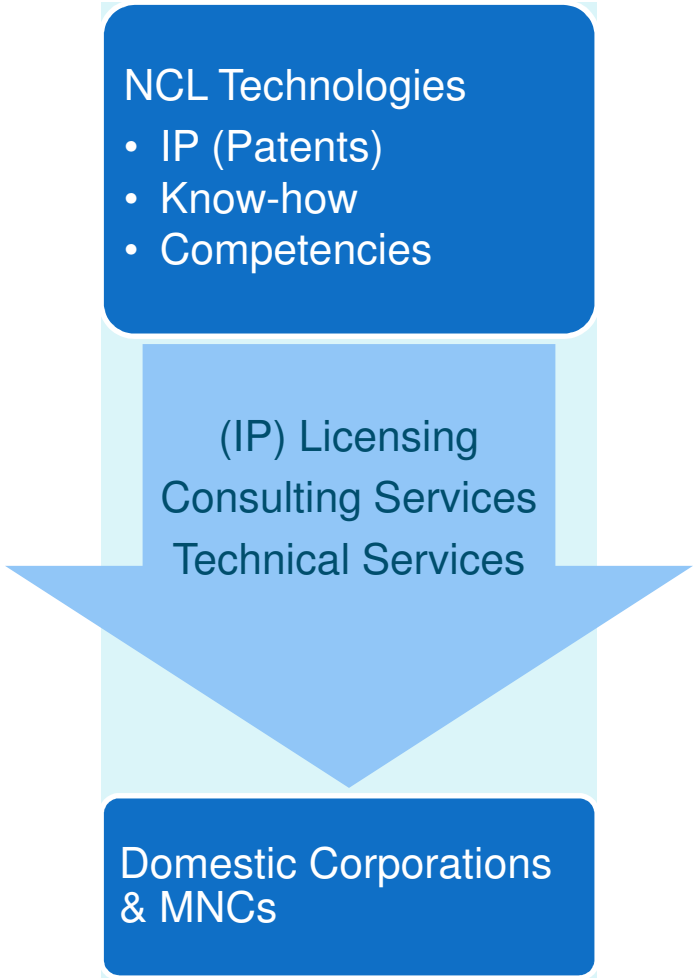
- **Knowledge alliances through public-private partnership; creating jointly owned and managed research entities with industry**

- **Encouraging knowledge driven entrepreneurship**

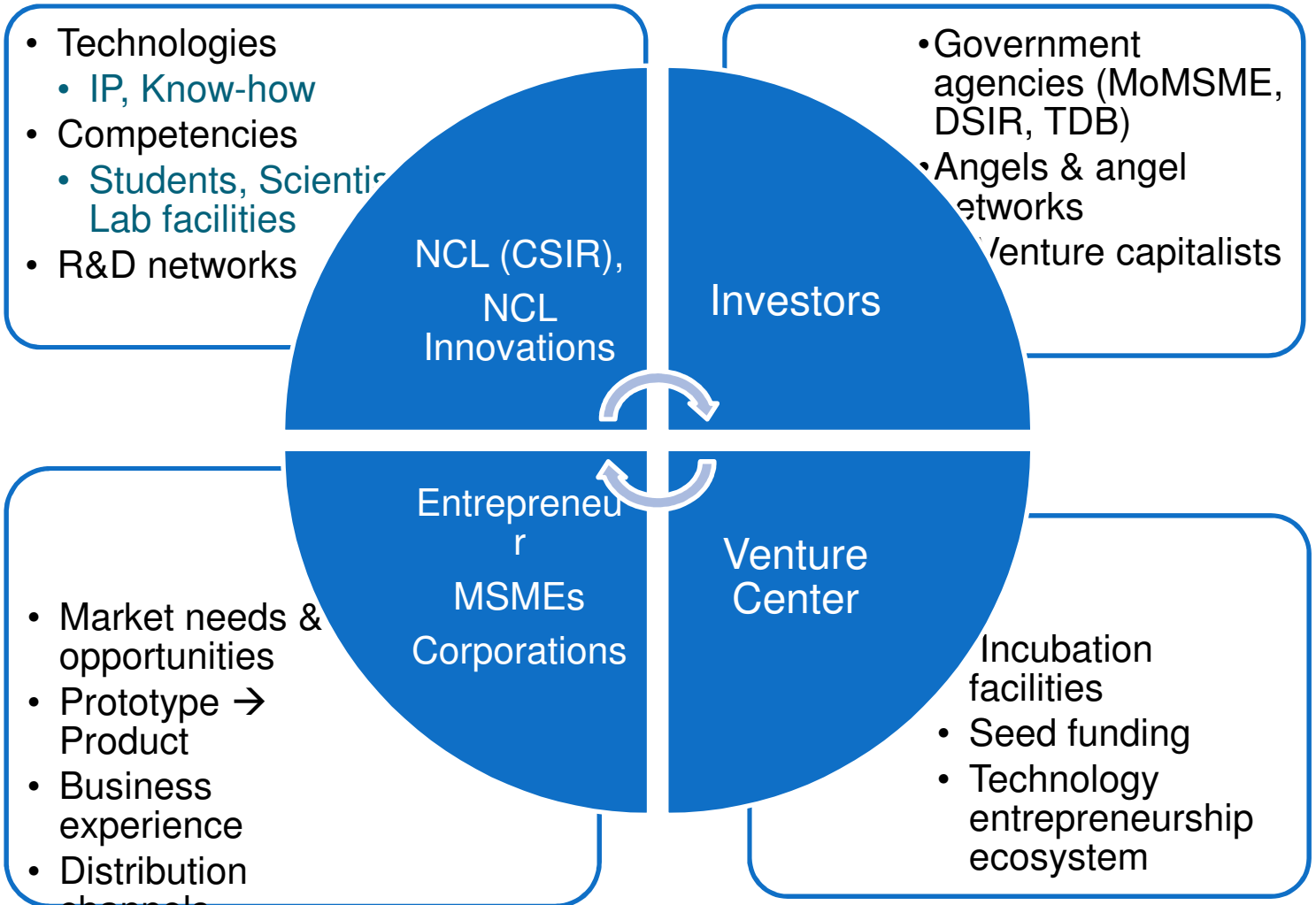
Technology development & transfer: Newer models



Technology Commercialization v1.0



Technology Commercialization v2.0



PUBLIC-PRIVATE PARTNERSHIP : CONSORTIUM MODEL

- **Areas of common interest to a few companies – access to generic knowledge**
- **Consortium agreements with service modules**
- **Project Advisory Boards with company participation**
- **Benefit sharing and possibility of bilateral projects**
- **Ownership of IP and proprietary knowledge vests with CSIR**
- **Rights of first refusal to consortium partners**

FACTORS THAT INHIBIT PUBLIC –PRIVATE PARTNERSHIP

- **"Gatorade" factor**

  - In the quest for windfall financial returns public institutions demand all encompassing IP rights and subsequent royalty payments from the corporate sector with such vigour that many projects are terminated by the lawyers ! Scientists in public organization vastly underestimate the effort needed to move an idea to a new product or service for which there is a commercial demand. This naivety can make negotiations over IPR and royalty issue an exercise in frustration

- **"Give us the money and we will work on something related to your interest"**

  - Scientists are usually looking for support for their own ideas, not those of others

FACTORS THAT INHIBIT PUBLIC –PRIVATE PARTNERSHIP

- **"Fund me for three years and I will give you a progress report "**
  - Timescales in public institutions are much longer than companies can tolerate; Companies are generally not in business to fund Ph D thesis
- **"Next quarter bottom line factor"**
  - Decreasing investments in medium and long term R&D
- **"We can buy any technology that we need"**
  -Acquire businesses with technology rather than develop
- **"For external research we will not pay overheads"**
  - Companies often sulk at paying real overheads to external research groups in spite of the fact that their internal overheads is often more than 100 % of their direct cost

BARRIERS TO KNOWLEDGE DRIVEN INNOVATIONS

- Cultural barriers (knowledge is free, making personal wealth out of knowledge is not right, separating the goddess of knowledge from the goddess of wealth in the Indian pantheon of gods)
- Immaturity of markets and risk averse
- Inability to connect basic discoveries with potential applications
- Weak innovation eco systems (mentoring, venture and angel funds)
- Peer recognition systems heavily biased in terms of abstract academic research; not enough incentives for individuals who wish to translate science into products and services

SOME USEFUL LESSONS LEARNT

- **Learn to walk the last mile**
- **Putting the team together and energizing the team**
- **Patience , perseverance and failure tolerant**
- **Who gets the glory and who gets the blame**
- **The role of a champion; the leader as a champion**
- **Going beyond the written contract**
- **Passion to succeed; Are you ready to stake your reputation?**

Science is an individual effort; technology is a collective endeavor

WHAT MUST CSIR DO FOR THE INDIAN CHEMICAL INDUSTRY ?

- **Demonstrate process intensification and application of micro-reactor technologies to the manufacture of fine chemicals. Build modular and reconfigurable continuous chemical plants with low capital cost and high process efficiency**
- **Demonstrate technologies to reduce waste, zero effluent discharge and minimize carbon footprint for chemical manufacturing processes**
- **Demonstrate Process Analytical Technologies for in process quality measurements**
- **Assist the chemical industry to shift to more sustainable raw materials and building blocks for the manufacture of chemicals**
- **Develop new products and processes to meet the growing global regulatory and environmental pressures, many of which are likely to act as non tariff barriers to export of products from India**

Can we conceive of a Chemical Technology Park in a PPP mode within CSIR where we can demonstrate the future of chemical manufacturing ?

TODAYS SCIENCE SEEDING TOMORROW`S TECHNOLOGIES

- Advanced and functional materials including nanomaterials
- Nano-structured materials and catalysis for energy conversion and storage (electrochemical, solar)
- Novel hybrid materials for harvesting solar energy
- Environmentally friendly polymers
- Biomaterials, tissue engineering and bio-conjugates for therapeutics
- Catalysis, chemical engineering and computational science to leverage clean technologies
- Establishing sustainable and /or renewable feedstocks for chemical manufacturing
- Harnessing modern biology to create a more sustainable chemical industry
- Selective separation processes for a diverse range of applications

SIGNIFICANT OPPORTUNITIES FOR DISRUPTIVE INNOVATION. HOWEVER, TODAYS CHEMICAL SCIENCE WILL REQUIRE A COMPLETELY DIFFERENT TRANSLATIONAL MODEL TO CONVERT KNOWLEDGE TO WEALTH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