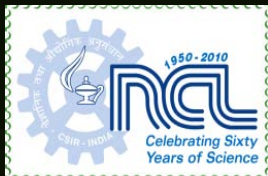


THE EVOLUTION OF SCIENCE, TECHNOLOGY AND PUBLIC POLICY IN INDIA : PAST, PRESENT AND FUTURE



**India –UK Frontiers in Science Workshop
Khandala, Maharashtra
October 10, 2014**

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Science, technology and innovation are social activities. They can not be done in isolation and therefore, we can not disregard its history.....History, if viewed as a repository of more than anecdote or chronology, could produce a decisive transformation in the image of science in which we are now possessed.”

Thomas Kuhn
The Structure of Scientific Revolutions,
Fourth Edition, 2012

THE SOCIAL FUNCTION OF SCIENCE

(J.D. Bernal, George Rutledge and Sons, 1939)

- Utility is the central objective of the scientific enterprise
- Central role of state in supporting / promoting science

The beginning of organized science or government funded or directed science

Roger Pielke, Nature, 27 March 2014, Vol. 507, 427
The Sage of Science, A. Brown, Oxford University Press, 2007

“ Diffusing the knowledge and facilitating the general introduction of useful mechanical inventions and improvements....and to the application of science to the common purpose of life “

*Count Rumford, Henry Cavendish and George Finch
Founding statutes of the Royal Institution, 1799*

SMALL SCIENCE VS BIG SCIENCE

Individual scientists pursuing truth leads to the most efficient social outcomes

Michael Polanyi

*The Republic of Science : Its Economic Theory,
Minerva, I , 54 (1962)*

The intellectual debate between Bernal and Polanyi was one of the most engrossing debates of the second half of twentieth century; With the decline of communism and the rise of capitalism, Bernal lost this intellectual battle !

GOVERNMENT FUNDED RESEARCH IS OF A RECENT ORIGIN

State funding of research is a post world War II phenomena

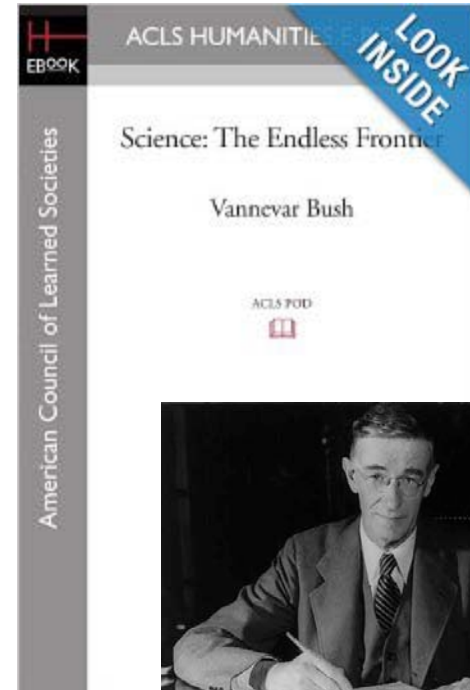
A large part of nineteenth and twentieth century research and explorations in science were not funded by the state.

It was the two wars that gave impetus for the state to step in and direct research

No government funded research project on energy technology led to the discovery of steam engine or electricity, nor the discovery of automobiles and airplanes a programmed outcome of a structured approach to transportation technology !

IMPACT OF SCIENCE ON SOCIETY : THE LINEAR MODEL

- 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
- This tenet was implicitly accepted by Governments around the world as an established public policy
- Only a few years ago, the world began to question this assumption
- Rising above the gathering storm: Energizing America for a better future : National Academy of Sciences , 2007; Is the frontier really endless ? Bruce Alberts, Science 330, 1587 (2010); Gathering Storm revisited : Rapidly approaching Category 5 : National Academy Press, 2010; Roger Pielke, Nature, 466, 922, 19 August 2010



1945

*The phenomenon of
Increased public funding with
reduced public accountability*

A ROMANTIC VIEW OF SCIENTIFIC RESEARCH

“ Scientific research has to do only with the respect with which we regard one another, the dignity of men, our love of culture. It has to do with : are we good painters, good sculptors, great poets? I mean all the things we really venerate in our country and are patriotic about. It has nothing to do directly with defending our country except to make our country worth defending”

Robert Wilson, arguing for support from the US Congress for building the Fermi National Accelerator, 1969

Source: Scientific Temperament: Three Lives in Contemporary Science, P. J.Hilts, Holiday House, 1984

WHY SHOULD GOVERNMENT FUND SCIENCE ?

- Economic growth and prosperity of a nation depends on investments in science (Vannevar Bush's hypothesis)
- Science is too delicate or precious to leave it to non governmental sectors
- Government intervention is necessary in S&T to prevent free market failures of emerging technologies
- Government and the scientists who get funded have the best collective wisdom on the future strategic directions of science and technology
- Politicians love to fund science; spend small money and take credit for large successes
- It is patriotic to fund science (like defending our borders)
- Our country needs to produce more Noble Prize winners

Scientists love public funds, because it comes with no obligations other than to their own community

DOES GOVERNMENT INVESTMENT IN S&T DRIVE ECONOMIC GROWTH?

- US became a rich nation around 1900 when there was no state funding of science; the industrial revolution occurred without state funding
- Much of twentieth century's economic growth was the consequence of two World Wars
- Economic activity is stimulated by privately funded research; Publicly funded research has no effect on economic growth (*The Source of Economic Growth, OECD Report, 2013*)
- Returns on publicly funded research is near zero
- Between 1998 and 2003, the budget of US NIH doubled. What were the economic or health outcomes of this increased investment ?
- GDP growth of a country has no correlation to its investment in S&T
- Investment in science and engineering research boosts economic growth (*CaSE, UK Report, Chemistry World, June 2014, p.9*)

The integration of Vannevar Bush's tenet with the economic theories of Joseph Schumpeter and Robert Solow in the early fifties led to the creation of the thought (or myth) that Government investment in R&D is critical to a nation's growth

Terence Kealey, www.telegraph.co.uk/news/politics; Roger Pielke, <http://thebreakthrough.org/index.php/voices/roger-pielke-jr/tall-tales-of-economic-growth/>; C.Macilwain, *Nature*, vol.495, 143, 13 March 2013

THE PERILS OF ASKING GOVERNMENT TO SUPPORT SCIENCE

Improve the conduct of research that “can transform and improve our lives, advance our understanding of the world and create meaningful new jobs”

Tom Coburn

Senator from Oklahoma

NSF Appropriations, 2011

Politicians have overblown expectations from the scientific enterprise, from the exalted to the mundane !

WE ARE STILL GRAPPLING WITH SEMANTICS !

- Basic research
- Fundamental research
- Curiosity driven research
- Directed basic research
- Use inspired basic research
- Translational research
- Socially relevant research
- Applied research

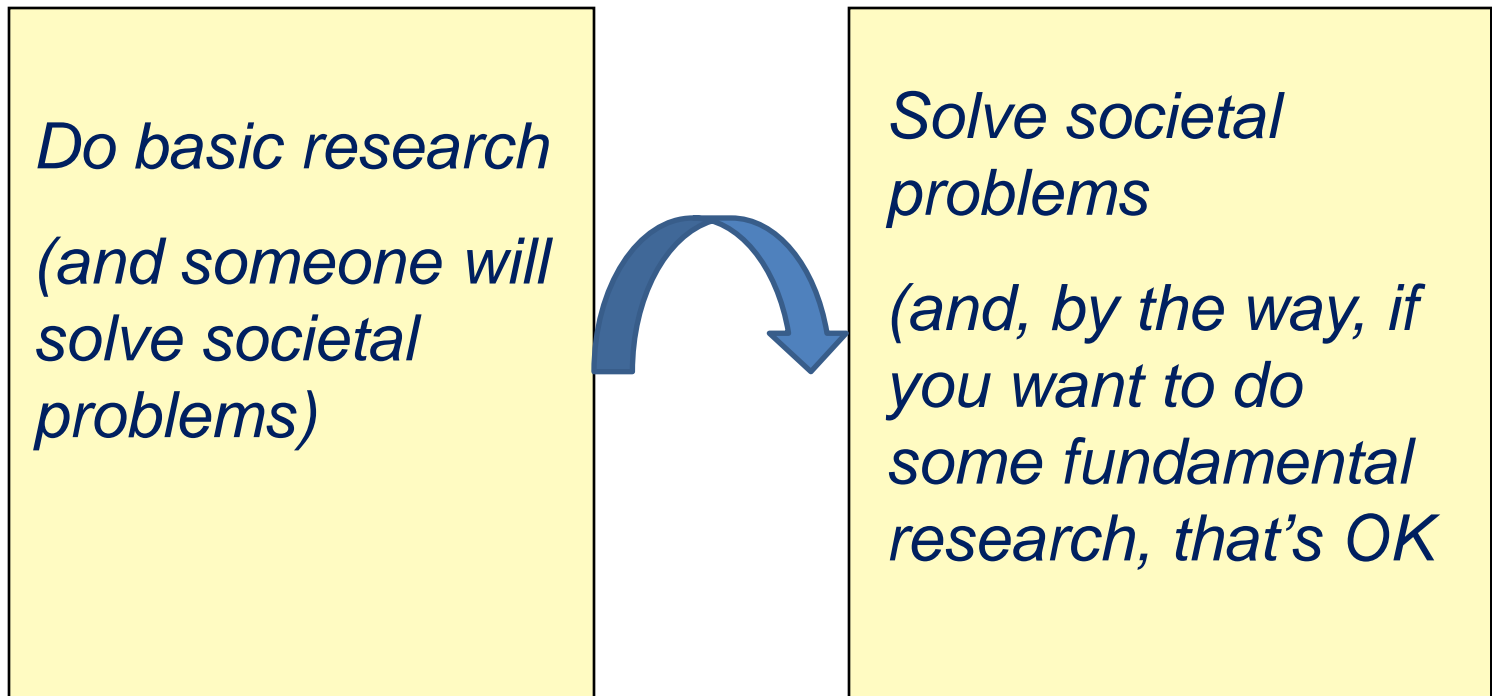
The lack of precision in the language of the scientists is symptomatic of the lack of clarity on the nature of scientific enterprise

TRANSLATIONAL SCIENCE

- Translational research is a way of thought about conducting scientific research to make the results of research applicable to population under study and is practiced in the natural, biological and social sciences (*en.wikipedia.org/wiki/translational-research*)
- A term increasingly used in biology and medical science
- Develop, design, engineer and produce/ commercialize: from bench to bedside
- Translation of discoveries to applications was once the exclusive domain of industry
- With industry stepping back, Government through public funding is increasingly stepping in to fill the vacuum, especially in high risk R&D
- Success of translational efforts using public funds still not proven

The belief that public funds invested on needs identified by Government and focused on direct applications is the panacea for our ills goes against the lessons of history; Government picking technology winners is beset with great dangers and risks

BASIC RESEARCH IN TIMES OF CHANGE IN SOCIAL CONTRACT BETWEEN SCIENCE AND SOCIETY



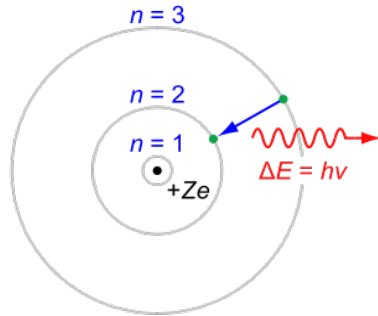
Pasteur's Quadrant



Fundamental Research



Bohr



Pasteur



Average
Academic
and
Industrial
R & D



Edison

Use Inspired Research



1997

SCIENCE IN UNCERTAINTY IN TIMES

Chemistry World, July 2014, p.6

NEWS AND ANALYSIS

Australian science base eroded by cuts

FUNDING

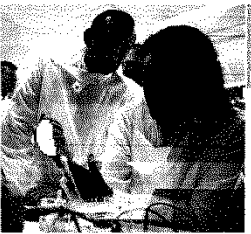
Scientists' treaty decisions as 'potholes'

Australian research community is pining for what has been described as short-sighted and politically motivated cuts, outlined in the new conservative government's fiscal budget.

Only medical research emerges as a real victor with the erosion of a \$200 billion (€131 billion) fund by 2017, but overall there will simply be less science research in Australia in three years' time', according to Les Field, science policy secretary at the Australian Academy of Science. Field says the government 'failed to realize that medical research needs underlying expertise in the theoretical and physical sciences, and that support is being eroded'.

'To an eye-brow-raisingly greater', says Michael Wegan, secretary of the Commonwealth Scientific and Industrial Research Organisation (CSIRO), 'cutting above the individual level, but by aggregating researchers as it will be built up through a new R&D consultation for its funding advice. The money will be used to fund research on the hand reaches an \$825 billion goal.'

'There is no thought as to how to use the money they don't have any understanding of the science system', says Wegan. CSIRO's largest government research organisation - facts of \$231.4 million, it will lose 450 staff on the next year. Coupled with 200 previously announced cutbacks, this means the organisation will shrivel by almost 20% by last year. There was further bad news for CSIRO with reports that eight research facilities will also be closed.



Tony Abbott's government is halving a new \$550 billion medical fund

have been cut from clean energy programmes which were delivering jobs on the ground'. She argues these were positive activities to take advantage of the insurance market. It is great opportunity to change the economy has been eroded - the question is whether through will ignore or a fundamental misunderstanding.

Fee reduction
From 2015, the university funds model is changing so that universities will be able to fund their own core fees. Universities will have to cover the rest of their operating costs, and trying to fund operating costs from what is promised in the year's budget - not one year's budget but a five-year budget. Universities will get a 10% increase in their operating costs, but a 10% decrease in their operating costs, and a 10% increase in their operating costs, but a 10% decrease in their operating costs.

Chemistry World, April 2014, p.9

NEWS AND ANALYSIS

Obama's science budget disappoints

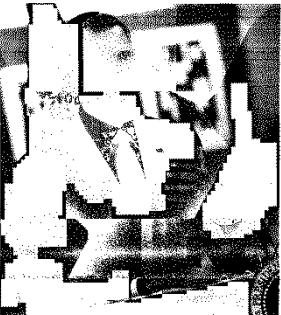
US

Funding fails to keep pace with inflation

US researchers and science agencies are expressing significant disappointment at funding proposals for research agencies in President Obama's budget request for 2015. The proposed increase allows agencies to keep their heads above water, therefore the opportunity for new funding for chemistry and other disciplines, will not be very bright, warns Glenn Rankin, a spokesperson for the American Chemical Society.

The Obama administration's budget request, released on 4 March, would allow about \$1 trillion (€600 billion) for discretionary spending, including science agencies, the same level agreed to in the bipartisan budget deal reached in December 2013.

Specifically, the president would provide \$11.54 billion in federal funding for R&D, an increase of 0.2% from the current level. Meanwhile, non-federal R&D would receive \$66.9 billion, an increase of 0.2%, and total research would receive \$78.4 billion, which represents a reduction of about 0.1%.



Science advocates have been disappointed by the president's proposed budget

We can chatter, it's a strain error that needs to be corrected. Researcher and chief executive Macy 'Many researchers have been forced to shut their doors and staff promising new clinical trials, leaving patients with more delay to access treatments and therapies'.

Fiat cash
Even though Democrat Bill Clinton Johnson, who on the science, space and tax committee that oversees research areas, expressed reservations at the president's budget to be concerned by 'that we've decreased funding' number of key areas of its government's R&D budget. In particular, she noted it would provide funding for the research and development program, such as the National Space Administration's research in its performance in coming years.

In its request for FY14, administration sets aside for the Wide-Field Infrared Survey Telescope (WFIRST) space observatory, which is a joint effort between NASA and the European Space Agency. It also provides funding for the Strategic Science and Technology Observatories for Infrared Astronomy (SOTI), the world's largest infrared telescope, which is a joint effort between NASA and the European Space Agency.

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Above and beyond
The initiative [L] is above and beyond the approved funding levels agreed to in the bipartisan deal. In light of the fact it will likely face an uphill battle on Capitol Hill, nevertheless, Rankin calls the president's budget request a 'step far beyond the dark shadow of sequestration, referring to the automatic across-the-board cuts that kicked in in March 2013.' In light of our nation's continuing difficult national economic stress, the president's budget seems to provide for predictable and sustained funding for the science enterprise', he adds.

In fact, the budget request would also replace the sequestration cuts slated to begin in 2016 with new spending cuts, added tax revenue and immigration reform. But many US research bodies are not so enthused. 'The intricate funding levels for the agencies aren't and isn't the best

science advocates have been disappointed by the president's proposed budget

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Government funding of science under stress; no no country are the scientific community are the satisfied

Portuguese chemistry faces disaster

FUNDING

A third of academic chemistry labs close

Scientific research centres across Portugal are facing dramatic funding cuts following a large-scale review carried out by the country's Foundation for Science and Technology (FCT). The chemical sciences have fared particularly badly, with more than a third of chemistry departments evaluated set to receive no or minimal funding over the next five years, putting them at significant risk of closure.

The decision is part of the 2013 evaluation of R&D units carried out by the FCT, the main government organisation responsible for funding research in Portugal. During the first stage of the evaluation, research centres are reviewed and graded by panels of experts appointed by the European Science

Foundation, based on several criteria including scientific merit, productivity and strategic plans.

Only those deemed 'very good', 'excellent' or 'exceptional' will move on to the next stage of the review, which will decide how much funding each department will get. Those given a 'poor' or 'fair' rating will start receiving no or minimal funding over the next five years, putting them at significant risk of closure.

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FCT funding is vital for chemistry research in Portugal, explains Anthony Burke, a chemistry professor at the University of Évora's chemistry department, which is one of the groups affected. 'Besides Rui Flávor', he found that in many research fields some of the most productive [centres] were evaluated from the second stage', he says. 'Something definitely went wrong in this evaluation procedure.'

But the FCT strongly denied that its assessment methods were in any way flawed. It issued a statement stating it had 'full confidence in the robustness of the ongoing review' and that it was being carried out with 'total transparency, rigour, independence and in line with the highest international standards'.

Research centres can appeal the FCT's decision, and some have already begun this process, Emma Stoop

Chemistry World, July 2014, p.9

Scientists unsure about Modi

POLITICS

New Indian government must address underfunding

India may have disappointed scientists in the past, but the new government must address underfunding of science, says a group of scientists. The new government must address underfunding of science, says a group of scientists. The new government must address underfunding of science, says a group of scientists.



Will Modi government deliver for scientists?

research institutes and generate new papers.

Most scientific research is funded by the government, says a group of scientists. The new government must address underfunding of science, says a group of scientists. The new government must address underfunding of science, says a group of scientists.

IN THE PAPERS

Rhino extinction
Rhino extinction is being prevented, says a group of scientists. The new government must address underfunding of science, says a group of scientists. The new government must address underfunding of science, says a group of scientists.

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IS PHILANTHROPY AN ALTERNATIVE TO GOVERNMENT FUNDED SCIENCE ?

Emergence of philanthropic funding of science

New Institutions

- Janelia Farm
- Allen Institute of Brain Sciences
- Broad Institute
- Wellcome Trust
- Schmidt Ocean Institute
- Ellison Medical Foundation
- Bill and Melinda Gates Foundation
- Perimeter Institute of Theoretical Physics, Waterloo, etc

High net worth individuals/ not for profit entities

- Craig Venter(Celera)
- Elon Musk (Tesla)
- Gordon Moore
- Fred Kavli
- David Koch
- Kris Gopalakrishnan (Brain Research Institute)
- Tata Trust (IIT Mumbai), etc

William J. Broad,

http://www.nytimes.com/2014/03/16/science/billionaires-with-big-ideas-are-privatizing-american-science.html?_r=0

IS PHILANTHROPY AN ALTERNATIVE TO GOVERNMENT FUNDED SCIENCE ?

- Science philanthropy is emerging as the biggest patron of big science, a third pillar along with the Government and the private sector
- The donors are attempting to do what public funding of science has been less efficient at accomplishing; massive and guaranteed funding, greater freedom to the investigators to pursue risky ideas and fabulous research infrastructure
- Pursuit of big science; high risk explorations with a long term payoff; escape from the vagaries of Government funding which is subject to political uncertainties and bureaucratic controls
- There is both criticism and support for philanthropic funding of basic science
- Will such funding skew research priorities, enrich elite universities, undermine political support for Government funded research ?
- As a third pillar of funding of research, philanthropic funding is yet to be objectively assessed.
- Entrepreneurship, new technologies and markets are throwing up increasing number of high net worth individuals, much quicker than ever before in the history of the world. Many of these individuals are driven by their desire for a lasting place in history.

“For better or worse the practice of science in the 21st century is becoming shaped less by national priorities or by peer-review groups and more by the particular preferences of individuals with huge amounts of money.”

Steven A. Edwards, American Association for the Advancement of Science

INDIAN SCIENCE IN PRE INDEPENDENCE PERIOD

- Sir CV Raman
- S Ramanujan
- Sir KS Krishnan
- S N Bose
- Sir M Visvesvaraya
- J C Bose
- Birbal Sahni
- PC Ray
- M N Saha



None of these individuals were recipient of state funds for their research !

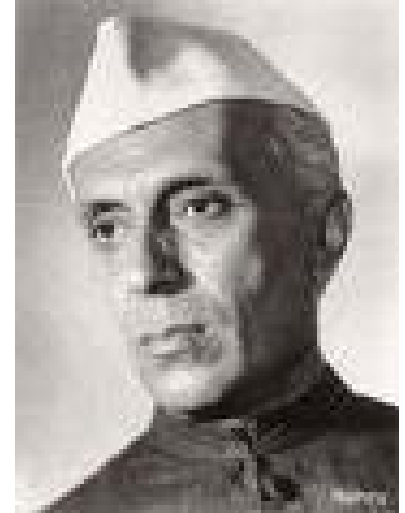
POLITICAL AND ECONOMIC THOUGHT : EARLY YEARS OF INDIA'S INDEPENDENCE

- State wielding “commanding heights” of the economy (Socialistic Pattern of Society)
- State ownership of industries; Government’s ability to promote technologies in public enterprises
- Control on import of processes, products and knowhow; regime of industrial licenses
- Central planning as an instrument of public policy (The Soviet Model)

For a country gaining independence after almost four hundred years of external dominance, issues such as “self-reliance”, “conserving foreign exchange” and “indigenous development” of technology were the underlying basis of Indian pride, echoes of which we hear even today

NEHRUVIAN GRAND VISION OF SCIENCE

“ I realized that science was not only a pleasant diversion and abstraction, but was of the very texture of life, without which our modern world would vanish away.....It was science alone that could solve these problems of hunger and poverty, of insanitation and illiteracy, of superstition and deadening custom and tradition, of vast resources running to waste, of a rich country inhabited by starving people.”



Indian Science Congress, Calcutta, 1938

BEYOND MERE PRACTICE OF SCIENCE : THE SCIENTIFIC TEMPER

Large numbers of people talk glibly about science today and yet in their lives or actions do not exhibit a trace of science.....But science is something more. It is a way of training the mind to look at life and the whole social structure...So I stress the need for the development of a *scientific mind and temper* which is more important than actual discovery as it is out of this temper and method that many more discoveries will come.

*Jawaharlal Nehru,
Inaugural Speech at the opening of National Physical Laboratory, New Delhi,
January 1950*

Nehru borrowed the concepts of “scientific thoughts” from Francis Bacon, John Stuart Mill and Bertrand Russell and gave it his own unique idiom

BUILDERS OF SCIENTIFIC INSTITUTIONS NEHRU'S COMRADE-IN-ARMS

- **Dr. Homi Bhabha** established the TIFR and BARC, leading to nuclear science and research. Today India has 14 reactors producing nearly 4000 MW electrical power
- **Professor Vikram Sarabhai's** space vision enabled India to acquire the capability to design, develop, build and launch any type of satellite from Indian soil. The recent journey of an Indian spacecraft to the orbit of Mars is a vindication of this vision
- **Professor Shanti Swarup Bhatnagar** created multiple CSIR laboratories in various disciplines for developing technology for India's industrial development
- **Dr D. S. Kothari** created a chain of Defense R&D laboratories for promoting self-reliance in critical defense technologies.



(It shall be the duty of every citizen of India) “ to develop the scientific temper, humanism and the spirit of inquiry and reform”

*42nd Amendment Part IV-A Article 51-A
on Fundamental Duties to the Constitution of India, 1976*

For Nehru the State was an instrument for building the scientific temper in the society; he assumed that the spread of education and research in S&T will embed the “scientific temper” in the lives of every Indian

IMPACT OF S&T ON SOCIETY

Some noteworthy successes

➤ The Green Revolution (Agriculture)

➤ The White Revolution (Milk)

➤ The Blue Revolution (Space)

➤ The Grey Revolution (IT and Communication)



Much of these transformations were a consequence of India's post independence investment in S&T education and infrastructure

PUBLIC POLICIES ON SCIENCE AND TECHNOLOGY

- Science Policy Resolution of 1958 (March 4, 1958)
- Technology Policy Statement of 1983
- Science and Technology Policy of 2003
- Science, Technology and Innovation Policy 2013

PUBLIC POLICIES IN S&T : EVOLUTION

1958

Pursuit of science as a tool to realize the objective of a **welfare state**; foster , promote and sustain the cultivation of science and scientific research; to **encourage individual initiative** for the acquisition and for the **discovery of new knowledge**

1983

To attain technological competence and self reliance, **develop indigenous technology, restrict import of technology** to only critical needs, offer protection to locally developed technologies

2003

Direct efforts to alleviate poverty, enhancing livelihoods, remove hunger and malnutrition, reduce regional imbalances and combine India's traditional knowledge and wisdom with modern science and technology; promote **globally competitive technologies, define policies for intellectual property protection for publicly funded science**, and ensure that the S&T enterprise in the country is fully committed to its **social responsibilities and commitments**

2013

Integration of science, technology and innovation to create **value in society** or **wealth in economy**; increase **private sector** participation in R&D ; convert R&D outputs to commercial applications; recognize, reward and respect **performances which create S&T to wealth**;

Reference: <http://www.dst.gov.in/>

POLITICAL AND ECONOMIC EVENTS THAT INFLUENCED INDIA'S SCIENCE POLICIES

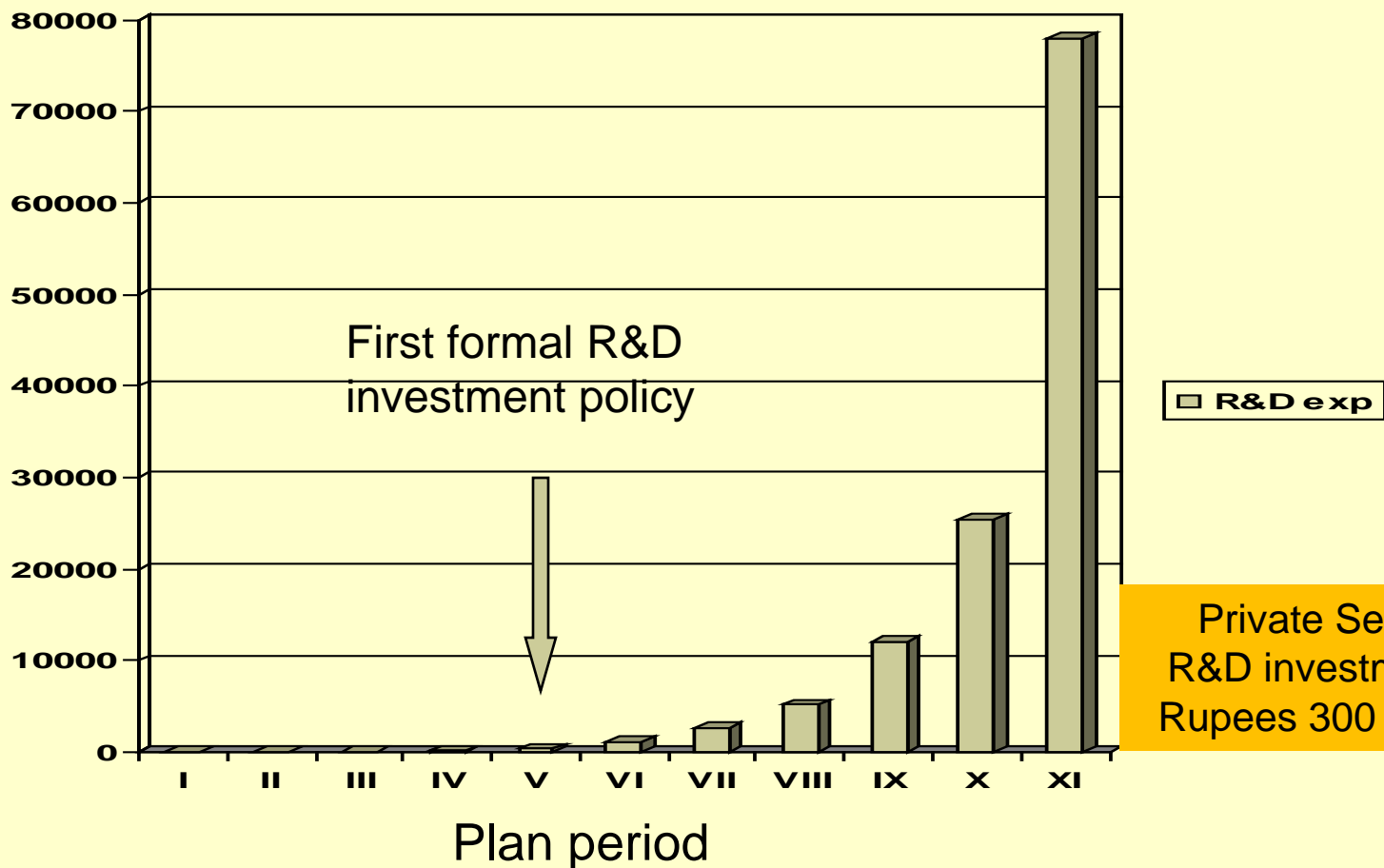
- The crisis of food, 1970
- The first nuclear explosion at Pokharan, 18 May 1974 leading to wide spread sanctions and embargo on technology exports into India
- The liberalization of economic policy, 1991
- The era of coalition Governments, 1989 to 2014
- The second nuclear explosion at Pokharan, 18 May 1998 leading to further economic sanctions
- The National Action Plan on Climate Change and the Eight Missions, 2007

The electoral verdict of 2014 and the emergence of a single party majority right-of-center Government is likely to have a profound impact on India's future science policies

INDIA'S R&D INVESTMENTS

Rupees
800 billion

Rupees in
Crores (10
million)



***R&D INSTITUTIONS AND NATIONAL INVESTMENT ON R&D
(DSIR, 2007)***

R&D Institutions	Number of institutions	Percentage of national investment on R&D (2003-04)
Central government R&D institutions	707	62.6
Public sector institutions	115	4.5
State government institutions	834	8.5
Universities and institutions of national importance	284	4.1
Private sector institutions	2020	20.3
Total	3960	100

UNIVERSITIES AND NATIONAL LABORATORIES: CONTINUING CONFLICT

- “National laboratories will drain the universities and compete for scarce resources. We must seriously consider the impact of independent stand alone publicly funded research laboratories on our universities : Meghnad Saha (1)
- “The Council of Scientific and industrial research must be renamed as the Council of Suppression of Independent Research” : J.B.S Haldane, 1950
- “Shah Jahan built the Taj Mahal to bury one of his favorite women. The National laboratories were built to bury scientific instruments”: Sir C.V. Raman(2)
- “All these laboratories were brought to existence in the same way. The planning was based on similar institutions abroad, divided into divisions and sections, and an estimate of staff made based on this basis. An attempt to fill the post was then made based on advertisements” : Dr Homi Bhabha (2)

References: 1.S.S Bhatnagar on Science, Technology and Development, ed. V. V. Krishna, Wiley Eastern, 1993, p.17 ; 2. Journey into Light, G. Venkataraman, Indian Academy of Sciences, 1988, p.517, p.463)

INDIA AND INNOVATION

(Source : Cornell U, INSEAD and WIPO)

- India ranks 66th amongst 142 economies on innovation capacity and efficiency. Switzerland #1, UK #3, USA #5, Ireland #9
- India's strengths: Gross capital formation, investment in new business, industrial cluster development, growth rate, IT exports, creative goods export
- India's weakness : Political stability, ease of starting a business, human capital, school life expectancy, teacher : pupil ratio, knowledge absorption capacity, poor IP culture, poor branding; poor design and engineering skills

US Patents (2005-10)

Infosys : 13

Dr Reddy's Lab : 34

IBM, India : 250

GE, India : 193

India has to transition from a *“Factor”* driven to *“Efficiency”* driven and ultimately *“Innovation”* driven economy

INNOVATION : INDIAN SCENE

- 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
- The large corporations of the world knew better how to manage Indian talent. Indian talent today creates IP and value for the global corporations
- Few Indian organizations have learnt to effectively manage intellectual talent
- Universities and academia are driven by goals of peer recognition and the tyranny of factors and indices (H-index , Impact factor, funds); wealth creation not on top of its agenda
- The reasons are , both, socio – cultural as well as economic

Can India become an science and technology driven innovation powerhouse if the share of manufacturing in our GDP continues to be so dismally low ?

INDIA'S S&T IN THE NEXT DECADE

- S&T operates within the framework of politics, economics and social fabric of a nation; India is changing rapidly in all these spheres
- Resources will always be lesser than the demands of a growing economy.
- Private sector will become increasingly more important; Government function will be limited to acting as regulators and facilitators, not gatekeepers
- Government focus will remain limited to public health, water, sanitation, education, infrastructure, energy and national security.
- In the economic sphere emphasis will be on manufacturing industries leading to creation of employment; However, much of “come, make in India - sell anywhere” policy will be initially based on capital and technologies sourced from outside India
- Funding for scientific research in public institutions will become more directed and even scarcer in the next few years. The dream run in increase in funding for S&T between 2000 and 2010 is unlikely to be repeated
- Greater pressure to focus more on science that contributes to “nation building” and improve the “quality of life” of its citizens.

More questions are likely to be asked on how and where S&T is making an impact; merely stating that we are doing cutting edge, globally competitive science will not do !

THANK YOU

