



**Dr. B.P. PAL**  
**(1906-1989)**

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# **RESEARCH AND HIGHER EDUCATION - INDIAN CHALLENGES**

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I am deeply honoured to be delivering this lecture in memory of one of India's most distinguished scientists, Dr. Benjamin Peary Pal. The topic I have chosen is one of general relevance and I will address some issues in the areas of research and higher education. I am conscious of the fact that it would have been more appropriate to honour Dr. Pal's memory by speaking on a scientific topic, especially in relation to agriculture. Unfortunately, I am not competent in this area and will, therefore, discuss a more general subject.

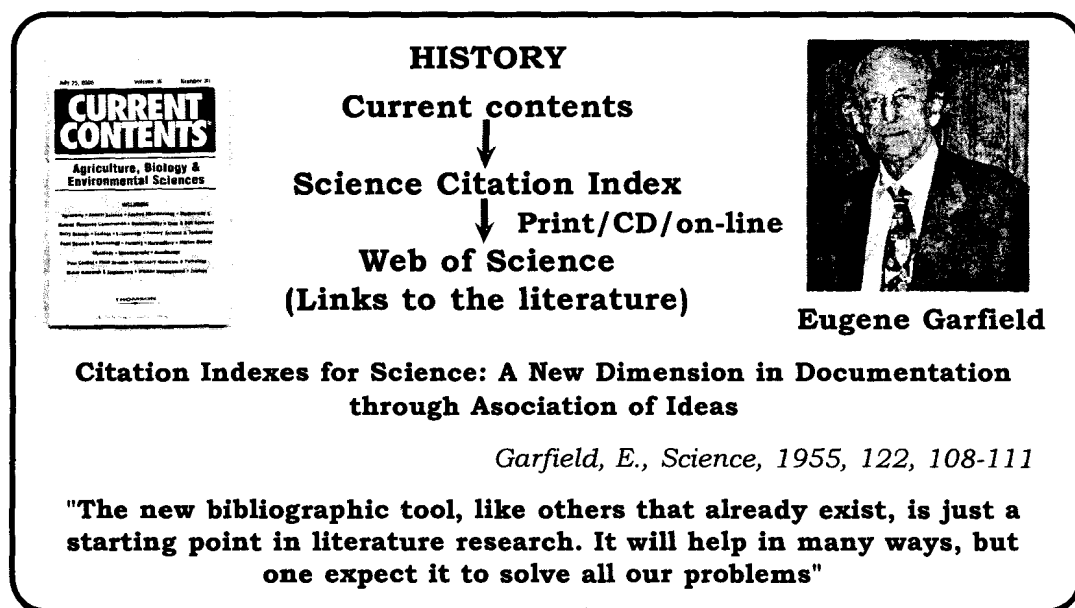
The sector of higher education in India is currently in a stage of unprecedented expansion. There are immense challenges posed by privatization and globalization. Rising expectations of a new generation of Indians have clearly propelled the area of education to the forefront of public discourse. In my presentation I will restrict my focus only to the sphere of higher education and research; areas with which I have some familiarity.

The role of Universities in India has changed dramatically over the last 50 years. The rise of specialist universities devoted to engineering education, medical universities for medical education and law universities have apparently left conventional universities completely impoverished. Scientific research which encompasses science and engineering, medicine and agriculture has become completely fragmented. Universities maintain departments in humanities and social sciences. In most technical institutions there is no discussion of social science and economics, subjects which are of great importance today. In discussing the state of scientific research and higher education I would like to digress for a moment to consider the problem of measuring and assessing science. We can divide science into two broad classes: 1) Academic science, which is often of limited utility and 2) Applied science, which has clear goals and targets.

Academic science is what is practiced in Universities and in most research institutions. Applied science is predominantly practiced in the strategic agencies of government and in industry. This separation is an artificial one, and we must remember that good science will eventually be applicable. There are many examples of research carried out as a

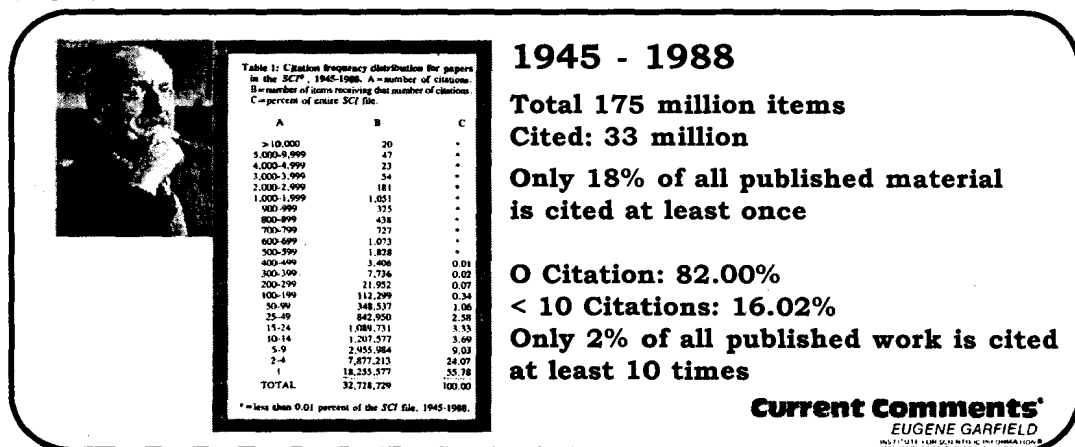
laboratory curiosity, which have eventually had great practical value. One famous example, in recent times, is the discovery of Magnetic Resonance Imaging (MRI). We can measure scientific activities in two ways: 1) Personal judgements which may be informed or prejudiced and 2) Impersonal quantitation using methods of scientometrics.

The creation of the Science Citation Index by Eugene Garfield and its evolution into the Web of Science has transformed the manner in which science is judged (Fig.1).



**Fig. 1**

About 20 years ago, Garfield performed an interesting analysis in which he examined the citation to material published between 1945-88 (Fig.2).



**Fig. 2**

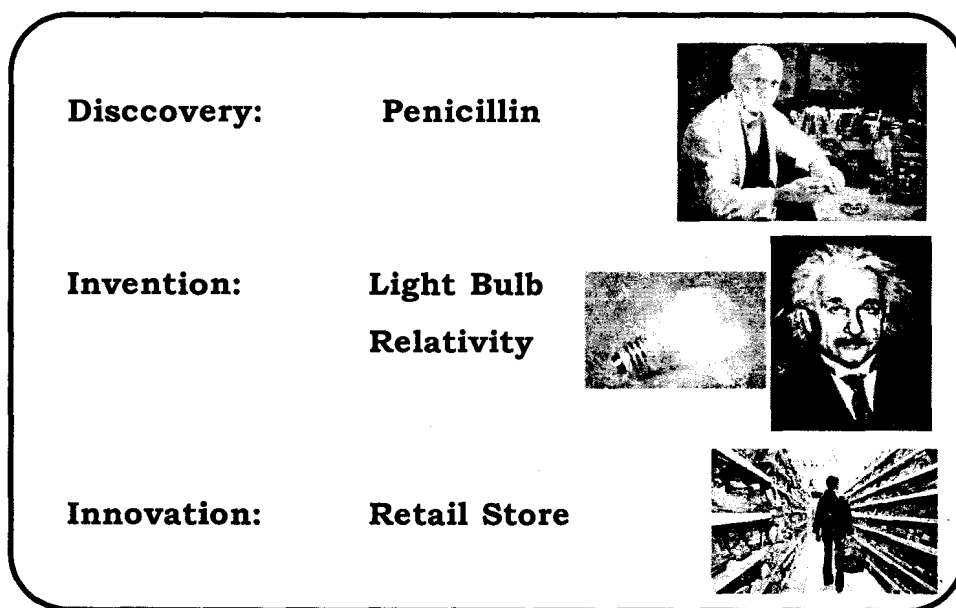
Of the 175 million items, a very small fraction was cited at least once, suggesting that the volume of scientific literature is no indication of its general utility. Citation analysis is applied indiscriminately today, in assessing scientists, journals, institutions and countries. Many widely discussed analyses place India in a relatively poor position. It is a matter of great concern for those who worry about science policy directions. It is also the reason why we must worry about the status of research and higher education in India.

I will now return to my original theme of research and higher education. My presentation will focus largely on science, because it is a subject with which I have some familiarity. We may ask “are science and engineering considered distinct”? The following quotations provided some perspective:

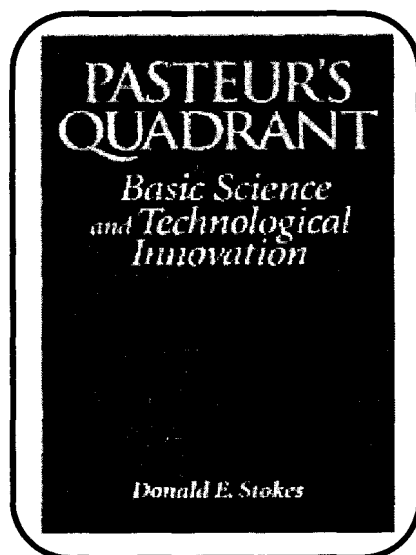
***“Often considered distinct, engineering and science are frequently difficult to distinguish” Henry Petroski American Scientist, 2008, Vol. 96, 368.***

***“The scientist seeks to understand what is: the engineer seeks to create what never was” Theodore von Karman.***

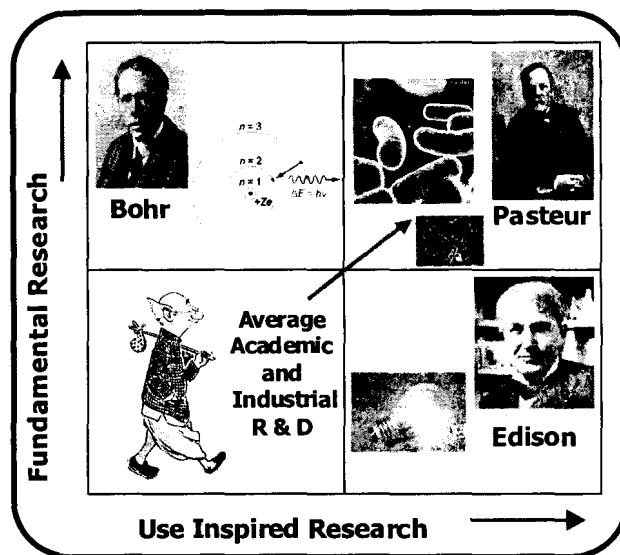
Today’s scientist, especially in the areas of biology and agriculture may indeed “seek to create what never was”; blurring the distinctions between scientists and engineers. Research institutions in India are challenged to make discoveries and are encouraged to provide an ambience which promotes invention and innovation. To be successful, our institutions may need a fundamental transformation. Figure 3 attempts



**Fig. 3**



**Fig. 4**



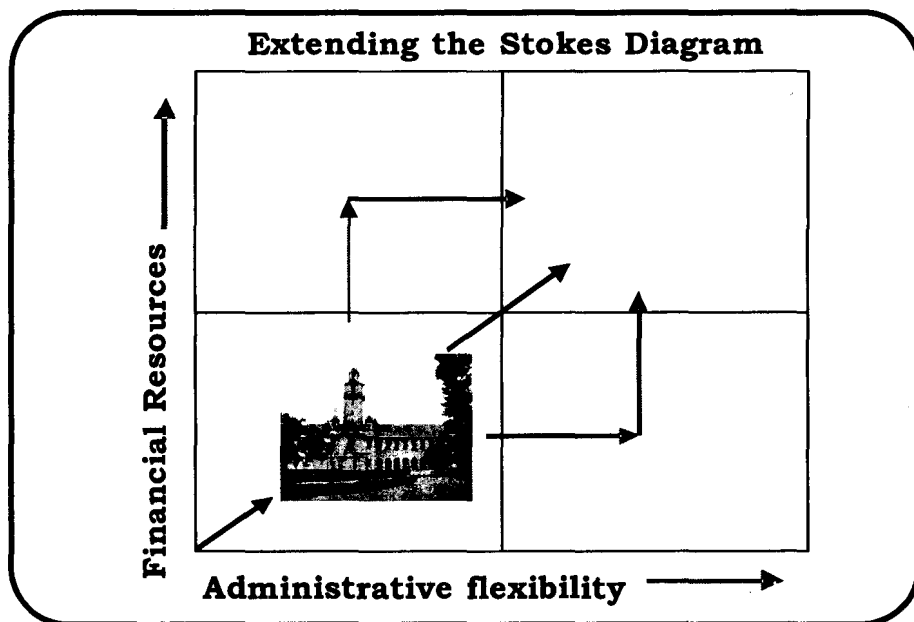
**Fig. 5**

to explore the possible meanings of the words “invention” “discovery” and “innovation”. The word innovation is used in different contexts and means different things to different people. I would like to draw your attention to an analysis of basic science and technological innovation published over a decade ago. (Fig. 4).

Donald E. Stokes, a professor of political science, introduced the idea of an innovation space, within which he identified a region that he imaginatively named as Pasteur’s Quadrant.

I have taken the liberty of modifying the Stokes diagram to illustrate some of our current concerns. You will note that the x-axis is a measure of use inspired research (applied science), while the y-axis is a measure of fundamental research (basic research). Following Stokes’ ideas we divide “research space” into four quadrants. The top left quadrant is named after Niels Bohr while the bottom right is named after Thomas Edison. In many ways Bohr and Edison symbolize pinnacles of fundamental and applied research. The top right quadrant is named after Louis Pasteur, whose contributions to basic and applied science are unmatched. Pasteur was the founder of organic stereochemistry; his early work provided insights into the chirality of molecules and optical activity. He was also one of the most influential figures in microbiology, contributing immensely to the development of vaccines and in understanding the nature of infectious disease. The bottom left quadrant is the area occupied by most institutions in academia and industry. Figure 6 poses the question as to how we can enhance the quality of both basic

and applied research in our research institutions. It is easy to represent the key parameters that worry heads of institutions along the two axes.



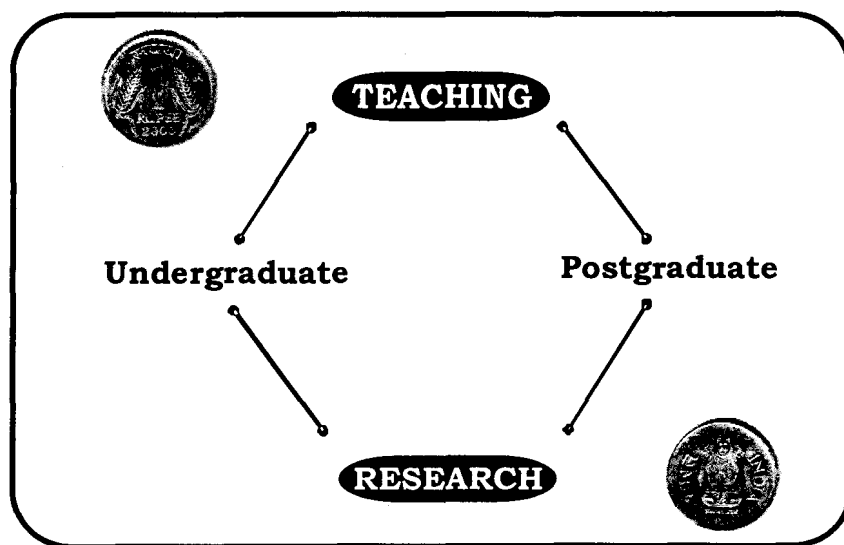
**Fig. 6**

Over the last 50 years research has no longer been an important activity in universities. The growth of specialized research institutions and national laboratories has resulted in a separation of research activities. The best universities in the West have a strong component of teaching, embedded in a research environment. Research and teaching are two sides of the same coin (Fig. 7). Universities in India often function as affiliating bodies or colleges, with only a limited post-graduate section in science and a relatively limited involvement in research.

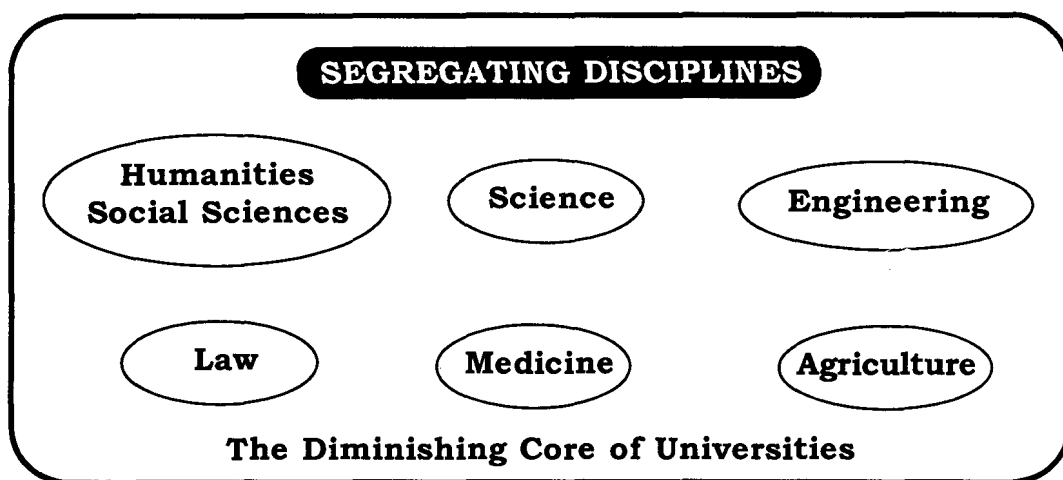
I have earlier mentioned the diminishing core of universities, as a consequence of the segregation of disciplines (Fig. 8).

In Fig. 9, I schematically illustrate the possible pathways of restructuring institutions of higher learning using Stokes' conceptual plane, by defining "academic space". Since I have been trained in chemistry, you will pardon me if I illustrate the problem of transformation using an analogy from the subject of chemical kinetics (Fig. 10).

The illustration shown in Fig. 10 draws the attention to a barrier that needs to be crossed for a transformation. It also illustrates the danger of reversibility. We are all acutely aware that, in most institutions, it is easier to hasten the process of decay, rather than to facilitate the process

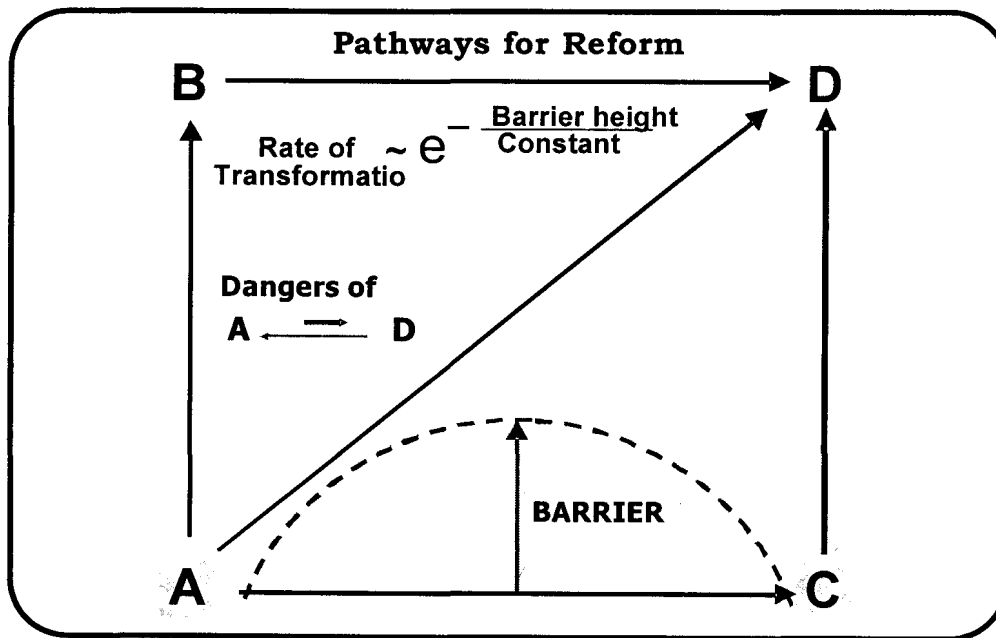
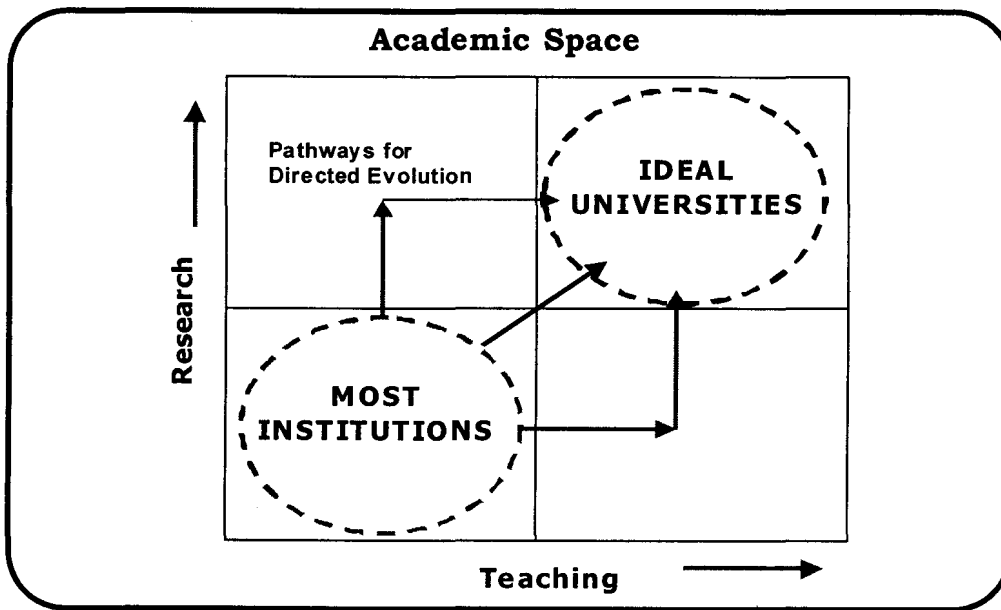


**Fig. 7**

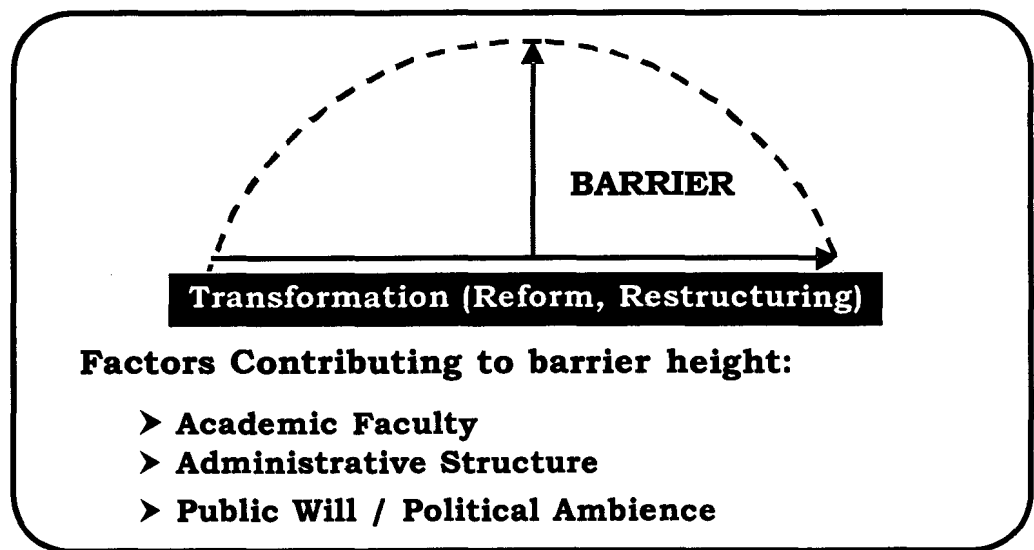


**Fig. 8**

of improvement. I will now ask a difficult question as to what are the factors which constitute the height of the "barrier". I will remind you that in chemical kinetics the rate of transformation is dramatically determined by the barrier to be crossed; the exponential relationship in Fig. 10 will immediately tell you that there will be a very steep fall in the rate of a transformation as the barrier height increases. In translating the language of chemistry, to the issue of transformation in "academic space", I







**Fig. 11**

summarize in Fig. 11, the key factors which will retard, our attempts to improve our institutions.

The key issues of concern are listed below:

- 1) Should recruitment of faculties be regional or national. Many state institutions suffer in comparison with central institutions because faculty recruitment is geographically limited.
- 2) The allocation of financial resources needs to be centrally addressed since many states have limited budgets to support research activities.
- 3) The problems of governance at all levels in centres of higher education have been widely discussed. The relationship between autonomy and academic responsibility needs to be widely understood and appreciated by both government and the academic community.

Over the last few years, the National Knowledge Commission has presented a wide set of recommendations in which they address issues of expansion in higher education, the need for promoting excellence and the necessity for making education accessible to all by promoting inclusion. Figures 12, 13 and 14 provide a concise summary of the recommendations.

**NATIONAL KNOWLEDGE COMMISSION  
RECOMMENDATIONS OF HIGHER EDUCATION 2007**

**Expansion**

- ☞ Create more Universities (1500 by 2015)
- ☞ New Regulatory Body (Oversee UGC, AICT, MCI,  
BAR Council.....)
- ☞ Increase Public Spending (1.5% GDP / 6%)  
Higher Education Sector
- ☞ 50 National Universities

**Fig. 12**

**NATIONAL KNOWLEDGE COMMISSION  
RECOMMENDATIONS OF HIGHER EDUCATION 2007**

**Expansion**

- ☞ Reform Existing Universities
- ☞ Restructure Undergraduate Colleges: Autonomous Cluster
- ☞ Promote Enhanced Quality: Student Choice, Teacher  
Evaluation
- ☞ Salary Differentials

**Fig. 13**

**INCLUSION**

- ☞ Ensure access for all deserving students:  
(Needs-Blind admission) National Scholarship Scheme

**AFFIRMATIVE ACTION**

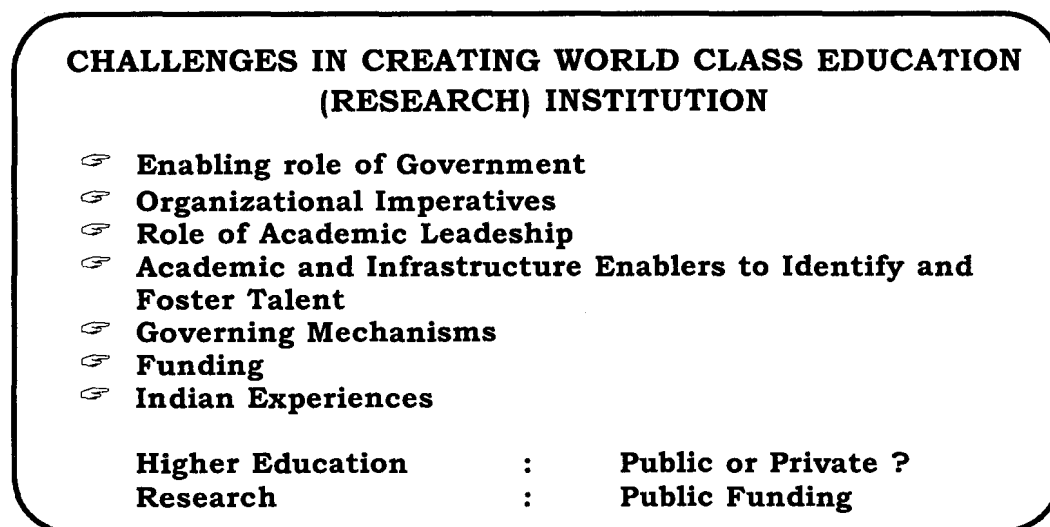
- ☞ Reservation
- ☞ Use of Deprivation Index

**ACTION**

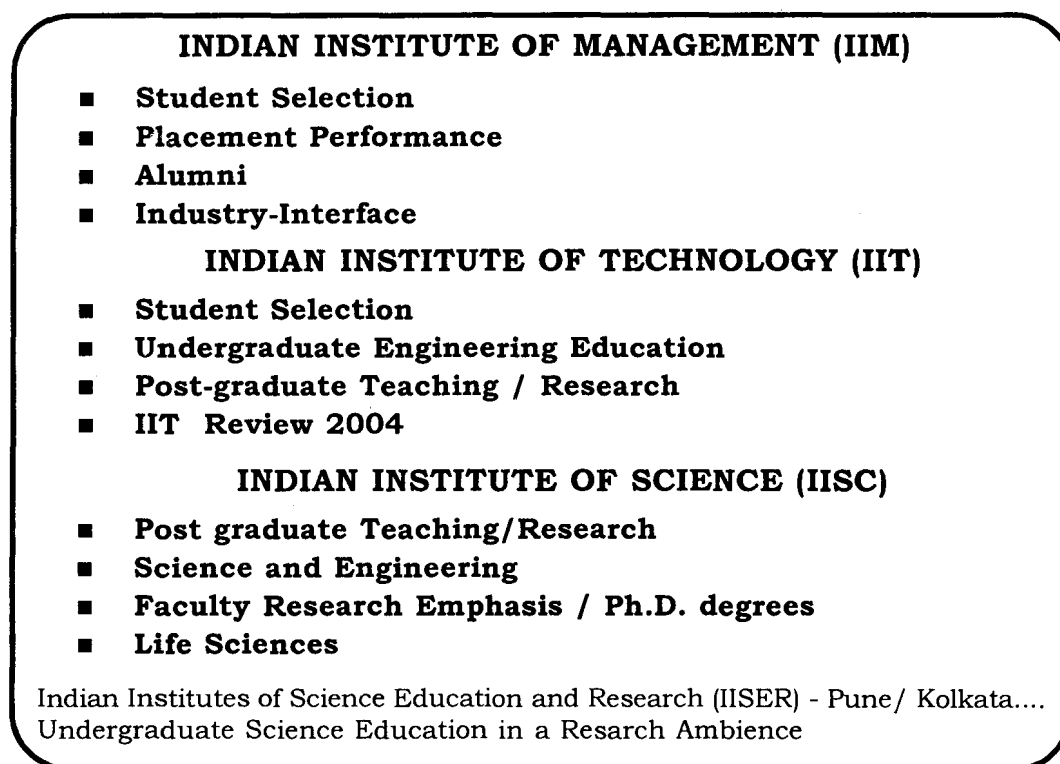
- ☞ Reforms within Existing Systems
- ☞ Changes in Government Policies
- ☞ Amendments/New Statutes of Legislation

**Fig. 14**

There has been a great deal of discussion in India on the challenge of creating world class educational research institutions. Fig. 15 summarizes key issues involved.



**Fig. 15**



**Fig. 16**

Over the last 50 years institutions like the Indian Institutes of Technology (IITs) and Indian Institutes of Management (IIMs) have been widely recognized for the high quality of education that they provide. Fig. 16 summarizes some parameters that may be used in evaluating the performance of our best institutions.

<b>Affiliated College</b>	<b>:</b>	<b>Undergraduate teaching</b>
<b>Autonomous College</b>	<b>:</b>	<b>Undergraduate and Postgraduate teaching Research</b>
<b>University</b>	<b>:</b>	<b>Affiliation Centre Postgraduate teaching Research</b>
<b>Research Institution</b>	<b>:</b>	<b>Postgraduate teaching Research</b>
<b>National Laboratories (CSIR, DAE, ICMR, ICAR..)</b>	<b>:</b>	<b>Research</b>
<b>Deemed Universities</b>	<b>:</b>	<b>Degree granting device</b>
<b>Deemed and Customized</b>	<b>:</b>	<b>Dept. Atomic Energy (DAE), Dept. of Space</b>

**Fig. 17**

### **CREATING AN AMBIENCE**

- ☞ **Governance**
  - **Institution Building**
  - **Consolidation**
  - **Expansion/Modernization**
- ☞ **Faculty/Student performance**
  - **Evaluation**
  - **Carrot and Stick (Tenure and Rewards)**
- ☞ **Research Facilities**
  - **Funding**
  - **Development Corpus**
- ☞ **Promoting Scholarship**
  - **Academic Debate**
  - **Participatory Governance**
  - **Interdisciplinary Dialogue**

**Fig. 18**

### **PARAMETERS OF INSTITUTIONAL PERFORMANCE**

- **Students Trained/Degrees Awarded**

Performance of Alumni

- **Research Papers Published**

Impact

- **Intellectual Property**

Patents/Technology Transfer

Licensing/Royalty Income

- **Resources Generated**

Magnitude of Corpus

### **The Role of Private Philanthropy Public-Private Partnership**

**Fig. 19**

A major matter of concern in the sector of higher education is the proliferation of the number of institutions that now grant advanced degrees. The list provided in Fig. 17 highlights the nature of the problem.

In discussing the manner in which academic institutions need to go forward, we must recognize the importance of creating an ambience and the need to constantly review institutional performance. Figures 18 and 19 summarize important issues that need to be considered.

In concluding this lecture, I must recall that my own institution, the Indian Institute of Science is completing a century of existence in a few days. The last one hundred years have been a great learning experience in the evolution of an institution which was originally conceived as an “institute of research” or a “university of research”. This history, which spans the periods before and after independence, will be worth understanding even as we try to create new institutions which will excel in the area of research and higher education.