Indian Innovation: The Changing Landscape and Emerging Challenges

R A Mashelkar
Changing Landscape

1. India’s 3 Freedoms!
2. Indian Corporate Innovation Movement
3. Transformation of Public Institutions
4. Emergence as a Global R&D Platform
5. Innovative PPPs
India’s 3 Freedoms

- **First Freedom** - 1947
  Political

- **Second Freedom** - 1991
  Trade and Economic

- **Third Freedom** - 2008
  Technological?
Second Freedom (1991)

Let the customer have any colour of the car as long as it is black

Henry Ford

Let the customer have any car as long as it is Ambassador/Fiat

Indian Government (Pre 1991)
Second Freedom (1991)

Indica to Indigo

If Telco had been allowed to develop as it should have been, I have no doubt we'd be making cars in India. And a Tata car would have been dominant as the Tata truck is today.

JRD Tata Feb 1978
Wheel Turns the Full Circle

1950s
British Morris Oxford

Indian Ambassador

50 years later
Indian Indica

City Rover
And Spiraling Up....
Third Freedom (2008)

- 123 will open doors for access to dual use technology
- Besides Nuclear, great impact on civilian sectors
- Just an example!
SARAS- First indigenous civilian aircraft

Delayed by 2 years!

No access to starter generator- just one of the 15000 components
Changing Landscape

1. India’s 3 Freedoms!

2. Indian Corporate Innovation Movement

3. Transformation of Public Institutions

4. Emergence as a Global R&D Platform

5. Innovative PPPs
Did not exist 30 years ago
Number one in India
Doubled up every 3 years
Basis : Scale - Scope - Cost
Now Innovation!
The Reliance Innovation Movement.....

Growth is Life
Innovation- Way of Life
Innovation Led Growth
Corporate Innovation Movement

**Drugs & pharmaceutical industry**
- Copying molecules to creating molecules

**Auto industry**
- New indigenously designed models launched globally

Game changing innovations too!
R&D Intensity of Indian Corporations in All Reporting Firms and Three Key Sectors, 1991–2004

(R&D spending as a percentage of sales)

Source: Compiled from data in Bowonder and others (2006).
<table>
<thead>
<tr>
<th>Car</th>
<th>Year introduced in U.S.</th>
<th>Horse power</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model T</td>
<td>1908</td>
<td>20</td>
<td>19,700</td>
</tr>
<tr>
<td>Beetle</td>
<td>1956</td>
<td>24</td>
<td>11,333</td>
</tr>
<tr>
<td>Mini</td>
<td>1961</td>
<td>34</td>
<td>11,777</td>
</tr>
<tr>
<td>Tata Motors</td>
<td>2008</td>
<td>33</td>
<td>2,500</td>
</tr>
</tbody>
</table>

*Adjusted to 2007 U.S. dollars

Source: Tata Motors
Denial Driven Innovation!

High Performance Super Computers

From Public R&D
To
Private R&D
Public R&D

“ANGRY INDIA DOES IT!”

The Washington Post

“ANGRY INDIA DOES IT!”
Now Private R&D- TATAs showing the way!

EKA, 4th Fastest Supercomputer
Corporate Innovation Movement

Drugs & pharmaceutical industry

Copying molecules to creating molecules
India can do it!!

Indian Tuberculosis Breakthrough

- Discovery of a new drug molecule, first in last 40 years
- Reduces treatment duration from 6 months to 2 months (in combination)
- In phase II clinical trial

- And many more in the offing...
V Reddy
India’s first recombinant Hepatitis B vaccine

International
Hepatitis B - $18 per dose

40% of UNICEF’s Hep B vaccine supply

Initial funding through ITDP of World Bank (SPREAD)
1984- USD 250 and a garage

2004 – IPO oversubscribed 33 times. Crosses USD 1 billion mark on the first day of listing.

Today she is the richest woman in India!!
Among World’s 100 Most Powerful Women - Forbes 2008

Initial Funding through ITDP of World Bank (TDICI)
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Top Ten Achievements of 20th Century

Jayant Narlikar (2003)
“The Scientific Edge,” Penguin

S. Ramanujam’s – mathematics (20s)
Meghnad Saha’s – ionization equation (20s)
S.N. Bose – particle statistics (1922)
C.V. Raman – Raman Effect (1928)
G.N. Ramachandran – Molecular Biophysics (mid 50s)

Atomic Energy Commission – Nuclear Power – (50s)
Green Revolution (70s)
Space Program (late 70s)
Superconductivity (late 80s)
CSIR Transformation (late 90s)
CEO of CSIR Inc.

Dr R. A. Mashelkar, FRS has hauled India’s laidback laboratories into the real world
CSIR in the Company of

Infosys
Wipro
Hindustan Lever
Reliance
HDFC
HMT
Ranbaxy etc

WORLD CLASS IN INDIA
A CASEBOOK OF COMPANIES IN TRANSFORMATION

Sumantra Ghoshal  Gita Piramal  Sudeep Budhiraja
CSIR being used as a model of institutional transformation by World Bank
In my work in the ECA region, I have recommended CSIR as a model of how countries can harness their top quality scientific research institutions to the task of industrial technology development, innovation, and global competitiveness. Unfortunately, as I wrote you in my previous email, the Monday morning, very few countries in ECA have developed coherent, concerted policies to meet this challenge. Policies exist in principle, but fail short when it comes to actually implementing the necessary reforms and policy adjustments. I am writing to you for two reasons. First, as we discussed briefly this past Monday, I have been asked to organize a high level brainstorming session among public private partnerships to support industrial competitiveness and innovation. The brainstorming session, which will be co-chaired by Mr. Wolfensohn and Russian Prime Minister Fradkov, will convene in Moscow on February 4. I sincerely hope you will be able to participate since I believe the CSIR model is especially relevant for Russian policy makers. I am also interested in hearing your thoughts on this matter.

Dr. A Watkins
Head, ECA Region
World Bank
## Major PCT Applicants from Developing Countries (2002)

<table>
<thead>
<tr>
<th>Rank</th>
<th>Applicant</th>
<th>Country</th>
<th>No (appl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Council of Scientific &amp; Industrial Research</td>
<td>India</td>
<td>184</td>
</tr>
<tr>
<td>2</td>
<td>Samsung Electronic Co.</td>
<td>Rep of Korea</td>
<td>184</td>
</tr>
<tr>
<td>3</td>
<td>Biowindow Gene Development Inc</td>
<td>China</td>
<td>136</td>
</tr>
<tr>
<td>4</td>
<td>LG electronics Inc</td>
<td>China</td>
<td>125</td>
</tr>
<tr>
<td>5</td>
<td>Huawaei Technologies Co.</td>
<td>China</td>
<td>84</td>
</tr>
<tr>
<td>6</td>
<td>Ranbaxy Laboratories Ltd.</td>
<td>India</td>
<td>56</td>
</tr>
<tr>
<td>7</td>
<td>LG Chem Ltd.</td>
<td>Rep of Korea</td>
<td>47</td>
</tr>
<tr>
<td>8</td>
<td>SAE Magnetics (H.K.) Ltd.</td>
<td>China</td>
<td>31</td>
</tr>
<tr>
<td>9</td>
<td>The National University of Singapore</td>
<td>Singapore</td>
<td>28</td>
</tr>
<tr>
<td>10</td>
<td>Philips Electronics Singapore PTE Ltd.</td>
<td>Singapore</td>
<td>24</td>
</tr>
</tbody>
</table>
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5. Innovative PPPs
INDIA’S EMERGENCE AS A GLOBAL R&D PLATFORM:
THE NEW CHALLENGES AND OPPORTUNITIES

Dr. R.A. Mashelkar
Director
National Chemical Laboratory, Pune

4 March 1995
India is a developing country but it is a developed country as far as its intellectual infrastructure is concerned. We get the highest intellectual capital per dollar here.

John Welch
CEO, GE
Intellectual Capital per Dollar

SCI publications per dollar?

Citations per dollar?

Patents per dollar?
<table>
<thead>
<tr>
<th>Country</th>
<th>SCI Publications (1997-2001)</th>
<th>GDP per Capita</th>
<th>SCI Publications per GDP per Capita/ per year</th>
</tr>
</thead>
<tbody>
<tr>
<td>India</td>
<td>77201</td>
<td>487</td>
<td>32</td>
</tr>
<tr>
<td>China</td>
<td>115339</td>
<td>989</td>
<td>23</td>
</tr>
<tr>
<td>United States</td>
<td>1265808</td>
<td>36006</td>
<td>7</td>
</tr>
<tr>
<td>Germany</td>
<td>318286</td>
<td>24051</td>
<td>3</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>342535</td>
<td>26445</td>
<td>3</td>
</tr>
<tr>
<td>Japan</td>
<td>336858</td>
<td>31407</td>
<td>2</td>
</tr>
<tr>
<td>Canada</td>
<td>166216</td>
<td>22777</td>
<td>1</td>
</tr>
<tr>
<td>Italy</td>
<td>147023</td>
<td>20528</td>
<td>1</td>
</tr>
<tr>
<td>Korea, Rep.</td>
<td>55739</td>
<td>10006</td>
<td>1</td>
</tr>
<tr>
<td>France</td>
<td>232058</td>
<td>240461</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Basic source: David King, Nature, July 2004
## Multinational R&D Centres - Snapshot of Employment

<table>
<thead>
<tr>
<th>Company</th>
<th>India R&amp;D jobs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Texas Instruments</td>
<td>1300</td>
</tr>
<tr>
<td>Motorola</td>
<td>1500</td>
</tr>
<tr>
<td>Cummins</td>
<td>400</td>
</tr>
<tr>
<td>GE</td>
<td>5000</td>
</tr>
<tr>
<td>Bosch</td>
<td>2000</td>
</tr>
<tr>
<td>Cisco</td>
<td>1000</td>
</tr>
<tr>
<td>Adobe</td>
<td>800</td>
</tr>
<tr>
<td>Cadence</td>
<td>500</td>
</tr>
<tr>
<td>Intel</td>
<td>2900</td>
</tr>
</tbody>
</table>

Source: CLSA Asia - Pacific Markets
### Multinational R&D Centres - US Patents Generated from India

<table>
<thead>
<tr>
<th>Entity</th>
<th>Patents by Indian Entity</th>
<th>Patents by Global entity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Texas Instruments</td>
<td>225</td>
<td>745</td>
</tr>
<tr>
<td>Intel</td>
<td>125</td>
<td>1,126</td>
</tr>
<tr>
<td>CISCO Systems</td>
<td>120</td>
<td>242</td>
</tr>
<tr>
<td>IBM</td>
<td>120</td>
<td>3,343</td>
</tr>
<tr>
<td>Phillips Innovation Campus</td>
<td>102</td>
<td>1,203</td>
</tr>
<tr>
<td>GE</td>
<td>95</td>
<td>1,758</td>
</tr>
<tr>
<td>Analog Devices</td>
<td>33</td>
<td>87</td>
</tr>
<tr>
<td>Adobe Systems</td>
<td>10</td>
<td>30</td>
</tr>
<tr>
<td>Oracle India Development Centre</td>
<td>10</td>
<td>85</td>
</tr>
<tr>
<td>Sun Microsystems</td>
<td>10</td>
<td>615</td>
</tr>
<tr>
<td>Ciba Speciality Chemicals</td>
<td>9</td>
<td>154</td>
</tr>
<tr>
<td>Cadence Design Systems</td>
<td>4</td>
<td>33</td>
</tr>
</tbody>
</table>

The Tide beginning to turn….

Flight of Human Capital

• Brain Drain

• Brain Gain

• Brain Circulation
Lotka’s Inverse Square Productivity Law

1% of population carries 90% of intellectual capacity

Loose 1% - you lose 90%!
A flight to a land of opportunity

“A scientist is like a painter. Michael Angelo became a great artist because he had been given a wall to paint. My wall was given to me by the United States”

Ricardo Giacconi Nobel Laureate
Emerging Trends

Recent NASSCOM Study

• Approx 30,000 R&D professionals returned to India in the last 3 years
• IIT graduates migrating abroad
  – ~70% (ten years ago)
  – ~30% (today)
IT specialists are coming to India because frontline development work is being done here. Executives, managers and supervisors are coming in at all levels because India is no longer a hardship country. Even interns coming to companies like Infosys, Biocon, and Mahyco to learn first hand about a real happening place.

First came the money – FII and FDI, then came the technology – R&D and manufacturing. Now, come the people.
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New Millennium Indian Technology Leadership Initiative

POSITIONING NMITLI : PROJECTS

- High Market Certainty
- Low Technology Certainty

India so far operated here

NMITLI
NMITLI FOUNDATION

TALENT

TECHNOLOGY

TOLERANCE
NEW MILLENNIUM INDIAN TECHNOLOGY LEADERSHIP INITIATIVE (NMITLI)

10000 pamphlets sent across the country
1 July 2000
Grand Challenges

Igniting and networking the best minds

Largest PPP in India

Over 100 Private Sector Enterprises

Over 250 Institutions
BIOPROCESSING BREAKTHROUGH IN LEATHER

Ambient preservation of skin without salting or drying

Enzyme only processing for removal of hair, flesh and fat and opening of fibers

Microbial conversion of sulfate into elemental sulfur

Chemical Free (enzyme only) Processed Skin in a tannery
Emerging Challenges

1. STI continuum through conducive policies
2. Building Innovation Ecosystem
3. Talent Supply (Quality and Quantity)
4. Inclusive Innovation
5. Creating more Tatas!
STI Continuum through conducive Policies….

- Science Policy- (1958)
- Technology Policy- (1983)
- Science and Technology Policy- (2003)

**Needed Now-**

- Science, Technology and Innovation Policy-?
Emerging Challenges

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The Innovation Ecosystem

Science
Creativity without any “constraint”: Pure Science

Engineering

Technology
Creativity with “constraints”: Cost, boundary-conditions...
Reality-Check

BRIDGE

NSF Universities IBM

DoD Research Labs. intel

Decades of investment

1st transistor!

2004 Pentium
Entrepreneurship v/s Technopreneurship

- **Good news** - 18% of the workforce is engaged in entrepreneurial activities

- **Bad news** - Less than 3% of its workforce is in modern private sector while 90% is in informal sector - mostly in low productivity and low skill activities.
Patent Illiteracy

 Publish or Perish
 V/S
 Patent, Publish and Prosper

 Bose (1898) to Basmati (1998)
 The journey continues....
Emerging Challenges

1. STI continuum through conducive policies
2. Building Innovation Ecosystem
3. Talent Supply (Quality and Quantity)
4. Inclusive Innovation
5. Creating more Tatas!
Talent Supply

- Balancing
- Expansion
- Inclusion
- Excellence
Expansion!

- 30 Central Universities
- 5 Indian Institutes of Science Education and Research
- 8 Indian Institute of Technology (IIT)
- 7 Indian Institute of Management (IIM)
- 20 Indian Institute of Information Technology
- 1600 Polytechnics
- 10000 Vocational Schools
- 50000 Skills Development Centres
Talent Supply....

- Only 17% of youth in mid 20s and older have secondary education.
- Gross enrolment in higher education is only 12% compared with 90% in South Korea and 68% in Russia.
- < 7000 PhDs a year in STE.
Talent supply....

- Underinvestment
- Teaching without Research
- Outdated Curricula
- Crisis - Teachers: Both, Quality and Quantity
- Role of private sector and foreign universities
In science, too many seats but not many takers

VANITA Chitkara and NOVITA Singh
New Delhi, July 5

At this rate, colleges may stop of-
INSPIRE- Just one initiative by DST
Innovation in Pursuit for Inspired Research

• Science and Innovation scholarship to 1 million youngsters
• Provide mentorship- even through Nobel Laureates
• Scholarship for doctoral research including research career opportunity
Emerging Challenges

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Inclusive Innovation
Needs
Gandhian Engineering:

Getting More from Less for More
Medicines: Including the Excluded
Medicines for the poor need to be:
PSORIASIS

Before treatment

After treatment
Psoriasis Treatment

- Leading US Bio pharmaceutical firm
- Antibody injection under the skin
- Cost of treatment: $20000!
- Time for Development: 10 years!
- Cost of Development: Few hundred million dollars!
Psoriasis Treatment

Cost of treatment: $20000!
Time for Development: 10 years!
Cost of Development: Few hundred million dollars!

$50?
5 years?
< $10 mn?
“When you want to achieve results which you have not achieved before, it is an unwise fancy to think that they can be achieved by using methods that have not been used before”

- Sir Francis Bacon
Standard Drug Discovery Process

(molecule -> mice -> men)

Reverse Pharmacology Process

(men <-> mice <-> men)
Team India: Bioactive Molecule Network

- RRL JAMMU UNIV GNHU
- IMTECH PGI
- C CRUM CBT DUSC
- CSMCRI RRL NCL
- GOA UNIV
- AVS
- COchin UNIV RRL
- ANdHRA UNIV
- Jammu Palampur Chandigarh Roorkie
- CBRI CDRI CIMAP ITRC NBPI
- BHU
- LUCKNOW
- Bhubneshwar Jabalpur Kolkata
- Varanasi
- Ahemdbad Bhavnagar Bhopal
- Pune Goa
- Hyderabad Waltair
- Chennai Mysore Calicut ThiruvanthapuraM
- ANNAmaLAI UNIV
- RRL TAMPCOL CFTRI

Legend:
- CSIR Labs
- Universities
- Other organizations
## Reverse Pharmacology Approach
(ESIR Innovations)

<table>
<thead>
<tr>
<th>Drug</th>
<th>Clinical Indication</th>
<th>Industrial Partners</th>
</tr>
</thead>
<tbody>
<tr>
<td>AP9CD</td>
<td>Breast Cancer</td>
<td>Indigene</td>
</tr>
<tr>
<td>RRLJ-CD-SFE</td>
<td>Psoriasis</td>
<td>Genova Biotech</td>
</tr>
<tr>
<td>NMITLI-OA-JP</td>
<td>Osteo-arthritis</td>
<td>Cadilla Pharma</td>
</tr>
<tr>
<td>NMITLI-DM-FN</td>
<td>Type II Diabetes</td>
<td>Sree Dhootpapeswar</td>
</tr>
<tr>
<td>RRLJ0125-F09</td>
<td>Hepatocellular Carcinoma</td>
<td>Indigene</td>
</tr>
<tr>
<td>RJM0035</td>
<td>Hypertension</td>
<td></td>
</tr>
</tbody>
</table>
Cost $12000 to $18000
4 billion people

Income- Less than $2 a day

Will take 15 years income to buy this foot alone!!
THE GLOBAL SCOURGE OF LAND MINES LEFT THOUSANDS LIMBLESS, AND THEN TWO GIFTED INDIANS DEVELOPED

The $28 Foot

BY TIM MCGIRK
Including the Excluded
Yet another challenge
Making India Literate

Can Technology Help?
Illiteracy in India

200m illiterate – 70 million male, 130 million female

Illiteracy reducing at around 1.3% per annum

Will take around 20 yrs to clear the backlog

Can we do it in five years?
Yes, we can!
Present Methodology & its constraints

Constraints

• 200 hours of instructions – high dropouts

• 600,000 trained teachers for 600,000 villages?
Computer Based Functional Literacy (CBFL)

Based on the theories of cognition, language and communication

Emphasizes on learning words rather than alphabets

Method focuses on reading
Achievements so far

- 100,000+ persons made literate
- Software installed in 100,000 Village Knowledge Kiosks
- 8 Languages also Sotho of South Africa
- Cost less than $2.5 per person
Some personal motivations for literacy

Technology thus CAN Transform lives of 800 million illiterates in 5 years!

... I did not know how to help my children in their studies
... I had to seek help in getting directions to get about
... now I check their reports, and refuse to sign on them if they are not doing well ...
Transformational Innovation

“Very soon, your chauffeur will drive to your house in a Nano. You will need to make space in your driveway for your chauffeur's car, but more importantly, you will need to make space in your minds for this transformation.”

- R A Mashelkar
Emerging Challenges

1. STI continuum through conducive policies
2. Building Innovation Ecosystem
3. Talent Supply (Quality and Quantity)
4. Inclusive Innovation
5. Creating more Tatas - not by size but driven by Innovation, Compassion and Passion
More of Tatas…

- EKA
- INDICA
- INDIGO

Computer Based Functional Literacy (CBFL)