INDUSTRY ACADEMIA INTERACTION : MYTHS AND REALITY

Knowledge Economy Partnership
Symposium on Collaboration between Industry and Academia
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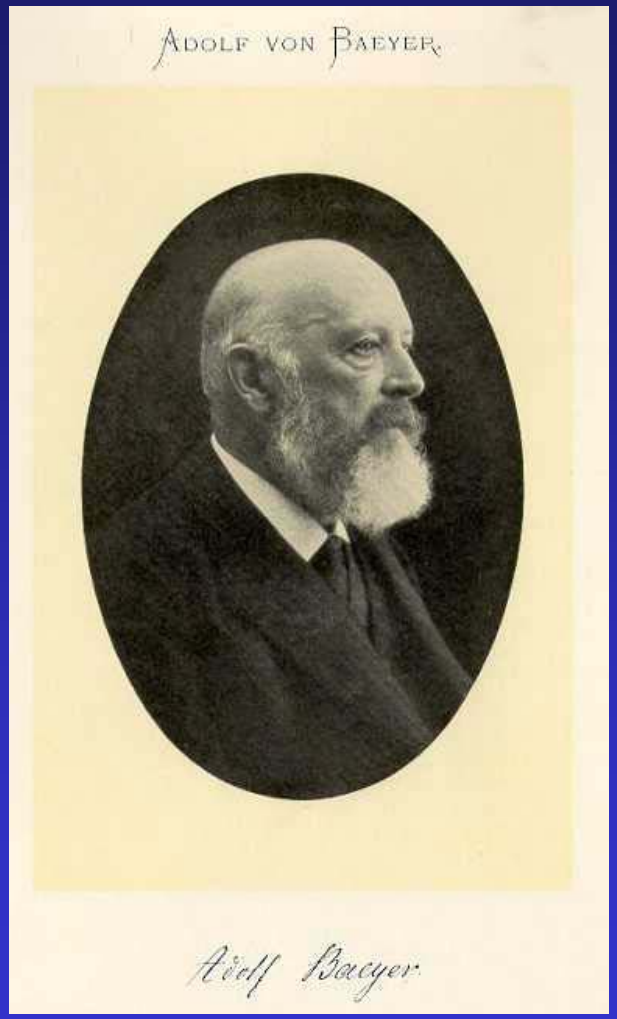
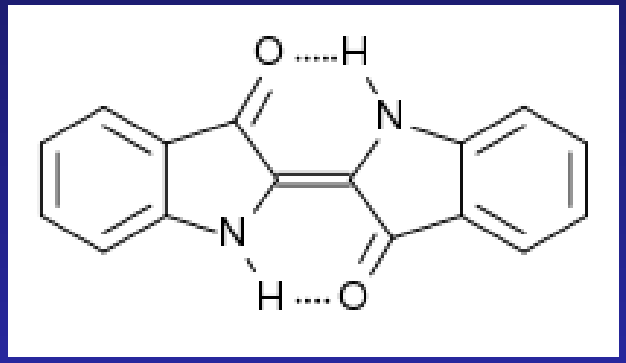
INDUSTRY-ACADEMIA INTERACTIONS

- **The academic origins of industry**
- **The dawn of industrial R&D :The rise and fall of corporate or central R&D as drivers of innovation**
- **The nature of scientific enterprise**
- **Linking science to markets: The new paradigm**
- **Industry-academia relationships: Myths and realties**

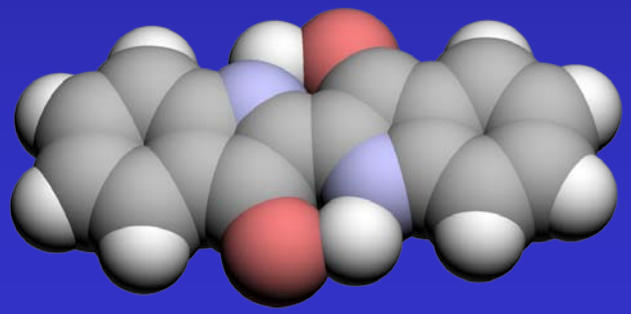
BEGINNING OF INDUSTRIAL CHEMISTRY : THE INDIGO SYNTHESIS



Adolf von Baeyer (1835-1917)
Professor of Chemistry, University of Munich



Synthesis of a plant derived natural product, from Isatin and 2-Nitrobenzaldehyde (1878-80)



Nobel Prize , 1905

THE DAWN OF THE CHEMICAL INDUSTRY: THE MANUFACTURE OF INDIGO

BASF commences manufacture of synthetic Indigo (1897)

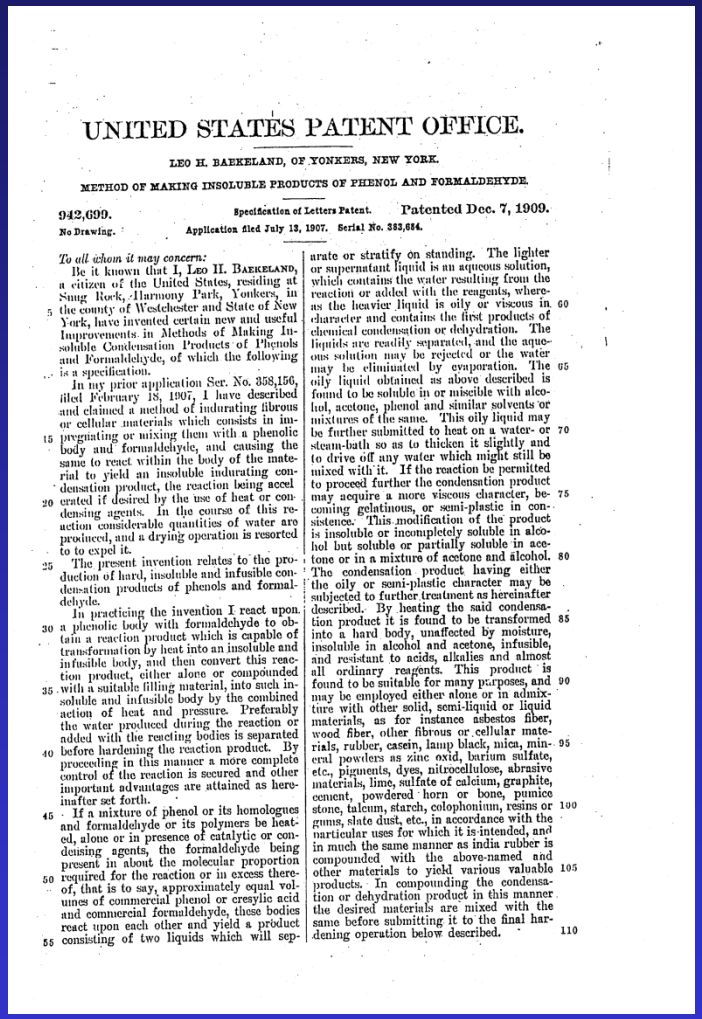
BASF develops a more economic route based on N-2-carboxyphenyl glycine, derived from aniline, which had become just then available from coal tar distillation

Indigofera Tinctoria

Indigo dye

Blue denim

THE DAWN OF THE CHEMICAL INDUSTRY: THE MANUFACTURE OF BAKELITE



UNITED STATES PATENT OFFICE.

LEO H. BAEKELAND, OF YONKERS, NEW YORK.

METHOD OF MAKING INSOLUBLE PRODUCTS OF PHENOL AND FORMALDEHYDE.

942,699. Specification of Letters Patent. Patented Dec. 7, 1909.

No Drawing. Application filed July 13, 1907. Serial No. 383,884.

To all whom it may concern:

Be it known that I, LEO H. BAEKELAND, a citizen of the United States, residing at Snug Rock, Harmony Park, Yonkers, in the county of Westchester and State of New York, have invented certain new and useful Improvements in Methods of Making Insoluble Condensation Products of Phenols and Formaldehyde, of which the following is a specification.

In my prior application Ser. No. 358,156, filed February 18, 1907, I have described and claimed a method of indurating fibrous or cellular materials which consists in impregnating or mixing them with a phenolic body and formaldehyde, and causing the same to react within the body of the material to yield an insoluble indurating condensation product, the reaction being accelerated if desired by the use of heat or condensing agents. In the course of this reaction considerable quantities of water are produced, and a drying operation is resorted to to expel it.

The present invention relates to the production of hard, insoluble and infusible condensation products of phenols and formaldehyde.

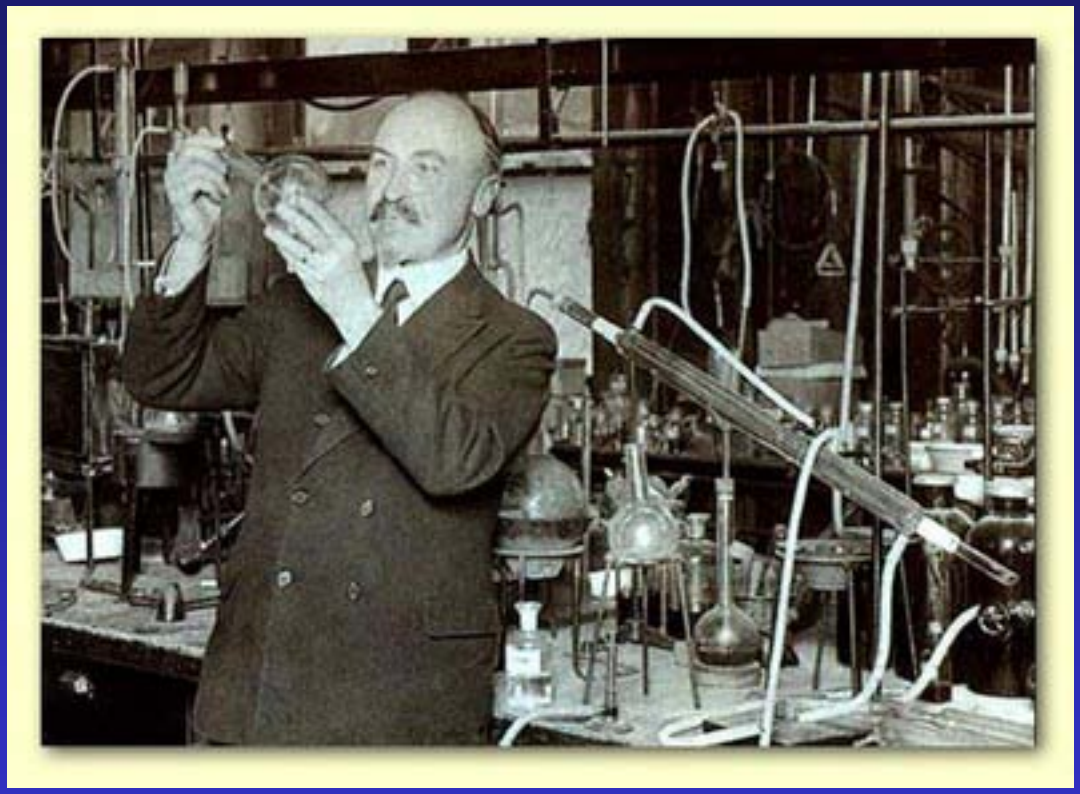
In practicing the invention I react upon a phenolic body with formaldehyde to obtain a reaction product which is capable of transformation by heat into an insoluble and infusible body, and then convert this reaction product, either alone or compounded with a suitable filling material, into such insoluble and infusible body by the combined action of heat and pressure. Preferably the water produced during the reaction or added with the reacting bodies is separated before hardening the reaction product. By proceeding in this manner a more complete control of the reaction is secured and other important advantages are attained as hereinafter set forth.

If a mixture of phenol or its homologues and formaldehyde or its polymers be heated, alone or in presence of catalytic or condensing agents, the formaldehyde being present in about the molecular proportion required for the reaction or in excess thereof, that is to say, approximately equal volumes of commercial phenol or cresylic acid and commercial formaldehyde, these bodies react upon each other and yield a product consisting of two liquids which will separate or stratify on standing. The lighter or supernatant liquid is an aqueous solution, which contains the water resulting from the reaction or added with the reagents, whereas the heavier liquid is oily or viscous in character and contains the first products of chemical condensation or dehydration. The liquids are readily separated, and the aqueous solution may be rejected or the water may be eliminated by evaporation. The oily liquid obtained as above described is found to be soluble in or miscible with alcohol, acetone, phenol and similar solvents or mixtures of the same. This oily liquid may be further submitted to heat on a water- or steam-bath so as to thicken it slightly and to drive off any water which might still be mixed with it. If the reaction be permitted to proceed further the condensation product may acquire a more viscous character, becoming gelatinous, or semi-plastic in consistence. This modification of the product is insoluble or incompletely soluble in alcohol but soluble or partially soluble in acetone or in a mixture of acetone and alcohol. The condensation product having either the oily or semi-plastic character may be subjected to further treatment as hereinafter described. By heating the said condensation product it is found to be transformed into a hard body, unaffected by moisture, insoluble in alcohol and acetone, infusible, and resistant to acids, alkalies and almost all ordinary reagents. This product is found to be suitable for many purposes, and may be employed either alone or in admixture with other solid, semi-liquid or liquid materials, as for instance asbestos fiber, wood fiber, other fibrous or cellular materials, rubber, casein, lamp black, mica, mineral powders as zinc oxid, barium sulfate, etc., pigments, dyes, nitrocellulose, abrasive materials, lime, sulfate of calcium, graphite, cement, powdered horn or bone, pumice stone, talcum, starch, colophonium, resins or gums, slate dust, etc., in accordance with the particular uses for which it is intended, and in much the same manner as india rubber is compounded with the above-named and other materials to yield various valuable products. In compounding the condensation or dehydration product in this manner the desired materials are mixed with the same before submitting it to the final hardening operation below described.

US Patent 942, 699, December 7, 1909

- Baekland set out to discover a substitute for Shellac, then wholly supplied by India to the world
- In the process he made the first man made material, heralding the age of plastics, a discovery considered as revolutionary
- Heat resistant and insulating
- Baekland named his new material Novolak
- He founded a company called Bakelite Corporation in 1910 to manufacture the product

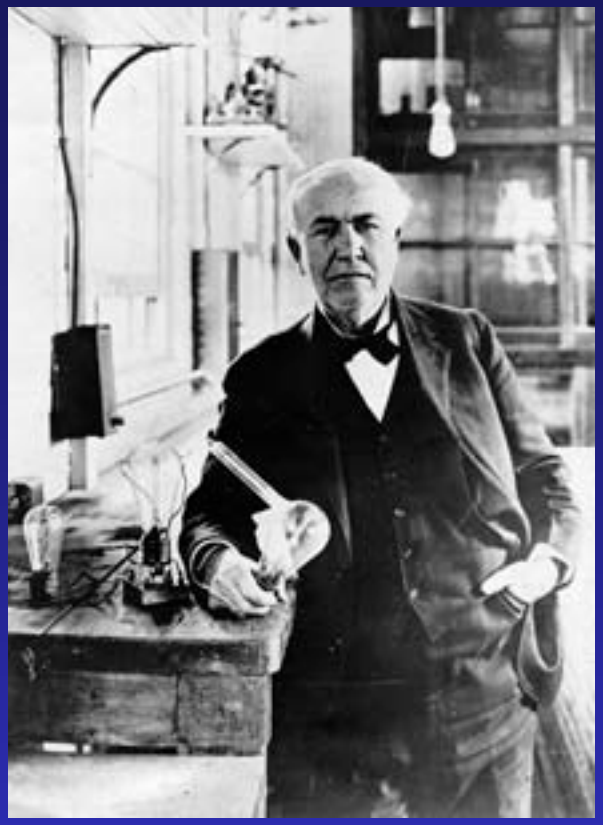
THE DAWN OF THE CHEMICAL INDUSTRY: THE MANUFACTURE OF BAKELITE



Leo Baekland (1863-1944)

When asked why he chose to work in the field of synthetic resins, he replied " to make money "

EDISON AND MENLO PARK : THE BIRTH OF INVENTION FACTORY



Thomas Alva Edison (1847-1931)

Menlo Park, NJ Laboratory

- Most prolific inventor in the history
- Edison holds the record for the largest number of patents granted to an individual inventor, 1093
- Inventor of phonograph, incandescent bulb, motion picture camera, alkaline battery and many others
- First to organize and manage research , a forerunner to the later day corporate research laboratories of companies
- Assembled a cross functional global team of coworkers, from Germany(glass blowing), Switzerland (watch making),mathematicians, chemists , carpenters and machinists
- In 1900 Menlo Park employed over hundred people who were inventing for a salary and living; the beginning of corporate R&D

INDUSTRY – ACADEMIA LINKAGE

- The western world moved from agrarian to industrial and then on to knowledge driven enterprises over two hundred years. The system had the time to accept and manage the change

- The industrial revolution laid the foundation of industrial R&D; Large corporate research facilities became the visible symbols of successful enterprises. They hired large number of highly educated professionals and provided them an ambience to create and innovate

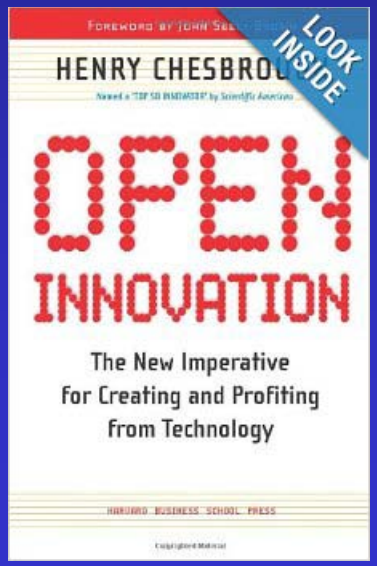
- However, beyond the late eighties , the monolithic central or corporate R&D centers began to disintegrate as competition around the world enlarged and technology diffusion became more rapid

THE RISE AND FALL OF CORPORATE R&D

- Corporate R&D flourished for over two centuries, ushering in the explosive growth of industries in Europe, Japan and America
- DuPont, GE, GM, IBM, Exxon, Bell Labs, Kodak, Shell, BASF, ICI, Dow , Monsanto, Hoechst, Ciba, Bayer etc became great hub for science and technology.
- Corporate R&D were large and diverse with a balance of curiosity and market driven programs . Industry had great execution and process skills .It attracted the best of talent ; Flory, Rochow, Knowles, Pederson, Davisson, Bardeen, Shockley, Penzias, Carrothers, Langmuir, Hay some of whom went on to win Nobel Prize.
- Post nineties R&D restructured as part of SBU and funded by business; leadership transitioned from professional R&D managers who had cut their teeth in S&T to professional managers
- Corporate leadership under pressure to perform and time needed to recover investments in R&D became short. Increasing input cost, product liability, environment , health, safety and sustainability issues made investment in R&D more risky.

THE RISE AND FALL OF CORPORATE R&D

- Breakup of large corporations: mergers, acquisitions by private equity and even disappearance of companies: ICI, Hoechst, Monsanto, Ciba
- Research expenses became a cost ; cost reduction led to downsizing of internal R&D.
- Corporations sought out external partners for performing research and seed new ideas. Initial motivation was cost reduction
- Open innovation, Reverse innovation, Connect and Develop, co-creation etc., became the new jargon
- Academic labs became Innovation hubs for industry
- New models of academic industry interactions emerged
  - Contract R&D
  - Joint centers of research in academic campuses
  - Industry new venture funds to encourage start ups



2003

These changes, created in its wake, new dichotomies and dilemma

STRUCTURE OF SCIENTIFIC ENTERPRISE

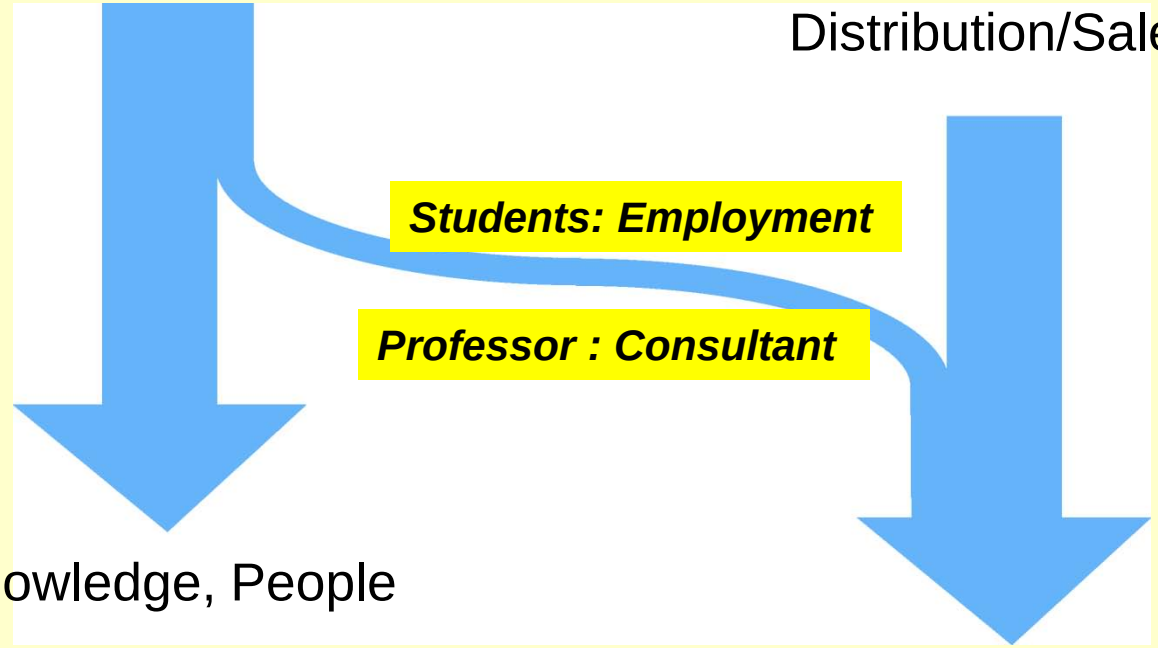
Money

University **Government** Laws, Regulation

Industry

("Liebig" Model:
Professor/Student/Problem/Thesis)

(Development, Manufacturing,
Distribution/Sales)

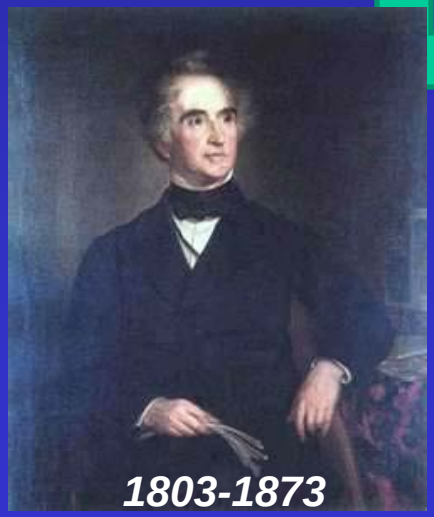


Knowledge, People

Products/Solutions for Problems

LIEBIG'S MODEL

Professors + Money → **University + Students** → **Knowledge + Scientists + Engineers** → **Industry** → **Money** → **Industry + Government** → **Professors + Money**



1803-1873

LEIBIG MODEL OF RESEARCH TRAINING

Professor assigns a problem to a student

The student solves the problem , gets his Ph D; the professor becomes famous

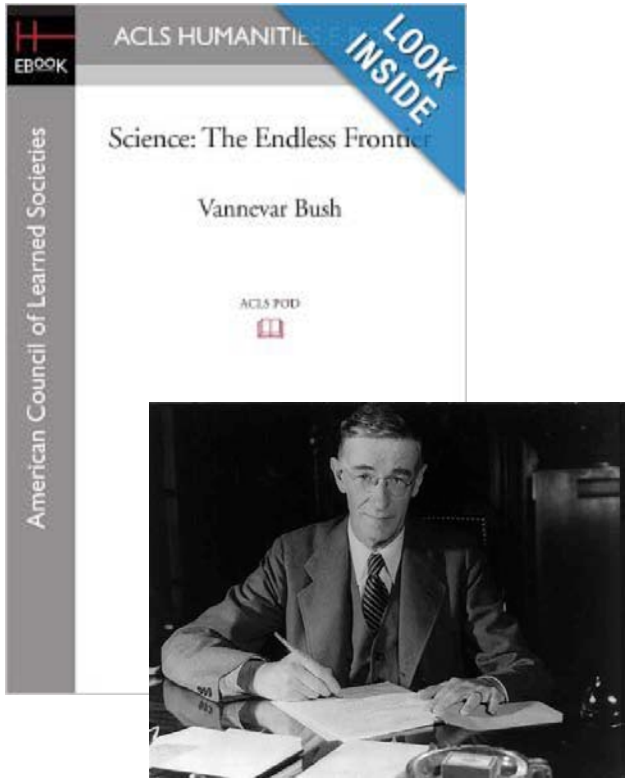
The student goes on to become a professor and repeats the process all over again

EXAMINE THE MODELS

- **Is the "Liebig Model" obsolete?**
- **Is the current model of the university ("a collection of semi-isolated experts") still workable?**
- **Can curiosity-driven basic research survive?**
- **Should research be driven by large missions ?**
- **Should translational research be funded by the state or should be left to industry ?**

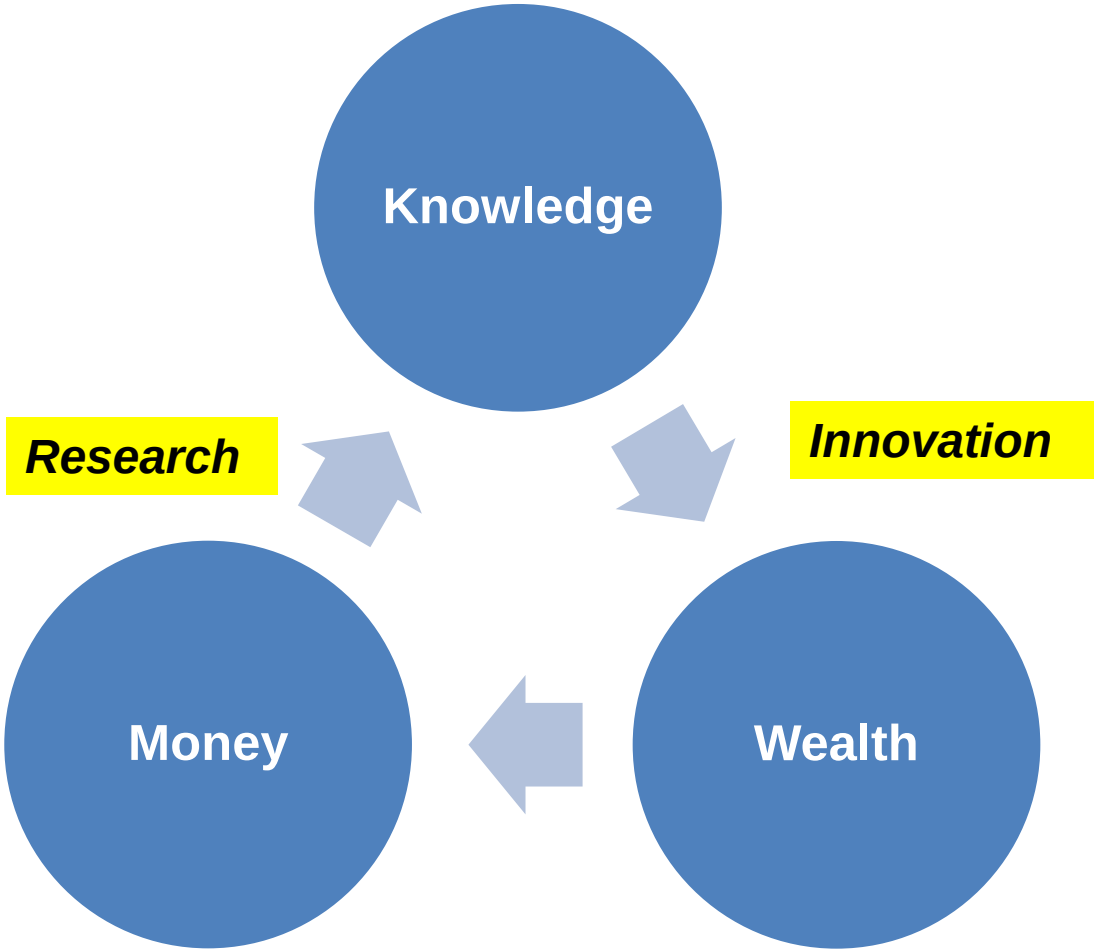
LINEAR MODEL OF IMPACT OF SCIENCE

- The tenet : investment in “basic research” by a nation ”performed without thought of practical ends” will lead to prosperity for its people.
- More Money, more Institutions, more research, more papers and PhD’s will result in greater prosperity and wealth creation in society
- Basic leading to applied leading to development leading to production and markets : A linear model
- Is the frontier really endless ? Bruce Alberts, Science 330, 1587 (2010)
- Rising above the gathering storm: Energizing America for a better future : National Academy of science , 2007
- Gathering Storm revisited : Rapidly approaching Category 5 : National Academy press, 2010



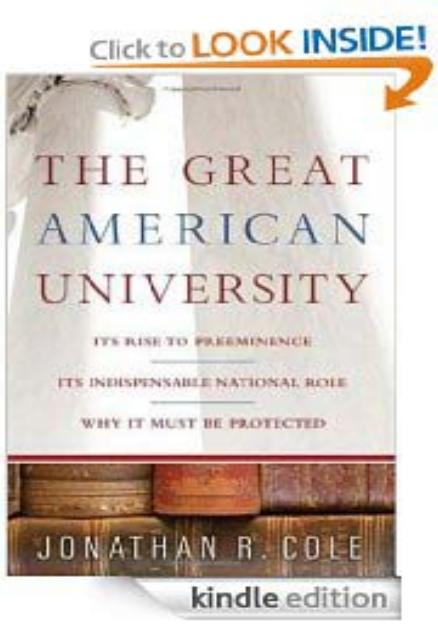
1945

WEALTH CREATION IN SCIENCE AS A VIRTUOUS CYCLE : MYTH?



THE BIRTH OF RESEARCH UNIVERSITIES

- Academia and industry : Fundamentally different goals and value systems
- Academic values: Universalism, organized skepticism, creation of new knowledge, free and open communication of ideas, disinterestedness, free inquiry and academic freedom, international communities, peer review systems, loose governance, vitality to the community
- The Bayh-Dole Act of 1980 changed the paradigm. University Intellectual property changed the rules of the game



2010

PURPOSE OF A UNIVERSITY

- **Teach to educate**
- **Perform research to train**
- **Exploit Knowledge for public good ?**

Universities are good at discovery and creation of new knowledge; they have poor skills in exploitation

ISSUES IN EXPLOITATION OF ACADEMIC RESEARCH

- One extreme view is that academic research and commercial considerations of results do not mix
- Commercial considerations of research do create conflict in academia between the need to disseminate knowledge and limit access to knowledge
- Public pays twice for the same invention; taxes support university research that yields the invention and the high monopoly prices charged by the provider when the invention reaches the market
- Bayh- Dole Act in USA led to more IP licensing than spin offs

Should academic departments avoid redirecting research purely for commercial outcomes ? Should commercial opportunities be considered only as welcome by products ?

THE TWO CULTURES OF UNIVERSITY AND INDUSTRY

UNIVERSITY

- **Explore – curiosity driven research**
- **Create knowledge**
- **Organized discipline wise**
- **No hierarchical control**

INDUSTRY

- **Exploit – business driven research**
- **Utilize knowledge**
- **Inter/multidisciplinary**
- **Structured/hierarchical control**

THE PRINCIPLES OF A KNOWLEDGE ORGANIZATION (Sveiby 1997)

	INDUSTRY	*ACADEMIA*
People	Cost generators	Revenue generators
Power base	Level in hierarchy	Level of knowledge
Task	Supervise subordinates	Support colleagues
Production	Physical tangible assets	Knowledge and intangible assets
Revenue flow	Tangible (financial)	Intangible (ideas, customers)
Manifestation of production	Hardware	Concepts
Production flow	Machine driven	Idea driven
Effect of size	Economics of scale	Economics of scope
Purpose of learning	Application of tools	Creation of tools

BUSINESS DRIVEN AND CURIOSITY DRIVEN RESEARCH

Business :Current Markets	Curiosity : Future Markets
Strategy : Innovation driven Synthesis of known knowledge	***Strategy :*** Discovery driven Perceived needs
IPR	IPR Publications
Outcome : cost / efficiency / productivity/ quality / NPI	***Outcome :*** New business Growth of enabling science
Returns : Incremental	***Returns :*** Exponential
Paradigm : Solution to problems	***Paradigm :*** Solution in search of problems

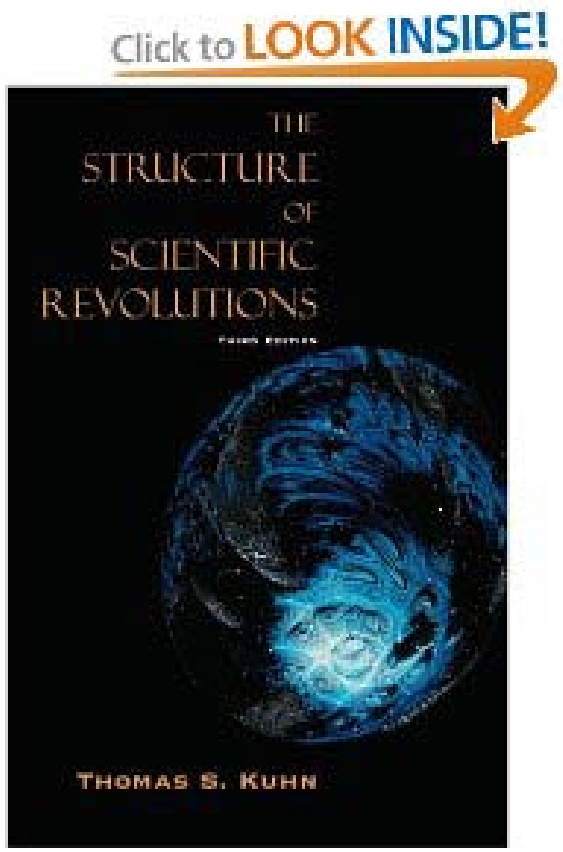
HERDING CATS: BEING ADVICE TO ASPIRING ACADEMIC AND RESEARCH LEADERS

(Geoff Garret and Graeme Davies (2010)

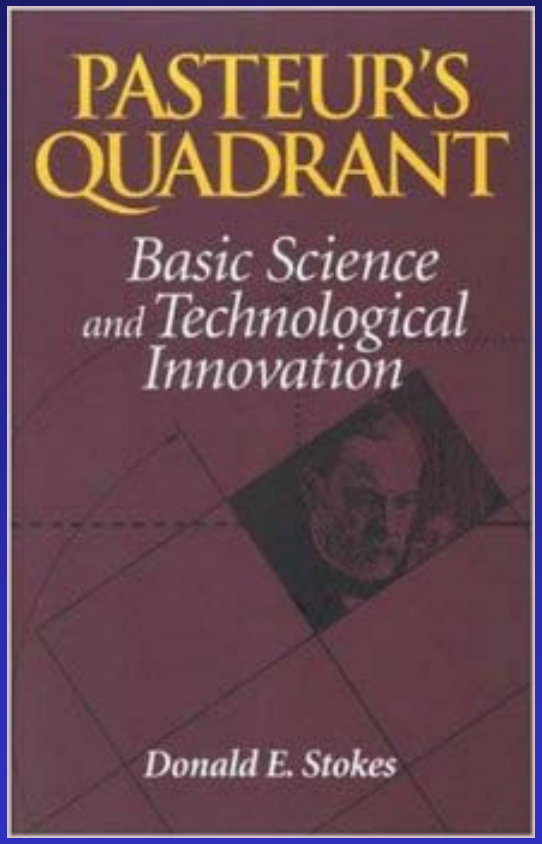
- **In professional lives most academics and researchers will – like cats- seek to exercise as much as independence as possible.**
- **Researchers are typically individuals with high ideals and a frequently argumentative style**
- **Often very conservative and resistant to change**
- **Considerable difficulties in seeking cross boundary collaborations.**
- **Many institutional processes are bureaucratic in nature**

THE NORMAL AND DISCOVERY SCIENCE

- Normal Science : Develops existing and accepted ideas or scientific paradigms; solution of puzzles; answer is not important, but elegance of solution is more important
- Discovery Science: Fundamental change in thought; solutions to problems; answer is important



The Structure of Scientific Revolution, T .S. Kuhn , University of Chicago Press, 1962



Pasteur's Quadrant, D.E. Stokes, Brookings Institution, 1996

Pasteur's Quadrant

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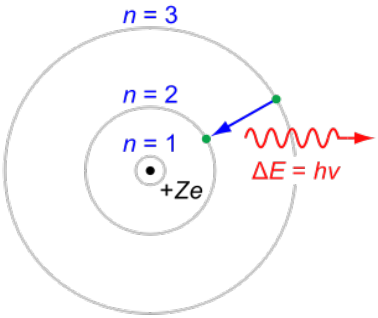
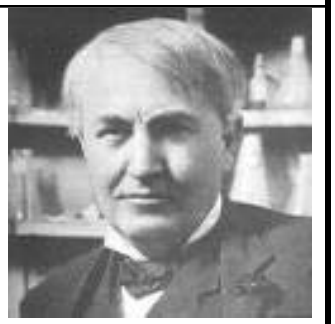


Pasteur

Average
Academic
and
Industrial
R & D



Edison

Fundamental Research

Use Inspired Research

BASIC AND APPLIED SCIENCE : ARE THEY DIFFERENT ?

There is science and the applications of science : Louis Pasteur

The emergence of concept of use inspired science
It means using basic science for a purpose and practical problems as stimulus to curiosity driven research (G. W. Whitesides and J, Deutch, Nature 460, 21 (2011)

SCIENCE : IS IT FOR

- Pleasure ?
- Profit ?, or
- Pleasure and Profit ?

Does it benefit anybody ?
Is it worth the money spent on it ?
Is it directed at the right objectives ?
Is there too much or too little?
Is it too basic or applied ?
What are the rewards of research ?

As the world attains prosperity, science is taken for granted and is increasingly being questioned

SCIENCE IN THE 21st CENTURY

- **Blue skies vs Directed Science**
- **Small vs Big Science**
- **Individual vs Team Science**
- **Curiosity driven vs Grand Challenges or Utilitarian Science**
- **Open access vs Intellectual Property**

RESEARCH ENTERPRISE : COMPLEXITIES

- **Individual or solo research**
- **Collaborative research**
- **Mission driven research**
- **Research leading to IP**
- **Research leading to products and prototypes**
- **Research aimed at societal needs**
- **Teaching , mentoring and communication**

THE NON LINEAR PROCESS : SEAMLESS INTEGRATION OF RESEARCH AND INNOVATION

- **Research : ideas, concepts, principles, techniques, theories (*Discover)***
- **Translation : proof of concept, connecting solutions with needs, validation (*Develop*)**
- **Defining the customer and his needs (met or unmet) and cost –performance targets, prototype or pilot plant development, customer acceptance, business plan, investment and economics *(Demonstrate)***
- **Marketable Product *(Deploy)***

Success in the laboratory does not always translate into success in the market place

RESEARCH AND INNOVATION : A RELAY RACE OR A ROWING OF A BOAT ?

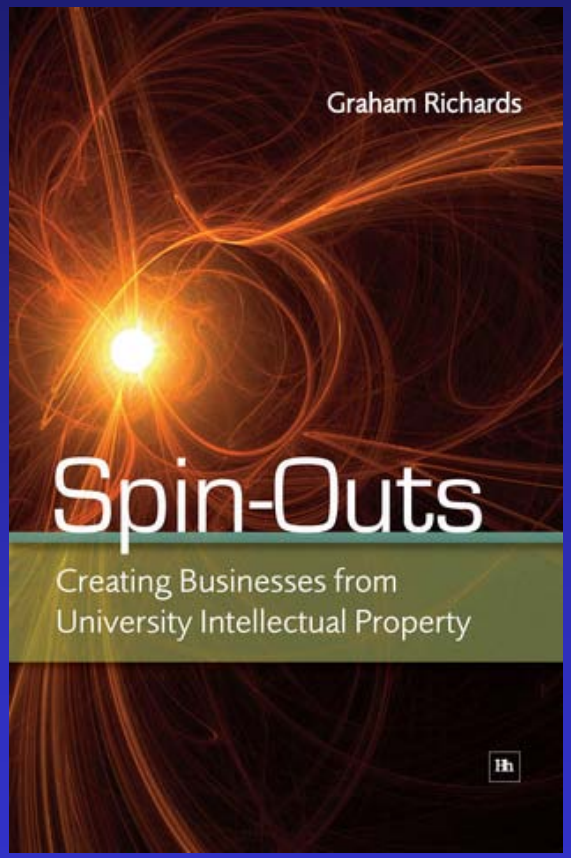
OR IS IT MORE LIKE A SYMPHONY ORCHESTRA ?

Organizing scientific research on the scale of big operatic and theatrical production is still something new in science

Spin outs : Creating Businesses from University Intellectual Property : Graham Richards (2009)

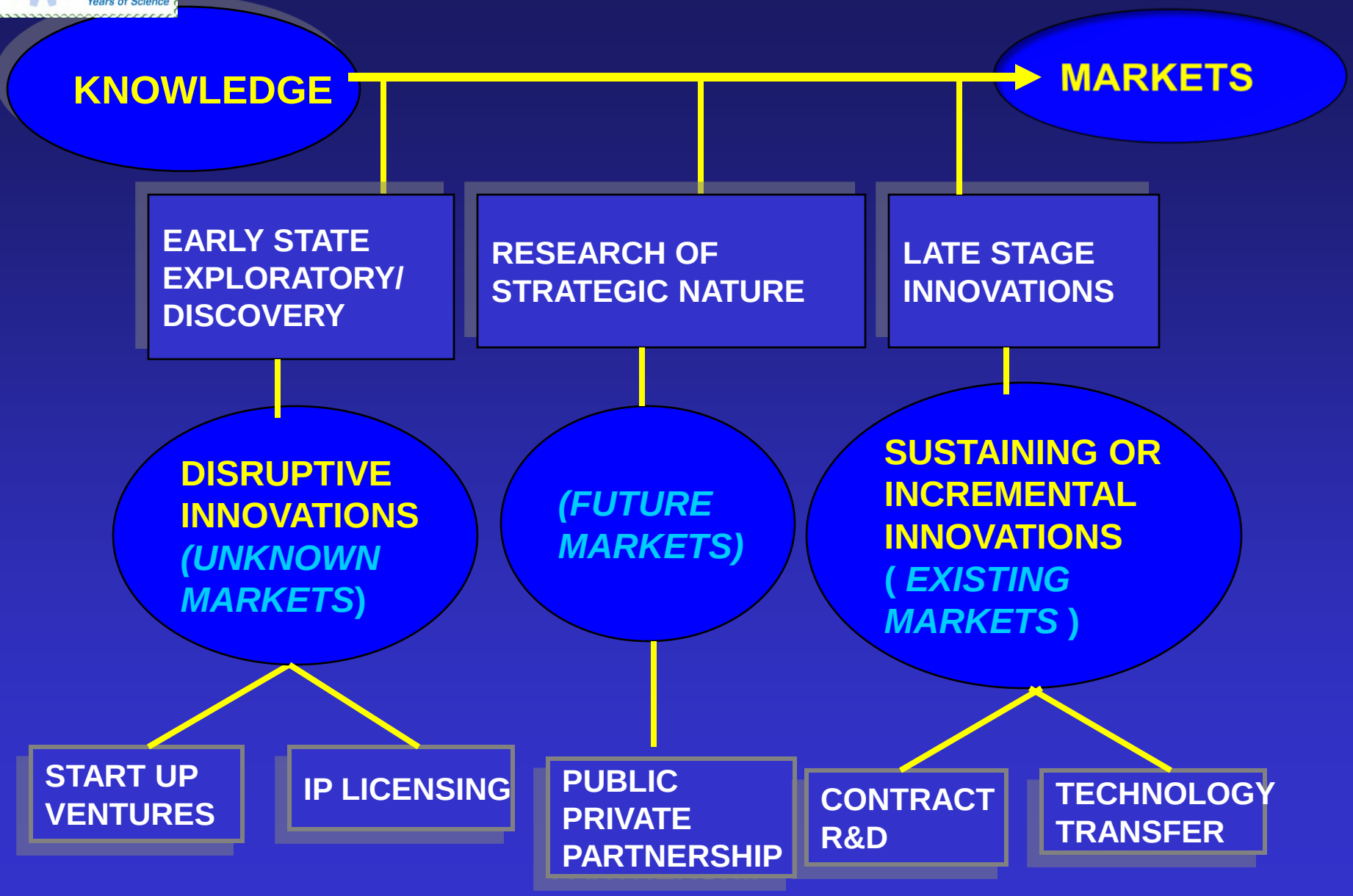
- **Experience has shown that most of the really successful spin outs have been based on research that was not seen originally to be a likely source of profitable intellectual property. The so called “ blue skies” research is a far better source than that which obviously exploitable for profit at the outset.**

- **The key is to recognize the potential, The best person to do this is the individual who is doing the research with a little advice and support form someone who understands the commercial process**



Spin Outs : Creating Businesses Form University Intellectual Property, Graham Richards, Harriman House, 2008

LINKING KNOWLEDGE TO MARKETS



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)
- Tendency of academic community to assume a high pedestal
- Immaturity of markets and risk averse
- Inability to connect basic discoveries with potential applications
- Weak innovation eco systems
- 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

INNOVATION : THE INDIAN CHALLENGE

- Mindset not oriented towards problem solving
- Institutions are predominantly resource driven
- Distance from markets and users
- Technology management capabilities
- Weak institutional mechanisms for technology transfer, IP licensing etc.
- Weak “investment ready” technologies
- Weak supporting eco systems
- Missing incentives and recognitions
- Inadequate risk takers , both, in industry and academia

FUTURE OF INNOVATION

- Innovation = Invention + Implementation
- The process of innovation is not necessarily efficient
- Innovation will move from large enterprises to small companies
- Disruptive innovation will most likely emerge from publicly funded institutions / Universities
- Larger companies will need to build entrepreneurial, agile R&D teams through an open innovation or venture models
- Partnership and collaboration in R&D will become necessary criteria for success based on shared responsibilities, risks and benefits

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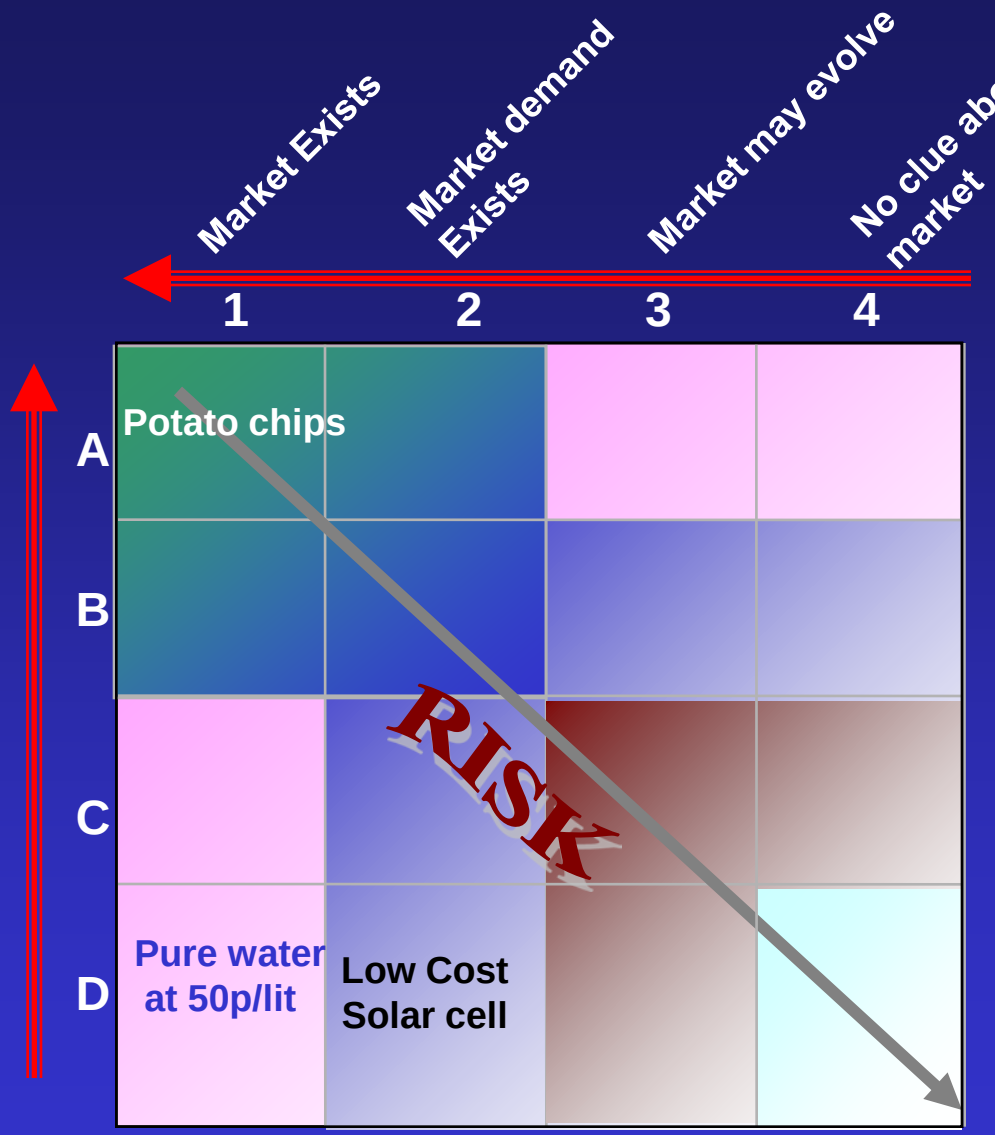
INDUSTRY – ACADEMIA LINKAGE : INDIAN SCENE

- Weak and rare
- Socio – cultural as well as economic reason
- The competitive advantage of companies in India not dependent on technological innovations but on process innovations
- Few large companies with deep traditions of research
- The western world moved from agrarian to industrial and then on to service based enterprises over two hundred years. The work force had the time to accept and manage the change through skill up-gradation and education
- In India we seem to have missed the full blown industrial revolution. Our businesses are increasingly focused on service models.

INDUSTRY – ACADEMIA LINKAGE : INDIAN SCENE

- We, therefore, missed the beneficial aspects of the manufacturing revolution. India began to industrialize in the early fifties, but before this process reached maturity, India migrated to a service economy
- R&D in industrial enterprises never became institutionalized. There was no established innovation processes in majority of the Indian companies, barring a few honorable exceptions.
- Service industry does not require process or product innovations, but only innovations in delivery and cost management.
- In India, even R&D began to assume a service model, largely due to the cost arbitrage. A large proportion of R&D that is conducted in India by companies are for customers outside India, both by global MNC's and by Indian companies.
- The outsourced R&D model never gave Indian organizations an opportunity to take a concept to the market completing the full innovation chain. Instead they were only deployed to do those things where they had some competence

PRE COMPETITIVE POSITIONING OF KNOWLEDGE AND TECHNOLOGY BASE



Knowledge exists, Technology exists

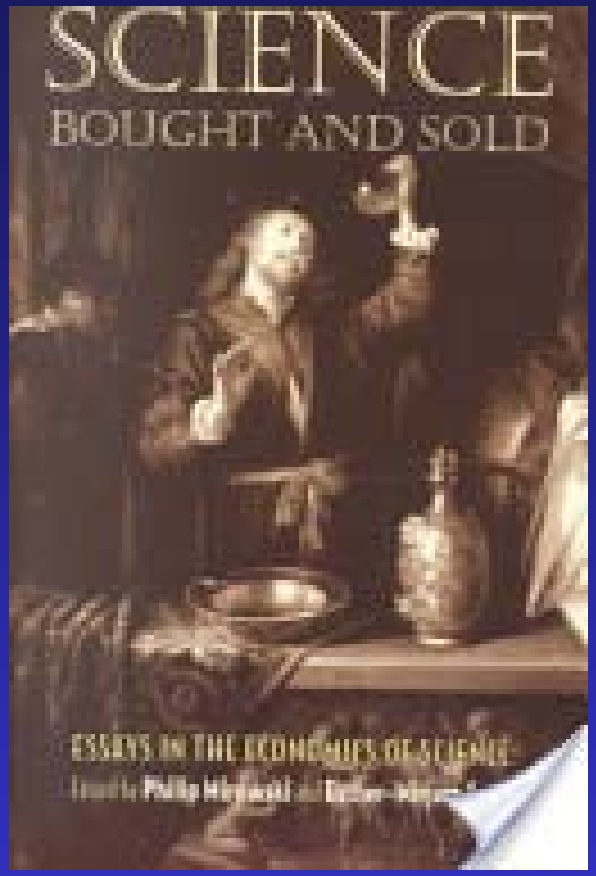
Knowledge exists, Technology needs to be developed

Knowledge exists, No clue about Technology

Problem exists, Knowledge needs to be developed

Academia needs to operate increasingly in the lower half of this knowledge – market matrix

Goethe once said about science: "To one man it is the highest thing, a goddess; to another it is a productive cow who supplies them with butter. We must honor the goddess and feed the cow.



Science Bought and Sold: Essays in the Economics of Science, University of Chicago Press, 2002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