THE EVOLUTION OF INDIA'S SCIENCE,TECHNOLOGY AND PUBLIC POLICY:

Lupin Science Park
Science Day
February 28, 2017

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OUTLINE

- The epochal events of February 28
- Science in pre-independent India
- Origins of modern scientific enterprise
- Science in the 21st century
- Science in Independent India : Evolution of public policies
- Science in contemporary India

The epochal events of February 28

“We have got a young student with fine intellect, doing research in our laboratory. A side issue of his work has been published in *Nature* (24 Oct, 1907). The prophecy of the great man (MLS) is now going to be fulfilled. If circumstances do not go against us, Raman will be the brightest ornament of IACS.”

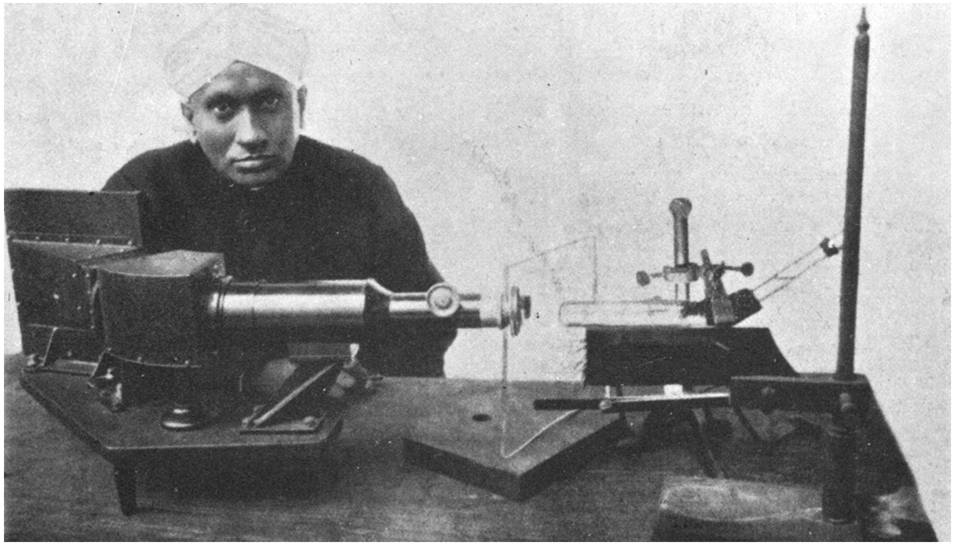
A.L Sarkar, son of Mahendra Lal Sarkar, founder of IACS, 21 November 1907

C. V. Raman
7 November 1888 - 21 November 1970

1906 Stood 1st in M.Sc (did not attend classes!!)
1907 Assistant Auditor General, AG`s Office, Calcutta
1907 Starts research at IACS, part time and publishes the first paper

“Indian mind is not inferior ; what we lack is courage and a spirit of victory. If that indomitable spirit were to arise, nothing can hold us from achieving our rightful destiny”

THE RAMAN EFFECT



On February 28, 1928, through his experiments on the scattering of light, Raman discovered a phenomena called Raman Effect

Raman was supremely confident of winning the Nobel Prize in Physics. He was disappointed when the Nobel Prize went to Richardson in 1928 and de Broglie in 1929. He was so confident of winning the prize in 1930 that he booked tickets in July, even though the awards were to be announced in November, and would scan each day's newspaper for the announcement, tossing it away if it did not carry the news. He did eventually win the 1930 Nobel Prize in Physics "for his work on the scattering of light and for the discovery of the effect named after him ". He was the first Asian and first non-white to get a Nobel Prize in the sciences.

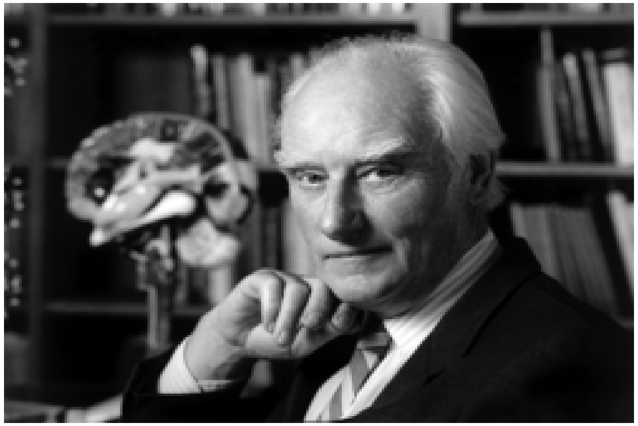
ASUTOSH MUKHERJEE ON RAMAN'S SACRIFICE

"I admire the courage and spirit with which Raman exchanged a lucrative official appointment for a university professorship. This instance encourages me to entertain the hope that there will be no lack of seekers of truth in the Temple of Knowledge which it is our ambition to erect.""

" Sir Asutosh ventured to ask an young and unknown official to devote himself to the pursuit of knowledge under the aegis of the Calcutta University. This, on his part, was an act of courage. But for the action of Sir Asutosh, my scientific career would long ago suffered an abrupt termination."

C. V. Raman

28 FEBRUARY 1953 : ANOTHER HISTORIC DAY FOR SCIENCE

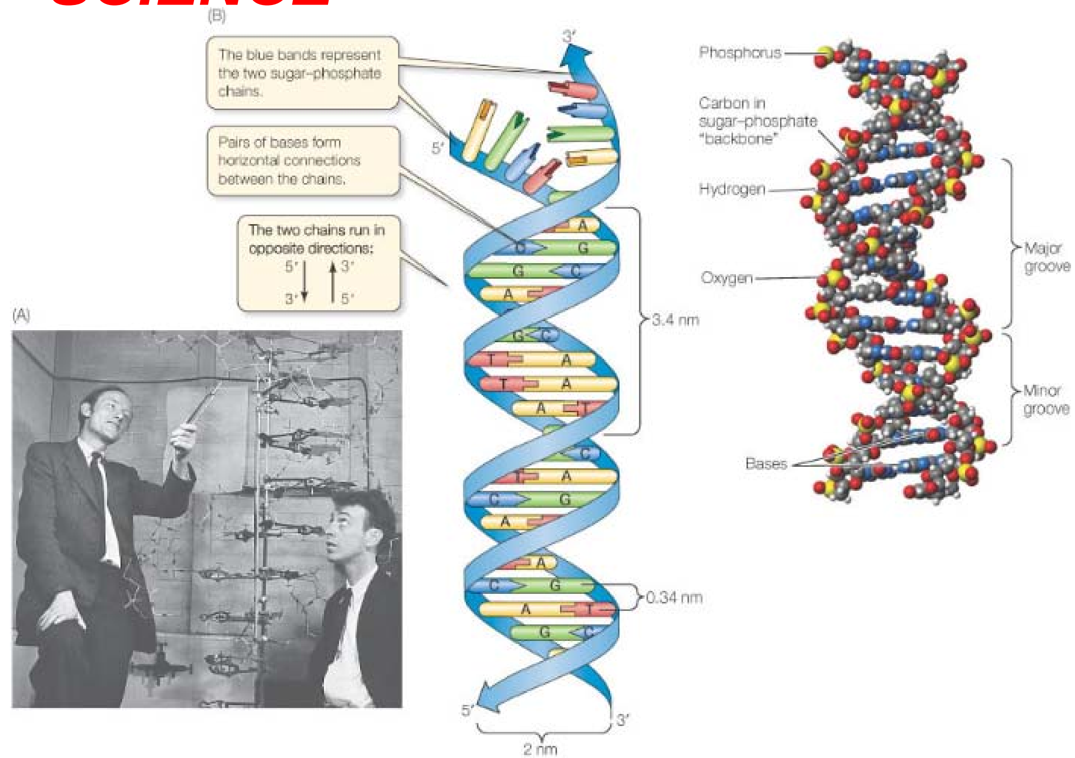


F.Crick (1916-2004)

Then

J.D.Watson (1928-)

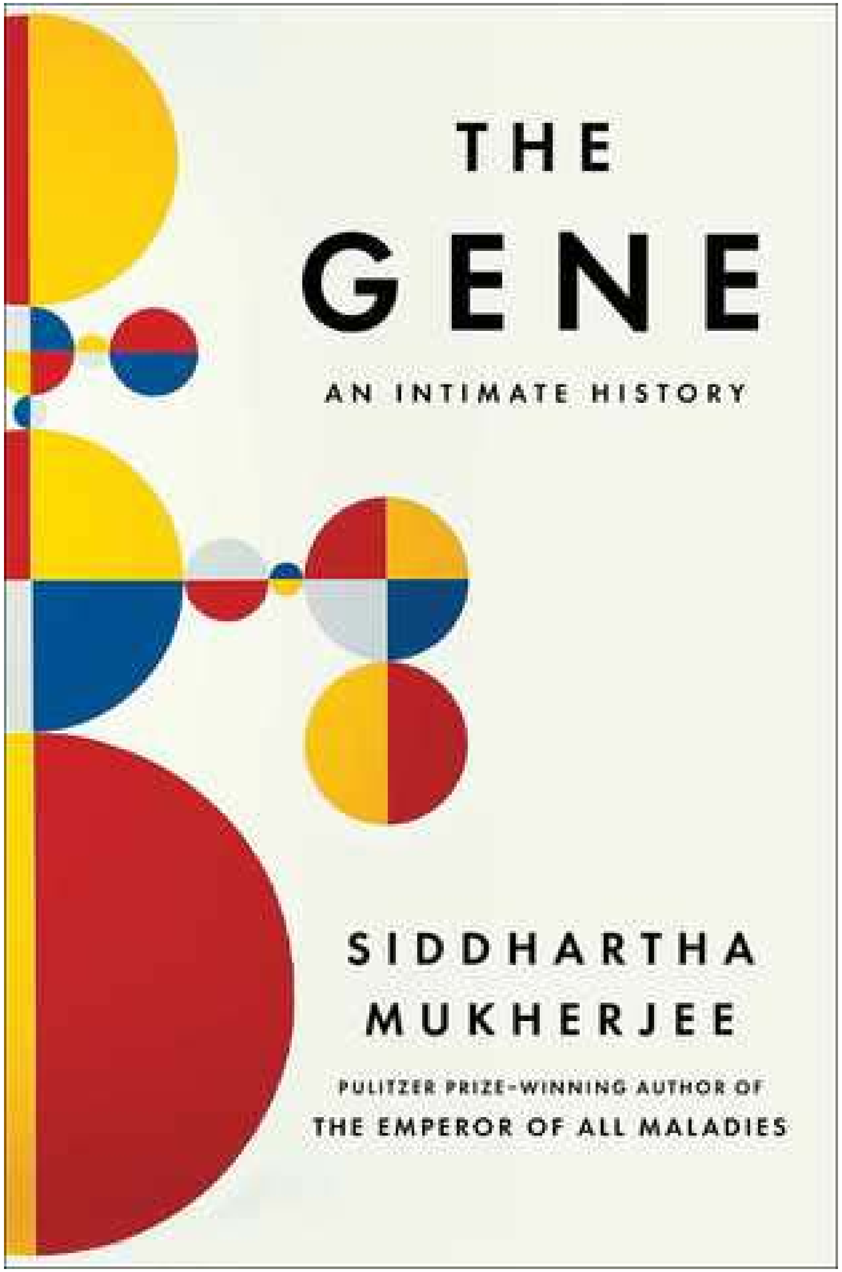
Now



"This structure has novel features which are of considerable biological interest"………It has not escaped our notice that the specific pairing we have postulated immediately suggests a possible copying mechanism for the genetic material"

Watson and Crick in Nature, April 25, 1953

“Three profoundly destabilizing scientific ideas ricochet through the twentieth century, trisecting it into three unequal parts: ***the atom, the byte, the gene***. Each begins its life as a rather abstract scientific concept, but grows to invade multiple human discourses- thereby transforming culture, society, politics and language. But the most crucial parallel between the three ideas is conceptual: each represents the i*rreducible unit-the building block, the base organizational unit- of a larger whole: the atom of matter; the byte of digitized information and the gene, of heredity and biological information”*



Science in pre-independent India

MISSED OPPORTUNITY FOR INDIAN SCIENCE

By the thirteenth century the free spirit of the western mind was adapting to hypothesis driven and evidence based scientific methods for exploring our physical and material world; however, the Indian mind had been enslaved by successive conquests by alien cultures. The age of reason and enlightenment bypassed us, both materially and literally.

India's awakening

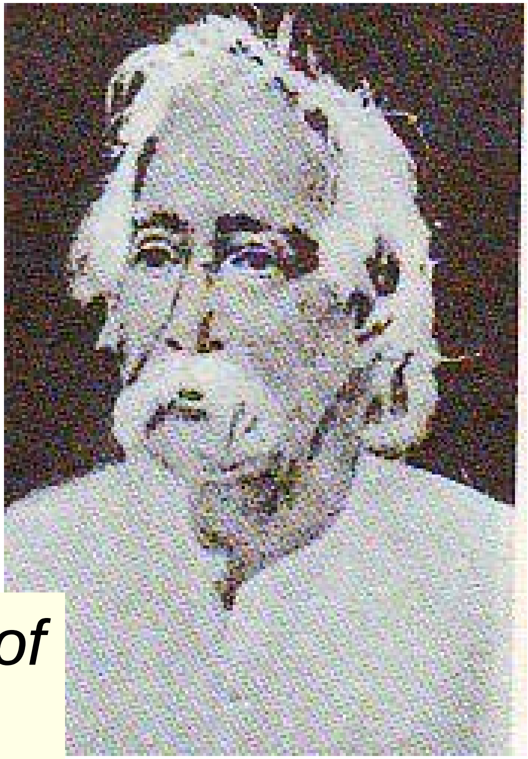
Long years ago we made a tryst with destiny, and now that time comes when we shall redeem our pledge, not wholly or in full measure, but very substantially. At the stroke of the midnight hour, when the world sleeps, India will awake to life and freedom. A moment comes, which comes but rarely in history, when we step out from the old to new, when an age ends, and when the soul of a nation, long suppressed, finds utterance.

Jawaharlal Nehru, Midnight August 14, 2017

MAHENDRA LAL SARKAR'S VIEWS ON INDIAN ASSOCIATION FOR THE CULTIVATION OF SCIENCE,ESTD 1876

"The sole function will be science-learning and science- teaching. We should carry on unaided by the (British) Government or more properly speaking, without seeking its aid. **I want freedom for the institution. I want it to be solely native and purely National.**"

"I reiterate my conviction that if our country is to advance at all and take rank with civilized nations, it can only be by means of science. To this end, I have given the best portion of my life, but I am sorry to leave this world with the impression that my labours have not met with the success it deserves." (*Last letter*, Nov. 1903**)**



1833-1904

Indian science was born by a deep sense of nationalism; to contribute to science was considered as a national service

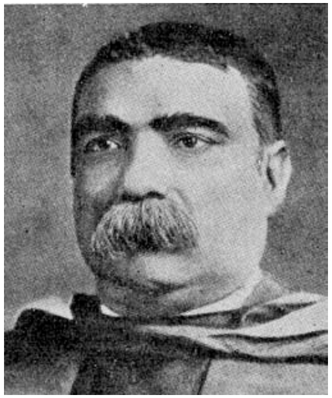
PROFESSOR NIL RATAN DHAR: ANOTHER STAUNCH NATIONALIST

1892-1986

- Mentored by Acharya P. C. Ray, 1909
- Founder of the discipline of Physical Chemistry in India
- A staunch nationalist who believed in the power of evidence based science and science as a tool for nation building

" I sincerely believe that sound progress of our nation depends essentially on science and its applications and I have preached this gospel for over 40 years. I am extremely keen on seeing Indian scientists taking up this ***matter of national regeneration through science with hard labour, great fortitude, devotion and sacrifice."***

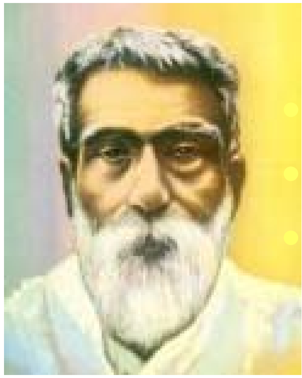
BEGINNINGS OF MODERN INDIAN SCIENCE



Asutosh Mukherjee (1864-1924)
First Indian to publish a paper (1881)

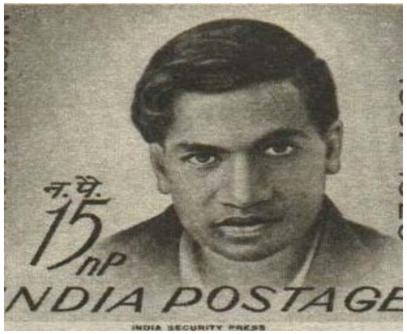
J. C. Bose (1858-1937)

- Microwave communication, semiconductor
- Missed the 1902 Nobel (Marconi)
- "Satyagraha": Salary boycott



P. C. Ray (1861-1944)

- First to do research in Chemistry
- Established Bengal Chemical and
- Pharmaceuticals (1901)



S. Ramanujan (1887-1920)

- FA fail (1908), First paper 1911, FRS (1918)

JEWELS OF INDIAN SCIENCE IN PRE INDEPENDENCE PERIOD

- C V Raman
- S Ramanujan
- Sir K S Krishnan
- S N Bose
- Sir M Visvesvaraya
- J C Bose
- Birbal Sahni
- P C Ray
- M N Saha



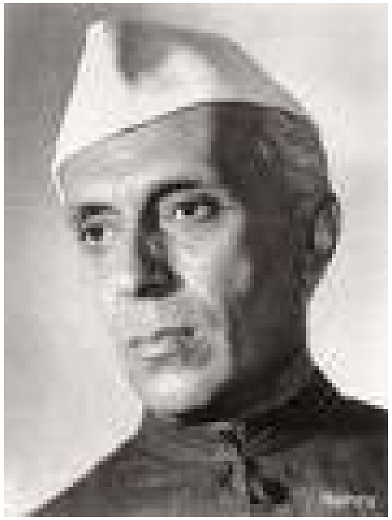






NEHRUVIAN GRAND VISION OF SCIENCE

" 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

Origins of modern scientific enterprise

THE ORIGINS OF MODERN SCIENCE

- Scientific modernity began around 1700 with the publication of Isaac Newton's publication of "Opticks"
- This was the forerunner to the Age of Reason and the emergence of Enlightenment
- Enlightenment provided an exalted view of human rationality and claimed that all individuals have the right as well as the power to shape their own destinies
- This led to the emergence of rational scientific inquiry processes resulting in epoch making discoveries and eventually to the industrial revolution

MAN IN CONTROL OF HIS OWN DESTINY

- I think; therefore, I am : Rene Descartes (1596-1650), Father of western philosophy and believer in rationalism
- The Critique of Pure Reason: Immanuel Kant (1724-1804), Mind shapes our experience; proposed the concept of space and time as well as cause and effect
- How we think (1910) ? : John Dewey(1859-1952), American philosopher and thinker who propagated the view that democracies encouraged free thought

Human individuals are the primary agent of creativity

You are that which you create : Don Reitz, American Sculptor 1920-2014

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

Thomas Kuhn defined the history of science in the mold of an evolution

The domain of the natural is not essentially different from the domain of the social

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 rationale for organized science, government funded or directed science

Roger Pielke, Nature, 27 March 2014, Vol. 507, 427

The Sage of Science, A. Brown, Oxford University Press, 2007

THE ROMANTIC VIEW OF 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!

THE ROMANTIC VIEW OF SCIENCE

“ 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

GOVERNMENT (PUBLIC) FUNDED RESEARCH IS OF A RECENT ORIGIN

- State funding of research is a post world War II phenomena

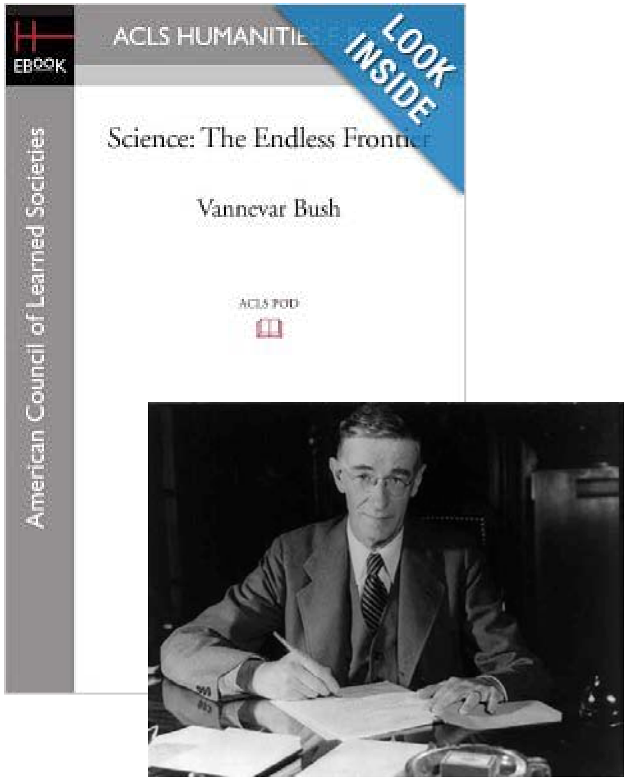
- A large part of nineteenth and twentieth century research and explorations in science were not funded by the state.

- 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 !

PUBLIC FUNDING OF SCIENCE : THE ORIGINS

- 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
- This tenet was implicitly accepted by Governments around the world as an established public policy



1945

The Cold War fuelled large public investment in science driven by the military-industrial complex; with the collapse of the Communism, this rationale was lost

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

JUSTIFICATION FOR PUBLICLY FUNDED SCIENCE

- Public funding of science provides a framework of theory and experimental data that places limits on available space for innovation
- It creates human resources trained in critical inquiry
- It supports innovation that are too risky for industry to pursue
- Public funded research has led to a vast body of knowledge that lie at the foundation of all technologies
- Science leading to solutions in areas such a new energy sources, public health, built habitats, environment, natural resource conservation and recycling will need public investments

It is perfectly reasonable to build an economic case for basic research. However, to realize value one needs practical and financial support to underpin training, networks and start up investment

M . Peplow, www.chemistryworld.org, August 2015

J. Stilgoe, The Guardian, October 26, 2015
V. Sivaram, The Newsweek, October 28, 2015

Science in Independent India : Evolution of public policies

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" and "indigenous development" of technology were the underlying basis of national pride, echoes of which we hear even today

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 ay 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

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

42^{nd} 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

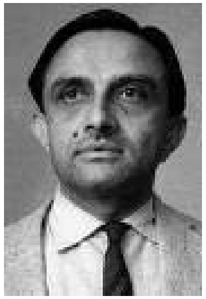
SCIENCE IN INDIA POST 1950

- Science in pre-independent India was predominantly individual science pursued within the confines of an University
- State funding of science began in the early fifties. Emphasis was on creation of large R&D organizations to serve developments in industrial research (CSIR), atomic energy (BARC), space research(ISRO), agricultural research(ICAR), medical research (ICMR) etc.
- In education, focus was on creating exclusive institutes for technology (IIT's)
- Education, originally a state subject, became a concurrent subject and federal government began to create central institutions. State Universities were left to the mercy of state funding

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.

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

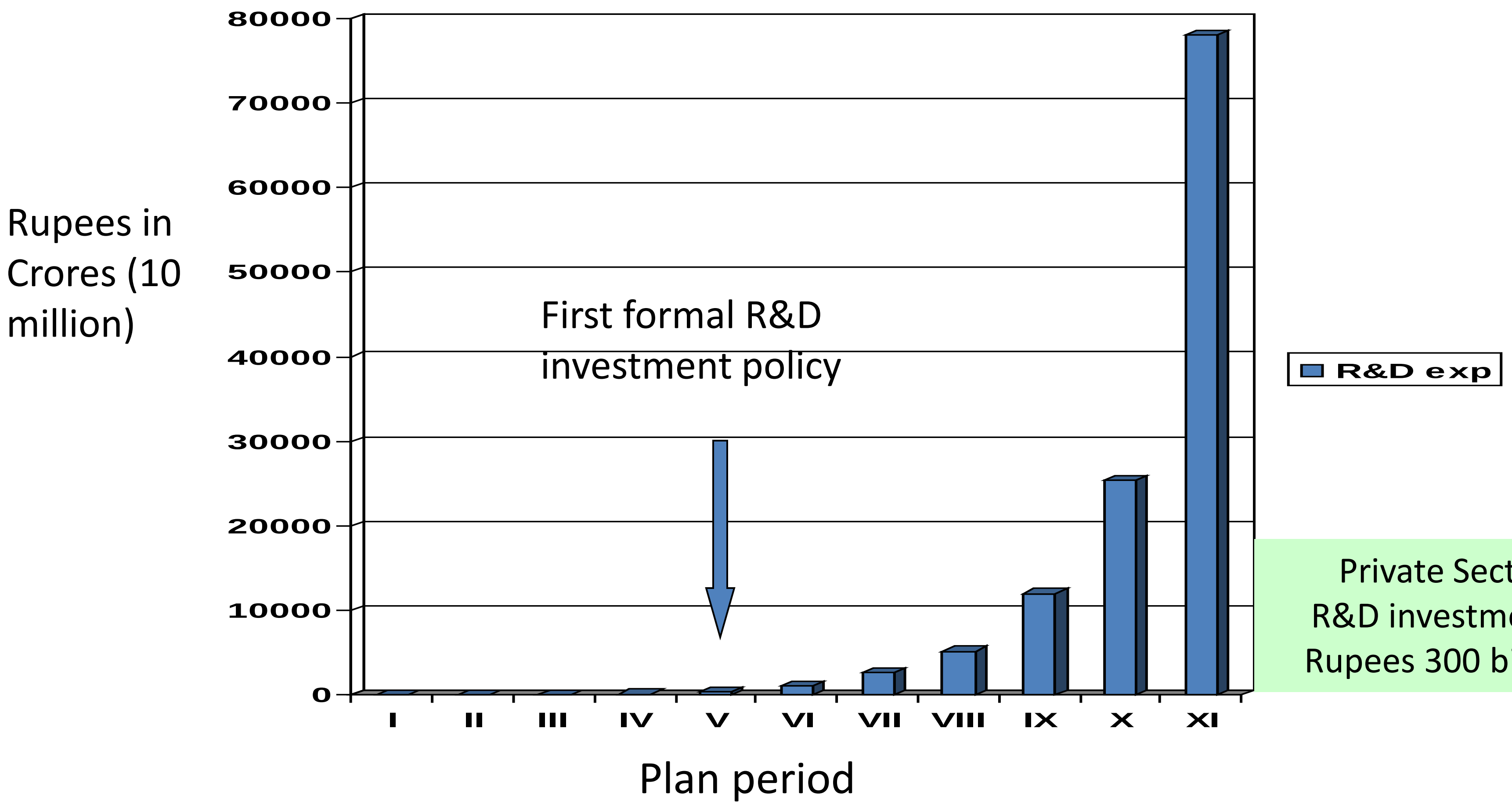
- Science Policy Resolution of 1958 (March 4, 1958)
- Technology Policy Statement of 1983
- Science and Technology Policy of 2003
- Science, Technology and Innovation Policy 2013

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

INDIA'S R&D INVESTMENTS

Rupees 800 billion



Private Sector R&D investment : Rupees 300 billion

INDIA SCIENCE INDICATORS

- R&D investment as a % GDP (2011) : 0.88
- Gross domestic expenditure on R&D : 42.8 billion US $ (PPP, constant 2005 prices)
- Gross expenditure on R&D per researcher : 201,800 US $ (PPP, 2013)
- Number of researchers : 1,93,000
- Total publications : 53,733 (4 % of global)
- Patents granted per million population : 1.6 (USA 160, UK 90, China 13, Russia 7.7)

RESEARCH SPENDING AND SCIENTIFIC PROWESS

Country	R&D as % GDP	GERD *, 2015 at PPP $ billion	Share of world GERD, %	GERD per researcher, PPP $ thousand, 2013	Share of Publications, %	Researchers, lakh	Patents per million population
USA	2.8	396.7	28.1	313.6	25.3	12.65	910
UK	1.8	-	-	-	6.9	2.59	-
Japan	-	-	-	-	5.8	6.61	3,716
S.Korea	-	-	-	-	4.0	3.22	4,451
Brazil	1.2	-	2.2	210.5	2.9	1.39	34
China	1.9	290	19.6	195.4	20.2	14.84	541
India	0.9	42.8	3.2	201.8	4.2	1.93	17 Country

- Gross Domestic Expenditure on R&D
- Source : UNESCO Science Report, 2015; Nature, 2011, 2013 and 2015

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

R&D Institutes	**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

GLOBAL RANKINGS : INDIA

- Global Innovation Index (INSEAD), 2015 : 81
- Global Competitiveness Index, 2016 : 50/142 (USA 2, UK 10 , China 49)
- Global Intellectual Property Index (University of Maastricht, NL): 7.05, 37/38
- Bloomberg Innovation Index, 2016 : 45/50 (S. Korea 1, Sweden 3, Singapore 6 and USA 8)

India has to transition from a "Factor" driven to "Efficiency" driven and ultimately "Innovation" driven economy

INDIA’S PUBLIC FUNDED S&T FOCUS SHIFTING TO TRANSLATIONAL RESEARCH

- DBT : Commercialize public funded R&D; create TTO’s : 150; Technology and Business Incubators : 40
- DST : Promote start ups and high risk as well as industry relevant research
- CSIR : Align R&D with national missions, sanitation, cleaning of rivers, smart cities etc; 50 % of expenditure earn through external grants, licensing incomes and industry collaborations

Increasing pressures on publicly funded science to deliver solutions that benefit society

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 !

Science in the 21st Century

SCIENCE IN THE 21st CENTURY

- Scientific, technological and social trends are rapidly transforming the way we live and work
- Technology is ubiquitous in the world we inhabit today; yet an average citizen has far little understanding of science and technology today than in the past
- Public policy discourse has also tended to become biased, opinionated with selective dissemination of information
- We all realize that science and technology have to provide answers to many critical problems that we face today; yet we do not have a coherent and shared vision of how we will accomplish this goal
- A scientific order, philosophy and public policy that served us for over fifty years is now broken; there is a need to construct a new public policy framework that will defend future science

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, Carothers, 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 business managers
- Corporate leadership came under increasing pressure to perform; time needed to recover investments in R&D became short.
- Increasing input cost, globalization, faster technology diffusion, product commodatization, product liability, environment , health, safety and sustainability issues made investment in R&D more risky.

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

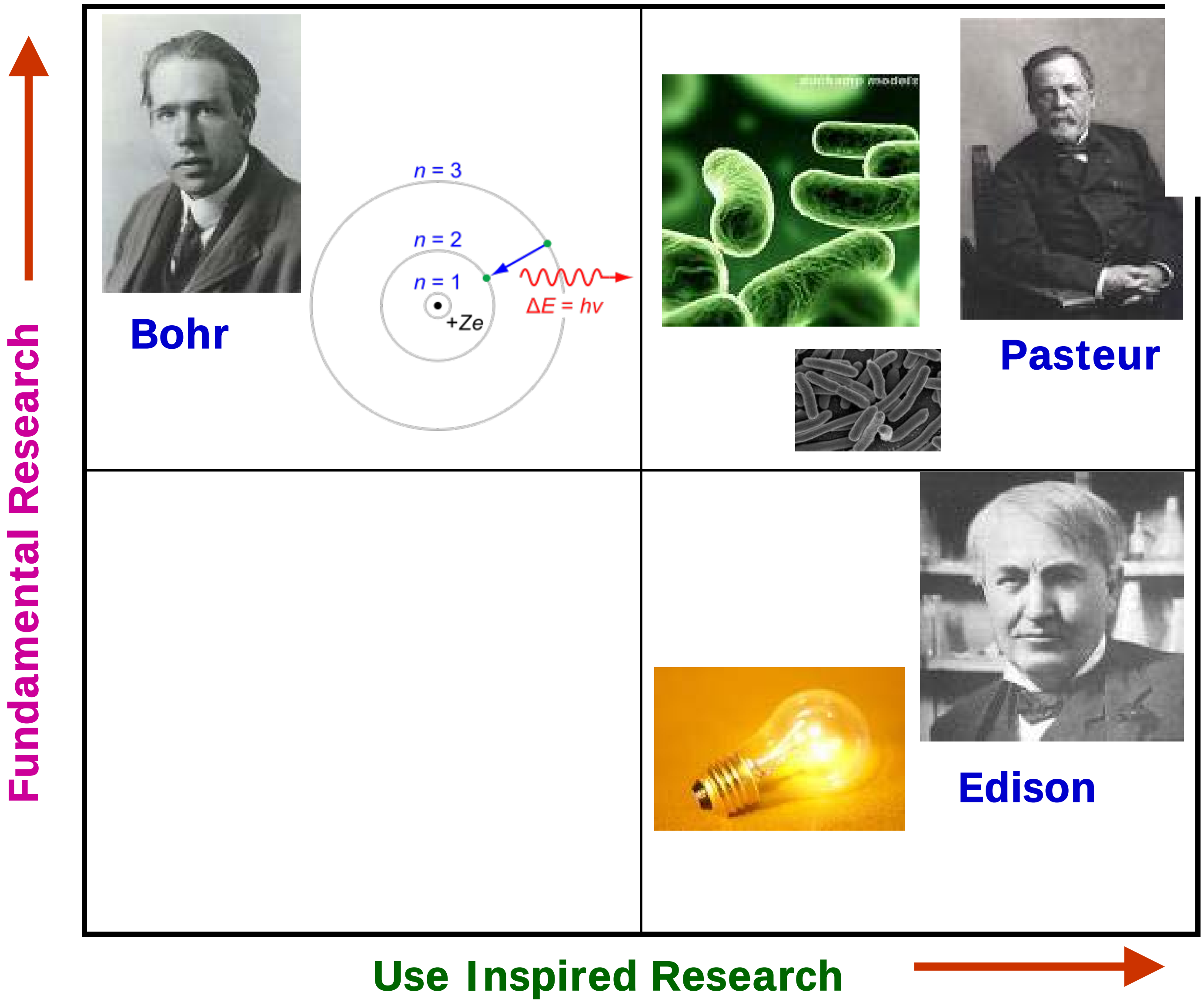
The lack of precision in the language of the scientists is symptomatic of the lack of clarity on the nature of scientific enterprise

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

Pasteur's Quadrant



1997

BASIC AND APPLIED SCIENCE : ARE THEY DIFFERENT ?

Metaphor: Buckets of paint vs painting

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 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

THE FUTURE OF SCIENCE

- Science increasingly is interdisciplinary and cross functional
- New paradigms in research funding; public funding increasingly tied to demonstrating measurable benefits to society
- Turbulence on global economy and politics beset with income inequality, low growth, anti-intellectualism and oscillations between globalization and isolationism
- An impatient citizenry, looking for quick solutions and increasingly aspiring for an “ideal” world, which may be beyond our reach

Science, technology and public policy is yet to come to terms with this new reality; we seem to be seeking solutions to future problems using old processes and methods

WHY SHOULD GOVERNMENT FUND SCIENCE ?

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SCIENCE IN UNCERTAIN TIMES

Obama's science budget disappoints

US

Funding fails to keep pace with inflation

US researchers and science advocates are expressing significant disappointment at funding proposals for research agencies in President Obama's budget request for 2015. 'The proposed increase only 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 Ruskin, a spokesperson for the American Chemical Society.

The Obama administration's budget request, released on 4 March, would deliver 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 \$135.4 billion in federal funding for R&D, an increase of 1.2% from the current level. Meanwhile, non-defence R&D would receive \$65.9 billion, an increase of 0.7%, and basic research would receive \$32.1 billion, which represents a reduction of about 1%.

Inflationary pressures

Some of the biggest research agencies, like the National Institutes of Health (NIH), the National Science Foundation (NSF), Nasa and the Department of Energy's Office of Science, would see their budgets increase 1% or less under the president's proposal. NIH's funding would reach \$30.2 billion, NSF's would go to \$7.3 billion and the Department of Energy's Office of Science's would hit \$5.1 billion. Nasa, too, would see its overall budget rise about 1%, but its science budget would fall by about 3.5% to \$5.15 billion.

The president's funding requests become bleaker after accounting for inflation. For the US economy as a whole, inflation between fiscal year 2014 and 2015 is 1.7%, according to White House figures. In addition, the biomedical research inflation rate is projected at around 3%.

Nevertheless, details about the administration's proposed budget remain elusive. For example, it is unclear how the requested funding increases or cuts for science agencies would be dispersed across programmes or research directorates.

Meanwhile, the research lobby has been comforted by the fact that the president has submitted to Congress, alongside his budget proposal, a separate \$56 billion Opportunity, Growth and Security Initiative that would provide an extra \$5.3 billion for R&D activities. This would include an additional \$970 million for the NIH, \$886 million for Nasa and \$552 million for the NSF. But that proposal will need congressional approval, which appears unlikely.

Above and beyond

'The initiative [...] is above and beyond the approved funding levels agreed to in December,' says Ruskin. 'In light of that it will likely face an uphill battle on Capitol Hill.' Nevertheless, Ruskin 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 times, the president's budget strives 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 lobby groups are not enthused. 'The anaemic funding levels for these agencies wasn't and isn't the best we can muster, it's a strat error that needs to be cor says Research!America pr and chief executive Mary 'Many researchers have al been forced to shutter the and stall promising resea clinical trials, leaving pati with more delays to acces treatments and therapies.

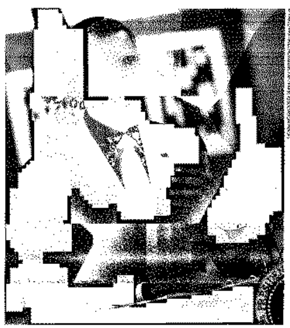
Flat cash

Even fellow Democrat Ed Bernice Johnson, who ser the science, space and tec committee that oversees research areas and agenci expressed reservations ab the president's budget rec She is concerned by 'flat c even decreased funding' i number of key areas of the government's R&D budge In particular, she noted th proposed funding for Nas reach even 2014 levels. It' Johnson says it will 'hind agency's performance in coming years'.

In its request for Nasa, administration sets aside for the Wide-Field Infrare Survey Telescope (WFIRS space observatory that wo probe exoplanets and sea for dark energy. It also pr ending the US's involvem the Stratospheric Observatory for Infrared Astronomy (SOFI the world's largest airborne observatory that is an 80:20 partnership of Nasa and the German Aerospace Center. Th administration's proposal co just days after SOFIA reached operational status.

Given that this is an electio year, and sharp differences ha been expressed between the political parties about fundin in 2015, observers agree that the fate of the budget remain uncertain. In addition, they a that the odds of Congress pas the Opportunity, Growth and Security Initiative seem espec long because it exceeds the budget caps that recently gai bipartisan support.

Rebecca Trager



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

Australian science base eroded by cuts

FUNDING

Scientists decry decisions as 'politicised'

Australia's research community is reeling from what have been described as short-sighted and politically motivated cuts, outlined in the new conservative government's first budget.

Only medical research emerges as a real winner, with the creation of a A\$20 billion (£11 billion) fund by 2023. 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 realise that medical research needs underlying expertise in the chemical and physical sciences, and that support is being eroded'.

'It's an easy headline grabber,' says Michael Borgas, secretary of the Commonwealth Scientific and Industrial Research Organisation (CSIRO) union, talking about the medical fund, but he argues it 'politicises' research as it will be built up through a new A\$7 consultation fee for seeing a doctor. The money will be ploughed into medical research once the fund reaches its A\$20 billion goal.

'There is no thought as to how to use the money: they don't have any understanding of the science system,' says Borgas. CSIRO – the largest government research organisation – faces cuts of A\$111.4 million. It will lose 420–500 staff in the next year. Coming on top of 300 previously announced redundancies, this means the organisation will shrink by around 20% in just two years. There was further bad news for CSIRO with reports that eight research facilities will also be closed.

Sleight of hand

Both Field and Borgas welcome an additional year's funding for big infrastructure projects, such as the Australian Synchrotron and the Square Kilometre Array's supercomputer. But a feature of the budget will see science funding redirected from one programme to another, so although CSIRO budgets will be supporting infrastructure, there will be less money for its scientists to use the facilities. Field bemoans the short-term approach the government is taking: 'One has to work out what infrastructure you need and how to support it – and that transcends the lifetime of a government.'

Environment, climate change and renewable energy are all big casualties of the budget – most notably the intended abolition of the Renewable Energy Agency that will save A\$1.3 billion, and the A\$10 billion Clean Energy Finance Corporation. A\$162.9 million will be cut from the carbon capture and storage flagship, and a commitment to 1 million solar roofs has been withdrawn.

Abandoning carbon pricing will cost the Australian treasury A\$20 billion, while mining corporations will get A\$13 billion in subsidies through diesel fuel rebates, asset depreciation rules and offsetting the costs of exploration, says Victoria McKenzie-McHarg, climate campaign manager at the Australian Conservation Foundation. 'Billions of dollars have been cut from clean energy programmes which wer delivering jobs on the ground.' She argues these were position Australia to take advantage of its natural resources: 'A great opportunity to change our economy has been squandered – the question is whether through willful ignorance or a fundamental misunderstandin

Fees quandary

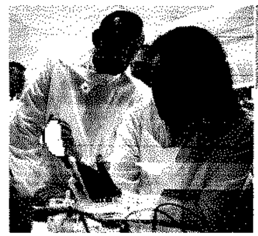
From 2016, the university fundi model is changing so that universities will be able to decid their own course fees. Universiti will have to cover an 8.5% drop i funding compared with what wo promised in last year's budget – and one which already included stringent cutbacks. Changes to t higher education loan program mean interest rates payable by students taking out the loans wi be set at the higher 10 year bond rate, rather than inflation.

'Universities are still trying to unpack the consequences of undergraduate fees, and trying to work out what the market will bear,' says Field. Nor do universities yet know the impac of new fees for PhD and master students. 'Government support for science undergraduates has been hit hard, so universities wi have to work harder to recover more money from science students,' he says, 'so it's going to cost more to study science [...] and that may mean people choo shorter degrees.'

The Australian Research Council will have to find almost A\$75 million in efficiency saving over the next three years, and A\$92 million of its funding wil be redirected towards research into tropical health and medicin dementia and the Antarctic.

As the main agency which supports science other than heal and medicine, the success of gra applications is already just 20% says Field. Its settlement 'will put Australia into a zone where funding for chemical research, f example, may not be available.'

Angeli Mehta



Tony Abbott's government is backing a new A\$20 billion medical fund

THE BUDGET IN NUMBERS

Winners	Losers
A\$20 billion for a medical research fund	CSIRO funding cut by A\$111.4 million
A\$140 million to continue mid-career fellowships	Clean technology programmes axed saving A\$44 million
A\$150 million for the National Collaborative Research Infrastructure Strategy for 2015–16	Innovation and commercialisation programmes cut by A\$650m
	Carbon capture and storage flagship cut by A\$162.9 million

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

Portuguese chemistry faces disaster

FUNDING

A third of academic chemistry labs could 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 get nothing for the duration of the 2015–2020 funding period, starting in January 2015. Those rated 'good' will receive only core funding, ranging from €5000 (£3960) for the smallest labs up to €40,000.

Across all research areas, 22% of all centres evaluated were given a poor or fair rating and will get no funding at all. Of the 36 chemistry research centres evaluated, six failed to receive a high enough rating to proceed to the next round. Some of these centres received a very good or excellent rating in previous reviews, and are suddenly facing a severe loss of income.

'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 EU funding, the FCT is the principal source of funding for chemical research, including PhD and postdoc scholarships. There is virtually no industrial funding.'

The Portuguese Chemical Society (SPQ) said it is 'deeply concerned' by the review's outcome, and urged the FCT to look again at its evaluation processes.

'Several chemistry research centres have not passed the second stage of the evaluation process, which essentially condemns them to extinction,' they said in a statement. 'Some of these research centres have significant indicators of scientific productivity, based on the fact that they mostly received "excellent" or "very good" ratings in previous reviews.'

SPQ secretary general Sérgio Seixas de Melo tells *Chemistry World* that the society carried out its own bibliographic study based on data provided by Elsevier. 'We found that in many research fields some of the most productive [centres] were excluded 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 saying 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 Stoye

Scientists unsure about Modi

POLITICS

New Indian government must address underfunding

India may have dispatched a mission to Mars recently, but no Indian citizen has won a science Nobel prize since the country gained independence in 1947. As a new government takes centre stage in the world's largest democracy, the scientific community is demanding a renewed focus on science.

The new prime minister, Narendra Modi, has appointed endocrinologist Jitendra Singh as the new science and technology minister. Singh is a newcomer to politics and had not run for election until this year. 'Most of the ministers who are given this portfolio are low profile, and it's unfair to speculate on how he will perform based on his political experience,' says Mathai Joseph, a software R&D consultant and a former professor of computer science at the University of Warwick, UK. 'He has a background in science. I'm optimistic.'

Same old problems

The new government faces a set of problems that have plagued Indian science for years. 'Former Indian Prime Minister Manmohan Singh spoke of increasing the science and technology budget to 2% of GDP for donkey's years, but nothing happened,' says N Raghuram, associate professor of functional genomics and molecular biology at Guru Gobind Singh Indraprastha University, and former secretary of the independent scientific community watchdog Society for Scientific Values. India's current public spending on research and development is around 0.9% of GDP, which is lower than other rapidly developing countries, with China and Brazil spending 1.8% and 1.3% of their GDP on science, respectively. Moreover, India's contribution to global spending on research and development is a mere 2.7%, compared with China's 15.3%.

According to an analysis by the thinktank Centre for Public Policy Research, India's science budget was cut by 1.62% in 2012–13, compared with the previous year. However, it did see a year-on-year increase of 21% in 2013–14.

The last government earmarked just Rs82.5 billion (£829 million) for the ministry of science and technology, compared with Rs287 billion for the atomic energy and space departments in 2013–14.

Thomson Reuters data shows that while India's research output grew substantially from 2001 to 2013 – at nearly three times the rate of the global average – its percentage of highly cited papers remained low, hovering around 0.7% in 2011. Joseph blames this on a lack of money for universities. 'Universities are blamed for not creating enough PhDs,' Joseph says. 'But they do not have sufficient funding to create enough PhDs, to produce manpower for the research institutes and generate quality papers.'

Most scientific research in India is publicly funded, with the money controlled by government agencies. Joseph advocates creating an independent agency along the lines of the National Science Foundation in the US or the European Research Council to dispense science money. 'Creating independent agencies expedites the process of approvals for research,' he notes.

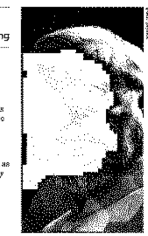
Ajey Lele, a research fellow at the Indian Institute for Defence Studies and Analyses, says the major tenets outlined in the science and innovation policy unveiled by the government in 2013 should be continued by the new one. 'Attracting private investments in R&D, for example, could be one fruitful area,' Lele says.

Environmental concerns

Meanwhile, the Modi government has renamed the environment ministry to include climate change in its title. 'It is a good move, symbolically, to include climate change under the portfolio of the environment ministry,' says Chandra Bhushan, deputy director general of the non-profit Centre for Science and Environment. 'This shows that this government is putting a little more emphasis on climate change than the previous one.'

However, Vinuta Gopal, Greenpeace India's climate and energy head, is sceptical about the government's commitment to protect the environment. 'In the first few days of governance, they've indicated how they're going to fast-track green clearances,' says Gopal. 'While the environment minister, Prakash Javadekar, keeps indicating that development will not be favoured over the environment, the message they're really sending out to the industry is that clearances would not be held up.'

Dinsa Sachan



Will Modi's government deliver for India on science?

IN THE PAPERS

Rothko restored

Rothko's *Black on Maroon* painting has been put bac on display in the UK's Tate Modern gallery, following months of restoration afte was vandalised with inde ink. Conservators used a mixture of benzyl alcohol ethyl lactate, applied unde a microscope using a very fine brush, to dissolve the ink bit by bit, removing th graffiti without damaging painting itself.

The Guardian, 14 May 201

Tomato pill for heart healt

A daily 'tomato pill' contai the antioxidant lycopene – the red pigment that gives tomatoes and peppers the colour – may help preven heart disease. Researcher found that tomato pills improved the function of blood vessels in a test grou 72 adults, when compared a placebo.

BBC News, 9 June 2014

Brushing back enamel

Unilever has launched a toothpaste that they clai restore and whiten damag teeth by regenerating 82% enamel in just three days use. The toothpaste conta calcium silicate and sodiu phosphate, which provide building blocks for a fresh of enamel (calcium phosp

The Daily Mail, 15 June 20

Booze bracelet

An ankle bracelet that can tell if the wearer has been drinking by detecting alc in their sweat will be trial in the UK for monitoring criminals convicted of dri related offences. The scr bracelet, which has been successful in the US, cont a fuel cell that works in a similar way to a breathaly generating a current whe alcohol is present.

The Times, 14 May 2014

SCIENCE IN UNCERTAIN TIMES

Funding impasse hits Illinois chemists

Political divisions create huge budget shortfalls

Chemistry departments in Illinois, US, are entering perhaps their toughest semester ever, facing budget shortfalls arising from a second year of stopgap state-level educational funding. Universities are among those caught in the crossfire, with politicians' inability to agree on expenditure hitting those with few other funding avenues hardest.

Chicago State University (CSU) has seen 'massive layoffs of administration, support personnel and faculty', says Edmundo Garcia, chair of CSU's department of chemistry, physics and engineering. CSU gets around 40% of its budget from the state, while income from tuition fees is also falling. This is partly because state subsidies for those in financial need went unfunded for several months, but also because students are worried and looking elsewhere. Undergraduate enrolment at CSU for 2016–2017 is currently down 50% compared with 2015–2016.

'We lived from 1 July 2015 until April 2016 without 40% of the money we need to run the school,' Garcia says. 'We let go almost all of our part-time faculty and full-time lecturers. We're in survival mode until this is resolved.'

The crisis began in June 2015 when Republican governor Bruce Rauner vetoed a state budget devised by the Democrat-controlled Illinois government. Rauner said the budget would add \$4 billion (£3 billion) to Illinois' existing debt, estimated to be around \$100–\$300 billion. In April 2016 the opposing sides agreed a \$600 million stopgap package for higher education, whereas the Democrat budget originally earmarked \$1.7 billion. In June, the opposing sides agreed another \$1 billion for higher education through to June 2017.

Eastern Illinois University (EIU) in Charleston, is fractionally better off than CSU, relying on state funding for a third of its budget. It has laid off many support staff, and 25 EIU faculty on previously recurring annual contracts have been lost in the past two years. Meanwhile, the chemistry department is questioning the affordability of using silver nitrate in gravimetric analysis teaching experiments, says Jonathan Blitz, an analytical chemist and president of the faculty union at EIU.

The University of Illinois has suffered less thanks to a greater diversity of funding sources. G Girolami, head of the Urbana–Champaign campus's chemistr department, says that research and teaching has been unaffect although faculty and non-unio staff have had no salary increas over the last two years.

Hopes that the situation will be resolved in the November U elections are tenuous. Rauner i up for re-election, but the entir Illinois House of Representativ and most of the State Senate is. Together, the House and Senat can override Rauner's veto. 'The House is a couple of votes short,' Blitz highlights, and if t Democrats gain seats, they cou force their budgets through. Ill income taxes may be raised aft the election, says Girolami, wh 'would certainly help'.

Andy Extance

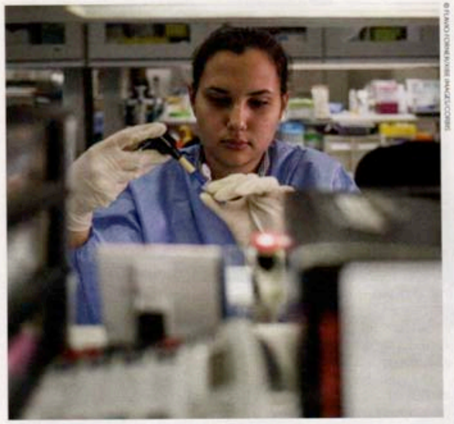
Economic woes squeeze Brazil science

Money earmarked for research held up by cuts

As economic woes grip Brazil, the country's scientific enterprise has been hit hard. The Brazilian economy is expected to contract 3.5% this year following a 3.8% contraction in 2015, marking its worst economic downturn in a quarter of a century. Science funding has taken a knock, despite arguments that such investment is exactly what's needed to pull Brazil out of its slump.

The budget for Brazil's Ministry of Science, Technology and Innovation (MCTI) has been slashed by almost 20% and sits now at about BRL4.3 billion (£875 million). The ministry also faced a significant reduction in 2015, and overall about one-third of its budget was lost from 2014 to 2016.

'There is a huge crisis in Brazilian science,' warns Helena Nader, president of the Brazilian



Funding for Brazil's popular international exchange scheme has been slashed

and entrepreneurship.

There was a call to create

them is available for release later this year. The rest of the

Without Borders, which was created by Brazilian President Dilma Rousseff, who is currently fighting impeachment, in 2011 to improve the nation's competitiveness in science and technology. The initiative is supported both by the Ministry and Education and the MCTI, through the respective funding agencies Coordinating Office for the Advancement of Higher Education (CAPES) and the National Council of Scientific and Technological Development (CNPq).

In its first four years of operation, Science Without Borders funded roughly 101,000 scholarships to enable the international exchange of Brazilian researchers, undergraduates and postgraduates. In 2015, about BRL3.7 billion was provided to the programme by CAPES and BRL1.1 billion by CNPq. This year, those amounts were slashed to BRL1.46 billion and BRL500 million, respectively.

Brexit storm shakes European Research Council

Europe's premier science council's mission at risk

(£43 million) to €1.8 2017, its first increas Switzerland has p

Pierre Bourguignon, president of the ERC.

But June's referendum result casts doubt on the UK's future eligibility. The loss of the UK and Switzerland would 'be a big blow to European science', warns Athene Donald,

the ERC itself of the ERC, ir was following US model, foc and imaginati general acade McConnell sa

Worst may still be to come for Spanish science

Effects of budget cuts from the financial crisis are still in

Nazario Martin, president of the Confederation of Spanish Scientific

the financial the blame for ountries, such as Italy and the UK, nding on R&D n. 'The problem ticians consider nstead of an n says. countries invest

model based on knowledge, and unfortunately the economic recovery hasn't reached our R&D system,' says Jorge Barrero, chief executive of COTEC. The shortfall in public R&D investment in Spain hasn't been made up for by the private sector either. According to COTEC, 47% of R&D was privately funded in Spain, while the private sector in other countries such as Germany, France and the UK covers around

dominated by SMEs, which constitute over 99% of companies and contribute over 65% of GDP – behind only Greece and the Baltic countries. 'These [small] companies already have trouble surviving, and they don't usually conceive research as something useful,' Martin says.

The funding shortfall and other problems, such as a brain drain, haven't affected productivity yet, however. According to CRUE's yearly report, scientific output has remained static. However, Gómez said that the worst is still to come. 'I think we have a good system, which is weathering the crisis quite well, but we must not relax. We are going to see the real effects in a few years.'

Science chief sounds alarm on funding

Calls for US research spending to exceed 3% of GDP

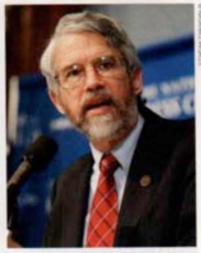
White House science adviser John Holdren and the leaders of three key US science agencies have warned that the nation must up its commitment to science and innovation to ensure it isn't outstripped by its competitors. Holdren expressed disappointment that the Obama administration has fallen short of the president's goal to increase spending on R&D to more than 3% of GDP.

'We haven't quite got there, we are still just under 3%,' Holdren

significant concern that the US's R&D intensity is decreasing relative to other nations.

It has always been a challenge to answer how much R&D investment is sufficient, but empirical evidence shows that the US is making an inadequate investment in science, technology and innovation, he said. The National Institutes of Health (NIH) is only able to fund about 16 or 17% of the grant proposals it receives, he added, when it is estimated that about 50% of the applications submitted have merit.

As another example, Franklin



White House science adviser John Holdren calls for the US to increase

within a dozen years of their PhD, is 'much, much lower' at her agency and elsewhere. 'We are very worried,' Cordova said. 'The other consequence of this is that we are losing people to science because they are getting discouraged by not getting their grant accepted.'

Despite its failure to achieve the 3% of GDP target, science and technology fared better under President Obama's budgets than almost any other sector of the government. 'That was a result of the president's understanding of how and why science and technology

WHAT THE FUTURE HOLDS ?

- New ways of practicing science; where science is done, how knowledge is shared and how credit is assigned
- Increased connectivity in the world of science driven by openness and real time collaboration
- Changes in global demography and its impact on mobility and talent; how will nation compete to attract talent?

It is impossible to predict the future; we can either create it or prepare ourselves to face it

THE FUTURE OF SCIENCE FUNDING

- Competing demands for public funding to meet the needs of a growing population and meet social objectives will limit spending on science
- Public funding will be heavily focused on outcomes that tackle the immediate problems of society
- Private funding of research will grow, not from industries, but from individuals, foundations, philanthropy, prizes and crowd sourcing; private institutes will be created for pursuing basic research
- Consumers of research will become its funders

Will the original meaning of a research university supported by public funds become redundant? Will public funding be limited to only teaching and imparting skills?

IS PHILANTHROPHY 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

IS PHILANTHROPHY AN ALTERNATIVE TO GOVERNMENT FUNDED SCIENCE ?

Emergence of philanthropic funding of science

New Institutions

- Janelia Farm
- Allen Institute of Brain Sciences
- Broad Institute
- Welcome 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

DOES PUBLICLY FUNDED SCIENCE DRIVE INNOVATION ?

- The linear model of pure science leading to applied science which in turn becomes useful technology is considered a myth by some
- Are scientific breakthroughs cause or effect of technological change ?
- Is there a relationship between public funding of science and economic development ?
- Does public funding crowd out private funding?
- Should the Government subsidize research for industry?
- Is innovation an autonomous, self perpetuating process? Does technology find inventors or vice versa?
- Is tinkering with existing technologies sufficient to produce "new" technologies?

Matt Ridley, Wall Street Journal, October 23, 2015

DOES PUBLIC INVESTMENT IN SCIENCE 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

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 !

IN CONCLUSION……….

- The human race in the early part of 21st century is living in an unprecedented period of peace and prosperity. More people in the world have been lifted out of penury in the last quarter century, people are healthier, living better and longer. Many basic human needs have been fulfilled; So it is no wonder an average citizen's interest in science and technology has also waned. He is no longer looking for "miracles of science"

- This does not mean the world has no problems; environment, energy, global warming, climate change are issues that are threatening the long term survival of this planet. However, an average human mind cannot grasp issues that do not impact him in his own life time. To make a case for science for solutions that are needed in a distant future is no easy task !

Beyond the science bubble

Research leaders in the United States and elsewhere should address the needs and employment prospects of taxpayers who have seen little benefit from scientific advances.

One question dominated discussions at the annual meeting of the American Association for the Advancement of Science (AAAS) at the weekend. Researchers, journalists and science lobbyists squeezed into conference rooms, perched on recycling bins and sat on the floor between rows of filled chairs as they strained to listen to those who tried to offer a response. The question was phrased in various ways, but the variations all boiled down to: how should science and scientists respond to the administration of President Donald Trump?

The answers were numerous too — from political activism to better communication — and were met with cheers, applause and the odd standing ovation. Many scientists will have left the Boston conference with renewed hope, or at least a sense of combined purpose. They had an answer of sorts to their question.

But it's the wrong question. It is not Trump that scientists must respond to. The real question is what science can do for the people who voted for him. Exactly who did support him, and why, is still being debated by political scientists, but it's clear that many of those who voted Trump are those he canvassed in his campaign and credited in his inauguration speech. It is people who feel left behind by supposed progress and who have suffered a real or perceived collapse in their quality of life.

PERSUADING THE UNCONVINCED

One speaker at the AAAS meeting appropriately sharpened the challenge. There are two types of taxpayer: those who pay up voluntarily because they believe in the public good that the money generates, and those who pay only because they will be put in jail if they don't. How many scientists, he suggested, could confidently say their project was so important to people that those people should be thrown into prison for not supporting it?

Just telling the same old stories won't cut it. The most seductive of these stories — and certainly the one that scientists like to tell themselves and each other — is the simple narrative that investment in research feeds innovation and promotes economic growth. 'It's the economy, stupid', so the saying goes, and as nations become a little less stupid by pushing against the frontiers of knowledge, so the benefits of all this new insight spread from the laboratory to the wider population, as improvements in the standard of living and quality of life.

This comfortable story has all the hallmarks of a bubble waiting to pop. For a start, it always has a happy ending. The hero of various quests, science slays the dragon of childhood disease and retrieves the elixir, if not of everlasting life, then at least of increased lifespan. And, like all good stories, this one comes with a pleasing twist: for when it sets off on its quest, science does not know exactly which good deeds it is planning to perform. Pure of heart and research, it is merely enough to send our science hero out into the world, with its consumables, overheads and a postgraduate squire paid for by donations from a grateful and trusting public.

This narrative is truthful enough to have sustained itself for many decades. From the famous discovery of the apparently useless laser that launched uncountable applications to how Einstein's theories of relativity underpin the Global Positioning System — these stories indeed make a case to Trump and his supporters that continued investment in science will help to create companies and jobs.

But as this journal and others have pointed out, it is also clear that the needs of millions of people in the United States (and billions of people around the world) are not well enough served by the agendas and interests that drive much of modern science. There are plenty of reports that show, for example, how public investment in the Human Genome Project has paid off many times over and created firms and jobs, but rather than trickling down through society, these benefits of discovery science arguably deepen the pools of wealth and privilege already in place — creating expensive new drugs that most people cannot afford.

> "The needs of millions of people in the United States are not well enough served by the agendas and interests that drive much of modern science."

It is right that more scientists should tell stories of the good their research can do. But it is more important and urgent than ever that researchers shoul[…] stories really end — a[…] of the people they clai[…] get to live happily eve[…] should focus more effo[…] cation and scientific research can help the many[…] to be displaced by the very inventions that scie[…]

As they ponder their next move in respon[…] Trump, science organizations — universities, fu[…] the rest — should look harder at social proble[…] and seek ways for science to help.

For example, some universities are incre[…] climate-change adaptation. There will be employment opportunities in creating companies that help cities and other regional communities to protect themselves from climate change (whatever the sceptics may be saying), stimulated by the readily applicable and intellectually stimulating insights and improved decision-making that research will deliver.

More universities, for example, could follow the example of Michigan State University in East Lansing, in building stronger links with their local communities, and seeking to work with them to tackle research problems that affect their quality of life. These include monitoring soil and water quality, for example, and addressing the challenges of regional demographics, such as the large numbers of elderly people who live alone in some regions and how to deliver health care to them.

There is also a need to tell these stories compellingly — stories that are harder to tell and of less global impact than the hunt for fundamental particles or new materials. And the most important audiences may not be inclined to listen. But those audiences matter. ■

Do the needs of the people served by the agenda and interests of modern science ?

Stories of impact of science on society is becoming harder to tell; and the important audience are increasingly less inclined to listen

Nature, 23 February 2017, p.391

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