CHANGING SOCIAL CONTRACT BETWEEN SCIENCE AND SOCIETY: EXPLORING THE CASE OF BIOTECHNOLOGY IN INDIA

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CERTIFICATE

This is to certify that the dissertation entitled **Changing Social Contract Between Science and Society: Exploring the Case of Biotechnology in India** submitted by **Renny T** in partial fulfilment of the requirements for the award of the degree of **Master of Philosophy** of this University is his own work and has not been submitted so far, in part or in full, for any other degree or diploma of this or any other university or institution.

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ABBREVIATIONS

AAFC	Agriculture and Agri-Food Canada
AIST	Advanced Industrial Science and Technology
BARC	Bhabha Atomic Research Centre
BBSRC	Biotechnology and Biological Sciences Research Council
CCBB	Centre for Computational Biology and Bioinformatics
CCMB	Centre for Cellular and Molecular Biology
CDFD	Centre for DNA Fingerprinting and Diagnostics
CIF	Central Instrumentation Facility
COSIST	Strengthening of Infrastructure in Science and Technology
CRHR	Contraception and Reproductive Health Research
CSIR	Council of Scientific and Industrial Research
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CUDOS	Communality, Universalism, Disinterestedness, Originality, Skepticism
DBEB	Department of Biochemical Engineering and Biotechnology
DBT	Department of Biotechnology
DNA	Deoxyribonucleic Acid
DSIR	Department of Scientific and Industrial Research
DST	Department of Science and Technology
EASST	European Association for the Study of Science and Technology
FICCI	Federation of Indian Chambers of Commerce and Industry
FITT	Foundation for Innovation and Technology Transfer
FRS	Fellow of Royal Society
GBPUA&T	G B Pant University of Agriculture and Technology
GMOs	Genetically Modified Organisms
ICAR	Indian Council of Agricultural Research
ICDDR	International Centre for Diarrhoeal Disease Research

ICGEB	International Centre for Genetic Engineering and Biotechnology
ICMR	Indian Council of Medical Research
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IICB	Indian Institute of Chemical Biology
IISc	Indian Institute of Science
IIT-D	Indian Institute of Technology –Delhi
IPRs	Intellectual Property Rights
IRDU	Industrial Research and Development Unit
JNU	Jawaharlal Nehru University
MHRD	Ministry of Human Resources Development
MIT	Massachusetts Institute of Technology
MoU	Memoranda of Understanding
MNC	Multi National Corporation
NCCS	National Centre for Cell Science
NIBIB	National Institute of Biomedical Imaging and Bioengineering
NIH	National Institutes of Health
NII	National Institute of Immunology
NIPGR	National Institute of Plant Genome Research
NMR	Nuclear Magnetic Resonance
NPK	New Production of Knowledge
NPL	National Physical Laboratory
NPUST	National Pingtung University of Science and Technology
NRC	National Research Council
NSF	National Science Foundation
NSS	New Sociology of Science
NVI	Netherlands Vaccine Institute
OECD	Organisation of Economic Co-operation and Development
OSRD	Office of Scientific Research and Development

OSS	Old Sociology of Science
PATH	Program for Alternative Technology in Health
PCR	Polymerase Chain Reaction
PLACE	Proprietary, Local, Authoritarian, Commissioned, Expert
PoC	Programme of Co-operation
R&D	Research and Development
SBT	School of Biotechnology
SCMM	Special Centre for Molecular Medicine
SHIPS	Strategic, Hybrid, Innovative, Public, Skeptical
SIT	School of Information Technology
SLS	School of Life Sciences
SSC	Superconducting Super Collider
STS	Science and Technology Studies
TB	Tubercle Bacillus
TBI	Technology Business Incubator
TERI	The Energy Resources Institute
UGC	University Grants Commission
UNIDO	United Nations Industrial Development Organisation
VINNOVA	Swedish Governmental Agency for Innovation Systems
WHO	World Health Organization

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Chapter 1

Introduction

The notion of science has been a dominant and enduring feature of Western thought since at least the time of Bacon. One of the most remarkable features of modern thought is the extent to which ideas about science have changed. A number of different disciplines have challenged traditional views about science. Although critical questions about the politics and impact of science have a longer pedigree, it is only comparatively recently that critical attention has been directed towards the internal workings of science. Now the practice of science is itself the object of critical scrutiny[1].It is pertinent to discuss here briefly the changing focus of sociology of science and how it treats science and society relationship then and now.

1.1 Changing Focus of Sociology of Science: An Introduction

Sociology of Science as a specialism of sociology, originating in United States ,which studies the normative and institutional arrangements that enable to be carried out; or as Merton puts it , 'a sub division of sociology of knowledge, dealing with the social environment of that particular kind of knowledge which springs from and returns to controlled experiment or controlled observation'[2].During the 1970s it became conventional to distinguish this literature from the European (largely British) dominated *sociology of scientific knowledge*, which is concerned more directly with what is counted as *science*-and why. The content of scientific knowledge is largely ignored in the former approach, which tends to assume both universal standards of logic and rationality, and fixed points in the physical world and in Nature. Proponents of the latter view, on the other hand, initiated a relativist revolution which drew

[1] Steve Woolgar.1980. *Science: The Very Idea.* London: Tavistock Publications.P-9.
[2] Robert K Merton.1968.*Social Theory and Social Structure*.Glencoe: Free Press.P-585.

attention to the social construction of the scientific knowledge-and claimed no access to a Truth and Reality beyond this human activity.

There are many developments in the field. There is a mushroom growth of approaches in sociology of science now. Mertonian functionalism and Marxian sociology were the dominant approach. With the coming of New Sociology of Science (Kuhnian sociology of science) it witnessed various approaches like scientific relativism, social constructivism; ethno methodology and so on. The focus of the discussion is also changed throughout the decades. Sociology of science was once sociology of scientists focused mainly on scientists and their social life. Most of the literatures in sociology of science talked about the impact of science on society .Only recently some scholarly works came with a focus on impact of society on science. Now there is a good number of studies not only in the cognitive sociology of science but also in science policy studies.

The Indian situation is different. Sociological studies of science in India are still dominated by a functionalistic framework. But some on policy studies too. In this context the present study is very relevant since it is dealing with an emerging field in science studies or science policy studies.

The social system of science has undergone a remarkable change. In the World War II scenario, the only driving force was the search for knowledge. No substantial government funding were available .Scientific research was pursued by a handful of small enterprises. Little interaction existed between academics and the industry. The post World War II scenario saw the parenthood of research change. Research was entirely driven by the search for new knowledge, on one hand, and, by economics, defence and health, on the other. The science based industries, such as biotechnology and information technology, grew. There was also a growth of industrial scientific research, which enabled to initiate an intense industry-academia interaction. Issues of IPRs and proprietary information and knowledge have begun to give rise to new debates on public versus private profit. New models of innovation chain and new paradigms of the science-economy and science-society contracts have begun to emerge[3].The change from a Mertonian or Bush model of linear science to a Post Mertonian system of science came into existence.

During the last two decades various studies have pointed to a variety of changes, such as an increasing orientation of science systems towards strategic goals, science as a market good and entrepreneurial science, commercialisation of knowledge etc. The emerging standard to which scholars have given such names as *Mode 2 knowledge production* (Gibbons et al., 1994) and *post-academic science* (Ziman, 2000).,These are radically transforming the nature of science. A closer look at the structure of science systems, changes can be easily identified from an *Old* social contract to a *New* social contract. It is pertinent to have a brief understanding of Old and New social contracts of science.

1.2 Old Social Contract of Science

The Old contract of science is a linear model of science. The Old notion of science is normally called as Mertonian notion of science. Under the Old contract between science and society, science was expected to produce reliable knowledge, which merely communicates its discoveries to society[4]. Mertonian ethos of science was the guiding principles of the traditional science or Mode 1 knowledge production. Merton ethos of science is called *CUDOS*: *Communality* of procedures and results within the scientific community, *Universalism* while evaluating the contributions to scientific knowledge, *Disinterestedness* in non-cognitive motivations and aspects of research, *Originality* in scientific research, and *Skepticism* while checking the reliability of methods and results etc. In the Old contract of science, problems are set and solved in a context of application. It is disciplinary in nature. It is hierarchical and tends to preserve its form. In the Old contract, science is believed to be a specialised expertise and scientists are the holders of that knowledge.

[3] Sambit Mallick.2008.Changing Practices in/of Science: The Context of Intellectual Property Rights in India. *Scientific Commons* 3 .p 1.
[4] Michael Gibbons.1999. Science's New Social Contract with Society .*Nature* 402(C81) :p.11.

The old contract of science was a hegemonic model up to World War II. The Mertonian ethos has faced many criticisms. With the emergence of intellectual property, the Mertonian ethos of science lost its relevance. With the coming of globalisation, the scientific research enters into a New Contract of science.

1.3 New Social Contract of Science

A great deal of ink has been spilled while discussing the current evolution in the social contract between science and society. In the New contract, knowledge is generated in a *context of application*. Another important characteristic of the new contract is *transdisciplinarity*, which refers to the mobilization of a range of theoretical perspectives and practical methodologies to solve problems. The knowledge is produced in a diverse variety of organisations resulting in a very *heterogeneous* practice. The range of potential sites for knowledge generation includes not only the traditional universities, institutes and industrial labs, but also research centres, government agencies, think tanks, high-tech spin off companies and consultancies. These sites are linked through networks of communications and research is conducted in mutual interaction. Another feature of the New contract is *reflexivity*. Compared to the old contract, now the knowledge is rather dialogic process, and has the capacity to incorporate multiple views. This relates to researchers becoming more aware of the societal-consequences of their work. Novel form of quality control constitutes another feature of the new contract of science. Traditional discipline –based peer review systems are supplemented by additional criteria of economic, political, social or cultural nature.

The following table gives an understanding of the old and new social contract of science:

Table 1.3.1 Comparison between Old and New Social Contract of Science

Existing/Old Social Contract	**Emerging/New Social contract**
Advancing knowledge	Creation of wealth
Science as part of culture	Part of commerce
Open Science Knowledge	Secrecy /IPR
Peer evaluation within science system	Knowledge production regulated and evaluated by different stakeholders in the society/governed by market forces/peer group is broadened.
Universities as teaching and advancing knowledge Academic tradition	Entrepreneurial Universities
Linear model of Innovation	Systematic based open innovation/ globalised.
Disciplinary science	Hybrid groups/ interdisciplinary groups/ networks

(Source: Krishna, 2007, 2009)

In the new and dynamic research field of the life sciences, notably in biotechnology, the separation of university and industrial research broke down completely. University-based scientists routinely moved into entrepreneurial roles as part of their self-understanding as researchers. In the 1980s two laws were passed in the United States designed to boost innovation by giving incentives to university professors and government researchers to team up with outside firms, or start their own companies. The *Stevenson-Wydler Technology Innovation Act* was designed to encourage the exploitation of technological know-how in government laboratories for commercial purposes. The *Bayh-Dole Act* allowed universities, non-profit research institutes and small businesses which performed research under government contracts to apply for patents in their own name and keep the profits of their work. Both schemes are now widely copied elsewhere. The government of India also came with a Draft of a university patenting Bill. It is under discussion now.

1.4 Significance of the Present Study

All the studies about the changing nature of science from a Model to Mode 2 came out in the European context. It is significant to understand the relevance of the debates in the context of developing countries. It is true that Mertonian social system of science is becoming less and less important in this globalised era. But the transformation of research systems that has come into focus in science studies literature in the context of industrially advanced countries is partially relevant to developing countries since these countries are still striving towards rapid industrialization and catching up with advanced Industrial economies(Krishna etal.,2000).

Vessuri (2000) argued that the role for developing countries in the new *distributed* production system is only that of passive consumers of predigested information products. Despite the claims of the advantages of *Mode 2* to tackle relevant local problems, what is already happening is that, as a predictable spin – off of the increasing commercialisation of universities in the developing countries, they are introducing their wares to the developing world directly, selling canned virtual courses, consultancy, services of the most varied sorts and research solutions through the redefined schemes of international cooperation. Many institutions of higher education in Latin America become the affiliate, branch or empty cage for new commercial endeavours of the knowledge institution from the North, ready to explore the last market frontier, that of knowledge.[5]

Rudolf etal. (1999) argued that the concept of Triple helix needs modification when it applied in developing countries. Since interactions among universities, industry and government vary from country to country and strongly depend on a

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[5] Hebe Vessuri .2000. Mode 2 or the Emblematic Disestablishment of Science: A View from the Edge. *Science, Technology & Society* 5 (2): P 206.

particular country's stage of development, a triple helix in Europe, Japan, and especially in the USA, will be quite distinct from one in developing countries.[6]

Sardana and Krishna (2006) studied the relevance of triple helix in Indian context and found that *bilateral* linkages and partnerships-mostly between government and public sector institutions, including universities seem to be more relevant and meaningful than tripartite relationships.[7]

Krishna stated that there is a basic change in the orientation of scientists from that based on *advancing knowledge* to that involved with *creation of wealth*; this is an important ideological shift. There is also a corresponding shift of emphasis from *basic research* to *technological innovation* and in the last decade much of this new inspiration is spreading across the rest of the developing world from the experiences of East Asia.[8] Even though scientists now do seem to be positively oriented to commercialisation of knowledge and accord high importance to it, they continue to assign equally high importance to publications compared to patenting in India. In India the acceptance of publications over patenting has some sociological reasons, like the institutional mechanism, traditional perceptions etc. It is very significant to understand these trends empirically in the Indian context. The present study tries to understand the relevance of Old and New contract of science through empirical analysis.

The present study explores the relevance of *'old' social contract of science* and *new contract of science* in the Indian context. It also explores to what extent the 'old' social contract holds relevance in the Indian setting. It analyses the relevance of the phenomenologies of New Mode of Knowledge Production such as *collaborative research, multiplication of sites, socially robust knowledge etc.* in the Indian context. The present study is specifically conceived to explore the *New Social Contract of Science* in the context of biotechnology sector in the Delhi region.

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[6] Peter Rudolf Seidl and Waldimir Pirro Lengo. 1999. Comments on the Application of the Triple Helix of Innovation to Developing Countries. *Science and Public Policy* 26 (2): p 138.
[7] Deepak Sardana and V.V. Krishna, 2006. Government, University and Industry Relations: The case of Biotechnology in Delhi region. *Science, Technology & Society* 11 (2): P. 371.
[8] V.V. Krishna. 2001. Changing Policy Cultures, Phases and Trends in Science and Technology in India. *Science and Public Policy* 28 (3): p 189.

1.5 Objectives of the Study:

1. The major objective of the study is to explore the relevance of old/ existing and new/ emerging social contract to the field of biotechnology through the orientation of scientists. Given the limitations of time and the scope of the study a small sample of biotechnology scientists from five institutes/ university are selected from the Delhi region.

2. Another objective of the study is to explore and understand science and society relationships in social studies of science literature, particularly from the perspectives of sociology of science. Various literatures on science and society relationship in sociology of science are discussed. Mainly focused from Mertonian sociology of science to the recent debates in STS.

3. To explore the changing nature of science – society relations in terms of *old* and *new* social contract between science and society; and identify its components.

1.6 Chapterisation

In the light of the main objectives outlined above, the present M.Phil dissertation is structured as follows:

The chapter following the present one (Chapter 2), briefly discusses the historical development of the social system of science in general. It is an attempt to look at a brief history of the origin and development of science, social role of scientists, social system of science, professionalisation and institutionalization of science etc. This chapter is added because to understand the changing nature of science it is pertinent to have a basic understanding of the nature of science in the past.

The chapter 3 'Science and Society Relationship in Social Studies of Science Literature' discusses various literatures in science and society relationship. In this chapter an effort is made to review the main approaches in sociology of science, Mertonian ethos of science, post-Mertonian era of science etc. It discusses the nature of science in Mertonian old model of science. The chapter also discusses a variety of approaches to explain new model of science. This chapter is an important one because it tries to give a background of the present study.

Chapter 4 discusses in detail the characteristics of emerging contract of science. It explains the phenomenologies of new contract of science like, reflexivity in research, transdisciplinarity quality control, homogeneity, socially robust knowledge, etc. It also gives a brief idea of the differences between *old* and *new* contract of science.

The methodology (Chapter 5) follows next. It discusses in detail the statement of the problem, specific objectives of the study, rationale for taking biotechnology, rationale to take Delhi as the region of study, definition of concepts, key research questions, working hypothesis, research design, universe of the study, sampling, limitations etc. are discussed in this chapter.

The major objective of the present study, 'to explore the relevance of old and new social contract to the field of biotechnology through the orientation of scientists in Delhi region' is discussed in the present chapter (chapter 6). It also explains a brief history of biotechnology and the development of biotechnology in India. The major finding coming out of this chapter is that some aspects of the old social contract of science like peer review publication, reward system etc. are still relevant to Indian setting. It also proved that to some extent Indian biotechnologists have accepted the norms of new social contract, even though not completely. Another important finding arising is that majority of the scientists are in favour of the proposed Bill on University patenting in India, Public Funded R&D (Protection, Utilization and Regulation of Intellectual Property) Bill. The chapter discussed perceptions of scientists on various themes like collaborative research of biotechnology in India, transdisciplinary research, reward system, basic research, organisational structure, science and public, scientist's perception of proposed university patenting Bill etc.

The chapter 7 presents concluding remarks. On this concluding chapter an effort has been made to relate the working hypothesis framed at the beginning of undertaking the present study.

Chapter 2

Historical Background of the Social System of Science

Introduction

To understand the relationship between science and society, we need to know something of the position of the scientist in the community at large. Who is he, what is he expected to do, to what social group, or rank or class, or organization, or institution does he belong? .In order to understand all these questions we need to trace out the role of scientists in society. The social role of the scientist has evolved; over a period of many centuries, and some of the institutions of the scientific community are really old. Many of the universities of Europe, for example, are as ancient as any of our political and religious organisations, and the scientific academies are much older than any of our industrial corporations. However the task of describing the whole history of science in detail would be quite beyond the scope of the present study. It is an attempt to look at a brief history of the origin of science, development of science, social role of scientists, social system of science, professionalisation and institutionalisation of science, which is very important to understand the nature of scientific profession and science of our age, i.e. in a globalised world.

2.1 Evolution of Science

The word *Science* is derived from the Latin word *Scientia,* meaning knowledge. The term *Science* in its broadest sense embraces all forms of systematised knowledge. Science in our age is understood as knowledge and cognizance of something specific, implicit, or implied. However, to assign any specific definitions to it will be an exercise in futility, for, as Bernal has pointed out, "....... Science has so changed its nature over the whole range of human history that no definition could be made to fit."[1]

Many scientists and philosophers have not accepted this view. For instance, while extensively reviewing Bernal's pioneering work *The Social Function of Science*, H. Dingle has criticised Bernal for using the term 'science' in ten different ways. According to him the author should have begun. "....... by identifying this phenomenon [of science] and delineating as clearly as possible what it was in itself, a part from any function it might have or any relation in which it might stand to other phenomenon ...."[2].

Bernal's reply is that for a concept "... so wide-ranging in time, connection and category, multiplicity of aspect and reference has to be a rule".[3] A similar view had been expressed by the eminent scientist and philosopher Albert Einstein (1898-1948) in the following words: "Science as something existing and complete is the most objective thing known to men. But science in the making, science as an end to be pursued, is as subjective and psychologically conditioned as any branch of human-endeavor-so much so that the question 'What is the propose and meaning of science?' receives quite different answers at different times and from different sorts of people.[4]

Science, more than any other human occupation, has continuously changed its contours and dimensions along with the onward march of civilization. Even a cursory glance at its history will show that science is not an entity to be chained to any particular definition of any age. Science has enjoyed a series of definitions, and when they are placed in their historical perspective, it becomes easier to appreciate the advancement it has made. But, ever since the early days of civilisation, science has consistently maintained a particular character and, as such, has always remained a highly necessary social activity of the ruling class.

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[1] J.D.Bernal. 1969. *Science in History*. (Vol. I The Emergence of Science). Harmondsworth: Penguin Books.p.3.
[2] H. Dingle .1949. Science and Professor Bernal. *Science Progress* 146: p.52.
[3] J.D.Bernal, op.cit.,p.31.
[4] Albert Einstein. 1935. *The World As I see it*. London p: John Lane. p.55.

Unlike the modern times, when specialisation and super-specialisation has become the order of the day, the scientists of antiquity were specialists in more than one scientific field. It was common practice to employ court astronomers as court astrologers, the court physicians also made use of astrology. Due to lack of social objectives, these astrologers, astronomers, and physicians disdained and scorned the words of craftsman. As a result, the "mystery of craftsman" (equivalent to technology of our age) and the "lore of priest" (equivalent to modern science) existed in water-tight compartments. Therefore, although an independent entity of science was established in antiquity (at least in Greece), its productive role could be appreciated only when a fusion between science and technology took place in the late sixteenth and the early seventeenth centuries in Britain. Science was gradually established as a distinct branch of study, concerned with a series of observed facts systematically classified. These demonstrated truths and observed facts were colligated by bringing them under general laws and hypotheses. Gradually trustworthy methods for the discovery of new truths also developed within the domain of science. The term 'scientist' came into existence in 19^{th} Century only. Before that they were known as *natural philosophers*. However it should not be inferred from the above that science in relation to time and place has always progressed uniformly. The Centres of scientific activities have keep on changing from time to time.

2.2 Centres of Scientific Activity

There have been periods of rapid advance, stagnation, and also decay. Science, by its very nature does not climb an ascending straight path, but moves in a zigzag fashion corresponding to the phases of rapid advancement and decline. Ben-David has argued that the centres of scientific activity have been continually shifting, which, unlike in our age, did not lead but followed the epicenters connected with commercial and industrial activities. Classical city state of Greece and the kingdoms of Western Europe had little or no place for science as such. The Greek heritage gradually retrained to its place of origin in the East.[5] A fresh air of science stirred Syria, Persia, India, and China and was later brilliantly synthesized during Islam (although the Islamic science never emancipated itself from the multiplicity of issues caused mainly by the acceptance and then fusion of the number magic of Plato with the "quality hierarchy" of Aristotle) .

From the Islamic Middle East science and techniques entered medieval Europe, where they underwent a transformation which heralded the gradual emergence of modern science. It is true that science as a systematic knowledge system has developed in the land of Europe. But one should trace the history of Pre-European science or Pre-modern science. In the literatures of the history of science the western historians have intentionally forget the history of the science of the *East* or *Other* culture. Only few scholars like Joseph Needham from the West really studied and tried to understand the science of the *other* societies.

2.3 Development of Science

When we trace the emergence of science we need to explain the factors that transformed the ancient into modern science. Ancient science, confined to the earliest mathematical and astronomical documents, was taught by priests and scribes in monasteries and temple schools. At that time only such schools were existing and were available even to those holding posts in government and army. Science was not a subject of its own, and constituted only a part of religious and philosophical doctrines. As a result, for a long time science remained somewhat indifferent to the practical application of its conclusions. Also for a long time technology had to do without the help of science. The trend of scientific revolution during the Renaissance first took place in North Italy, then in Germany, followed by England. Galileo (1564-1642), Kepler (1571-1630), Bacon (1561-1626), Newton (1642-1727) were the giants that spearheaded this revolution. This scientific revolution showed for the first time the desirability and possibility of collaboration between scientists and technologists.

[5]Joseph Ben-David. 1979. *The Scientist's Role in Society: A Comparative Study.* New Jersey: Prentice-Hall, Inc. p.22.

Ziman noted that a meaningful and truthful dialogue and cooperation between these two fields (science and technology), enunciated by Francis Bacon in England, Rene Descartes (1596-1650) in France, and Simon Stevin (1548-1620) in the Netherlands, and due to the existence of conditions that could make capitalism possible, the scientific revolution of the Renaissance ushered in the Industrial Revolution giving an unbroken and active tradition to science and its development.[6]

This development is divided into four major periods. During the first, centered in Italy, mechanics, anatomy and astronomy were renewed and replaced the ancient doctrines of man and the world. During the second phase, Science travelled to the Low Countries of France and Britain hammering out a new mathematical-mechanical interpretation of the world.[7] Thus, after a gap, the third phase occurred in industrial Britain and France, struggling the shake off the yoke of feudalism. It opened to science new avenues of experience such as electricity, which was untouched by the Greeks. It was during this period that science had a decisive impact on power production, machinery, and chemicals transforming the techniques of production and means of transport. The fourth, and the greatest transformation, is the scientific revolution of our own age. Science is now emerging on a global scale revolutionizing the old concepts and creating new industrial firms. As we know, science is penetrating and permeating each and every aspect of human life. Now we also find science directly involved and decisively influencing both the horrifying drama of wars and the beneficial social revolution.[8] We have witnessed science is questioning the law of the nature through cloning, stem cell research etc. These are all different issues altogether.

In the past, progress in science had largely occurred without any knowledge of history. It is in this context that Henry Ford had remarked that "history is bunk". The customary tendency for the common man, being grown up as he is in a society whose integral constituent is scientifically based technology, is to judge the close

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[6]John Ziman. 1976. *The Force of Knowledge: The Scientific Dimension of Society*. Cambridge: Cambridge University Press. p.36.
[7] Peter Dear. 2001. *Revolutionizing the Sciences: European Knowledge and Its Ambitions, 1500-1700*. Hampshire: Palgrave.p.17.
[8] H.K.Singh. 1978. *Science and Our Age*. New Delhi: Allied Publishers p.19.

relationship between these two vital aspects (science and society) of human existence as something quite self-evident. He generally accepts them without questioning their existence. Howsoever understandable this might be, it deserves severe condemnation. Such attitude creates an atmosphere of brainless enjoyment tantamounting to nothing less than utter malignancy. Such attitude is unscientific and historically incorrect as it lacks an appreciation of the stupendous intellectual efforts which scientist and technologist down the centuries have carefully and painfully invested in order to reach the present-day level and which they are still investing with renewed fervour to reach yet higher levels. Now it is generally accepted that progress in science is quicker, safer, and surer if it is done in the light of its past history. Any scientist, who tends to overlook, undermine, or ignore this scientific and historical truth, does it at the great risk of his professional competence and regulations.[9]After having discussed about the development of the sciences it is logical to look into the nature of the institution of modern science. Modern era witnessed the institutionalization and professionalization of science, which shaped the scientific community as an organized group.

2.4 The Institution of Modern Science

Science in our age has grown up into an institution giving employment to hundreds and thousands of men and women. However, this is a very recent phenomenon. Science has achieved an importance comparable to the far older professions only in the present century. Today, for many people not associated with its disciplines, science is an activity pursued by a set of people called the scientists. The word *scientist* itself is not very old. It was first used by Whewell in 1840 "to describe a cultivator of science in general". It may be pointed out that many regard science as what scientists do as an easy and acceptable definition of science. So we can say ancient science failed to develop not because of its immanent shortcomings, but because those who did scientific work did not see themselves as scientists.

[9] H.I Pledge. 1947. *Science since 1500*. London: H.M. Stationery Office. p.61.

Instead, they regard themselves primarily as philosophers, medical practitioners or astrologers.[10]

In order to explicate the status of the modern science in the present society it is essential to explain how the notion of social system of science evolved. The scientific communities were not like the present organized scientific community. There were very few full-time posts for professional research. It was best to be born to wealth, like Boyle and Huygens, or to find a patron, like Ray.[11] It was almost incidental that professors such as Newton and Malpighi made such splendid scientific discoveries; in those days, active research was no more expected of a university teacher than it is now of a school master. Natural philosophy was essentially an obsessive hobby, in which a physician, a professor, a priest, a monk, an aristocrat or even a shopkeeper could indulge himself just as nowadays he might take to rock-climbing or chess. In an age above there was genuine leisure for many members of the upper or middle class, research was almost entirely an amateur activity for a law well educated or intellectually curious enthusiasts.[12]

After having discussed the emergence of the specific role of scientists, it is pertinent to analyse the social, economic, religious, political or philosophical climate of Europe in the seventeenth century that drew such people from other private obsessions, such as cranky theology, mystical poetry, political intrigue or making money into these new channels of thought and action?. There is no satisfactory answer to this question. For this we have to understand the sociology of these changes. Some scholars have blamed capitalism; others discuss the effect of Protestantism. Some have attributed these changes to philosophical movement triggered off by the Renaissance and the Reformation, and others have linked it with the emergence of new techniques such as printing, mining and the ocean sailing ship. All these factors may have prompted few individual to take up the role of scientists.But the large scale mobilization of people for the organized and systematic pursuit of science must have been possible through some institutional organizations such as scientific academies.

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[10] Joseph Ben-David. 1971. *The Scientists Role in Society*. New Jersey: Prentice-Hall Inc .p.45.
[11] Steven Shapin. 1996. *The Scientific Revolution. Chicago*: The University of Chicago Press. p.153.
[12] John Ziman.1976. op.cit. p.46.

2.5 The Scientific Academies

One of the most important institutions of the scientific community was the *learned society* or *scientific academy.* It paved the way for the development of modern science. Here it is an attempt to have a brief outlook of scientific academies.

It was natural enough for the Savants (as scientists were then called) to get together in little clubs to discuss their research or to make experiments. The first properly constituted scientific society in Europe was probably the *Academia dei Lincei,* founded in Italy in 1603, of which Galileo was a member.[13] This did not service. But informal groups of scientists began to meet regularly, in Oxford, and in Paris, in the 1640s, and formed the nucleus of the Royal Society of London (1662) and of the Academic des sciences (1666). Lord Brouncker (1640-84) was the first president of the Royal Society of London. He was a competent mathematician and lent an aristocratic tone to the whole proceedings: the Royal Society has continued to belong to the establishment, with adequate connection among the Top people. The most important figure represented is Francis Bacon. Again, if we were to concern ourselves with the philosophical origin of European science, then Lord Chancellor Bacon would be the hinge about which it all turned.[14]

His writings on experimental philosophy in the 1620s, were the source of a new fashion in English thought, and the Royal society was almost a realization of the 'House of Solomon' described in his *New Atlantis* Bacon argued that careful experiment and observation would infallibly lead to new scientific discoveries and to valuable technical advances. History has not entirely justified his optimism, for the underrated the role of formal theory, and did not appreciate the difficulty of improving existing practical methods by random experimentation. Nevertheless the Royal Society was faithful to the programme implicit in Bacon's philosophy, and we do well to honour him as the father of scientific method.[15] The Society played a major role for the transformation of science. The research in the society played an

[13] Hilary Rose and Steven Rose.1969. *Science and Society.* London:The Penguin Press: p.10.
[14] Thomas Sprat.1959. *History of the Royal Society.*London :Routledge: p.17.
[15] John Ziman.1968. *Public Knowledge* .Cambridge: Cambridge University Press: p.14.

important part in clearing away superstition, witchcrafts, dogmas inherited from Aristotle and other mental bric-a-brac and establishing simple facts.[16] The Society was also active in the collection of natural objects and books, organizing expeditions, manning official enquiries and other useful business.

From the sociological point of view the Royal society became important as meeting place for the scientific community, where they used to communicate their knowledge to their fellow- Scientists. The *savants* were no longer isolated individuals; they belonged together in a recognized social group. The new academies immediately become centres for the communication of scientific knowledge. In this way science became an organised social activity.

Despite its royal charter, the Royal society was, from its foundation, a self-governing and self-perpetuating association without official power. Its funds were never lavish. Like any private club, it had to draw its income from the subscriptions of its Fellows, who carried no privilege beyond the right for the letters of FRS after their names.[17]

The Paris Academy, by contrast, had official status as an organ of the state Louis XIV, in the manner of his government, made official visits paid pensions to its members, and provided funds for research.[18]

When it was reconstituted in 1699, the number of members was fixed, with three paid academicians in each of the fields of geometry, astronomy, mechanics, anatomy and chemistry. Each academician also had two associates with a pupil in the true spirit of aristocracy and bureaucracy. The *Academie des Sciences* was thus much more like a government research institution than its English counterparts. The Berlin academy, organized in 1700 by Leibniz, who became its first president, followed a similar pattern. This difference between the English and Continental styles in the organization of science reflects the difference between parliamentary and autocratic

[16] John Ziman. 1976. op.cit., p.56.
[17] Joseph Ben-David. 1971. op.cit. p.47.
[18] John Ziman. 1976. op.cit.p50.

government. But the important principle is that the new academicians are elected by the existing members was established from the beginning.[19]

The scientific community of Europe had grown steadily over the century, not merely in absolute numbers but by the spread of science to countries such as Switzerland, Sweden, Scotland and the United States. The internationalism of eighteenth- century science is apparent if we study the lives of men like Lagrange who served both-the Berlin and Paris Academies, and Euler, who was, in fact, the mainstay of the Imperial Academy of Science of St. Petersburg, established by Catherine the Great in 1725 on the French model. This institution, although of great distinction and a significant asset to Russian culture, was actually staffed almost entirely by non- Russians, who were paid well to serve a foreign government. The analogy with the German refugees who made such a contribution to British and American science after 1930 is not quite correct; but the principle that scientific knowledge recognizes no frontiers is not new.[20]

The continuity of scientific organisations through political revolution is remarkable. The Imperial Russian Academy was a body of professional research workers, more or less independent of the universities. The modern Soviet academician is not only a distinguished scientist; he is also the paid director of a research laboratory under the control by the Academy. In the Soviet Union, and in other countries of Eastern Europe that have adopted the Soviet pattern, the universities are primarily teaching institutions, with very meagre facilities for research. This can be interpreted as a reflection of a more centralized and rationalized government system in communist countries or is the difference from the practice of Western countries.

By this time, in fact, the Royal Society had degenerated into a sort of fashionable club; open to distinguished people in general without any scientific claims. For e.g.: William Smith (1769-1839), whose observations of geological strata and geological maps were the basis of all geological research, was only a canal surveyor; he was helped financially by the President of the Royal Society, Sir Joseph Banks (1743-1820) , but was not sufficiently genteel to be elected an FRS. Banks had

[19] J.D. Bernal. 1969. op.cit. p.67.
[20] Ilyin and A. Kalinkin 1985. *The Nature of Science*. Moscow: Progress Publishers: p.77.

made his name as the botanist on James Cook's voyage to the South Seas in 1768- an expedition organized by the Royal society on behalf of the British government- but he was also an extremely wealthy man.

In addition to the academicians, the scientific community of 1770 also included a number of university professors. Some of these like Linnaeus, Black and Galvani, actually taught the subjects on which they did research.[21] But the curriculum in most European universities was still organized on the medieval pattern, emphasizing theology, classics and philosophy, and with professional schools in law and medicine. A chair of mathematics, natural history or anatomy provided suitable support for an occasional original scholar but there was very little encouragement of scientific research. To this day, most of the universities in Spain are similarly staffed by professors chosen for their skill in passing examinations, and for less relevant social aptitudes, without regard to ability in research; they are expected to devote themselves to lecturing at length on subjects whose permanence and continued relevance are taken for granted.

Science in the late eighteenth century was widely respected and officially encouraged. Nevertheless, most active scientists were still amateurs, with other means of support. It was an age of relative peace and prosperity where the leisurely life of the gentry and of professional people like doctors and priests allowed adequate time and facilities for private research.[22] To play at chemical or electrical experiments, to have read one or two popular scientific works, to attend a conversation at the Royal Society-these were fashionable hobbies, in keeping with the climate of opinion in the 'Age of Enlightenment'. It was also an age of great technical advance, in engineering and industry – but that was a different world, scarcely connected with the realm of natural philosophy.

[21] John Ziman. 1976. op.cit., p.54.
[22]Edward Shills 1970. The Profession of Science. *The Advancement of Science* 24:p.471.

2.6 Science in the Nineteenth Century

By1870, the scientific community was quite transformed. This is the century in which science became fully 'academicised'.[23] It had grown enormously. It is difficult to estimate the actual number of people contributing seriously to science in the latter half of the nineteenth century, but it must have been many thousands. The lists of famous scientists in the histories and bibliographies can no longer be expected to be complete. This is obvious from Derek de Solla Price's count of scientific journals. If there were indeed, something between 5,000 and 10,000 learned journals in 1870, and then there must surely have been at least the same number of readers and contributors. Solla Price had shown the growth of scientific activity in her book *Little Science, Big Science* (1963). For every single scientific paper or for every single scientist in 1670, there were 100 in 1770, 10,000 in 1870- and 1,000,000 in 1970.[24] Whether or not there will be 100,000,000 or so scientists in 2070 and 10,000,000,000 in 2170 remains to be seen, the rapid and uniform expansion from the past up to the present is the significant fact with which one must reckon.[25]

2.7 Academicization

It is quite clear, however, that science had moved, lock, stock and barrel, into the universities; Most of the people who contributed to pure science were now engaged in academic work, as professors or would-be professors. A few wealthy amateurs, such as Fizeau (1819-96) and Darwin were still indulging their hobbies. In medicine it was not universal for a practicing physician to experiment with new scientific techniques, and there were, of course, small numbers of government official employed as experts in astronomy, geology, surveying etc. But to say that a man was a *scientist* almost automatically implied that he had an academic post.[26]

[23]Charles C. Gillispie. 1990. *The Edge of Objectivity: An essay in the History of Scientific Ideas.* Princeton: Princeton University Press. p.29.
[24]Derek de Solla Price. 1963. *Little Science, Big Science.* New York: Columbia University Press: p.37
[25] John Ziman .1976.op.cit., p.57.
[26] Joseph Ben-David.1971. op.cit. p.78.

In England the professors were teaching students in a number of new universities that had started to offer science degrees. Until about 1850 it was not possible to receive a regular training in the experimental sciences. A rich young man might pick up a smattering by attending special lectures at the ancient universities. For a poor boy, such as Michael Faraday the only entry to the scientific profession was by apprenticeship as laboratory assistant.[27] Towards the end of the 19th century, the degree of Bachelor of Science (or its equivalent, the 'Natural Sciences Tripos' at Cambridge) had become the regular qualification for research and for science teaching. The natural sciences had now become 'subjects' at school and at university and gradually grew until they were being taught to an appreciable fraction of the youth of the nation.[28] In England, unfortunately, this took place by the creation of an optional *science side*, running in parallel with classical and modern curricula in the higher forms of the Public and Grammar Schools. From this failure to bring science right into the older literary curriculum stems the deplorable present-day separation of art and sciences into 'Two cultures'.[29] Academicisation of science was happened in various countries in different times.

2.8 Academicization of German Science

But it was in nineteenth-century Germany that Science became completely academicised. Many new universities were founded and began to compete for the ablest scholars, judged much more for their research output than for their capacity as teachers. For the first time, the original scientific ability was considered the prime qualification for academic advancement. Unfortunately, there were no paid posts below the rank of professor. A graduate trained in basic science and philosophy was expected to support himself as best he could whilst he prepared a dissertation for the senior degree of *Doctor of Philosophy* so- called because that had been the central discipline of the medieval university, rather like 'Arts' at Oxford and Cambridge. The

[27] J.R. Revetz. 1973. "Tragedy in the History of Science". In: M.Teich and R.Young eds.*Changing Perspective in the History of Science*. London: Heinemann. pp.26-27.
[28] John Ziman. 1968. op.cit., p.29.
[29] C.P. Snow. 2006. *The Two Cultures* (with an Introduction by Stefan Collini).Cambridge :Cambridge University Press: p.19.

aspiring school was then allowed to take pupils as a Private Dozent, or Private Tutor. But he also needed a private income, for he received no regular salary, even though he was expected to devote himself to research and teaching. The competition for preferment was intense, but if he was lucky he might eventually be called to a well–paid appointment as a professor. This plateau, achieved in his 30s or 40s, was comfortable enough and carried high social status, but there was still an incentive to continue research which might carry him into a more senior chair at a more famous university.[30]

In many ways it was harsh system, trading heavily on personal ambition and perseverance in the early years. But if transformed the style of scholarship in all branches of *Wissenschaft*, the Germen word that includes both natural sciences and the humanities. From the middle of the nineteenth century, German science leapt ahead, becoming much more rigorous, competitive and professional. It also made research more cooperative. Each professor would acquire a group of assistants, consulting his seminar – what we should now call a *research group*. These assistants were very dependent on his good will and patronage, for only the recommendation of your own professor could guarantee preferment to a chair elsewhere. In this way seminar became a school of research, engaged in the solution of the problems proposed by the professor and devoted to his methods and scientific opinions. The university as a whole was little more than a federation of such groups, to which students would come for advanced lectures and research supervision. The connection between research and specialised teaching was thus firmly emphasized, at the expense of an integrated curriculum.[31] The establishment of the graduate school, like of our age was basically developed in Germany.

2.9 Origin of the Modern Graduate School

The German model of Graduate school was copied by various countries. In 1870 it was deliberately copied at John Hopkins University, and rapidly transformed

[30] L.Feuer. 1963. *The Scientific Intellectual.* London: Basic Book : p.43.
[31] John Ziman 1976. Op.cit. pp.60-61.

the style of advanced Scholarship at the major US universities. This is the origin of the modern graduate School where formal lecture courses and examinations are combined with a few years of quasi-original research, embodied in a written dissertation, for the Ph.D. degree. We can say that the present system of *PhD* had its origin from 19th century. The German trend was resisted in England until the early years of this century, but has now become the standard form of advanced training in research throughout the English-speaking world. In France and Italy there were other traditions, but the actual succession of cycles of degrees has very much the same content as in the American graduate school.

For the better part of a century, therefore, science has been closely connected with the universities. Nobody attempts to do research unless he has had at least an undergraduate education in his chosen discipline. Most research workers, whether or not they actually work in universities, have been through graduate school and learnt the technique of research on the way to the title of PhD.[32]

University teachers of science were expected to spend a great part of their time doing research, and the leaders of the scientific community, respected and honoured for their contributions to knowledge, are mainly employed as university professors. Even in an applied science such as medicine, where professional practice plays such an important part, clinical research is largely concentrated in the teaching hospitals. It is hard for us now to imagine a world in which scientific research was not a major aspect of academic life, and the universities were not the main source of basic scientific knowledge.

As research became a more professional activity, it acquired its own special buildings. The Cavendish Laboratory at Cambridge founded in 1871, by a private benefactor, was one of the first buildings dedicated specifically to research in pure science.[33] The first Cavendish Professor, James Clerk Maxwell, had not graduate students, but by the end of the century, under the leadership of J.J. Thomson (1856-1940) this was one of the main centers of physics research in the world. Here, in

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[32]Baltimore ,D. 1992. On Doing Science in the Modern World, Tanner Lecture delivered in the University of Cambridge, UK.

[33] J.D.Bernal. 1946. *The Social Function of Science*. London: George Routledge and Sons Ltd p.77.

1895, came Ernest Rutherford (1871-1937) to study on radioactivity that made him famous. The Institute Pasteur in Paris was established in 1888 around the great Louis Pasteur (1822-1895), who had discovered the role of bacteria in disease. The immediate purpose of this institute was to deal with cases of hydrophobia, using Pasteur's technique, but medical research workers began soon to gather there until it became a world center for the new sciences of bacteriology, microbiology and molecular biology.[34]

The Royal Society in London was no longer open to more wealth or high birth. To be elected an FRS was an honour signifying active research and positive contributions to science. The Fellows still included many amateurs, such as Darwin, and Sorby but the majority was professional academics. Victorian pundits like T.H.Huxley (1825-95) used it as a base within the establishment for organizing all the things that needed to be organized in education, in industry, and in the government. But there was a price to be paid for these high scientific standards and official influence. The business of the Royal Society was now cut off from contact with the lay public; it became rather esoteric and inward-looking, concerned mainly with the special affairs of the scientific and technical community. The failure of leadership in the nineteenth century is evidenced by the formation of new learned societies in the main branches of science. Each of then began to do, in its own specialized field, all the things for which the older scientific academies had originally been founded. In the absence of adequate facilities for meetings and publications within the Royal society, the geologists, the chemists, the zoologists etc. branded together and formed their own societies for the same purposes. To some extent, this was natural as a consequence of increasing specialization into separate 'disciplines' in the scientific and academic world. Yet it is noteworthy that this process did not occur, as it might have done, under the general umbrella of the Royal Society. The learned societies are extremely important in the modern scientific world as the means by which much of the practical work of publications, conferences, professional and educational consultation, etc. is carried out. An organization such as the American Chemical Society has an annual income of many millions of dollars, and publishes thousands of pages of scientific

[34] John Ziman. 1976.op.cit,. p.62.

research. Neither in Britain nor the USA is there any general federation of such societies where the general business of the whole scientific community can be discussed and represented to the outside world.[35]

2.10 Industrial Research

By the end of the nineteenth century, academic science was in full bloom, but industrial science was only pushing a few sprouts through the earth. Very little use was made of deliberate research in industry. Individual inventors such as Thomas Edison (1847-1931) set up their own research workshops and applied scientific principles to the improvement of techniques in manufacture, agriculture, mining etc. but they seldom contributed to basic science. The modern idea of a research department in every factory had still to be born. Governments employed astronomers, geological surveyors, public health officials and other technical experts, but did not regard it as part of their duty do subsidize research into pure or applied science for general social purposes. Dynamite was invented in 1866 by Alfred Nobel (1833-96) who made a great fortune by manufacturing explosives; it was not the product of a research laboratory of any Ministry of Defense.

Nevertheless, the German dye and chemical industry prospered in the 1870s, and took the lead from Britain by the employment of professional chemists, not only for routine analytical testing but in the development of new processes and products. The universities produced many Ph.Ds with research experience: those who could not find places in the academic profession were welcome in industrial management and innovation. By the 1880's there were several firms in Germany and Switzerland employing a dozen or so scientists in their research laboratories, although these were still on the scale of the university institutes presided over by such academic grand chams as Von Baeyer (1835-1917) or Hofmann (1818-92). Really large scale industrial research belongs to the present century, from the First World War onwards.

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[35] Ibid. p.66.

Although science became rapidly organised in Europe and North America, until the later part of the 19th century the centre of organized research was in German universities. Towards the end of the 19th century two developments occurred. First, the German universities ceased to expand at their previous rate, and second, systematic institutionalized connections between science and industry were established.[36] For example Chemistry, which always had a very close relation with practice, became the basis for capital intensive industry in Germany during the later part of the 19th century. By the middle of the 20th century especially during the two world wars, the utilisation of science for war efforts and use of science as a major factor in industrial production led to the transformation of the pure, academic science that previously represented the nature of science into research in the interests of productive practice.[37]

Closely connected to these developments was also a trend towards large scale organization of science under government and industrial research settings. From the middle of the 20th century science has been increasingly supported by both government and industry as integrated to their political, social and economic proposes.

From the beginning of the 20th century the organization of science under-government progressed steadily. For eg: in colonial India at least, ten science organisations in agriculture, telecommunications, meteorology, trigonometry, geology, botanical survey, archeology etc. were created under the colonial government by 1910.[38] Other examples are Britain's DSIR (1918), Australia's CSIRO (then SIR) in 1926, India's CSIR (1942). In OECD countries more than three quarters of resources are concentrated in the business and government sectors. It is rather alarming to note that about 90% research efforts in OECD countries are directed towards defense, space and nuclear objectives in research.[39]

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[36] Ravetz. J.R. 1971. *Scientific Knowledge and Its Social Problems.* Oxford: Clarendon Press. p.38.
[37] Ibid.
[38] Deepak Kumar, 2006. *Science and the Raj.* New Delhi: Oxford University Press: p.79.
[39] V.V.Krishna.1987. Scientists in Laboratories: A Comparative Study of Organisation of Science and Goal Orientation of Scientists in CSIRO (Australia) and CSIR (India) Institutions. PhD Thesis (Sociology), University of Wollongong, Australia.

Since the 1980's is not the same phenomenon as it was in the days of Galileo, Newton and the establishment of Royal society. One of the most distinguishing features of present day science is that, by its location in formal institutions, it tends to exclude the pursuit of science by a lone independent *natural philosopher*. The large scale increase in support of, and employment of scientists in institutions sponsored by industry and government over the years has fostered the growth in developed and developing countries, such as India, of 'mission-oriented' research effort. [The term 'mission-oriented' research has evolved from science policy work. Basically the term refers to directed character of all research except 'pure' or 'basic' research which is defined by Frascati Manual, OECD 1976 as "to acquire new knowledge of the underlying forms of phenomena and observable facts". Mission-oriented does not mean that it is not constrained by 'cognitive' traditions, when even basic research is supported with an intention to reap economic and social benefits. Such research may also be regarded as mission-oriented.][40]

The Scientist is no longer an independent agent free to investigate whatever problem he thinks best. Nor is he likely to have personal contact with a private patron who will provide for all his needs. Rather, in order to do any research at all, he/she must first apply to the institutions or agencies that distribute funds for this purpose, and only if one of them considers the project worth the investment can be proceed.[41]

From the beginning of the 20th century a steady increase in the state and industrial patronage of science was seriously limited the professional autonomy of scientists. The professional regulation is gradually being both supplanted and regulated by social, economic and political considerations. For Scientists employed in big government sponsored science agencies, research is highly constrained by various factors at the same time that it is mediated by certain organizational strategies. Scientists are increasingly being drawn into negotiations with the funding agencies. These agencies are getting involved not only in selection of research projects, but negotiation between scientists and funding agencies operate during the ongoing research project as well.[42] In consequence, it follows that the concept of autonomy in science is severely limited. As Ziman has observed as "science is collectivised and

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[40] ibid.
[41] J.R. Ravetz 1971. op.cit.,p.44.
[42] K.D. Knorr- Cetina. 1981. *The Manufacture of Knowledge: An Essay on the Constructivist and Contextual Nature of Science.* London: Pergamon Press. p.37.

industrialised", involving as it does the large extent to which science is being organised in big mission-oriented agencies, and organisational constraints limit personal autonomy in research.[43]

Conclusion

In this chapter we explored the historical background of the social system of science. At every stage, it is clear that the particular differences between one historical epoch and the next, and between one country and another. Between 1670 and 1870 the scientist changed his position in the social framework. He begins as a very peculiar and isolated individual, a *devotee* of science, noticed and honoured only if he makes some truly astounding discovery. By the end of the nineteenth century he has become member of a recognised profession, employed in academic teaching but encouraged and supported for his research. Through his learned societies and by his contributions to industrial progress, he has acquired high social status.

It is also clear that science has undergone continuous transformation in all its aspects from the way of doing science to the way of communication. In this globalised age we can find entrepreneurial scientists working both at the universities and industries/ firms. Indeed the status of professor/scientist has changed to a mere 'knowledge *worker*'. The science of the present century is different from the science of the nineteenth century. There is a real and urgent sense that the scientific enterprise is in transition. Several scholars draw attention to this changing nature of science by referring to the idea of a previous *golden age of science*. Various scholars in science studies have argued that the nature of scientific research has changed. For John Ziman it is a shift from *academic science to post academic science* (2001) and for Gibbons et al, (1994) it is a change from *Mode 1* to *Mode 2 Knowledge Production*. In this chapter we discussed the historical background of the social system of science. In the coming chapters we would explore in detail about the new emerging social contract between science and society.

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[43] John Ziman. 1981. What are the Options? Social Determinants of Personal Research Plans. *Minerva:* 14(1) : p.29.

Chapter 3

Science and Society Relationship in Social Studies of Science Literature: A Theoretical Analysis

Introduction

Science and Technology Studies (STS) is an interdisciplinary field usually defined as the confluence of three fields with distinct intellectual lineages and orientations: *history of science, philosophy of science, and sociology of science.* All three have been marginal to their named disciplines, because surprisingly few of the original practitioners of history, philosophy, or sociology of science were primarily trained in history, philosophy, or sociology. Rather, they were natural or exact scientists who came to be disenchanted with the social entanglements of their chosen fields of study[1]. The field is rapidly becoming established in North America and Europe. Because it is interdisciplinary, the field is extraordinarily diverse and innovative in its approaches. Because it examines science and technology, its findings and debates have repercussions for almost every understanding of the modern world[2].

In the last quarter century, STS has come into its own as an academic field. It now sports its own professional societies, journals, handbooks, degree programmes not to mention funding streams and cross-disciplinary gurus like Bruno Latour and Donna Haraway[3]. In India also we have interdisciplinary gurus, though the number is less. The major figure among them is J.P.S. Uberoi. We will discuss more on this in the later part of this chapter. The present chapter discusses the science and society relationship in social studies of science, mainly from Sociology of Science, its various approaches and recent debates.

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[1] Steve Fuller. 2007. *New Frontiers in Science and Technology Studies.* Cambridge: Polity Press. p. 1.
[2] Sergio Sismondo. 2004. *An Introduction* to *Science and Technology Studies.* Oxford: Blackwell Publishing. p. vii (Preface).
[3] Steve Fuller. 2006. *The Philosophy of Science and Technology Studies.* London: Routledge. p. 4.

3.1 The Main Approaches in Sociology of Science

The sociology of science and technology is an umbrella which is shared by those sociologists who study science from a sociological perspective, and by others who also study science, from various other perspectives, but with no real homes of their own. They include not only sociologists but also anthropologists, economists, psychologists, historians, philosophers, political scientists, educationalists, journalists, plus several working physical and biological scientists. Sociology of Science has benefited considerably, from the work of all these practitioners when it has been directed towards the solution of problems concerning the organization and social consequences of science in society. Each of these specialists brings his own particular methods and skills to bear on such problems. It is, however, possible and convenient to separate out some of the main approaches to the sociology of science that have helped such scholars to organize their research and to interpret their results. Some of these approaches, not surprisingly, are linked to general theories of society, for as soon as science began to be seen as a social activity it began to be described and explained in similar terms to other social activities.[4]

3.1.1 Marxist Sociology of Science

The first people to look at science systematically in a social context were Marxist scholars such as J.B.S. Haldane, Joseph Needham, and, particularly, J.D. Bernal, all of whom were eminent scientists in England between the wars. Bernal, in his book, *The Social Function of Science*, first published in 1939, expressed the essential arguments of this group in a manner and with a force that is still very relevant for the student of science today. Bernal saw science as the major tool in the transformation of the social and natural world. Science, however, is not simply a social activity but also a practical enquiry and, Bernal claims, it can properly develop only where there is a union of theory and practice. In the pre-modern world this union was largely absent, and so the insights of the ancients had to remain mere speculation

[4] Leslie Sklair. 1973. *Organized Knowledge: A Sociological View of Science and Technology*. London: Hart-Davis, MacGibbon. p.58.

until the era of experimental science, when the experimental scientist, part craftsman and part theoretician, created modern science, in response to the material needs of his social situation.[5]

For Bernal, the scientist is a worker, albeit with some peculiarities in his work situation, and science in common with most social institutions is somewhat stunted in its growth in crudely capitalist societies. In science, as much as in any other single aspect of modern life, the contradictions of capitalism are apparent. This is noted by Marx in a speech delivered in 1856, where he draws attention to the 'antagonism between modern industry and science on the one hand and modern misery and dissolution on the other hand' (quoted in Bernal, 1939, p. 235). Still it is very relevant.

The Marxist Sociology of Science and Technology, then sets scientific activity clearly within the context of the Marxist theory of social change, and gives it an important place. And it was the potential of science and technology for human welfare that provided the focus for this and many other studies. The First World War had shown that science and technology were not merely hobbies for the rich and inventive, nor were they simply marginal additions to the nation's history books: clearly science and technology were vital to national survival and prosperity.[6]

In this atmosphere it was hardly surprising that scientists and others with various interests in science and its applications began to examine seriously the multitude of questions surrounding the social role of this traditionally neglected area. Government departments, prestigious investigating committees, the universities, and the growing voluntary associations of scientists, all contributed towards the debate, the core of which was the issue of the planning of science for the social good[7]. The possibility and desirability of intelligent and socially beneficial science policy-making, the opposition to which declines year by year in all advanced nations, is the legacy of the Marxist Sociology of Science.

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[5] J.D. Bernal. 1939. *The Social Function of Science*. London: George Routledge and Sons Ltd. p.13.
[6] D.S.L. Cardwell. 1957. *The Organisation of Science in England*. London: Heinemann. p. 27.
[7] Leslie Sklair. 1973. op.cit,. p. 59.

3.1.2 Structural-Functional Sociology of Science

Sociologists in America, however, became concerned with the problems of the sociology of science from a quite different perspective. A long tradition going back to Max Weber and beyond, had led to questions about the crucial institutional changes which were supposed to have shaped Western Civilization. So, just as Weber himself had been concerned with the emergence of capitalism in predominantly protestant societies, Robert Merton, in a lengthy monograph, whether science as a social activity was not also meaningfully and historically related to the Calvinist way of looking at the world.[8]

Merton's conclusion, like that of Weber, was that the systems of ideas could be fruitfully related, though neither man-contrary to widespread belief-was rash enough to claim that Puritanism caused either capitalism or science. In a series of papers, Merton has developed the modern sociology of science in a manner that concentrates attention on the way in which science as a system of social relationships operates in society. This approach emphasises the social rules, the norms, of science and the rewards that are built into it in order that it should work efficiently.

This is the *structural-functionalist* approach, and is the one followed by most sociologists who study science. R.K. Merton is the most important proponent of this view and he is ably supported by many of his students also have themselves made significant contributions to the field. The basic premise of this approach is that scientists are organized into a social system and, like all social systems as analysed by the functionalists, the values and norms or rules of the system are such as to ensure that the system continues in roughly the same way as before. When things happen that might serve to disrupt the system, then mechanisms of social control, the teeth of the rules which are legitimated by the underlying values, are bared on the offending phenomena, and they are either destroyed or contained, or the system changes in some way to accommodate them.[9] Thus, Merton points out, the virtual absence of fraud in science is explained not by the exceptional honesty of scientists but by the norm of

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[8] Robert K. Merton. 1938. Science, Technology and Society in Seventeenth Century England. *Osiris* 4: 360-632.

[9] Talcott Parsons. 1951. *The Social System.* Glencoe: Free Press. p.7.

disinterestedness, which holds the scientist at all times accountable to his colleagues and largely eradicates the possibility of cheating. Falsifying results is both too difficult to pull off successfully and abhorred by the scientific community, so that, as Merton comments, 'the dictates of socialized sentiment and expediency largely coincide, a situation conducive to institutional stability'.[10]

According to Merton, sociology of science is set on the meso-level, where communities, professions, institutions, organizations, disciplines, specialties, research areas and, generally speaking, the socio-cognitive sub-systems of research take place Merton's meso-level option (apparent since his early works) is well in line with his bent for the social history of science and technology, and quite different both from the macro level of epistemology and philosophy of science and from the micro level of history of scientific thought, the case-studies of which could hardly be chosen as solid foundations for a general theory of science and technology. Merton shared with other historians of science (such as Ossowska and Ossowsky) the idea of science as a process; science-in-the-making became a valuable research subject for the social sciences, and the specificity of the sociology of science and autonomous specialty, the mission of which is to study scientific practices and behaviours, and not scientific theories and models.[11]

Merton is responsible for the meso-level modeling of scientific professional behaviour, and his sociology of science is above all sociology *of scientific professions*. Nevertheless, Merton sketches the sociology of science as part of the sociology of knowledge. In *Social Theory and Social Structure*, Merton states that the sociology of science is 'a specialized field of research which can be regarded as a subdivision of the sociology of knowledge, dealing as it does with the social environment of that particular kind of knowledge which springs from and returns to controlled experiment or controlled observation.'[12]

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[10] R.K. Merton. 1963. *Social Theory and Social Structure*. Glencoe: Free Press. p.559.
[11] Leonardo Cannavo. 1997. Sociological Models of Scientific Knowledge. *International Sociology* 12(4): p.476.
[12] R.K. Merton. 1968. *op.cit,*. p.585.

In principle, Merton's statement is absolutely correct. But the European sociology of knowledge – up to the Second World War – had very little interest in natural science, both as a product, and as a process in accordance with the objectivist viewpoint, represented by the syllogism: *nature is objective; natural science reflects it; hence, natural science is objective*. In compliance with his Marxist approach, Karl Manheim argued that the scientific knowledge of nature cannot be subjected to sociological analysis: it is objective, since it is corresponding isomorphic to the deep structures of reality whereas the ideological conditioning of collective forms of thinking is a suitable subject for the sociology of knowledge.[13]

The contemporary sociology of scientific knowledge, sometimes conditioned by a neo-Marxist bent, on the one hand overestimated Manheim's contribution, which had been so indifferent to the cultural consequences of the 20th century revolution in Physics and, on the other hand, underestimated the anthropological research on the social origin of the interpretative categories of reality, space and time. Manheim's views about the sociological analysis of scientific knowledge were outdated, especially if compared with the French school of sociology and social anthropology (Marcel Mauss, Levy-Bruhl and, to some extent, Emile Durkheim), and with other leading scholars as well such as Thorstein Veblen, Max Weber and Max Scheler. In particular, Max Scheler, often neglected because of charges of conservatism, related the natural and experimental sciences to the social sciences, stating that experimental science goes with the contractual capitalist *Gesellschaft*, in which technology is being shaped as the integration of economy and scientific knowledge, and that the central aspect of the science-and-society relation is not the conditioning of society on science, but vice-versa, the impact of science on society.[14]

The leftist bent of European sociology of knowledge after the Second World War disregarded Scheler and underestimated the significance of the work of Veblen, who had shown, in *The Place of Science in Modern Civilisation* (1908), how scientific theories were influenced by economic and social constraints, since the habits of life influence the habits of thought, and also ignored the work of Max Weber, in

[13] Karl Manheim. 1929. *Ideology and Utopia*. New York: Harcourt, Brace. p.27.
[14] Stephen Cotgrove. 1970. The Sociology of Science and Technology. *British Journal of Sociology* 21(1)): p.4.

particularly his essay in *science as vocation*. One should read the essay science as a vocation properly. In this essay he is clearly saying that scientific work is a source of great personal satisfaction and the scientist experiences intense excitement from the making of a discovery. He is talking about the inner vocation for science. he argued that without this passion one have no calling for science and should do something else[15]. It is very relevant in a century where people choose science or practice science only for material benefits. In this essay he dealt not so much with the place of science in society as with the 'inward calling' for science. In his other works, however, he was concerned with relating the development of the rationalist economic ethic, as embodied in the other areas of social activity, particularly religion. The interest in Science, though, not specifically articulated, is there by implication, as part of the rational scheme of values.

So, Mertion's statement that sociology of science is a part of sociology of knowledge seems to be more wishful thinking than reality. On the other hand, Merton, while defining sociology of knowledge as the European variant of sociology of Mass Communication, relates it to the study of opinion, and not to the reliable, standardized and certified knowledge we call 'science'. Furthermore, if one considers that Merton was George Sarton's disciple, and that his early works were all devoted to the social history of science, then the sociology of science can be rightly regarded as stemming and developing from the social history of science and technology.[16]

There are many criticisms of functional approach in sociology of science. Merton's approach to science as a social activity is based upon his conception of science as an intellectual pursuit, as the disinterested search for knowledge and truth. Hence when Merton formulates his sociology of science, it is pure science alone that he is concerned with. Mertonian sociology of science refers only to pure science or *academic* science. Hence by definition, and at other times by implication, large sections of modern science are excluded from the analysis resulting in the 'fallacy of

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[15] Max Weber. 1989. "Science as a Vocation". In P. Lassman, I. Velody and Martins eds., *Max Weber's Science as a Vocation.* London: Unwin Hyman. p.8.
[16] Leonardo Cannavo. 1997. op.cit., p.477.

generalisations from unrepresentative samples'.[17] To use Sklair's phraseology, the Mertoian Sociology of Science might perhaps be more aptly termed the sociology of pure science or sociology of academic science[18] Non-academic (industrial) scientists are considered to be deviant scientists in so far as they do not live up to the norms of science as stipulated, and they are considered to be translated academic scientists when their employment circumstances do not permit them to act like academic scientists.[19] It is not my intention to criticize the model here. I will discuss the limitation of Mertonian models in the present era of science in the next chapter. I thought while discuss the functional approach it is important to show the limitation of the framework. That's what I did here in a nutshell.

It is well known that up to the end of the 1960s the sociology of science developed primarily in the United States, as organisational analysis of scientific communities, within a functionalist frame. During the so-called 'Old' sociology of science (OSS; that is, Merton's school) passed through a crisis, because of its difficulties in accounting for scientific change, which was, of course, just the actual or ascribed strength of Thomas Kuhn's theory of paradigms.[20]

3.1.3 Thomas Kuhn and the New Sociology of Science (NSS).

The development of the New Sociology of Science (NSS, that is, the Kuhnian approach to science and society) in Europe during the 1960s was a valuable change, not only in comparison with the prevalence of science studies, such as the philosophy of science and the history of scientific thought, but especially in relation to the next development of the social studies of science.

The approach-typical of the NSS of linking up different levels and contexts (cognitive and organisational; micro, meso and macro, etc.) of the scientific enterprise allowed the creation of a new and complex specialty, the dynamics of science and

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[17] Radhika Ramasubban. 1977. "Towards a Relevant Sociology of Science for India". In: Stuart S. Blume ed., *Perspectives in the Sociology of Science.* New York: John Wiley and Sons. p.159.
[18] Leslie Sklair. 1973. *op.cit.*,p.161.
[19] Ibid.
[20] Michael Mulkay. 1980. Sociology of Science in the West. *Current Sociology.* 28(3): p.11.

technology, a part of the social studies of science. Contrary to the functionalist OSS, the NSS prepared the poly-paradigmatic turn of sociology of science. New cognitive and communicational research programmes shaped a new sociology of scientific knowledge, open to the social and political studies of science and technology, to the social studies of public scientific communication, and to the social ethics of science as well.

Kuhn's masterpiece work, *The Structure of Scientific Revolutions* (1962) challenged the dominant popular and philosophical pictures of the history of science. In place of the formalist view with its normative stance, Kuhn substituted a focus on the activities around scientific research: at least officially, he insisted that science was merely what scientists do. Kuhn's picture does include large historical patterns, but in place of steady progress he substituted periods of normal science punctuated by revolutions. He suggested that scientific methods, theoretical formulations, criteria for the evaluation of problems and for the definition of solutions were not universal, but varied over time. As is now well known Kuhn went on to suggest that scientific paradigms were subject to occasional breakdown and hence revolutionary transformation[21]. Kuhnian approach was really paved the way for a cognitive sociology of science. It is responsible for a set of remarkable theoretical effects. First, it integrates the social aspects within, rather than with, the cognitive and methodological aspects of science. Second, although seemingly 'revolutionary' it aims at celebrating the reconstruction of an evolutionary model of social change: thus, 'anomaly' is to 'paradigm' as 'mutation' is to 'chromosomal inheritance' Third, it shifts the analysis of scientific change from the macro level of big modelling to the meso level, where the forming and institutionalizing of disciplines, specialties and research areas are studied. As a consequence, the NSS can be defined as sociology of socio-cognitive sub-systems, since in this cluster research fields, disciplines, specialties, research areas, communities and problem-oriented groups can be put together. The methodological framework for studying the socio-cognitive sub-systems allows us to differentiate between two opposite views of the sociology of science: on the one hand, the NSS, meso-level-oriented and very interested in the structural and

[21] Stuart S. Blume. 1977. "Sociology of Sciences and Sociologies of Science". In :Blume ed., *Perspectives in the Sociology of Science*. New York: John Wiley and Sons. p.10.

nomothetic factors of science dynamics; on the other hand the revival of relativism and constructivism, operationally translated into a micro-level sociology, the research program of which is limited to cultural and idiographic phenomena.[22]

3.1.4 Constructivist and Relativist Sociology of Science

For the micro-level of sociology of science the so-called constructivist and phenomenological *strong programme* – the fundamental notion is the Kuhnian concept of consensus. Consensus – as Kuhn rightly put it – is not only grounded on cognitive bases, but also on factors deriving from inside the professional community as well. As such, those reasons are micro-social, and they set beside the reliable rationality and reasonableness of methodological rules the personal plans, interests, strategies and tactics for survival and promotion in the social stratification determined by the scientific reputation system. For methodological reasons, the strong programme is at adds with the NSS, since the NSS maintains an orthodox concept of scientific methodology, a research programme not exclusively *internalist*, and the working hypothesis of differentiating between science and common sense[23] Within the strong programme – so interested in the discontinuities in scientific method, in the externalist working hypotheses and in the reappraisal of commonsense in the construction of scientific knowledge four prevailing trends can be identified:

a) *Scientific Relativism* (Harry Collins, Trevor Pinch

b) *The Theory of Scientific Interests* (Barry Barnes, David Bloor)

c) *The Analysis of Scientific Discourse* (Nigel Gilbert, Michael Mulkay, Steven Yearly)

d) *The Ethnography and Ethnomethodology of Scientific Work* (Karin Knorr-Cetina, Bruno Latour, Michael Lynch, Steve Woolgar)

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[22] John Ziman. 1984. *An Introduction to Science Studies*. Cambridge: Cambridge University Press. p.105.

[23] Sergio Sismondo. 2004. *op.cit.*,p.43.

Schools and research teams of the strong programme refer to phenomena and view points hardly comparable. Yet, it is possible to find out common perspectives. The four trends of the strong programme seem to introduce *irrationality* as a structural element of scientific behaviour. To some extent, as well as logical rationality, social and economic rationality comes into play: that is, theoretical consensus and conflict, scientific discourse construction and conceptual mediation, are more determined by the logic of dispensable resources and of cost/benefit assessment of scientific options, than by the methodological consistency of evidence and interpretation.[24]

The field of science studies is now very rich interns of methodology, approaches and scholars. My intention was to touch the basic knowledge of the various approaches in social studies of science before starting the *social relations in science and society* in the social studies of science literature. Because it is very necessary to be familiar with various approaches in order to understand the real issue under study.

3.2 The Status of Science Studies in India

Science Studies or Sociology of Science is one of the neglected fields of sociology in India. There are various reasons behind this. One factor is that there are only few scholars of science studies in India. Another important factor is the hegemony of the mainstream topics in sociology like caste, class, marriage and kinship etc. I think to some extent, the lack of communication between science studies scholars and pure sociologists are also a factor. If we look at the scholars in science studies, many of them are from central Universities/Institutes (JNU, DU, IITs) and not from state Universities. In the state Universities the situations is pathetic in the sense that they deal with only'old' topics in sociology. There is need to build up a network of science studies scholars, who really practices science studies and people from other institutes includes state universities who are studying various aspects of science. There are a good number of a good number of studies on history of science/medicine

[24] Loeonardo Cannavo. 1997. op.cit., p.489.

from various state universities. It is important, to accept those studies and encourage them to continue to do so. The *Centre-Periphery* dichotomy should not be practiced in the field of science studies in India. Here is the significance of a *Science Studies Network* in India, where various scholars on different aspects of science, its *history*, *philosophy*, *anthropology sociology*, *psychology* and *economics* can get together and share their knowledge.

Even though the number of studies or specialists are very few in number, we have some prominent scholars in India who explained the social institution of science.. Here we see some of the prominent Indian studies. Madhav Govind has reviewed some prominent studies in sociology of science in India. He has reviewed the contributions of Ashok Parthasarathy, E.Haribabu, Radhika Ramasubban, JPS Uberoi,Shiv Viswanathan and V .V Krishna.(Govind 2006,39-44).They are all leading figures of Science Studies in India, especially JPS Uberoi,V.V Krishna, Shiv Viswanathan and E. Haribabu. Having said that we have to accept the contributions of another group of scholars in science studies, ie, the advocates of Alternative Sciences like Ashis Nandi, Claude Alvares etc. Discussing their contribution is beyond the limit of the present study. The following is a brief discussion of the contributions of some of the prominent figures of science studies in India (Govind, 2006, 39-44).

Ashok Parthasarthy (1969) observed the effect that interaction between Indian culture and International science had on science organization and research behavior. He claims that this shapes local scientists' self-confidence negatively and affects their capacity for independent thought, and injects a 'caste system' in science (based on overseas versus local education) into the local community.[25]

E. Haribabu's study reveals valuable insight into the internal dynamics of scientific community. He focuses on 'the system of peer evaluation in Indian science within the socio-cultural context of science in the country and its historical interaction with international science.[26] His study is located in the interactional approach which

[25] Ashok Parthasarthy. 1969. Sociology of Science in Developing Countries: The Indian Experience. *Economic and Political Weekly* 4 (31): 2. pp.1277-80.
[26] E. Haribabu. 1991. A Large Community but Few Peers: A Study of the Scientific Community in India. *Sociological Bulletin* 40 (1 & 2): pp.77-88.

was one of the earliest attempts at theorising in the western sociology of science, which for long constituted a dominant 'paradigm', as distinct from the Marxist 'paradigm' which was the most influential among 'externalist' approaches. Haribabu in his another paper tried to show that in India a shift in cognitive values from *knowing for its own sake* to *knowing with an eye on patent*. He argued that the era of industrial research and big science has begun in India only recently. He argued that though academic research continues to be carried out the essential character of science will change.[27]

Radhika Ramasubban in her study has suggested that a Marxian Sociology of science is not relevant for the study of science in India and vehemently criticized the functionalist sociology of science. She asserted: "It is not hard to understand why the functionalist sociology of science is an unreal analytical framework within which to analyse Indian science. It is only the Marxian sociology of science with its historical perspective and relating science to its economic basis, which provides the necessary insights into the functioning of science as a social activity".[28]

J P S Uberoi's work, *Science and Culture* is a masterpiece in the field of theoretical sociology of science. Uberoi advocates for semiological method for science in place of positivist method of science. He argued: "The foundation of positivist method is based on mutually exclusive division between the truth and the reality. It rejects all relations of a higher transcendental, eminent or dialectical unity of mutual participations or of reciprocal dependence between the truth and the reality".[29]

Shiv Viswanathan's study of scientists in NPL, New Delhi is a basic study of scientists and their laboratory life. However, his study is confined to the debate between basic research versus applied research[30] and he traced the history of how the nature of research in NPL has undergone charges from academic science to industrial

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[27] E. Haribabu 1999. Scientific knowledge in India: From Public Resource to intellectual property" *Sociologlical Bulletin* 48 (1 & 2): pp.217-231.
[28] R. Ramasubban, 1977. "Towards a Relevant sociology of science for India". In Blume ed. Perspectives in the Sociology of Science. New Yrok: John Wiley and Sons. p. 188.
[29] JPS Uberoi. 1988. *Science and Culture*. New Delhi: Oxford University Press. p.19.
[30] Shiv Viswanathan. 2007. "The Rise of Industrial Research". In : S. Irfan Habib and Dhruv Raina eds.*Social History of Science in Colonial India*. New Delhi; Oxford University Press. p.300.

science. He studied political, economic factors and individual charismatic leadership. He discussed about the three phases of the introduction of the Western Science in India. The first of these called the era of the Great Surveys. It was a period that involved the development of a host of field organizations under the inspired impetus of the Asiatic Society of Bengal. The establishment of Universities in the presidencies constitutes the hallmarks of the second phase. The relation of science to the economy was not the primary concern in either of these two phases. It is only in the third phase that systematic institutional links were sought between science and the Indian economy. This culminated in the establishment of agricultural research and in the eventual rise of the industrial research laboratory.[31]

V.V. Krishna's work on scientists in laboratories is one of the pioneering study in the field delving into the dynamics of cultural and social context of science from a cross-cultural perspective. He studied two laboratories – CSIR, India and CSIRO, Australia. Both these laboratories have similar historical origin and organisational structures besides being involved in similar research area. It was a bold attempt in linking the goal orientation of scientists to their political and social context.[32]

In fact V.V. Krishna pioneered in various debates of science studies in India like Globalisation of Science, New Mode of knowledge production, Triple Helix, Changing nature of University and Innovation Systems in Asia-Pacific etc.

From the above discussion we got a brief idea of the science studies in India. In fact there are many scholars who have studied science from historical, economic and psychological perspectives. However the present study is limited to the sociology of science. One thing is clear from the various literatures that in India the dominant paradigm of science studies is functional analysis. We hardly find studies on the recent debates in science studies like Mode 2 Knowledge Production, Post-Industrial science, Triple Helix etc. Only few scholars are dealing with these fields like,

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[31] Shiv Visvanathan. 1985. *Organisation for Science: The Making of an Industrial Research Laboratory*. New Delhi: Oxford University Press. p.8.

[32] V.V. Krishna. 1987. Scientists in Laboratories: A Comparative Study of the Organisation of Science and Goal Orientations of Scientists in CSIRO (Australia) and CSIR (India) Institutions. Ph.D. Thesis, University of Wollongong, Australia.

Krishna, Haribabu etc. There is an ample scope for the study of the status of science studies in India.

3.3 Science and Society Relations: Then and Now

Science systems are said to be in transformation. Last two decades various studies have pointed to a variety of changes, such as an increasing orientation of science systems towards strategic goals, science as a market good and entrepreneurial science etc. Various studies have pointed to the change of science and society relationship over the time. The social institution of science has changed from a Metonian paradigm to Post-Metonian paradigm. There is a basic change in the orientation of scientific communities from that based on *advancing knowledge* to that involved with *creation of wealth*. With the emergence of the culture of intellectual property rights and creation of wealth from knowledge, the norm of secrecy is of longer a taboo and this will withhold new knowledge from the public for a certain period of time depending on the contextual situation of establishing priorities in the commercialisation of knowledge.[33] It is already proved that the old system of science and the social institution of science had given way to the new system of science. It is pertinent to analyse here the old and new system of the social institution of science.

3.4 The Dominance of Academic Science: Mertonian Ethos

The writings of Robert K Merton (1910-2003) have had a broad and lasting effect on how historians, sociologists and policy-makers understand the relation between scientific practice and institutional structures. As a sociologist, Merton tended to start with a few fundamental observations into practice which he then connected strongly to social theory. For example, in examining how scientists were rewarded for their research, he saw that reward came primarily in the form of recognition rather than money, an insight that helps account for the importance

[33] V.V. Krishna. 2001. Changing Policy Cultures, Phases and Trends in Science and Technology in India. *Science and Public Policy* 28(3): p.189.

scientists place upon citation as a reward system. Merton's writings on science have had more influence than *The Normative Structure of Science*. This short essay attempts to define the "ethos" of science by reference to four norms or "institutional imperatives", which he called *universalism, communism, disinterestedness,* and *organized skepticism*[34]. Like social norms generally, the normative structure of science is not explicitly learned, and almost never explicitly taught; rather, these norms are internalized by scientists themselves as part of their scientific training. They constitute the social mores of the scientific culture, and are reinforced by cultural practices and organisational structure. [35] Merton's early invocation of the scientific ethos was aimed at understanding the autonomy of science with respect to other social institutions, especially political institutions.[36] Discussing Merton's contribution to the field of sociology of science is not under the scope of the present study. Here the intention is to discuss the Mertonian ethos of science and the social institution of science.

3.4.1 Universalism

Universalism means that the claims of science are not constrained by social and national markers. Because there is no such thing as American, French, or German science. The acceptance or rejection of claims entering the lists of science is not to depend on the personal or social attributes of their protagonist, race, nationalist, religion, class, and personal qualities are such irrelevant.[37] Universalism for Merton does not mean that the claims of science are universally applicable or universally true; his point is that limits on scientific claims are determined by the rules of science rather than by the prejudices of society. The norm of universalism has implications beyond the negotiation of claims it means, for example that "careers must be open to

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[34] Robert K. Merton. 1973. *The Sociology of Science: Theoretical and Empirical Investigations.* Chicago: Chicago University Press. p. 270.
[35] Stephen Cole. 2004. Merton's Contribution to the Sociology of Science. *Social Studies of Science* 34 (6): 829-844.
[36] Alan Richardson. 2004. R.K. Merton and the Philosophy of Science. *Social Studies of Science* 34 (6): P. 856.
[37] R.K. Merton. 1973. op.cit., p. 270.

talents" and that though scientists may be bigots or snobs in daily life, social prejudice must not be allowed to affect the behavior of scientists as scientists.[38]

3.4.2 Communism

Communism, which Merton sometimes put in quotes, should not be confused with the political system of the same name. The communistic norm refers to the sharing of scientific information among scientists and for the good of the scientific enterprise. In Merton's eloquent phrasing, "property rights in science are whittled down to a bare minimum by the rationale of the scientific ethic". [39] The products of science are 'public property', and so the practice of scientists must affirm the public character of knowledge. "Secrecy", Merton wrote, "is the antithesis of this norm",[40] scientists may not hoard the information they develop of the conclusions they draw, but they must freely share their results, methods, and materials.

3.4.3 Disinterestedness

Disinterestedness, like communism, is subject to confusion. By referring to science as disinterested, Merton does not mean that scientists possess no internal motivation. Scientists are surely guided in their work by passions and commitments; however, in submitting their work to peer review and testing by the scientific community, Merton pointed out, scientists subordinate their own interests to the wider protocols of the institution. In scientific communication, the norm of disinterestedness is upheld by such practices as the correction and the retraction. Although sometimes a scientist refuses to accept the judgement of the larger scientific community, the consequence of such refusal is severe. The norm of disinterestedness, Merton writes with what we would now see as misplaced optimism, helps explain "the virtual

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[38] Ibid p. 272.
[39] Ibid.
[40] Ibid p. 273.

absence of fraud in the annals of science".[41] The public admires science precisely because of the separation of science from social interest. The administration is dangerous, however because it makes the public more likely to be swayed by pseudo scientists – or what Merton called "new mysticisms" – who use "the borrowed authority of science" to influence political and other authorities.[42]

3.4.4 Organized Skepticism

According to Merton, it is a methodological as well as an institutional norm – think of the routine practices of hypotheses testing and experimental control. But it has broader implications as well. Because the scientist "does not preserve the cleavage between the sacred and the profane, between that which requires uncritical respect and that which can be objectively analysed",[43] science sometimes comes into conflict with sources of religious, economic, or political authority.

The list of norms was not final. In later writings Merton talked about the norms of *originality*, which allows all the norms to functions within a reward system that sets great value upon priority of discovery (1973, pp. 297-302), and humility, which may be viewed as an outcome of disinterestedness (1973, pp. 303-305). Like all social norms, the norms of science "are expressed in the form of prescriptions, proscriptions, preferences, and permissions" (1973, p.269). The norms as such are rarely stated directly, rather, scientists learn to behave in certain ways – by sharing data freely, for example, or by accepting the reputation of a cherished idea as part of the process – that help these norms emerge as tacit limits of acceptable behavior within science.

It is clear that these norms – widely discussed by Robert Merton and continually re-appraised from the late 1960s to the late 1970s, by his school (e.g. Cole and Cole, 1967, 1968, 1973, 1975, 1978) and by the exchange theorists (Hagstorm, 1965, 1974; Storer, 1966) is an ideal type of ethos (the system of values,

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[41] R.K. Merton. 1996. *On Social Structure and Science*. Chicago: The University of Chicago Press. p. 274.
[42] R. K. Merton. 1973. op.cit., P. 277.
[43] Ibid. pp. 277-278.

norms and behavior patterns) consistent with an ethics (the system of social expectations, shared and approved) intrinsically in line with the stereotype of 'pure science'.[44]

The Mertonian ethos of Science was a hegemonic model up to Second World War. After Second World War what happened was that the sudden emergence of private funded research and research organization, industrial science etc. Mertonian ethoses have failed to deal with industrial science. There are various criticisms faced by Mertonian ethos, one important is that Mertonian ethos are the ethos of pure academic science and not of industrial science. With the emergence of intellectual property, the Mertonian ethos of *universalism, communism, disinterestedness* and *organized skepticism* lost its place. The details of this aspect will be discussed later. It is clear from the above discussion on Mertonian ethos is that the social institutions of science (peer evaluation, open knowledge, public good of science, disciplinary based development) etc. were the pillars of the set system of science.

It is clear that after the Second World War the importance of *mission-oriented science* has increased. The result is the side-lining of basic sciences. We have example like Manhattan project. It was not *curiosity-oriented* project rather *mission-oriented.* It is at this time the famous Bush report came out with strong support for basic science.

3.5 Mertonian Ethos in Post- World War era: The Legacy of the Bush Report

The most important postwar development in government science funding involved a significant shift in Policy. On July 25,1945, less than a month before the end of the war, OSRD Director Vannevar Bush submitted his report *Science: The Endless Frontier* to President Truman (Franklin Roosevelt, who commissioned the report the previous November, had died in April). Some federal grants for scientific research already existed: in particular, the National Institutes of Health (NIH) had a limited programme, and the Department of Agriculture also offered grants for

[44] Leonardo Cannavo.1997.op.cit. p. 481.

research under its general mandate. V. Bush, however, advocated a greatly expanded federal grants programme for basic science research under a single administrative unit – a National Research Foundation – that would provide great leeway to researchers in determining the shape of their research. Bush's proposed foundations rest on five principles:

1) Long-range support for research

2) An administrative agency composed solely of people selected for their "interest" and capacity".

3) The agency should promote research through contracts or grants to organisations outside the Federal Government. It should not operate any laboratories of its own.

4) Support of basic research in the public and private colleges, universities, and research institutes must leave the internal control of policy, personnel, and the method and scope of the research to the institutions themselves. This is of the utmost importance

5) Foundation (grantee) accountability to the President and the Congress.[45]

Bush's report never mentions Merton, but his report, designed to provide scientists with autonomy and freedom of inquiry, supports a conception of basic science that is Mertonian in all of its essentials or in Michael Polanyi's Republic of Science

In advancing a lofty vision of scientific progress that was broadly consonant with the Mertonian norms, Bush's proposal was rather bold. For example, Bush's report embraced the communistic ideal by advocating the post war listing of security restrictions on wartime knowledge:

"It is my view that most of the remainder of the classified scientific materials should be released as soon as there is ground for belief that the enemy will not be able to turn it

[45] Vennevar Bush. 1945. The Endless Frontier. *Transactions of the Kansas Academy of Science* 48(3). p. 255.

against us in this war. Most of the information needed by industry and in education can be released without disclosing its embodiments in actual military material and devices. Basically there is no reason to believe that scientists of other countries will not in time rediscover everything we now know which is held in secrecy. A broad dissemination of scientific information upon with further is held in secrecy. A broad dissemination of scientific information upon which further is held in secrecy. A broad dissemination of scientific information upon which further advances can readily be made furnishes a sounder foundation for our national security than a policy of restriction which would impede our own progress although imposed in the hope that possible enemies would not catch up with us". [46]

Recall that in Europe, where the ink was barely dry on the German surrender, the former theatre of war was the site of a scramble among the Allied powers for Axis war secrets and rocket technology. Bush's advocacy of a "broad dissemination of scientific information" in such a context, and where new threats were already being perceived, could be seen as fairly visionary.[47] So was his advocacy of a research programme that was run by science professionals rather than political appointees, that distributed monies without narrowly focused national-interest ends, and that saw administration of the foundation as a buffer between scientist and elected officials. John Ziman points out that the patronage structure of postwar academic science would create many such buffers: "all patronage, public or private, is channeled through communal filters, primarily the filters of peer review.[48] Seeing the grant as a political buffer is one way of understanding its difference from the research contract: whereas contract funding requires that the contractor pursue ends – specified by the contracting agency, grants are given for goals identified by the applicant. Of course, the applicant must appeal to the values and concerns of the contracting agency, and the success of a grant application may depend on factors beyond the applicant's control. Nevertheless, grants allow researchers a striking amount of freedom, and it was this freedom – a necessary condition for pursuit of science according to the Mertonian norms – that Bush was keenly interested in maintaining. Bush's report really gives importance to Basic Science research. The scientist doing basic research

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[46] Vannevar Bush. 1945. Science: *The Endless Frontier.* Washington, D.C: Public affairs Press.
[47] J. Merton England. 1976. "Dr. Bush writes a Report". *Science* 191 (4222): p.45.
[48] John Ziman. 2000. *Real Science: What it is, and what it Means.* Cambridge: Cambridge University Press. p. 52.

may not be at all interested in the practical applications of his work, yet the further progress of industrial development would eventually stagnate if basic scientific research were long neglected. Basic research leads to new knowledge. It provides scientific capital.[49]

Though Bush's plan was not wholly adopted, many scholars acknowledge that the essential outline of his idea for distribution of U.S. federal monies to science has become the standard. The new model took hold quickly. The NIH expanded its grants programme starting in 1947, and the National Science Foundation (NSF), the federal agency that came closest to meeting Bush's vision, was created in 1950. Grants for defense related basic science came from the ONR and other defense-related agencies, and still other agencies supported other areas of basic science research. In addition to individual research grants, the NSF and other federal agencies supported basic scientific research more generally, especially within universities. As John. T. Wilson notes," it was support of basic research almost exclusively within university and college settings, which established and cemented the NSF's relationships with the higher education community".[50] More than simply an institutional relationship, this support mechanism helped define academic science in basic research terms and, in so far as science was identified with basic research, like wise defined science itself under the Mertonian norms.

The public image of science during the post-war period was that of academic science. By contrast, research performed within-industrial settings during this same period was hardly seen as science at all but rather as "technology" or applied science. The image contrast in every particular: the institution of academic science is the university, and the institution of industrial science is the corporate Research and Development [R & D] laboratory, academic science is supported by grants, and industrial science is underwritten by real and anticipated profits, academic science is driven by both curiosity and opportunity, and industrial science is driven by a business agenda; academic science is disseminated widely through peer-reviewed publications, and industrial science is closely held and restricted; academic science

[49] V. Bush 1945. The Endless Frontier. *Transactions of the Kansas Academy of Science*. 48(3): p. 241.
[50] John T. Wilson. 1983. *Academic Science, Higher Education, and the Federal Government. 1950-1983*. Chicago: University of Chicago Press. p.9.

generally focuses on basic questions, and industrial science generally focuses on application . One has to analyse the relevance of these dichotomy between academic science and industrial science in the present globalized world. Here it is an attempt to discuss various recent debates on the changing nature of science.

3.6 Towards a Post-Mertonian Science Culture

A great deal of ink has been spilled discussing the current evolution in the social contract between science and society, as the rationales for society supporting scientific research have been significantly challenged by recent developments in the research environment. Examples of this include the growing number of connections between the university and industry, the greater prominence of societies in the promotion of further research, and an increasing public awareness that even basic scientific research has the potential for harm.[51] New models of social contracts have therefore been suggested, models that try and address the changes occurring in the composition of the research climate while providing a rationale for continued government (or society) funding of scientific research. Michael Gibbons promotes the understanding that has gained prominence in the literature, arguing that 'contextualized knowledge' is the result of the increasing complexity and diversity of modern societies, and these societies ability to *speak back* to science. This switch to contextualized or *socially robust knowledge* has entailed a move towards objective – drive research programmes, scientists needing to enter the public sphere to produce acceptable science, and knowledge productions to be transparent and participatory to be valid.

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[51] Aldo Geuna, A.J. Salter and W. Edward Steinmueller. 2003. *Science and Innovation: Re-thinking the Rationale for Funding and Governance*. Northampton, MA: Edward Elgar Publishing. p.24.

3.6.1 Post-Normal Science

This concept originate from policy-relevant science fields and starts from an acknowledgement of the limitations of rational decision-making.[52] Given the complexity of current issues in environmental policy, it argues for a reassessment of the appropriate role of scientific research. In environmental debates, typically facts are uncertain, values in dispute, stakes high, and decisions urgent. According to this concept 'normal science' in the Kuhnian sense is not an adequate mode of knowledge production in this situation, as it assumes that problems can be divided into small-scale problems that can be handled without questioning the framework of paradigm.[53] There is a need for a scientific practice which can cope with uncertainty, with value plurality and with the decision stakes of the various stakeholders of the problems at hand. In addition it must have the capacity to support policy makers taking their time constraints into account. For this purpose the term 'post-normal science' has been invented. The most striking characteristic of post-normal science is public participation. The solutions that proponents of this model offer generally boil down to engaging stakeholders in decision-making processes or in the quality assessment of scientific knowledge-production. According to the post-normal science view, quality assurances of scientific input to policy processes should be performed by an 'extended peer community' (Funtowicz and Craye, 2005). To this end, several frameworks have been developed that enable dealing with different types of uncertainty, both on the level of model parameters and assumptions and on the level of societal perspectives and value diversity.[54] It is important features are the increased interaction across disciplinary and organizational boundaries – additional quality criteria and a greater reflexivity. It fits the ideal of contextualized research, yielding' socially robust knowledge'. Post-normal science does not have a descriptive content in the sense that it reports the emergence of a new mode of research. Rather, in a prescriptive sense, it

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[52] Laurens K. Hessels and Harro Van Lente. 2008 .Re-thinking New Knowledge Production: A literature review and a research agenda. *Research Policy* 37: p.743.

[53] Funtowicz, S., Ravetz, J. 1993. Science for the Post-Normal Age. *Futures* 25. p.740.

[54] Functowicz and Craye. 2005. "A Reflexive approach to dealing with uncertainties in environmental health risk science and policy ". *International Journal of Risk Assessment and Management* 5 (2): p.217.

expresses a need for new modes of knowledge production and aims to contribute to its fulfillment by developing the required tools.

3.6.2 Academic Capitalism

The book *Academic Capitalism* (Slaughter and Leslie, 1997) reports the observation of increasing market and market-like activities of universities in a set of empirical case studies. With *academic capitalism* they refer to two types of activities. First they point to the increasing market – like competitions for external funding; grants and contracts, endowment funds, university-industry partnerships, institutional investment in spin-off companies, or student tuition and fees. Second they discern increasing market activities for-profit activity, patenting or subsequent royalty and licensing agreements, spin-off companies and university-industry partnerships having a profit component.[55]

The advocates of Academic Capitalism explain this development by two factors. First increasing globalization enhances the pressure on industry to innovate and causes corporations to turn to universities for assistance. In the same time, the flow of public monies to universities is receding. Together these factors make universities more willing to engage in 'capitalised' activities. Notably, both identified causes are external, in the sense that they originate outside the science system.

In all the four countries (USA, UK, Australia, Canada) the authors of Academic capitalism have studied, governments promoted academic capitalism as a means of stimulating economic-growth. Except for Canada, they all succeeded in developing promoting policies. However, there are no clear indications for the success of market activities, as only some universities in the US manage to make money. Opposite of the potential benefits the authors identify substantial risks for researchers, universities and their managers. Market (like) activities can lead to 'business failure" to product responsibility, failure to meet societal expectations (with regard to

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[55] Sheila Slaughter and Leslie. 1997. *Academic Capitalism: Politics Policies and Entrepreneurial University*. Baltimore: John Hopkins University Press. p.16.

economic growth and employment) and neglect of students[56]. For this reasons, Slaughter and Leslie recommend governments to create incentives for universities to spend their money in the desired ways in order to avoid a decline in academic education. The curious empirical result is the observation that researchers are ambivalent with regard to 'altruism'. They hope that their research will benefit humankind, but this does not seem to be their first priority.[57] From their interviews slaughter and Leslie have got the impressions of researchers being pushed in the direction-of academic capitalism, but they do everything they cannot to become Mode 2 researchers. They do not show the intention of leaving university as they prefer to keep the advantages of being state-supported entrepreneurs.[58]

3.6.3 *Post-Academic Science*

In Ziman's notion of post-academic science, he incorporates elements from several other diagnoses. Mode 2, Academic capitalism and Post-normal science. Ziman intends to describe and explain a set of developments in scientific knowledge production. To summarise, post-academic science refers to radical, irrevertible, worldwide information in the way science is organized, managed and performed.[59] Post-academic science (or post-industrial science) can be characterized by the following five strongly connected elements.

First, science has become a collective activity: researchers share instruments and co-write articles. Moreover, both the practical and fundamental problems that scientists are concerned with are transdisciplinary in nature, calling for collective effort. Second, the exponential growth of scientific activities has reached a financial ceiling. The resources available for research seem not to increase much more, creating a need for accountability and efficiency. Thirdly, but strongly related, there is a greater stress on the utility of knowledge being produced. The success of applying

[56] Sheila Slaughter. 2005. From endless frontier to basic science for use: Social contract between science and society. *Science Technology and Human Values* 30 (3): p.538.
[57] Sheila Slaughter and Leslie. 1997. *Academic Capitalism: Politics Policies and Entrepreneurial University*. Baltimore: John Hopkins University Press. p.222.
[58] Ibid. p.206.
[59] John Ziman. 2000. op.cit,. p. 67.

scientific knowledge into products or practical solutions in some fields has made industry, government and the public impatient with its diffusion rate in general. There is an increased pressure on scientists to deliver more obvious 'value for money'. Next, the emergence of science and technology policy has strengthened the competition for resources. In the resulting situations, competitions for real money becomes more important than competition for scientific-credibility. Research groups can be conceived as small business enterprises, their staff as 'technical consultants'. Finally, science has become industrialized: the links between academia and industry become closer and funding increasingly comes from contract research. Although his approach is primarily descriptive, Ziman is not neutral towards the development post-academic science. In a recent paper Ziman draws attention to the 'non-instrumental roles of science', which are threatened in the post-academic era. If science is valued primarily as a mode of wealth creation, certain functions of knowledge production are overlooked. These include the creation of critical scenarios and world pictures, the stimulation of rational attitudes, and the production of enlightened practitioners and independent experts. Ziman is convinced that post-academic science here to stay; we cannot go back to the old academic model. However, he argues for a fuller consideration of the non-instrumental roles in the debate about the future of science.[60]

The concept of post-academic science is quite similar to that of Mode 2 Knowledge Production. There are no real contradictions between the content of both notions only some difference in emphasis. Indeed, Ziman refers to Mode 2 in a way that suggests he conceives it as a synonym of 'post-academic' science' or at least for the manifestation of that which he calls 'post-industrial science'.[61] Whereas Mode 2 refers to a particular way of conducting and organizing research that constitutes a limited but increasing part of the science system, post-academic science is a name for the whole science system in its new state. While Mode 2 explicitly states that Mode 2 emerges next to Mode 1 research and suggests a future in which both develop in *co-evolution*. Ziman speaks of post-academic science as a practice that replaces

[60] John Ziman. 2003 Non-instrumental roles of Science. *Science and Engineering Ethics* 9(1):p.19
[61] John Ziman. 2000. *op.cit.,*. p.80.

traditional academic research. 'Our exemplar is changing before our eyes into a new form-post-academic science'.[62]

3.6.4 Triple-Helix

The Triple helix model is based on the assumption that industry, university and government are increasingly interdependent.[63] This implies that different institutional spheres have to be studied in co-evolution. The model can be seen as a heuristic forcing researcher to systematically take into account all three spheres when studying dynamics of knowledge production and innovation. Triple Helix does not have a uniform descriptive message like New Production of Knowledge (NPK), but it rather constitutes a research programme that has yielded a variety of descriptive claims.

The central insight that this approach has yielded is the observation of 'an overlay of reflexive communications' between universities, industries, and governmental agencies. According to Etzkowitz and Leydesdorff (2000), in most countries there is a tendency towards a knowledge infrastructure in which these three instructional spheres (academia, state and industry) overlap. In this configuration the spheres can take each other's forms and hybrid organizations emerge at the interfaces. The linear model of utilization of scientific knowledge is replaced by new organisational mechanisms that integrate market pull and technology push. Basic research is linked to utilisation – through series of intermediate processes – such as government initiated programmes that facilitate university-industry interaction. The rise of this configuration is mainly due to the enhanced role of knowledge in our economy and society, and to the decreasing role of the military.

The role of universities in this configuration is often referred to as its *Third Mission*. Making a contribution to economic growth is becoming a central task next to teaching and research. Within the Triple helix literature, research with this mission is

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[62] Ibid. p. 60.
[63] Henry Etzkowitz and Leydesdorff. 1998. The Endless Transition: A "Triple Helix" of University-Industry-Government Relations. *Minerva* 36:p.204.

referred to as '*entrepreneurial science*'.[64] Here I think one has to mention Etzkowitz's masterpiece work *MIT and the Rise of Entrepreneurial Science* (2002). Here Etzkowitz is discussing how the MIT model has diffused in US universities. He argues that universities are increasingly incorporating social and economic development into their basic missions. Transferring basic research outputs from the lab to the market place has always required entrepreneurial vision and persistence – it is the recent embrace of the entrepreneurial role by faculty scientist or the institution itself that constitutes the current revolution.

Etzkowitz credits MIT with a number of innovations in university governance. Prominent examples include the "one day a week" consulting rule, the establishment of a contracts and grants office to manage industrial research funding and an office to manage intellectual property (the precursor to the present day university technology-transfer), and the financial support of firms established to commercialize university research.[65] Relying heavily on the triple-helix model of university-industry-government interaction to frame the concluding discussion, the book returns to its initial theme, stressing that the adoption of economic development as a core element of its mission has propelled the university from *secondary* to *primary* economic importance.

The new role of universities and its new relations with government and industry are roughly in agreement with the idea of Mode 2 science. Especially the context of application and organisational diversity are apparent Etzkowitz and Leydesdorff also confirm transdisciplinarity with their observation that new disciplines (such as computer science or nanotechnology) arise 'through synthesis of practical and theoretical interests'.[66] Etzkowitz and Leydesdorff prefer to speak of

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[64] Etzkowitz, Schuler Jnr. and Gulbrandsen 2000. The Evolution of the Entrepreneurial University. In : Jacob and Hellstorm eds.*The Future of Knowledge Production in the Academy*. Buckingham: Open University Press. p. 43.
[65] Henry Etzkowitz.2002. MIT and the Rise of Entrepreneurial Science. London: Routledge, p.27.
[66] Etzkowitz and Leydesdorff. 2000. The Dynamics of Innovation: From National Systems and "Mode 2" to a Triple Helix of University-Industry-Government Relations. *Research Policy* 29(2). p. 117.

Mode 2 as an 'emerging' system emphasizing historical dynamics. I their eyes the current knowledge infrastructure is characterised by mixes of Mode 1 and Mode 2.[67]

3.6.5 The New Production of Knowledge: Mode 2

The notion of Mode 2 Knowledge Production is coined in the New Production of Knowledge (Gibbons et al., 1994). The work was originally commissioned by the Swedish Council for Research and Planning, FRN, aiming to get a view on the future of universities.

The main proposition of the study is the emergence of a knowledge production system that is *socially distributed.* While knowledge production used to be located primarily at scientific institutions (universities, government institutes and industrial research labs) and structured by scientific disciplines, its new locations, practices and principles are much more heterogeneous. To clarify this assertion the NTK advocates introduce a distinction between Mode 1 knowledge production, which has always existed, and Mode 2 knowledge production, a new mode that is emerging next to it and is becoming more and more dominant. Five main attributes of Mode 2 summarises how it differs from Mode 1 (old social contract)

First, Mode 2 knowledge is generated in a *context of application.* Of course, Mode 1 knowledge can also result in practical applications, but these are always separated from the actual knowledge production in space and time. [68] This gap requires a so-called knowledge transfer. In Mode 2, such a distinction does not exist. A second characteristic of Mode 2 is *transdisciplinarity,* which refers to the mobilization of a range of theoretical perspectives and practical methodologies to solve problems. Transdisciplinarity goes beyond interdisicplinarity in the sense that the interaction of scientific disciplines is much more dynamic. Once theoretical consensus is attained, it cannot easily be reduced to disciplinary parts. In addition, research results diffuse (to problem contexts and practitioners) during the process of

[67] Ibid. p. 119.
[68] Michael Gibbons et al. 1994. *The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies.* London: Sage, p.2.

knowledge production. Thirdly, Mode 2 Knowledge is produced in a diverse variety of organisations resulting in a very *heterogeneous* practice. The range of potential sites for knowledge generation includes not only the traditional universities, institutes and industrial labs, but also research centres, government agencies, think-tanks, high-tech spin-off companies and consultancies. These sites are linked through networks of communications and research is conducted in mutual interaction. The fourth attribute is *reflexivity*. Compared to Mode 1, Mode 2 knowledge is rather dialogic process, and has the capacity to incorporate multiple views. This relates to researchers becoming more aware of the societal-consequences of their work (social accountability). Sensitivity to the impact of the research is built in from the start. Novel forms of *quality control* constitute the fifth characteristic of the new production of knowledge. Traditional discipline-based peer review systems are supplemented by additional criteria of economic, political, social or cultural nature. Due to the wider set of quality – criteria, it becomes more difficult to determine 'good science ', since this no longer is limited to the judgement of disciplinary peers.

In order to emphasize the width of the transformations, Gibbons et al. describe a number of developments in which they are visible such as the commercialization of knowledge, the massification of higher education and the increasing importance of globalization and collaboration

In 2001, three of the authors of NPK published a second book *Re-thinking Science: Knowledge and the Public in an Age of Uncertainty*. It can be read as a reaction of the criticisms that NPK has received. *Re-thinking* Science extends the argument of Mode 2 beyond the boundaries of the science system. Expanding its meaning, the term Mode 2, here refers to a society consisting of *transgressive* institutions. In a post-modern fashion, they argue that currently a de-differentiation of the various societal spheres (state, market, culture) is taking place. These are increasingly fuzzy and blurring categories that overlap and interact. According to Nowotny et al. (2001) this development constitutes the background against which the shift towards Mode 2 knowledge production takes place.

Thirdly, these scholars make attempts to specify the nature of new scientific practices and discuss additional observations of contemporary scientific practice. They describe changes they perceive in various institutions involved in knowledge production: industrial and governmental research institutes, research councils and universities. In particular, they introduce the concept of *contextualised science* which basically means that society now *speaks back to science*.[69] This refers to the demand for innovation to new regulatory regimes, and to the multiplication of user-producer interfaces. Depending on the degree of importance, one can speak of weak, middle range, or strong contextualisation. This development affects scientific activity not only on the organizational level, but also in its epistemological core[70] . Mode 2 or contextualised research yields *socially robust knowledge*, which has a different epistemological status than Mode 1 science. Perhaps surprisingly, the participation of a wider range of non-scientific actors in the knowledge production process enhances its reliability.

3.7 Science as Public Good vs. Market Good: A Developing Country Perspective

There are some scholars like Hebe Vessuri, V.V. Krishna etc have studied the application of these new trends of Science in the Indian context. V.V Krishna noted that the transformation of research systems that has come into focus in science studies literature in the context of industrially advanced countries is not without relevance in the developing world. But one must view terms such as 'post-academic' and post-industrial science with a great deal of caution in the context of developing countries – which are still striving towards rapid industrialisation and catching up with advanced industrial economies. Developing countries are a complex 'mosaic'; and are confronted with multitude of challenges. In the post-colonial era several developing countries still face the main challenge of rebuilding research capacities –through

[69] Nowotny et al. 2001. *Re-thinking Science: Knowledge and the Public in an Age of Uncertainty*. Cambridge: Polity Press. p.50.
[70] Ibid p. 94.

infrastructure and human capital in science and technology. Several of these countries are still struggling to build national scientific communities and universities.[71]

In the light of the debate generated by the new production of knowledge by Gibbons et al., though it is difficult to deny the transformation of the research systems in the context of developing countries, at the same time it is also difficult to characterize the ongoing transition in terms of Mode 2 production of knowledge. What seems to be a more realistic characterization is the emergence of new networks and partnerships between academic –industry and governmental sectors of research. There is certainly a change in the value orientations of 'academic science'; penetration of industrial and commercial interests in the academic and research institutions which are experiencing severe budget cuts; and the actors representing environment and ecology 'movements', which are increasingly influencing decision-making systems in science and technology.[72]

There is a basic change in the orientation of scientific communities from that based on 'advancing knowledge' to that involved with 'creation of wealth'; this is an important 'ideological shift'. There is also a corresponding shift of emphasis from 'basic research' to 'technological innovation' and in the last decade much of this new inspiration is spreading across the rest of the developing world from the experiences of East Asia.[73]

Behind the perception of East Asian success stories, particularly those of post-war Japan and the 'dragons' in the 1980s and 1990s, the new lesson is science and technology in the developing countries is certainly the creation of wealth from knowledge.[74] This does not mean that countries like India have given up doing basic research or that this domain of research is unimportant. However, when it comes to selecting research problems we can see a shift in the goal direction of research which is increasingly deemed as an investment factor. The notions of value addition, profit,

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[71] V.V. Krishna, Roland Waast and Jacques Gaillard. 2000. The Changing Structure of Science in Developing Countries. *Science, Technology and Society* 5 (2): p. 210.
[72] Ibid.
[73] V.V. Krishna. 2001. Changing Policy Cultures, Phases and Trends in Science and Technology in India. *Science and Public Policy* 28(3): p. 189.
[74] Ibid.

efficiency and so on, have assumed greater significance. Since the ideal of advancing knowledge is slowly but steadily being enveloped by the pragmatic value of creation of wealth, there is pressure to withhold critical elements of knowledge production from open publications (Krishna, 2001).

Haribabu noted that in India a shift in cognitive values from 'knowing for its own sake' to 'knowing with an eye on patent' is discernible. This is due to an emphasis on strategic research, its organization and the interests of the corporate sector-both national and multinational.[75]

It is true that the system of science has changed due to various reasons include globalization and liberalization and it is also obvious that the notion of science as a 'market good' is not only a phenomena of developed countries but of developing countries as well. But the intensity of change or transformation of science in developing countries is different from developed countries depends on its economic, political and social structure. Jean Francois Lyotard, *Post Modern Condition: A Report on Knowledge* (1979), in which he argues that the status of knowledge is altered as societies enter what is known as the *post-industrial age* and cultures enter what is known as the *post modern age*. The nature of knowledge cannot survive unchanged within this context of general transformation.[76] Sociologically speaking, due to globalization there are many changes happened to the social system of science.

3.8 The Present Study

The present study analyses the changing social contract between science and society in the Indian context. It explores the relevance of the *old* social contract (Mertonian ethos) and *new* social contract (Post-mertonianism) in the field of biotechnology in India. As we have discussed earlier, the emerging concepts of *Mode 2*, *Post-Academic Science* etc. has limitations when it comes to developing countries.

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[75] E. Haribabu. 1999. Scientific Knowledge in India: From Public Resource to Intellectual Property. *Sociological Bulletin* 48 (1 & 2): p. 217.

[76] Jean Francois Lyotard. 1979. *The Postmodern Condition: A Report on Knowledge*. Manchester: Manchester University Press pp.4-5.

The purpose of the study is to explore Indian situation with example from biotechnology area. Since all the emerging concepts of science i.e., Mode 2, Post-academic science etc. developed in European setting it is pertinent to analyse the applicability of the concepts in the Indian situation. Krishna et al, (2000) in their article argued that one must view terms such as 'post-academic' or 'Mode 2' science with a great deal of caution in the context of developing countries-which are still striving towards rapid-industrialisation and catching up with advanced industrial economies. It requires empirical data to prove this argument. The present study is an attempt to analyse the changing social contract between science and society empirically and consider biotechnology as a case. We cannot really deny the 'old' social contract (Mertonianism) in developing countries. Various studies have showed that there is equally high importance to publications compared to patenting among Indian scientists. In this context the present study analyse the relevance of 'old' ethos of science in the field of biotechnology in India.

The New Social contract of science (Mode 2, Post-academic science etc.) also not without relevance in the developing world. But the transformation will be different from developed nations. In this context it is very important to prove empirically the transformation which happened to Indian science.

Conclusion

In this chapter an attempt has been made to study the science-society relationship in social studies of science, especially from the perspective of sociology of science. As part of the review of literature different approaches in sociology of science, the status of science studies in India, and the changing structure of science etc. have been evaluated. The chapter has reviewed various literatures on the changing social contract of science and society started with the old contract (Mertonianism) and discussed various recent debates like post-normal science, post-academic science, and triple-helix and mode-2 knowledge production. We have seen that the system of science has entered into a new world of knowledge production .We have also discussed the relevance of these emerging trends in the Indian context. In the next chapter we would explore in detail about the emerging social contract and old social contract of science.

Chapter 4

Old and New Social Contract between Science and Society: An Analysis

Introduction

Many scholars in science studies have stated that in the past half-century society has begun to speak back to science, with equal urgency and conviction.Nowotny et al., argued that science has become so pervasive, seemingly so central to the generation of wealth and well- being, that the production of knowledge has become, even more than in the past, a social activity, both highly distributed and radically reflexive (Nowotny etal., 2001). It is clear from the last chapter that the old contract of science has still relevance in the developing societies. And we have also seen that the emerging social contract of science is also not without relevance to developing societies. But the level of transformation is different from the developed societies. It is pertinent to discuss here the components of both old and new social contract of science.

4.1 From CUDOS to PLACE

John Ziman takes Merton's four original norms and adds his later norm of *Originality* and spells out the reward system of academic science as *CUDOS:*

Communality of procedures and results within the scientific community;

Universalism while evaluating the contributions to scientific knowledge;

Disinterestedness in non-cognitive motivations and aspects of research;

Originality in scientific research;

Skepticism (organized, systematic) while checking the reliability of methods and results.

Ziman argued that the social organisation of academic science can be described in terms of the Mertonian norms or *CUDOS*. This description is, of course, highly idealized, but not completely unrealistic. Industrial science, by contrast, contravenes these norms at almost every point. The reason is that industrial science is not targeted towards the production of knowledge as such. Its goals, being practical, are extremely diverse. We can call it the instrumental attitude to science, which is summed up by the acronym R & D- a hybrid of *scientific research* and *technological development*.[1] This locates science at the *upstream* and of a one-way process by which useful discoveries and inventions eventually flow down into the home, the shop, the hospital and the workplace. The characteristic social practices of industrial science are based on principles that effectively deny the existence of any such ethos.[2]

Industrial science contrasts with academic science, Ziman notes, by being *proprietary* knowledge that is not necessarily made public (rather than communal). It is focused on *local* technical problems rather than on general understanding (contrasts with universalism). The researchers act under managerial *authority* rather than as individuals (contrasts with disinterestedness). Their research is *commissioned* to achieve practical goals, rather than undertaken in the pursuit of knowledge (contrasts with originality). They are employed as *expert* problem-solvers, rather than for their personal creativity (contrasts with skepticism). It is no accident, moreover, that these attributes spell out *PLACE*. That, rather than *CUDOS*, is what Ziman argued one get for doing post-academic science.[3] This shift is summarized in the following table.

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[1] John Ziman. 2000. *Real Science: What it is, and What it Means*. Cambridge: Cambridge University Press. p. 15
[2] Ibid. p. 78
[3] Ibid, p.79

Table 4.1 Academic vs. Post -Academic Science

Academic Science	Post academic Science
Communalist	Proprietary
Universal	Local
Disinterested	Authoritarian
Original	Commissioned
Skeptical	Expert

(Source: Ziman, 2000)

We are said to be entering a post-industrial era, characterised by multinational firms which are decentralized managerially into small, specialised service units, devolving much work to subcontractors, coordinated globally by information technology etc. And as industrial firms change their working methods, they restructure their research activities along similar lines. Their R & D laboratories are devolved into multi disciplinary matrices and global networks of temporary project teams, buying in specialist functions from independent contractors, and so on. In effect the new *Mode 2 Knowledge Production* is practically identical to the way in which up-to-date firms organize their research activities. What might be called post-industrial science differs from the earlier stereo-type of industrial science by substituting market competitions for command management. Researchers work in shifting teams, like small firms producing goods for a competitive market. Commercial enterprise and personal mobility replace managerial responsibility and career stability as organising principles.[4]

The debate started by Ziman was characterized by contrasting opinions. No one was able to raise a doubt about the presence, importance and extent of the collectivization process in science. But serious doubts were cast on the actual, rather

[4] David Kellogg. 2006. Toward a Post-Academic Science Policy: Scientific Communication and the Collapse of Mertonian Norms. *International Journal of Communications Law and Policy* (autumn issue). p. 12.

than ideal typical, existence of CUDOS. So, Broesterhuizen and Rip (1984) proposed new *SHIPS* for science. That is the values of;

- Strategic
- Hybrid
- Innovative
- Public
- Skeptical research

Contrary to Ziman's viewpoint, the collectivization process is not always to be considered as negative, since it does induce positive effects in research systems characterized by *bureaucratization* and *balkanization*.[5] Whenever the research resources are restricted, in absolute or relative terms, which are in the steady state scientific systems, the process of optimizing resources worsens the negative effects of collectivization, though it is apparent that the collectivization process is not a logical or temporal prius of the steady state[6]. In the steady state scientific systems, research internationalization decreases – the resources are allocated to few centres , the political bent of research management leads to a wider patronage system, the inter/intra-institutional competition increases, the research becomes more and more targeted and technological, the functional specialization of research staff increases, the organizational *lay management* prevails over the scientific *professional management* with regard to scientific choices, and the precariousness of scientific jobs increases. The *Mathew effect* – that is, the cumulative advantage of more prestigious or elderly scientists – and the *Podunk effect* that is, the cumulative, disadvantage of younger scientists and those belonging to less prestigious institutions are emphasized to the utmost level.[7]

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[5] E. Broesterhuizen and Arie Rip. 1984. No PLACE for CUDOS?. *EASST Newsletter* 3(3): 5-8.
[6] S.E. Cozzens et al. 1990. *The Research System in Transition*. New York: Kluwer Academic Publishers. p. 4.
[7] J. Gaston. 1978. *The Reward System in British and American Science*. New York: Wiley-Interscience. pp.121-4.

As we have discussed earlier that the Mertonian norms of science has less importance today. This day the status of the norms as descriptive of scientific practice or, as an ideal at best tacitly transmitted and seldom enforced remains unclear. No ambiguity, however, surrounds the values that Merton (and later Bernard Barber) posited as underlying the institution of science. If *communism, disinterestedness, universalism and organized skepticism* were the prerequisites for the production of objective knowledge in Merton's scheme, then a *liberal-democratic* society was the obvious environment in which science flourished.[8] Democracy, of course, is problematic. So too, is Merton's formulation of its ameliorative role vis-à-vis science.

The norm *communism*, for example, speaks directly to the communal character of scientific knowledge. Unlike those interested in the accumulation of property, scientists are said to earn *profits* – in the form of recognition, prestige, and research opportunities – as they share their intellectual property by publishing in scientific journals. Communication allows research findings to be scrutinized by those who will eventually deem or deny it to be reliable knowledge.

For Merton, in 1942, open-communication was an imperative for scientific integrity. However in the present day world, *secrecy* is a negotiable behavior – an article of faith for some, a deplorable condition for others. *Corporate science* has blossomed and it now interacts with many university research programmes, likewise, government patronage, especially in new generation disciplines (biotechnology, biomedicine etc.), has been tied more closely to several mechanisms of accountability.[9] The era of biotechnology, microelectronics, and artificial intelligence appears to have redefined the norms of science and the relevant actors who judge conformity to and deviance from them. There have been tremendous changes in the justifications for imposing new and sometimes competing imperatives on those once expected only to extend certified knowledge.[10]

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[8] Daryl E. Chubin. 1985. Open Science and Closed Science: Tradeoffs in a Democracy. *Science, Technology and Human Values* 10 (2): p. 73

[9] Ibid. p. 74

[10] Nico Stehr. 1978. "The Ethos of Science Revisited" In Jerry Gaston ed. *The Sociology of Science.* San Francisco, CA: Jossey-Bass: pp 172-173.

It is clear that science and its old ethos of science are in transformation. We have discussed the old ethos of science very clearly in the last chapter. We don't need to explain Mertonian ethos again here. Rather we would explain the characteristics of new contract of science and the difference between new and old contract.

4.2 Science's New Social Contract with Society

The old contract of the social institution of science is based upon peer evaluation, open knowledge, public good of science; disciplinary based development etc is said to be in transformation. The emerging social institution is just the opposite of the old social institutions of science as a result of the emerging new social contract of science. The following table explains it clearly;

Table 4.2 Old and New Social Contract of Science

Existing/Old Social Contract	**Emerging/New Social contract**
Advancing knowledge	Creation of wealth
Science as part of culture	Part of commerce
Open Science Knowledge	Secrecy /IPR
Peer evaluation within science system	Knowledge production regulated and evaluated by different stakeholders in the society/governed by market forces/peer group is broadened.
Universities as teaching and advancing knowledge Academic tradition	Entrepreneurial Universities
Linear model of Innovation	Systematic based open innovation/ globalised.
Disciplinary science	Hybrid groups/ interdisciplinary groups/ networks

(Source: V.V. Krishna 2007, 2009)

Under the prevailing contract between science and society, science has been expected to produce *reliable* knowledge, provided merely that it communicates its discoveries to society. A new contract must now ensure that scientific knowledge is *socially robust*, and that its production is seen by society to be both transparent and participative.[11]

Modern Science has until recently flourished partly because of a stable, underlying agreement between its practitioners and the rest of society. In other words, there has been a social contract between science and society, an arrangement built on trust which sets out the expectations of the one held by the other, and which-in principle includes appropriate sanctions if these expectations are not met. The social contract has been made up of general individual elements, reflecting broader contracts between government and society, between industry and society, and between higher education and society. The contract between university science and society, for example, has been based traditionally on the understanding that universities will provide research and teaching in return for public funding and a relatively high degree of institutional autonomy; under this contract, the universities, often supported through research- funding agencies, have been expected to generate fundamental knowledge for society, and to train the highly qualified man power required by an advanced industrial society.[12]

The contract with industrial research and development (R & D) has been based on an understanding that industry would provide for the appliance of science for the work of its laboratories and thus carry the discoveries of basic science into product and process innovations. In turn, government science was meant to use research establishments to fill the gap between university science and industrial R & D. The understanding has been that the state has been directly responsible for carrying out research related to national need; for example, in defence, energy, public health and standards.

For most of the twentieth century universities, government research establishments and industrial laboratories have therefore operated relatively

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[11] Michael Gibbons. 1999. Science's New Social Contract with Society. *Nature* 402 (C81) : p. 11
[12] Ibid.

independently, developing their own research practices and modes of behaviour. Recently, however, this relative institutional impermeability has gradually become more porous. Privatization policies, for example, have moved many government research establishments into the market place with the relaxation of the Cold War, governments have shifted their priorities from security and military objectives to maintaining international competitiveness and enhancing the quality of life. And many long established industries have been denationalized, while in many countries companies previously dependent upon government for R & D support through military technology projects have had to find these resources elsewhere, or in partnership with others, to compete in international markets.[13]

Meanwhile the expansion of higher education has been accompanied by a culture of accountability that has impacted on both teaching and research. In research, many academics have had to accept *objective* driven research programmes, whereas research funding agencies have been increasingly transformed from responsive institutions, responsible for maintaining basic science in the universities, into instruments for attaining national technological, economic and social priorities through the funding of research projects and programmes

These trends can be observed internationally, even if their precise form and timing has varied between countries. Cumulatively, they signal the end of the institutional arrangements through which science flourished during and after the Second World War, and thus mark the expiry of the social contract between science and society that has dominated this period. A new social contract is now needed. This cannot be achieved merely by patching up the existing framework. A fresh approach-virtually a complete *rethinking* of science's relationship with the rest of the society is needed .The new social contract between science and society is based on various features. Blurring of boundary is one of the important characteristic of new contract

[13] Edwin Mansfield. 1996. Modern University: Contributor to industrial innovation and recipient of industrial R & D support?.*Research Policy* 25: p.1048

4.3 Blurring of Boundary

One aspect of this new contract is that it needs to reflect the increasing complexity of modern society. For example, there are no longer clear demarcation lines between university science and industrial science, between basic research, applied research and product development, or even between careers in the academic world and in industry. There is now greater movement across institutional boundaries, a blurring of professional identities and a greater diversity of career patterns (Gibbons et al, 1994)

But the price of this increased complexity is a pervasive uncertainty. One way of looking at this is in terms of an erosion of society's stable categorizations, namely the state, market, culture and science. Alternatively, it can be seen as the cumulative effect of parallel evolutionary processes. There has been a co-evolution in both society and science in terms of the range of organizations with which researchers are prepared to work, the colleagues with whom they collaborate, and topics considered interesting. Whatever viewpoint one takes, science is now produced in more open systems of knowledge production.

One consequence is that the norms and practices of research in university and industrial laboratories have converged.[14] There are still differences between universities and industry, but these do not impact on what is considered sound scientific practice. Indeed, science and society more generally have each invaded the other's domain, and the lines demarcating the one from the other have virtually disappeared.

As a result, not only can science speak to society, as it has done so successfully over the past two decades but society can now *speak back* to science.[15] The current contract between science and society is not only promised on a degree of separation between the two, but also assumed that the most important communication is from *science to society*. Science was seen as the fountainhead of all new knowledge

[14] Yang S. Lee. 1996. Technology Transfer and the Research University: Search for the Boundaries of University Industry Collaboration. *Research Policy* 25: p 844
[15] Helga Nowotny et al. 2001. *Re-thinking Science: Knowledge and the Public in an Age of Uncertainty*. Cambridge: Polity p. 52.

and as part of the contract, was expected to communicate its discoveries to society. Society in turn did what it could do absorb the message and through other institutions primarily industry to transform the results of science into new products and processes.

Science was highly successful working in this mode, and for a long as it delivered the goods, its autonomy was seldom contested. Yet this success has ironically itself been instrumental in changing its relationship with society, drawing science into a larger and a more diverse range of problem areas, many lying outside traditional disciplinary boundaries. It is this increasingly intense involvement of science in society over the past half a century that has created the conditions that underpin the growing complexity and pervasive uncertainty in which we live, and encouraged the social and behavioural experiments described above.

But if it is widely recognized that science is transforming modern society, it is less often appreciated that society, in speaking back is transforming science. This is called *contextualization* and *contextualized knowledge* as the outcome of this reverse communication.[16] Contextualization affects modern science in its organization, division of labour and day-to day practices, and also in its epistemological core.

In relation to the former, for example, research carried out in both industrial and government laboratories, as well as the funding policies of research funding agencies, have opened up to a wide range of socio economic demands admitting more and more cross institutional links, and thus altering the balance between the different sources of funding of academic research. This in *speaking back* to science, society is demanding various innovations, for example the pursuit of national objectives, the contribution to new regulatory regimes and acknowledgement of the multiplication of user-producer interfaces.

In relation to the latter, the epistemological dimension, the increasing importance of *context* is also reflected in a relatively rapid shift within science from the search for *truth* to the more pragmatic aim of providing a provisional understanding of the empirical world that works. John Ziman has described science as a form of *reliable knowledge* that becomes established not in terms of an abstract

[16] Ibid p. 50

notion of objectivity but, concretely, in terms of the replicability of research statements and the formation of a consensus within the relevant peer group Reliable knowledge is therefore defined as such because it works.[17]

But what works has now acquired a further dimension that can best be described as a shift from *reliable knowledge* to what Nowotny et al call *socially robust knowledge*.[18] The latter characterization is intended to embrace the process of contextualization for. The *socially robust* knowledge has three aspects. First, it is valid not only inside but also outside the laboratory. Second, this validity is achieved through involving an extended group of experts, including lay experts and third, because society has participated in its genesis, such knowledge is less likely to be contested than that which is merely reliable.[19]The knowledge production in the new contract of science is not reliable but socially robust knowledge. It is pertinent to discuss about socially robust knowledge in detail here.

4.4 Production of Socially Robust Knowledge

Gibbons noted that there is a significant shift from reliable to socially robust knowledge. They made three observations. The first is that the basic conditions and processes that have underpinned the production of *reliable knowledge* are not necessarily compromised by the shift to *socially robust knowledge*. Indeed, if these conditions and processes have been undermined, it may have been as much by the narrow outlook of much scientific practice as by any attempt to widen the range of stakeholders, or more systematically to take into account the context in which science is produced.[20]

His second observation is that reliable knowledge has always only been reliable within boundaries. Science was recognized as inherently incomplete because it is, primarily a method rather than a final answer. But to achieve a reasonable degree of reliability the problem terrain had also to be circumscribed, and judgements on

[17] John Ziman. 1991. *Reliable Knowledge.* Cambridge: Cambridge University, Press. p.7
[18] Helga Nowotny et al. 2001.op.cit., p. 117.
[19] Michael Gibbons. 1999. op.cit; p. 13.
[20] Ibid.

what is included there restricted to those of a peer group, rather than opened to the scientific community as a whole.[21]

Gibbons further observed that pressure groups and ordinary consumers are demanding that the debate surrounding the health implications of GMOs be broadened to include the perspectives of the non-expert community. Both aspects of reliable knowledge are carried forward into socially robust knowledge. But although knowledge remains incomplete, this is no longer only in the conventional sense that it will eventually be superseded by superior science, rather it means that it may be sharply contested, and no longer remains within the controlled environment of scientific peers. This shift involves renegotiating and reinterpreting boundaries that have been dramatically extended, so that science can no longer be validated as reliable by only conventional discipline bound norms; while remaining robust, science must now be sensitive to a much wider range of social implications.

An example is the current debate surrounding genetically modified organisms (GMOs). Here, specialist peer groups have been challenged not only by pressure groups but also by ordinary consumers, for whom the research process is far from transparent, and who are demanding that it be more so. Here, knowledge of the health implications of GMOs may be *reliable* in the conventional scientific sense; but it is not *socially robust*, and will not become so until the peer group is broadened to take into account the perspectives and concerns of a much wider section of the community.[22]

A failure to persuade the broad public of the value of the US Super-Conducting Super Collider research programme may have contributed to the collapse of funding for the project. There was also a degree of contestation in the United States about the value of the Superconducting Super Collider (SSC), plans for which were dropped in 1992. In this case, however, unlike the case with GMOs, there was no spontaneous backlash from society generally about the value of the knowledge. Rather, it has been argued that the collapse of funding for the project was a result of

[21] Diana M Hucks and J. Sylvan Katz. 1996. Where is Science Going?. *Science Technology and Human Values* 21 (4): p. 392
[22] David Dickson. 2000. Science and its Public. *Social Studies of Science* 28(3): p. 468

the unwillingness (or inability) of a narrow disciplinary group to extend its boundaries sufficiently to persuade other scientists and politicians that the research would of wide benefits. Again we see a failure to achieve sufficient social robustness in the research process, however reliable it may be in its own terms (Gibbons 1999:14)

Gibbons's third observation is that the epistemological core of science has, over time, become crowded with norms and practices that cannot be reduced easily to a single generic methodology, or, more broadly, to privileged cultures of scientific inquiry. There is no one set of practices that describe much less lead to good science. The case for science can still be made in essentially functionalist terms; but many more factors now need to be taken into account before a solution that works can be adopted.

Nowotny et al; argued that one outcome of all these changes is that the sites at which problems are formulated and negotiated have moved from their previous institutional locations in government industry and universities into the *Agora* – the public space in which both *science meets the public*, and the public *speak back* to science. This is a space in which the media is increasingly active, and in which the new communication technologies play prominent role. It is also the domain in which contextualization occurs. Neither state nor market, neither exclusively private nor exclusively public, the *agora* is where today's societal and scientific problems are framed and defined, and their solutions are negotiated. This is no longer the domain of a relatively closed bureaucratic professional legal world of regulation, but of broader cultural political movements embodying antagonistic forms of interaction which have become part of the repertoire of how novel technologies are embedded and research products come to be accepted and used in wider social contexts. As a result of these and other changes, the state has become a transgressive institution, penetrated by but also penetrating market, social movements and individual responses by consumers and citizens.[23]

They further argued that what emerges is a more nuanced, more sociologically sensitive epistemology-which is more resilient than the 'hard core' of autonomous

[23] Helga Nowotny et al. 2001. *op.cit;* pp. 23-24.

self-referential epistemology which scientists have struggled to articulate and to defend. If science is to engage more strongly with the *agora*, its image of impersonal, objective, self-organizing structures purged of allegedly subjective elements will need to be complemented and corrected by putting people, human agents, back into science. Our conception of science has to find room for the wide range of people who engage in material scientific activities and are linked in concrete ways to other social spaces in the *agora* that go far beyond the laboratory. Rather than trying to protect a 'hard core' which turns out to be empty or irrelevant for practical purposes, the any soft layers and clusters need to be strengthened by making their knowledge claims more socially robust. Putting the people back into science is not a superficial task to be approached cynically or opportunistically, a public relations exercise to make them more visible (which is often how the need to improve the public understanding of science is presented). Nor is the challenge simply to create a new image of scientists as more approachable communicative or simply more humane – however important it is that scientists should display these qualities. At issue is much more than better public understanding of science and better education for scientists. Life in agora will be more challenging, requiring a radical re-thinking of science itself.[24]

The field of science is not just a laboratory activity, but an activity which needs legitimacy from various actors in our society includes laymen. The concept of *Agora* is similar to that of Habermas' concept of *Public Sphere*, in which public discussion of matters of general interest was institutionally guaranteed, where people can critically discuss and participate in the debates and the state authority was publicly monitored through informed and critical discourse by the people.[25]

Many features of the *Public Sphere* and *Agora* are same. Both concepts argued for open nature, public legitimacy, transparency etc. In order to be active in *Agora* the public should have a basic understanding of scientific problems or debate. For that science popularization and awareness programmes have to be made properly and above all massification of education is very important in a country like India.

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[24] Ibid. p. 197.

[25] Jurgen Habermas. 1989. *The Structural Transformations of the Public Sphere*. Cambridge: Polity Press. p..2

4.5 The Phenomenology of the New Mode of Knowledge Production

The new mode of knowledge production is characterized by the following attributes.

4.5.1 Transdisciplinarity

Transdisciplinarity is the privileged form of knowledge production in Mode 2. It corresponds to a movement beyond disciplinary structures in the constitution of the intellectual agenda, in the manner in which resources are deployed, and in the ways in which research is organized, results communicated and the outcome evaluated. In that regard Mode 2 derives its impetus from a context which is socially different from the one which prevailed before the rise of specialized, disciplinary science in the nineteenth century when the scene might have been described as non-disciplinary. Mode 2 is evolving from a strongly disciplinarised context and knowledge produced under these conditions is characterized by aiming a use or action that is towards *application* in its broader sense.[26]

In the production of transdisciplinary knowledge, the intellectual agenda is not set within a particular discipline, nor is it fixed by merely juxtaposing professional interests of particular specialists in some loose fashion leaving to others the task of integration at a later stage. Integration is not provided by disciplinary structures-in that regard the knowledge process is not interdisciplinary, it cuts across disciplines-but is envisaged and provided from the outset in the context of usage, or application in the broad sense specified earlier. Working in an application context creates pressures to draw upon a diverse array of knowledge resources and to configure them according to the problem in hand. The context of application is already intellectually structured, even if only in very general terms and provides heuristic guidelines. The search for fundamental computer architecture is already a search for architecture and not

[26] Gibbons et al. 1994. *The New Production of knowledge. The Dynamics of Science and Research in Contemporary Societies.* London: Sage p. 27

something else. Some participants may have a general idea of hour the search should proceed and what knowledge and skills are required. There can, of course, be more than one view as to the best way to proceed and such divergences may fuel a process of competition.[27]

Interdisciplinary is characterized by the explicit formulation of a uniform, discipline transcending terminology of a common methodology. The form scientific cooperation takes consists in working on different themes, but within a common framework that is shared by the disciplines involved. Transdisciplinarity arises only if research is based upon a common theoretical understanding and must be accompanied by a mutual interpretation of disciplinary epistemologies.[28] Cooperation in this case leads to a clustering of disciplinary rooted problem solving and creates a transdisciplinary homogenised theory or model pool.

In transdisciplinary contexts, disciplinary boundaries, distinctions between *pure* and *applied* research and institutional differences between, say, *universities* and *industry* seem to be less and less relevant. Instead, attention is focused primarily on the problem area, or the hot topic, preference given to collaborative rather than individual performance and excellence judged by the ability of individuals to make a sustained contribution in open, flexible types of organization in which they may only work temporarily. None the less, a new mode of knowledge production cannot simply force its way onto the institutional stage. A certain number of basic conditions must be fulfilled if it is to become institutionalised. The search for understanding must be guided by agreed models and sets of experimental techniques, its articulation must follow the canons of empirical method, and its conclusions must be communicable to a wider community and be repeatable by others. To qualify as such, knowledge must form an organized stock and its methods of working must be transparent.

The knowledge production within traditional disciplinary structures remains valid, interesting andimportant; Mode 2 is growing out of these structures and now

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[27] Gibbons et al. 2005. "Evolution of Knowledge Production". In Mark J Smith (Ed). *Philosophy and Methodology of the Social Sciences.* London: Sage. Pp-179-180.
[28] Sabine Maasen et al. 2006. Transdisciplinarity: New mode of governing science? *Science Technology and Human Values* 33 (6) p. 402

exists alongside them. Although they are at an early stage of development, some of the practices associated with the new mode are already creating pressures for radical change in the traditional institutions of science, particularly the universities and national research councils.[29]

4.5.2 Quality Control

In Mode 1, control is exercised by different types of knowledge producing institutions each of which has its own boundaries, structures of apprenticeship and rules of behaviour. Such institutions include for example, universities, national academies and the professional societies. Each has different ways of controlling membership, some provide training, establishing procedures whereby knowledge is produced and validated. Because knowledge production in Mode 2 occurs within *transient* contexts of application it is unlikely that the communities of practitioners who exercise quality control will be backed up by relatively stable institutions such as one finds in Mode 1. From the point of view of Mode 1 such a process of quality control necessarily appears as dislocated. It takes on transient and temporary forms, exhibits fluid condoms, and provisional norms, and occupies temporary institutional spaces which can accommodate knowledge producers with different institutional affiliations, either simultaneously or sequentially.

In Mode 2, success is defined differently from that in Mode 1. Success in Mode 1 might perhaps be summarily described as excellence defined by *disciplinary peers*. In Mode 2, success would have to include the additional criteria such as efficiency or usefulness, defined in terms of the contribution the work has made to the overall solution of transdisciplinary problems. In both cases success reflects a perception of quality as imaged by a particular community of practitioners. But all quality control is linked, legitimated and ultimately, receives its credibility and scientific authority from an idea, image, or concept of what constitutes good science including best practice. For example, at different times in history what constitutes

[29] Gibbons et al. 1994. *The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies*. London: Sage. p. 32.

good science has been guided by the ideal of truth and the search for unitary principles.

In Mode 2, the issue of assessing the quality of good research is two fold. One has to do with the fact that the community of practitioners is *transient* and *transdisciplinary*. The criteria of quality are not solely those that obtain in Mode 1 but include the additional criteria that arise out of context of application.[30]

The conventional wisdom is that discovery must precede application. By contrast, Mode 2 quality control is additionally guided by a good deal of practical, societal, policy-related concerns, so that whatever knowledge is actually produced, the environment already structured by application or use will have to be taken into account. When knowledge is actually produced in the context of application, it is not applied science, because discovery and applications cannot be separated, the relevant science being produced in the very course of providing solutions to problems defined in the context of application. Those who exert quality control in mode 2 have learned to use multiple criteria not only in general, but in relation to the specific results produced by the particular configuration of researchers involved.[31]

4.5.3 Knowledge Production in the Context of Application

In Mode 2, knowledge results from a broader range of considerations. Such knowledge is intended to be useful to someone whether in industry or government, or society More generally and this imperative is present from the beginning. Knowledge is always produced under an aspect of continuous negotiation and it will not be produced unless and until the interests of the various actors are included. Such is the context of application.[32]

Knowledge production in Mode 2 is the outcome of a process in which supply and demand factors can be said to operate, but the sources of supply are increasingly

[30] Gibbons et al. 2005. "Evolution of Knowledge Production". In Mark J. Smith ed *Philosophy and Methodology of the Social Sciences*. London: Sage p. 187
[31] Gibbons et al. 1994. *op.cit*; p. 35.
[32] Ibid. p. 4

diverse, as are the demands for differentiated forms of specialist knowledge. Knowledge production becomes diffused throughout society.

Research carried out in the context of application might be said to characterize a number of disciplines in the applied sciences and engineering for example, computer science, chemical engineering, aeronautical engineering etc. Historically these sciences became established in Universities but, they cannot be called applied sciences, because it was precisely the lack of the relevant science that called them into being. These applied disciplines share with Mode 2 some aspects of the attribute of knowledge produced in the context of application. But, in Mode 2 the context is more complex. It is shaped by a more diverse set of intellectual and social demands that was the case in many applied sciences while it may give rise to genuine basic research.[33]

4.5.4 Heterogeneity and Organisational Diversity

Mode 2 knowledge production is heterogeneous in terms of the skills and experience people bring to it. The composition of a problem solving team changes over time as requirements evolve. This is not planned or coordinated by any central body. As with Mode 1, challenging problems emerge, if not randomly, then in a way which makes their anticipation very difficult. Accordingly, it is marked by:

- An increase in the number of potential sites where knowledge can be created; no longer only universities and colleges, but non-university institutes, research centres, government agencies, industrial laboratories, think-tanks, consultancies, in their interaction.
- The linking together of sites in a variety of ways electronically, organizationally, socially, informally, through functioning networks of communication.

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[33] Ibid.

- The simultaneous differentiation, at these sites, of fields and areas of study into finer and finer specialties. The recombination and reconfiguration of these subfields form the bases for new forms of useful knowledge. Over time, knowledge production moves increasingly away from traditional disciplinary activity into new societal contexts.

In Mode 2, flexibility and response time are the crucial factors and because of this the types of organisations used to tackle these problems may vary greatly. Characteristically, in Mode 2 research groups are less firmly institutionalized; people come together in temporary work teams and networks which dissolve when a problem is solved or redefined. Members may then reassemble in different groups involving different people, often in different loci, around different problems.[34]Though problems may be transient and group short-lived, the organization and communication pattern persists as a matrix from which further groups and networks, dedicated to different problems, will be formed.

Mode 2 is thus created in a great variety of organisations and institutions, including multinational firms, network firms, small hi-tech firms based on a particular technology, government institutions, research universities, laboratories and institutes as well as national and international research programmes. In such environments the patterns of funding exhibit a similar diversity, being assembled from a variety of organisations with a diverse range of requirements and expectations which in turn, enter into the context application (Gibbons et al. 1994).

4.6 Social Accountability and Reflexivity of Science

In recent years, growing public concern about issues to do with the environment, health, communications, privacy and procreation and so forth, have had the effect of stimulating the growth of knowledge production in Mode 2. Growing awareness about the variety of ways in which advances in science and technology can affect the public interest has increased the number of groups that wish to influence the

[34] Ibid. p. 2

outcome of the research process. This is reflected in the varied composition of the research teams. Social accountability permeates the whole knowledge production process. It is reflected not only in interpretation and diffusion of results but also in the definition of the problem and the setting of research priorities.[35]

Operating in Mode 2 makes all participants more reflexive. This is because the issue on which research is based cannot be answered in scientific and technical terms alone. The research towards the resolution of these types of problem has to incorporate options for the implementation of the solutions and these are bound to touch the values and preferences of different individuals and groups that have been seen as traditionally outside of the scientific and technological system. They can now become active agents in the definition and solution of problems as well as in the evaluation of performance. This is expressed partly in terms of the need for greater social accountability, but it also means that the individuals themselves cannot function effectively without reflecting-trying to operate from the stand point of all the actors involved.

4.7 The Changing Research Environment

The research environment of the old contract of science is different from the new contract. The two important elements of the new research environment are as follows;

- The steering of research priorities
- The commercialization of research

[35] Michael Gibbons. 2003. Engagement with the Community: The Emergence of a New Social Contract between Society and Science. Paper Presented to the Community Engagement Workshop, Griffith University.

4.7.1 *The Steering of Research Priorities*

The first element in the transformation of research is the increasing desire to *steer* priorities. This operates at three levels.[36]

I. *The supranational level:* the successive European Community Framework programmes are perhaps the best example. These programmes have attempted to shape research priorities and build research capacity to meet identified social and economic needs. On the whole, these efforts have been supported by the research community because the framework programmes have been broad in their scope (and few areas have been categorically excluded) and because they have provided genuinely additional resources;

II. *The national level:* Although highly prescriptive research and development programmes (for example, those funded by ministries of health, defence or agriculture) have existed for sometime, there has been a growing tendency for all ministries to develop dedicated research programmes. These programmes rather confusingly, attempt both to focus on short-term political agendas and develop long term research capacities. There has been a tendency for foresight exercises, which initially attempted to predict future research needs in a relatively open and speculative way, to be succeeded by more directive approaches, as industry and trade ministries attempt to identify areas of international excellence and of inadequate research within the context of global economic competitiveness; and

III. *The system level:* In many countries, Research Councils have increasingly adopted more pro-active (or top down) research priorities in place of essentially reactive (or bottom-up) policies whereby the best research proposals, as identified by peer review, are funded. Much greater emphasis is now placed on thematic programmes. Although typically broad in their scope, these programmes are often the product of an awkward and unstable compromise between political goals, promising science, and available research

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[36] Helga Nowotny et al. 2001. Mode 2 Revisited: The New Production of Knowledge". *Minerva* 41: p. 181

capacity. In a similar way, universities have begun to manage their research priorities more aggressively, rather than simply providing a support environment (Nowotny et al; 2003)

4.7.2 The Commercialisation of Research / Engaged Research

The second element is the commercialization of research. The label of *commercialization of research* is misleading .Therefore Gibbons et al. argues that *engaged research* is an adequate description. This has taken two main forms. First, as the public funding of research has become less, adequate, researchers have increasingly turned to alternative sources of funding. Second, universities (and similar organisations) have become more aware of the value of the intellectual property generated by their research. More attention and anxiety, has focused on the first than on the second. The available public funding for research is inevitably outrun by the sheer fecundity of research potential, although this is not an argument for abandoning efforts to increase public funding.[37] The funding of research has always come from a plurality of sources; arguably, this contributes to the diversity and creativity of research system. Of greater concern perhaps is the tendency of governments to define their role in research funding in quasi-commercial, rather than in fiduciary terms. This attempt to align public policy with market priorities in research policy-creating what are, in effect, public-private partnerships-is likely to reduce diversity and creativity.

The second aspect, the determination to exploit intellectual property raises greater concern. The motives of universities and similar organizations are obvious enough. Public expenditure on higher educations and research generally has failed to keep pace with costs, and universities have been encouraged to develop alternative sources of income. With the emergence of a knowledge society, knowledge 'products', many of which are derived from university research, are increasingly valued not in terms of their long-term potential, but in terms of immediate *market*

[37] Dominique Pestre. 2003. Regimes of Knowledge Production in Society: Towards a more Political and Social Reading. *Minerva* 41: p. 251

return.[38] However understandable the motives, seeking to exploit intellectual property, have two important consequences.

First, by raising the question of who *owns* the property (i.e.., the individual researcher or research team, the research community or the institution), and then negotiating respective shares, the exploitation of intellectual property transforms the organizational character of the university. Second, the exploitation of intellectual property challenges the idea of science as a *public good*. This raises awkward issues. One is commercial confidentiality. If *intellectual property* is valuable, it cannot be given away freely by open publication in peer reviewed journals or a scientific conference open to all. However, the quality of science is largely determined by its exposure to refutation and counter-argument. This process becomes much more difficult if the circulation of research findings is restricted (Nowotny êt al 2003, Gibbons et al 1994).

4.8 Multiple Sites of Knowledge Production

In the new contract of science the sites of knowledge production has increased. The science of the single lab is slowly being replaced by networks of scientific actors collaborating among multiple sites, even internationally, while retaining their own host operations.[39]

Of course, scientific collaboration is hardly a new phenomenon. But academic science tended to forge its collaborations out of long-term relationships (such as mentor and protégé or as a result of interactions among scientists at meetings. In the new post- academic science, collaborations among scientists are increasingly possible where the scientists have never met in person. These collaborations known as virtual labs may last only as long as the experiment, after which each person or group will go its way. Moreover, in Mode 2 science different kinds of institutions are prone to collaboration. A Mode 2 project may begin in a university but branch out to include

[38] Nowotny et al. 2003. Mode 2 Revisited: The New Production of Knowledge. *Minerva* 41: p. 183.
[39] Helga Nowotny. 2006. Real Science is excellent Science-how to Interpret Post Academic Science, Mode 2 and the ERC. *Journal of Science Communication* 5 (4). p. 3.

consultant, technicians and researchers from industry and government. Alternatively, a research project may begin in a corporate setting but enlist the aid and expertise of academic researchers. On the other side of the virtual lab is the *virtual research corporation*, an organization with few permanent employees funded by government research contracts. The virtual research corporation subcontracts specific partners or consultants to develop publications and maintain credibility.

4.9 New Bond between Science and Social Need

Not even the most pure believer in academic science would discount social need entirely. Researchers in academic science always referred to the social good when necessary. Rare was the NIH grant application that did not invoke some possible drug, cure, therapy, or clinical application as the culmination of experiments in an animal model. Moreover, the direction of research has always been subject to fads, and these fads have been associated with perceptions of urgency. However, the last few years have seen the profile of social need rise in prominence. With diseases such as HIV/AIDS and breast cancer, the world saw for the first time that those affected by the disease could, through lobbying and protest, gain a recognized voice in how research was conducted. Such voices have multiplied recently with prominent celebrity cases of Parkinson's disease, Alzheimer's disease, and spinal cord injury, and with foundations advocating specific research agendas (such as embryonic stem cell research). Internationally, the intellectual property claims of pharmaceutical companies have been challenged especially with regard to the distribution of antiretroviral drugs in sub-Saharan Africa. The movement for access to medicines is of a piece with other components of the new textual economy because the very internationalization, multiplication, and distribution of knowledge that created vast new drug markets also created possibilities for resistance to being treated solely in market terms. In any event, such trends seem part of the landscape now. Perhaps addressing social need is simply more necessary than before perhaps; on the other hand, *New Knowledge Production* makes it more possible than ever to imagine the goals of research addressing social need effectively.

In Mode 2 science, both the meaning and the significance of projects and results must be explained to diverse groups representing a variety of stakeholders in the scientific process.[40] As its name suggests, academic peer review typically addresses fellow scientists-peers rather than corporate stakeholders, public interest groups, politicians, tax payers as such, and media organisations. Yet in Mode 2 science, these and other people and groups may have the power to increase or decrease funding for a project: they are typically interested in such issues as application, technological development, and licensing. The privatisation in New Production of Knowledge means both that projects are imagined early in terms of their application and that projects without obvious application come under increased scrutiny. The investigator in a Mode 2 context is never from having to justify a scientific projects worth and value to people who are not themselves scientists.

A new social contract of science involves a dynamic process in which the authority of science will need to be legitimated again and again. The maintain this, science must enter the agora and participate fully in the production of socially robust knowledge (Gibbons, 1999). According to some observers, these changes have already emerging in the management of large technology projects. Thomas P. Hughes, the eminent American historian of technology, has identified a new ethos among engineers who now recognizes that the deeper involvement of communities in decision making actually produced better engineering solutions in a number of projects.[41]

Conclusion

The present chapter is basically a theoretical analysis of the new social contract of science. In this chapter an attempt has been made to discuss the old and new social contract of science. The chapter also discussed the components of Mode 2 or new contract of science in detail. It identified the main differences between old and new contract of science. We have seen in the present chapter that the new contract

[40] Marilyn Strathern. 2003. Re-describing Society. *Minerva* 41: p.267.
[41] Thomas P. Hughes. 1998. *Rescuing Prometheus.* New York: Pantheon Books, pp. 301-303

of science is more open and more distributed. In the old contract ,science was left to make discoveries and then make them available to society, but the new social contract is based upon the *joint production of knowledge* by society and science. In this chapter an attempt has also been made to discuss the various characteristics of the emerging contract of science like flexibility, transdisciplinarity, heterogeneity, social accountability, reflexivity etc. The next chapter deals with the methodology

Chapter 5

Methodology

Introduction

The principal concern of methodology is wider philosophy of science issues in social science, and the study of how, in practice; sociologists and other social scientists go about their work, how they conduct investigations and assess evidence, how they decide what is true and false.[1]

The field of social research is virtually unlimited, and the materials of research endless. Every group of social phenomena, every phase of social life, and every state of past and present development are the materials for the social scientists. Since science is also a part of our social system it is very important to understand science sociologically.

Research planning on the other hand is nothing but series of actions or steps necessary to effectively carryout research and the desired sequencing of these steps. There are various steps involved in a research process. They are neither mutually exclusive; nor they are separate and distinct. They do not necessarily follow each other in any specific order and the researcher has to be constantly anticipating at each step in the research process the requirements of subsequent steps.

Given the limitations of data, time, scope and other resources needed to carry out an M.Phil dissertation, an effort is made here to follow various steps as below

- Statement of the problem
- Objectives
- Rationale to choose Biotechnology as the case
- Rationale to take Delhi as the region of study

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[1] Gordon Marshall. 2005. *Oxford Dictionary of Sociology*. New York: Oxford University Press. p.412.

- Definition of concepts
- Key research questions from the review of literature
- Working hypotheses
- The Research Design
- Universe of the Study and the rationale for the selection of Institutions
- Sampling
- Method of Study and Collection of data
- Limitation of the Data Collection
- Limitations of the Present Study

5.1 Statement of the Problem

Science and Technology Studies (STS) is a dynamic interdisciplinary field, rapidly becoming established in North America and Europe. Because it is interdisciplinary, the field is extraordinarily diverse and innovative in its approaches. The STS is emerged as a major discipline in Europe. In Asian countries in general and in India particularly the field of STS is still in its initial stage. So it is obvious that the theoretical models/ concepts developed in European setting are used here. It has various limitations when it applied in a society which is entirely different in terms of its culture, social structure, economic and political system from its birthplace of the framework. Scholars like Yogendra Singh, T.K Oommen, etc. have argued for Sociology for India. The same metaphor can be used for Science Studies also. A different framework to study the Indian scientific community is needed. One has to use the western paradigms critically and rationally and take only the accommodative aspects and try to develop a framework which is suitable to Indian setting.

The present study is basically an attempt to understand the *changing social contract between science and society* from the perspective of *social studies of science*.

It also explores the relevance of the emerging concepts which define the changing *social contract* of science in the Indian context. As we have seen there are many European scholars studied the changing nature of science in society. The emerging standard, to which scholars have given such names as *Mode 2 Knowledge Production* (Gibbons et al., 1994), *Post Academic Science* (Ziman, 2000) is changing our definitions of science itself.

It is true that Mertonian social system of science is becoming less important in with the emerging globalised era. But the transformation of research systems that has come into focus in science studies literature in the context of industrially advanced countries is partially relevant to developing world. As the developing countries are striving towards rapid industrialisation and catching up with advanced industrial economies perhaps, that transformation is partially relevant to developing world. (Krishna et al, 2000). Since all these concepts are developed in the western setting it needs to be analysed critically in the Indian setting. There are some studies which show the limitations of these concepts and had suggested modifications in the context of non-European countries.

Vessuri (2000) argued that the role for developing countries in the new *distributed* production system is only as of passive consumers of predigested information products. Despite the claims of the advantages of Mode 2 to tackle relevant local problems, what is happening is, a predictable spin–off of the increasing commercialisation of universities in the developing countries, they are introducing their wares to the developing world directly. For example, selling canned virtual courses, consultancy, services of the most varied sorts and research solutions through the redefined schemes of international cooperation etc are few of them. Many institutions of higher education in Latin America become the affiliate, branch or empty cage for new commercial endeavours of the knowledge institution from the North, ready to explore the last market frontier, that of knowledge.[2]

Rudolf et al. (1999) have argued that the concept of *Triple Helix* needs modification when it applied in developing countries. Interactions among universities,

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[2] Hebe Vessuri .2000. Mode 2 or the Emblematic Disestablishment of Science: A View from the Edge. *Science, Technology & Society* 5 (2): p.206.

industry and government vary from country to country and strongly depend on a particular country's stage of development, for example a triple helix in Europe, Japan, and especially in the USA, will be quite distinct from one in developing countries.[3]

Sardana and Krishna (2006) studied the relevance of triple helix in the Indian context and found that *bilateral* linkages and partnerships-mostly between government and public sector institutions, including universities seem to be more relevant and meaningful than tripartite relationships.[4]

Krishna stated that there is a basic change in the orientation of scientists from *advancing knowledge* to that involved with *creation of wealth*; is an important ideological shift. There is also a corresponding shift of emphasis from *basic research* to *technological innovation* and in the last decade much of this new inspiration is spreading across the rest of the developing world from the experiences of East Asia.[5] Although scientists now positively oriented to commercialisation of knowledge (patenting) and accord high importance to it, they continue to assign equally high importance to publications in India. The empirical investigation is needed to understand the Indian situation. The present study is an attempt on it.

The present study explores the present relevance of *'old' social contract of science* (Mertonian ethos) in the Indian context. It is important to study to what extent the 'old' social contract exists now. It analyses the phenomenology of New Mode of Knowledge Production like *collaborative research, multiplication of sites, co-authorship, socially robust knowledge etc.* in the Indian context. While discussing the emerging trends in science it is important to discuss present status of the old ethos of science or academic science in the Indian context.

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[3] Peter Rudolf Seidl and Waldimir Pirro Lengo. 1999. Comments on the Application of the Triple Helix of Innovation to Developing Countries. *Science and Public Policy* 26 (2): p.138.
[4] Deepak Sardana and V.V. Krishna.2006. Government, University and Industry Relations: The case of Biotechnology in Delhi region. *Science, Technology & Society* 11 (2): p.371.
[5] V.V. Krishna. 2001. Changing Policy Cultures, Phases and Trends in Science and Technology in India. *Science and Public Policy* 28 (3): p.189.

It is the need of the hour to analyse the relevance of the emerging trends of science in the Indian setting through empirical analysis. Hence the purpose of the study is to explore the Indian situation taking biotechnology as a case.

The study is very significant because it is a new topic of research. Very few literatures are available on this aspect. This study may be useful for the concerned authorities such as government, academics, and various science and technology organisations for the purpose of policy formulation and agenda setting.

5.2 Specific Objectives of the Study

1. To explore and understand science -society relationship in social studies of science literature, particularly from the perspective of sociology of science.

2. To explore the changing nature of science-society relations in terms of *Old* and *New Social Contract* between science and society; and identify its components.

3. To explore the relevance of old and new social contract to the field of biotechnology through the orientation of scientists in the Delhi region.

5.3 Rationale to Choose Biotechnology as the Case

Biotechnology is an important case to study because of its generic status implications for economic production in sectors as widely dispersed s agriculture, health, industry and environment. In fact, the growth in biotechnology Research and Development (R & D) has been rapid in the recent years.

The Indian biotechnology sector crossed the US$ 2bn mark during 2006-2007. Although this accounts for only a little more than 1 percent share of the global biotech market, the encouraging sign is that the sector is riding on a healthy growth rate of over 35 percent annually during the last five years. The prognosis is good and consensus among industry leaders and policy makers is that, with proper fiscal and policy initiatives, the sector could easily scale the US$ 25bn figure by 2015.[6] Today about 300 biotechnology companies in India, with the top ten accounting for 50 percent of the revenue generated, and R & D investment of the top five exceeding US$ 300 million.

Beside this, Biotechnology is an interesting case because it is characterized as an industry in which scientists and product development processes are collaborative. Since the present study is to understand the changing social contract of science and society, biotechnology is the best case because of research here is collaborative, interdisciplinary and also there are plurality of the research groups.

5.4 Rationale to take Delhi as the region of study

One of the main reasons to take Delhi as the region of study was the limitation of the M.Phil dissertation. The time and resources available for the study is limited. Delhi has also been chosen as the region of study because it is the capital city of India. It is supposed to have good institutes and universities which are conducting research in various field of biotechnology. Since it is the capital city it is easy to find scholars of excellence in various fields of biotechnology, because they located at various prestigious universities/ institutes in Delhi. Another reason was that the public private interactions (institutes and companies) in the field of biotechnology of Delhi region are quite sizeable.

5.5 Definition of Concepts

- ***New Social Contract of Science/Emerging Social Contract***

The transformation of *Mode 1* – disciplinary, homogeneous, socially reliable knowledge or *academic* knowledge production to *Mode 2* – transdisciplinary,

[6] Viren Konde. 2008. Biotechnology in India: Public-Private Partnerships. *Journal of Commercial Biotechnology* 14 (1): p.44.

heterogeneous, socially robust knowledge or *post-academic* knowledge production Simply we can say a shift from *Mertonian* ethos to *Post-Mertonian* ethos.

- *Old/Existing Social Contract*

The Mertonian ethos of science or institutional imperatives, which he calls universalism, communism, disinterestedness, and organized skepticism, which governed the system of science. Simply, *old social contract* of science means a science which is discipline oriented, and based on linear model of innovation.

- *Biotechnology*

Biotechnology is the modern biology that comprises diverse and sophisticated techniques to exploit cellular processes of bacteria, plants and animals to obtain highly useful and novel products. Biotechnology can also be defined as the controlled and deliberate manipulation of biological systems (whether living cells or components). For the efficient manufacture or processing of useful products. Simply, biotechnology is the fusion of biology and technology. It is the application of biological techniques to product research and development.[7]

5.6 Key Research Questions from the Review of Literature:

1) To what extent the old social contract of science holds relevance in the Indian context?

2) To what extent Indian biotechnologists have accepted the new social contract?

3) To what extent the emerging concepts of *Mode 2*, *Post-academic science* etc; are capable to explain Indian setting?

[7] Web M.D. 2008. *Webster's New World Medical Dictionary.* (3rd ed.) New Jersey: Wiley Publishing Inc. p.7.

4) To what extent Indian biotechnologists are aware and what is their opinion on public funded R & D (Protection, Utilization, and Regulation of Intellectual Property) Bill?

5.7 Working Hypotheses:

1. To some extent Biotechnologists in the Delhi region have accepted the norms of new social contract of science.
2. Some components of the old social contract of science like peer review publication; reward system etc; are still relevant in the Indian setting.
3. The emerging concepts of Agora/Public Participation of Science have limitations in the Indian setting.
4. Indian biotechnologists have positive attitude towards the new proposed bill on university patenting in India.

5.8 Research Design

A research design is a logical and systematic plan prepared for directing a research study. It constitutes the blueprint for the collection, measurement and analysis of data.[8] Thus the study includes both the components of *Exploratory* and *Diagnostic/Descriptive* as well.

➢ **Aspects of exploratory design**

- The sampling design is non-probability in nature. The data gathered from the subjects are not through random sampling. Rather it is purposive sampling.

[8] Bernard Philips. 1982. *Social Research Strategy and Tactics*. London: Macmillan Publishing Co. p.93.

The researcher deliberately selected the sample units that conform to some *pre-determined* criteria.

- It is a preliminary kind of study of an unfamiliar problem about which the researcher has little knowledge.
- The present study aimed to generate new ideas or insights into the problem under study.

➢ **Aspects of descriptive/diagnostic design**

- This study is designed to gather descriptive information and provides information for formulating more sophisticated studies or theoretical formulation.
- Data are collected by using appropriate methods.
- Concepts are verified through empirical observation.

5.9 Universe of the Study and the rationale for selecting the Institutions

The present study has been carried out at 5 Institutes/Universities in Delhi:

- *Jawaharlal Nehru University (JNU)*
- *Indian Institute of Technology -Delhi (IIT-D)*
- *National Institute of Immunology (NII)*
- *National Institute of Plant Genome Research (NIPGR)*
- *International Centre for Genetic Engineering and Biotechnology (ICGEB)*

Rationale for the selection of the Institutions

The study has been carried out at five major biotechnological/ interdisciplinary centres located in Delhi. From **JNU** four Centres were selected for the study i.e., School of Biotechnology, School of Life Sciences, Special Centre for Molecular Medicine and School of Information Technology. **School of Biotechnology** is one of the leading biotechnology schools in India. The faculties of the centre are well known in various fields of biotechnological research. The school was rated the best biotechnology school in the country in India's Top 20 Biotechnology Schools Survey conducted by *Biospectrum*. **School of Life Sciences,** since its inception, it has been a premier multi-disciplinary research and teaching department in the country. The school has followed innovative research in different areas of modern biology **School of Information Technology,** is very unique in the sense that it offers very innovative courses and the faculties come from various backgrounds such as Physics, Chemistry, Biology, Statistics and Computer science to carryout research in diverse fields such as Comparative Genomics, Systems Biology, Bioinformatics/ Computational Biology etc. **Special Centre for Molecular Medicine,** pioneered research and education in the field of molecular medicine, which is an interdisciplinary area within biomedical sciences in India and is the first national centre imparting PhD level training. The centre has already initiated many collaborative research activities with reputed national and international medical research institutes.

IIT-Delhi (Department of Biochemical Engineering and Biotechnology) has a unique place in the development of biochemical engineering discipline in India. The institute took an early note of the significant role that was to be played by biochemical engineers and biotechnologists in future industrial development of biotechnology related processes and products by initiating this activity in 1968.

National Institute of Immunology (NII) is a reputed national autonomous institute supported and supervised by the Department of Biotechnology, Government of India. The institute has already filed 30 international patents. The institute is rich in its research on some of the innovative fields of biotechnology.

NIPGR is selected because it is a premier institution for plant genomic research. The institute has already placed India among the major contributions to plant genomics. Several of the staff scientists are leading experts of plant genomics in India.

ICGEB is an international institute. It is an international organisation, whose statutes were signed by 26 countries under the form of an international treaty in 1994. The institution is structured in two components located in Trieste, Italy and in New Delhi, India.

5.10 Sampling

The sampling method in the present study used was purposive sampling. It is a non-probability sampling method. The researcher deliberately selected the sample units that conform to some pre-determined criteria. The present study has selected scientists based on their specialisations.Keeping that in view, the study tried to include almost all branches of biotechnological research and these institutes can be treated as true representative with respect to various fields in Biotechnology. The scientists were identified from the annual reports of each Centre and websites and taken on the basis of specialization. Thus, the sample was taken not based on random sampling, but was purposive in nature. The sample size of the present study is 28 scientists.

5.11 Method of Study and Collection of Data

The data was collected through both secondary and primary sources. The secondary data were collected through various sources like books, journals, unpublished research papers etc. The primary data (empirical study) were collected through a structured questionnaire and face-to-face interview with the selected scientists.

Taking into consideration of the objectives of the study a questionnaire, containing approximately thirty five questions (both open-ended and closed-ended question) relating to the various aspects of the present study were prepared and asked. The selected five scientists were interviewed and asked questions on various issues. The interviews helped the researcher to know the issues more deeply and exhaustively.

5.12 Limitations of the data collection

- Although it was difficult to get data from two autonomous research institutes, the cooperation of the university faculties are appreciable. They were really co-operative and ready to hear me.
- Some scientists were not ready to reveal the details of their research. So they just rejected and given common reasons like, *don't have time*, *very busy now* etc.
- Some scientists were simply rejected because the study is in social science. Perhaps the reason was lack of belief in social science research, interpretative nature of social science etc.
- Many of the scientists did not stick to their words regarding handing over of questionnaires. I had to visit their office many a times to collect the fill in questionnaires.

5.13 Limitation of the Study

Because of the limitation of the time and scope of an M.Phil dissertation the sample of the study was small. The present study did not use any sophisticated statistical tools. Because of the limited time only five interviews were carried out.

Chapter 6

The Old and New Social Contract and the Case of Biotechnology in Delhi Region: Empirical Study

Introduction

The major objective of the present study *'to explore the relevance of old/existing and new/emerging social contract in the field of biotechnology through the orientation of scientists in Delhi region'* is dealt in this chapter. It is based on the empirical study conducted in the five institutes situated in Delhi, India. As mentioned in the methodology chapter, the methodological tools employed in this part are questionnaire and face-to-face interviews with biotechnologists from the five institutes.

Keeping in view the objectives and hypothesis framed for this study, data and findings presented in this chapter are related to reward system, organizational structure, collaborative research, transdisciplinary research, globalisation of knowledge production, peer review, patenting, importance of publications, changing role of academic professors/scientists, opinion on new *University Patenting Bill*, public legitimacy and the significance of socially robust knowledge. One of the major findings arising out of the empirical research is that even though Indian biotechnologists have accepted the norms of new social contract of science, it is not fully. Some components of new contract of science are not relevant to Indian setting. On the contrary some aspects of the old contract of science are still relevant to Indian context.

Further some secondary sources of data are also utilized at arriving at the findings of empirical results of the study and also discussing a brief analysis of the status of Biotechnology in India.

6.1 Biotechnology: An Introduction

Biotechnology is a rapidly developing field in which new products and services are developed from an increasingly complex and cumulative set of interrelated technological processes and products. The ability to sequence genes, identify their functions and mutations, create systems to selectively express, regulate or silence genes, predict protein structures and expression, map the influence of genetic make-up on metabolism and analyse the vast amounts of genetic data has been dubbed as the genomics revolution (Mallick,2009:9).Scientists can now manipulate DNA, the fundamental building block of life. Early results range from the manufacture of genetically engineered drugs to the cloning of *Dolly*, the sheep. With the completion of the initial sequencing and first draft of the human genome, the next step is identification of new kinds of drugs.[1] Research centres of biotechnology all over the world is working on different micro aspects of biotechnology. There are many specialized institutes for various fields of biotechnology now.

The potential impact of biotechnology on the nation's economy is great because many major industrial sectors stand to be affected: agriculture, food processing, chemicals, pharmaceuticals, and environmental management.[2]

Recent breakthroughs in biotechnology have led to a rapid progress in understanding the genetic basis of living organisms, and the ability to develop product and processes useful to human and animal health, food and related industries. Many of these developments have taken place mainly in the United States and other developed countries.[3]

In recent years, several developing countries in Asia, including China, Singapore, India, Indonesia, Malaysia, the Philippines, Thailand and other have began to invest in biotechnology. They are closely following the OECD members in Asia,

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[1] Sheila Jasanoff. 2006. *Experiments without Borders: Biology in the labs of life*. BIOS Annual lecture at the London School of Economics, June 15, London.
[2] Cynthia K. Wagner. 1998. Biotechnology in Mexico: Placing Science in the Service of Business. *Technology in Society*. 20: p.61.
[3] Leon Wofsy. 1986. Biotechnology and the University. *The Journal of Higher Education* 57 (5): p.479.

viz., Japan and South Korea in terms of investments and allocations. However, the challenges and opportunities in the Asian region in the context of potential uses of biotechnology and its impact on the trade and economy of developing countries need to be explored further.

In the Asian region, India and China are two countries with huge capacities in biotechnology. For instance, the development of applied biotechnology in India, directed towards economic production of new and conventional biological products of wide spread human use, is of great importance. [4]

6.2 Biotechnology in India: An Overview

In his book *Wealth of Nations,* Adam Smith, wrote that "a true wealth of a nation is measured not by how much gold it possesses but by what it can produce". By this yardstick biotechnology is an unprecedented revolution through which the world's hunger can be eliminated by creating a new market space, particularly in India. It is true that information technology has contributed much to India's economic strength in the 1990s, but if the country is to get its due place in the comity of nations it has to create another market. This is why the tenth plan stresses biotechnology based national development (Scoones, 2002).

India's biotechnology sector received a huge boost from the sequencing of the human genome. The mass of raw data that emerged from the *Human Genome Project* has given researchers many leads to pursue. The work involves finding clusters of patients who are related and identifying common genes responsible for their condition. There is undoubtedly much potential in biotechnology, with possible applications in medicine, agriculture, energy, and pollution control and so on.[5]

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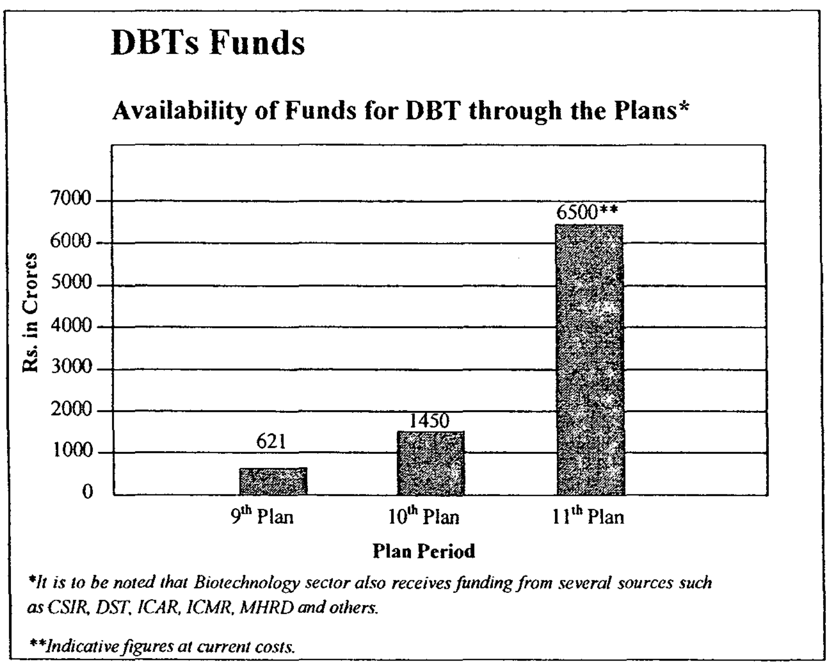
[4] Sachin Chatuvedi and S.R. Rao. 2004. "Biotechnology and Development: An Overview" .In Chaturvedi and Rao ed. *Biotechnology and Development: Challenges and Opportunities for Asia.* New Delhi: Academic Foundation, pp.18-19.
[5] Ian Scoones. 2002. Biotech Science, Biotech Business: Current Challenges and Future Prospects. *Economic and Political Weekly* 37(27) p.2725.

The Department of Biotechnology (DBT), under the Government of India, has taken a very broad definition of biotechnology. According to the several documents of DBT, one gets an impression that 'biotechnology is an application of recombinant and non-recombinant technologies in biological resource utilisation for product and process development aimed for commercialization'.[6]

There are several public agencies in India, such as the DSIR, DST, DBT, ICAR, ICMR, which have several programmes supporting biotechnology. Their total budgets have gone up in the last decade. Each of them has growing allocations for this particular technology. However, except the DBT, no agency separately announces budget allocations for biotechnology as the allocations are included into the broader heads for accounting purposes.

The annual budget of DBT has grown successively in the last one and a half decade. The following figure explains it in detail.



(Source: DBT Annual Report 2008)

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[6] Sachin Chaturvedi. 2005. Developments in Biotechnology: International Initiatives, Status in India and Agenda before Developing Countries. *Science, Technology & Society* 8(1) p.81.

However, besides increasing its budget allocations the DBT, Government of India has also taken several other steps for the promotion of biotechnological research in India. One important step is international collaboration.

6.3 International Collaboration in Indian Biotechnology

The DBT has made efforts to establish enduring collaborations with well-chosen strategic partners such as Australia, Canada, Finland, Norway, Sweden, Switzerland, UK and USA.

The DBT has signed two Memoranda of Understanding (MoUs) with Canada on December 5, 2006 with i) Department of Agriculture and Agri-Food of Canada (AAFC) and ii) National Research Council (NRC) Canada. The major objectives are i) to provide researchers and institutions with opportunities to exchange scientific information and to facilitate the exchange of scientists and ii) faster scientific cooperation and promote cooperative projects mutually beneficial to the two countries including industrial programmes. The identified priorities for cooperation include agriculture and food processing and storage; biopesticides and bio-fertilizers, functional and nutraceutical foods and impact on human nutrition; agricultural biotechnology, biomass utilization; sustainable alternative energy and environmental technologies and water quality.

A MoU in the area of biotechnology was signed between India and Denmark on 25th October 2004. The principal objective of this MoU is to facilitate broad opportunities for co-operation between the two countries in the area of biotechnology thereby promoting the areas of research of mutual benefit to both countries. Seven projects have been funded in 2006-07 in the areas of: biohydrogen production and biomethanation; fungal resistance in pearl millet, bioprocess engineering and stem cell.

A MoU in the area of biotechnology was signed between DBT and Academy of Finland, in July, 2005. The different areas in biotechnology which have been identified for joint collaborations are: advanced biotechnology, medical biotechnology, food biotechnology, agriculture biotechnology and environment biotechnology.

An agreement for cooperation in biotechnology between DBT, Government of India and German Federal Ministry of Education, Science Research and Technology (BMBF) Forschungzentrum Julich GMBH (FZJ) was signed in February, 2001. Specific areas for collaboration include: isolation, characterisation of micro-organisms for production for metabolites, NMR spectroscopy techniques for investigation of metabolic pathways; development of bio reactors for laboratory and industrial use; new cell culture techniques and over expression of proteins and protein design by genetic engineering.

A Programme of Cooperation (PoC) was signed between DBT and Governmental Agency for Innovation Systems (VINNOVA) in May, 2007. A delegation led by Secretary DBT visited Sweden to discuss the follow up action of the PoC signed with VINNOVA.

A MoU was signed in 1998 with the Biotechnology and Biological Sciences Research Council (BBSRC), Government of United Kingdom on co-operation in the field of biotechnology and biological sciences to facilitate broad opportunities for co-operation between the two centuries.

Isolation of *Alternaria brassicae* from different genotype of brassicae species was carried out. There is a joint collaborative programme of National Institute of Immunology with Center for Cancer Research and Cell Biology, Queen's University Belfast, UK.

The Indo-US Contraceptive and Reproductive Health Research (CRHR) programme was initiated with the intent of drawing on the expertise of Indian and US scientists and institutions in the area of reproductive biology, contraceptive research and development and reproductive health to promote and support collaborative research that will result in expanded contraceptive options and improved reproductive health. The programme completed ten years in November, 2007, and has achieved considerable success during the decade

The Indo-Swiss collaboration in Biotechnology in continuing programmes since 1999 and promotes research partnerships between Swiss and Indian institutions in various areas of biotechnology and fosters the technology transfer to the end-user. The mandate is develop products and biotechnological processes which have an impact on poverty reduction and sustainable management of natural resources in India to focus on innovative technologies in agriculture and environmental research.

The Indo-Norway collaborative programme has emphasis on vaccine research in the areas of human, animal and aquaculture diseases. During the ensuring period, a joint workshop was organized on fish vaccine development in Oslo, Norway with emphasis on major viral and bacterial diseases, current vaccination strategies. Currently, eight collaborative proposals are under active consideration.

The MoU signed between DBT and National Institute of Advanced Industrial Science and Technology (AIST), is being followed up with Joint Workshop by the AIST during January, 2008 in Japan on Computational Biology.

Programme of Cooperation (PoC) is being finalized with the National Pingtung University of Science and Technology (NPUST), Taiwan in the areas of Animal Health, Agriculture and Shrimp related aquaculture feed and disease management.[7]

It is clear that Indian biotechnology sector has collaboration with almost all the powerful countries in Europe, America and East Asia. It shows that collaborative research is an inseparable and primary character of Biotechnological research.

The Indian biotechnology sector has crossed the US $ 2bn mark during 2006-2007. Although this accounts for only a little more than 1 per cent share of the global biotech market, the encouraging sign is that the sector is riding on a healthy growth

[7] Annual Report, DBT 2008 pp.169-178.

rate of over 35 per cent annually over the last five years. The prognosis is good and consensus among industry leaders and policy makers is that, with proper fiscal and policy initiatives, the sector could easily scale the $25 bn figure by 2015. There are today about 300 biotech companies in India, with the top ten accounting for 50 per cent of the revenue generated, and R & D investment of the top five exceeding US $ 300 m.[8]

The following table gives an understanding of the public-private partnerships of Biotechnology in India.Infact the field of biotechnology cannot exist without partnerships or collaboration.

Table 6.3 Public-Private Partnerships of Indian Biotechnology Sector

Private Company	Public partners
Avestha Gengraine Technologies Pvt. Ltd., Bangalore	NCBS, University of Agricultural Sciences, ICRISAT, Imperial College, London, UK.
Bangalore Genei Pvt. Ltd., Bangalore	CCMB ,IBA-ICAR
Bharat Biotech, Hyderabad	DBT-AIIMS ,ICGEB-AIIMS ,CBT
Biological E, Hyderabad	IISc ,International Centre for Diarrohoeal Disease Research (ICDDR) Bangladesh, National Institute of Health (NIH), USA, Netherlands Vaccine Institute (NVI), Netherlands
Genotypic Technology, Bangalore	CBT ,IISc ,Madurai Kamaraj University

[8] Viren Konde. 2008. Biotechnology in India: Public-Private Partnerships. *Journal of Commercial Biotechnology*. 14 (1) pp.43-44.

Monsanto, Bangalore	IISc ,TERI ,Kenyan Agricultural Research Institute
Nicholas Piramal India Ltd., Mumbai	CBT ,NII
Panacea Biotech, New Delhi	JNU, Biotechnology Consortium of India , National Institute of Health, USA
Rallis India, Mumbai	ICGEB ,IISc ,Madurai Kamaraj University , World Health Organization (WHO)
Serum Institute of India Ltd., Pune	World Health Organization, Switzerland, Health Protection Agency, UK , Program for Appropriate Technology in Health (PATH), USA
Shantha Biotechnics Ltd., Hyderabad	CCMB ,IISc, BARC,NII ,IICB ,JNU ,ICGEB ,NCCS ,Anna University ,Osmania University,BARC Tata Memorial Hospital, International Vaccine Institute, Korea
Shapoorji Pallonji Biotech Park Pvt. Ltd., Hyderabad	CCMB ,University of Hyderabad ,Research Triangle Part, USA ,Technologie Park Heidelberg, West Germany
Strand Genomics Ltd., Bangalore	IISc ,CSIR Project Team ,CDFD
Workhardt Ltd., Mumbai	ICGEB

(Source Konde, 2008: 51)

Table shows the interaction between some of the public research institutions and private companies in the field of modern biotechnology in India. The companies listed here have more than one academic partner. It is clear that the number of collaboration is increasing in the field of biotechnology. Private companies have collaboration both with universities and research institutions and even with foreign universities and institutions. In fact collaboration has become the basic feature of biotechnology research. The following section discusses the application of Mertonian ethos/old contract in the field of biotechnology in India and the relevance of new social contract and analyses to what extent the new contract holds relevance in the Indian situation. As mentioned earlier the purpose of the study is to explore the Indian situation with example of biotechnology area.

In order to explore the relevance of old social contract and the emergence of New production of research in Biotechnology in India, an empirical study in the five research institutions has been carried out.

6.4 Institutional Profile of the Biotechnologists

Table 6.4 Institutional Background of the Scientists

Name of the Universities / Institutions	Total number of scientists
JNU	15
IIT-D	4
NII	4
ICGEB	4
NIPGR	1
Total	28

Source: data from the questionnaire.

As we have discussed in the methodology chapter the sample size of the present study is 28. It used both questionnaire and face-to-face interviews. Given the resource and time constraint the majority of the respondents were selected from four different Centres of JNU.To make the sample as representative and diverse as possible scientists were selected from other Institutes also. All the scientists selected for this study have some kind of foreign training. Few of them did their doctorate degrees from foreign Universities. But all the scientists have done their post-doctoral training from various foreign Universities. Many of them did their post-doctoral training from USA. A good number of scientists have done their post-doctoral training from National Institutes of Health, USA.

6.5 Emergence of New Social Contract

In order to know the orientation of scientists towards the New contract of science, they were asked some questions related to the new contract. The New contract is characterized by the following features.

6.5.1 Flexibility in Research:

Flexibility in research is one of the important characteristic of the New Contract.Inorder to know the orientation of scientists towards flexibility in research they were asked the present question:

Have you changed your area of specialisation over the period of time?

Table No.6.5.1 Flexibility in Research

University/ Institutions	Yes		No	
	Nos.	%	Nos.	%
JNU	13	86%	2	14%
IIT	3	75%	1	25%
NII	3	75%	1	25%
ICGEB	3	75%	1	25%
NIPGR			1	100%
Total	22	78.5%	6	21.5%

(Source: data from the questionnaire).

One of the characteristic features of new social contract of science is its flexibility in research. It is more of a problem - solving activity. According to Gibbons etal. in Mode 2 research group, people come together in temporary work teams and networks which dissolve when a problem is solved or redefined. Members may then reassemble in different groups involving different people often in different loci, around different problems.[9]

The table shows, a good number of scientists have changed their area of specialisation over the period of time. In response of the present question 78.5% of the scientists say that they changed their area of specialisation. Only 21.5% of the scientists say they haven't changed their area. The fact is that all these 21.5% of the scientists are junior scientists, who have just joined in the institutions after their Ph.D. It is true that fields like biotechnology; flexibility is a necessary component of research. They cannot stick with a particular area in their whole career. They used to change their area depends upon the circumstances like funding agency's demand, scope of the area etc. It is also true that the research group is short-lived and transient.

As we discussed earlier, it is more of a problem-solving activity. Here we can say that Indian biotechnologists have accepted the norm of flexibility in research, one of the characteristic of *New Mode of Knowledge Production.*

One of the leading biotechnologists from JNU expressed that:

> *.....I have changed my specialization. My academic career is very much diverse. I did my M.Sc in Chemistry and Ph.D in Molecular Biology. I have joined as a faculty in SBT, JNU. I worked on various aspects of diseases. Now I'm working on genetically assigned vaccines against diseases.....*

It shows how diverse and flexible the field of biotechnology research is.

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[9] Gibbons etal. 1994. *The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies.* London: Sage. p.2.

6.5.2 Collaborative Research and Biotechnology in India

In order to know the orientation of scientists towards collaborative research the present question were asked:

Have you done any combined/collaborative research?

Table 6.5.2 Collaborative Research in Biotechnology

Institutions	Yes		No	
	Nos.	%	Nos.	%
JNU	12	80%	3	20%
IIT	4	100%		
NII	4	100%		
ICGEB	4	100%		
NIPGR	1	100%		
Total	25	89.9%	3	10.1%

Source: data from the questionnaire.

The table clearly reflects that collaborative research is very much in the Indian biotechnology sector. The 89.9% of the scientists have done collaborative research. Most of the scientists stated that they collaborate with Indian universities as well as foreign universities. And a few of them opined that they used to collaborate with Indian industries. It is clear from the table that only 20% of the scientists never did any kind of collaborative research. In fact these 20% of the scientists are junior faculties/scientists. In the future they may do collaborative research since collaborative research is an important and necessary feature of biotechnological research.

A renowned biotechnologist from JNU says:

> *I collaborate both with international and national institutes. There is a new science called Systems Biology. We have started Systems Biology in our centre. But we didn't have an expert in this field. So I collaborate with a German Institute which is working on Systems. One of my students has already got a chance to join with an expert in Systems there in Germany. He is doing a Sandwich Ph.D. He will spend one year in JNU and then go to Germany for one year and again will be back to JNU. He will work with the German scientist's lab and learn Systems and will come to JNU and do the same in my lab. So that we can easily develop systems in our institute too. I have collaboration with a scientist from Holland, who is an expert in antigens. Another collaboration with an expert in bioinformatics from a reputed institute in USA. In India I collaborate with Indian Veterinary Research Institute. We collaborate to prepare genetically engineered things. I collaborate with IARI; they are experts in Plants and I am expert in antigens. We even published papers together. As far as Industrial collaboration is concerned, I had collaboration with Panacea Biotech* who bought my technology to the market (anthrax vaccines). Recently we published paper together. Now I have collaboration with Penentrial Biotech to make DNA vaccines to rabies.*

It is clear from his statement that biotechnological research cannot go without collaboration. Because the field is diverse and new specializations are coming day by day. Inorder to do meaningful and unique research it is pertinent to have collaboration in research.

Another professor from JNU observed about collaborative research in the following words:

> *....In my field of research it is imperative to do collaborative research. I have collaborative project between my own faculties, between across different schools in the university and with other institute in India and abroad. I have*

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* Panacea biotech bought the vaccines from this professor for Rs. 2 crores. Now it is ready for human clinical trials update the knowledge it is pertinent to do collaborative research.

also worked joint project with private enterprise and pharmaceutical companies......

As we have discussed in the earlier chapters, collaborative research is one of the important feature of the new knowledge production. Science is not a one-man activity, rather a team work, a hybrid group of researchers. Though collaboration is not a new phenomenon in science, the transnational collaboration is very new to science. We have seen international collaboration is very much in the Indian biotechnology sector.

6.5.3 Transdisciplinary Research in Indian Biotechnology

Transdisciplinary research is an accepted norm of the new contract of science, particularly in the field of biotechnology. They were asked the present question to get a proper understanding:

Have you done any projects with scientists from various disciplines (Transdisciplinary work)?

Table 6.5.3 Transdisciplinary Research in Indian Biotechnology

Institutions	Yes		No	
	Nos.	%	Nos.	%
JNU	7	46.7%	8	53.3%
IIT	4	100%	-	
NII	4	100%	-	
ICGEB	3	75%	1	25%
NIPGR	1	100%		
Total	19	67.86%	9	32.14%

Source: data from the questionnaire.

As we have discussed in the review of literature, transdisciplinarity is the privileged form of knowledge production in Mode 2. It corresponds to a movement beyond disciplinary structures in the constitution of the intellectual agenda, in the manner in which resources are deployed, and in the ways in which research is organized, results communicated and the outcome evaluated. Here attention is focused primarily on the problem area, or the hot topic, preference given to collaborative rather than individual performance and excellence judged by the ability of individuals to make a sustained contribution in open, flexible types of organisation in which they may only work temporarily.

The table 6.5.3 clearly reflects that transdisciplinary research work is common among the biotechnologists in India. The 67.86% of the scientists stated that they have done transdisciplinary research work. It is clear from the table that only 46.7% of the scientists from JNU said yes to the question. It shows the limitation of the university academic structure and prejudices among the university scientists. Almost all the scientists from the research institutes have done some kind of transdiscialinary research. In fact it is very important too in a field like biotechnology. The 32.14% of the scientists state that they haven't done any kind of transdisciplinary work till date. Many of them were junior scientists who just started their career.

One professor from JNU expressed:

> *....I collaborates with scientists working in the area of molecular biology and human genetics in my Centre and in the school of life sciences.....*

Another scientist from NII stated:

> *.....We are involved in doing a project where I along with other biologists, biochemists, chemists, stem all researchers etc. are involved....*

It is clear that transdisciplinarity is an accepted norm among the biotechnologists in India. Though transdisciplinarity has been practicing in the biotechnological sector in India, the kind of transdisciplinarity going on is not fully similar to that of Mode 2, because in Mode 2 transdisciplinarity excellence is judged by the ability of individuals to make a sustained contribution in open, flexible types of organization in which they may only work temporarily. Even though flexibility in research is there but the flexible organisational structure is not yet developed in the Indian scenario

6.5.4 Changing Role of Scientists in the New Production of Knowledge

As we discussed in the earlier chapters the role of scientists have changed. Now they have to play multiple roles like fund raising, firm owners and many. To get a proper understanding of this aspect the present question were asked:

Do you think compared to the earlier period do you think professors now have to perform multiple roles like fund raising, publicity agents, firm owners, and research director of a team of researchers etc.?

Table 6.5.4 Changing Role of Scientists in the New Production of Knowledge

Institutions	Yes		No	
	Nos.	%	Nos.	%
JNU	14	93.3%	1	6.7%
IIT	4	100%		
NII	4	100%		
ICGEB	4	100%		
NIPGR	1	100%		
Total	27	96.43%	1	3.57%

Source: data from questionnaire.

As we have discussed in the earlier chapters the role of scientists/professors has changed. Some scholars called them as *knowledge workers*, some *entrepreneurial scientists* etc. Anyway it is true that the traditional role of scientists/professors has changed in the new contract of science. They had to leave 'ivory tower' and have to deal with multiple roles. Keeping this in mind the scientists were asked.

From the table 6.5.4 it is very much clear that almost all the scientists (96.43%) accepted that the traditional role of scientists has changed now and they have to perform multiple roles like fund raising, publicity agents, firm owners, etc. Many scientists said that it is very important to do these roles in the present world of science. We can say here that Indian biotechnologists have accepted the norms of new contract of science, though not fully. Because it is not possible to say Indian biotechnologists/scientists have developed a notion of entrepreneurial science. Still the notion of entrepreneurial science is alien to Indian science. Because the institutional framework is not that smooth as European universities. It is evident from the field work that not all the scientists are arguing for commercialisation of knowledge. It reflects the changing orientation of scientists towards the commercialisation of knowledge.

It is evident from the above discussed tables 6. 5.1 flexibility in research 6.5.2 collaboration, 6.5.3 transdisciplinary, 6.5.4 changing role of scientists etc. that Indian biotechnological sector has accepted the norms of New Social Contract. Although all the aspects of New Social contract are not possible to explain the Indian Scenario, many of its features are observable in the Indian biotechnology sector.

6.6 Relevance of Old Contract/Mertonian Ethos

6.6.1 Mertonian Norm of Communism

Among many norms related to the old social system of science the norm of communism has come under direct influence of new change. According to R.K. Merton, the communistic norm refers to the sharing of scientific information among scientists and for the good of the scientific enterprise (Merton, 1973). Keeping this Mertonian norm of communism in mind the present question was asked:

Do you share the research findings with fellow scientists freely and without the feeling of fear?

Table 6.6.1 Norm of Communism among Indian Biotechnologists

Name of the Institution	Yes		No	
	Nos.	%	Nos.	%
JNU	11	73.4%	4	26.6%
IIT	4	100%	-	
NII	2	50%	2	50%
ICGEB	3	75%	1	25%
NIPGR	1	100%	-	-
Total	21	75%	7	25%

Source: data from questionnaire.

From a reading of this table we can understand that 75% of the scientists do share their research findings with their colleagues. Here we have to differentiate that they share only findings not the process. Even though this is not the *communism* Merton had talked about at least they are ready to discuss their findings with colleagues unlike European universities, where research is only for material/economic benefits. However the interaction with scientists shows that they are very much infavour of patenting, again it is against the norm of communism. It seems that Mertonian ethos become less important today, especially in biotechnology. But some of its aspects hold relevance today.

One eminent biotechnologist from JNU expressed:

> *Certainly I share the findings with my colleagues. We share only findings, because we have to apply for patenting. In that case we don't declare publicly, we don't talk so much detail on it. There is a chance to be replicated*

Another eminent scientist from ICGEB stated:

> .....*We publish our work which is available freely. We also share our clones after signing agreement with the recipient.....*

So, it can be interpreted that Mertonian norm of communism as such is an ideal norm, which lost its relevance now. But some aspects of this norm still exist. The scientists are ready to discuss about their research findings with their fellow scientists which shows the existence of communism in a different way.

6.6.2 On Old Model of Reward System:

In order to know the attitude and perception of the scientists towards the old reward system the present question were asked:

Do you believe in the old model of reward system like awards, honorary editorship of journals, eponymy etc.?

Table 6.6.2 Scientists' Perception of Old model of Reward System

Name of the Institution	Yes		No	
	Nos.	%	Nos.	%
JNU	7	46.6%	8	53.4%
IIT	3	75%	1	25%
NII	4	100%		
ICGEB	3	75%	1	25%
NIPGR	-		1	100%
Total	17	60%	11	40%

Source: data from questionnaire

From the above table we conclude that almost 60% of the scientists say that they believes in the old model of reward system like awards, honorary editorship of journals, eponymy etc. It shows the importance scientists give to the old ethos of science. At the same time 40% of the scientists did not believe in the old model of reward system Again it shows the emergence of new contract of science, where the existing reward system is in transformation.

One scientist from JNU expressed:

> *Yes I believe in the old model of reward system but partly. The queries and method of finding the answers themselves are rewarding too*

Another professor from JNU stated:

> *....I have a problem with the old rewarding system of eponymy. If the contribution is a breaking discovery then there is no problem to affix the name of the scientists. If it is an activity in normal science I don't think it is important to do like this and there is no use of it.....*

It is evident from the above discussion that even though most of the scientists were in favour of the old model of science they were very critical on it and they do not fully believe in this reward system but with modification in the existing rewards system. From the field work it becomes clear that the scientists value old social institution of science, though not blindly. Again it proves the importance of old social institutions of science among the Indian scientists.

6.6.3 On Old Model of University Research

To understand the perception of scientists towards the traditional role of university the present question was asked:

Do you think university should be a place for only teaching and advancing knowledge?

Table 6.6.3 Scientists' Perception of the role of Universities

Name of the Institution	Yes		No	
	Nos.	%	Nos.	%
JNU	11	73.3%	4	26.7%
IIT	2	50%	2	50%
NII	4	100%		
ICGEB	3	75%	1	25%
NIPGR	1	100%		
Total	21	75%	7	25%

Source: data from the questionnaire.

The table clearly reflects that almost 75% of the scientists responded that university should be a place for only teaching and advancing knowledge. Only 25% of the scientists were responded against this. Here too it shows that the notion of entrepreneurial science has not much relevance in the Indian setting. One can interpret from the table that old notion of science or Mertonian notion of science has relevance in the Indian setting.

6.6.4 Universities and Basic Research

In order to understand the perception of the Scientists towards Basic research they were asked the present question:

Do you think universities/ research institutes should give more importance to basic research?

Table 6.6.4 Scientists on Basic Research in Universities

Name of the Institution	Yes		No	
	Nos.	%	Nos.	%
JNU	8	53.3%	7	46.7%
IIT	3	75%	1	25%
NII	2	50%	2	50%
ICGEB	2	50%	2	50%
NIPGR	1	100%	-	
Total	16	57.14%	12	42.86%

Source: data from the questionnaire.

Form the table 6.6.4 it is clear that 57.14% of the scientists feel that universities/research institutes should give more importance to basic research.

A Scientist from JNU remarked:

> *......Good science will only flourish when research in basic sciences is very strong. The world over universities has promoted and has excelled in basic science and it should remain like that. However, commercial projects also are important. So, industry-university partnership should be there (a good model has to be developed for this), but not at the cost of development and promotion of basic science......*

However, another eminent scientist from JNU has different opinion on this. She remarked:

> *I don't think universities/research institutes should give more importance to basic research. Basic science is a limited activity of human faculty, application oriented research and industrial / agricultural/economic growth of a country highly depends on its invention and use of knowledge which is*

expected to be created by the universities and institutes. Science has crossed its boundary of the pure subjects, basic research joining hands with applied sciences has changed the shape of the world like World Wide Web (WWW) system of concept has discovered and implemented by physicist, computer scientists and engineers and its application has reached every home in developed and underdeveloped countries, will it be called basic research or applied research?

It is clear from the table that 42.86% of the scientists were disagreed with the issue. We can see from the table that more than fifty percentage of the scientists agreed that university should give more importance to basic research. This reflects that traditional value and importance of basic research is still very much retained the orientation of scientists.

6.6.5 Scientists' Perception of Peer Review System (Old Model):

The present question was asked to understand the scientists' perception of the old system of peer review.

Do you believe in the existing system of peer review judgements?

In response to the question 96.43% of the scientists stated that they believe in the existing system of peer review judgements, where only scientists from a particular discipline used to act as reviewers. Again it clearly shows that majority of scientists (96.43%) believes in the existing system of peer review judgements. It reflects that the old system/existing system of peer review are relevant in the Indian context.

Beside this, large number of scientists stated that they believe in existing peer review judgements, but not within India

An assistant professor of JNU stated:

.....Yes I believe in the existing system of 'peer review' judgements, if done properly. But if it is a mockery of the system like it in India, then no.......

Similarly another scientist from NII expressed:

....Yes I believe in the existing system of peer review, but not within India.....

So, the scientists do not trust in the transparency of peer review judgements in India. Still the majority of the scientists are in favour of existing peer review judgements.

6.6.6 Scientists' Perception on Publications in eminent Science Journals

In order to know the perception of scientists towards publications they were asked the present question:

Do you think that peer review publications in eminent science journals are as important as commercialization of knowledge?

Table 6.6.6 Scientists' Perception of Publications in Peer reviewed Journals

Name of the institution	Yes		No	
	Nos.	%	Nos.	%
JNU	12`	80%	3	20%
IIT	4	100%		
NII	4	100%		
ICGEB	3	75%	1	25%
NIPGR	1	100%		
Total	24	85.71%	4	14.29%

Source: data from the questionnaire.

The table clearly indicates that majority of the scientists consider the peer review publications in eminent science journals are as an important as commercialisation of knowledge. We see from the table that 85.71% of the scientists have stated that publications in eminent science journals are greater importance for them.

One professor from JNU expresses:

> *Of course, publications in eminent science journals are as an important as commercialization of knowledge. In fact, publications in eminent peer reviewed journals are of greater importance*

Similarly another professor from JNU stated:

> *.....Yes, publications in eminent science journals are more importance for me. Suppose journals like Science or Nature has published your article that means your article is really extraordinary. It is very difficult to get publish articles in these journals. There is no doubt that it gives more popularity and acceptability than a patent.....*

However another scientist from ICGEB argued:

> *....I don't think peer review publications are as important as commercialisation of knowledge. In fact commercialisation of science should be given more importance. The money generated from commercialisation of science can then be spent for additional scientific knowledge with a specific aim of public good....*

It is evident from the table that only 14.29% of the scientists disagreed with the present question. A vast majority of the scientists argued that peer review publications are very important for them. It again proved the existence of old ethos among the scientists in India. One can interpret from the above mentioned table that it is difficult to assume and the old institutional ethos of science has undergone a big transformation. But it is also true that some aspects of the old social system of science hold no relevance today. But one cannot totally deny the existence of old ethos of science in the Indian setting.

In order to explore more on the perception of scientists on publications, they were asked the following question.

Among the following, which one is more important for you?

a. Publications

b. Patenting

c. Equal importance to publication and patenting

Table 6.6.7 Scientists' Perception of Publications and Patenting

Importance	JNU	IIT	NII	ICGEB	NIPGR
Publication	10 (66.7%)	4 (100%)	2 (50%)	2 (50%)	1 (100%)
Patenting					
Equal importance to publication and patenting	5 (33.3%)		2 (50%)	2 (50%)	
Total	15	4	4	4	1

Source: data from questionnaire

It is evident from the table that not a single scientist stated that patenting is important for them. Most of them expressed that they give importance to publications. The 66.7% of the scientists from JNU said that they give importance to publications 33.3% of them said that they give importance to both publications and patenting. At the same time all the scientists from IIT have expressed that they give prominence to publications and 50% of the scientists from NII expressed that they give importance to publications, however another fifty percent of scientists from NII said that they give equal importance to publications and patenting. The case is with the scientists from ICGEB, fifty percent were infavour of publications and fifty percent in favour of equal importance to publications and patenting.

It is clear that in the Indian setting the old social contract of science/Mertonian social institution of science still holds relevant.

Krishna (2000) states that the transformation of research systems that has come into science studies literature in the context of industrially advanced countries is partially relevant to developing world. It is true that Mertonian system of science is becoming less and less important in the face of the emerging situations, but some of the aspects are still applicable in the developing societies.

From the field work it is clear that some aspects of the old social contract are still relevant in the Indian setting. From a reading of the various tables it is clear that the scientists were infavour of various aspects of old social contract of science. For instance table 6.6.1 clearly indicates that 75% of the scientists share their research findings with their colleagues. It shows the existence of the Mertonian norm of communism, even though slightly in a different way. Table 6.6.2 showed that 60% of the scientists believe in the old model of reward system. Table 6.6.3 and 6.6.4 shows that majority of the scientists considers university should be a place for only teaching and advancing knowledge and agreed that universities should give more importance to basic research. Table 6.6.5 throws light on the scientists' perceptions of peer review system and found that 96.43% of the scientists believed in the existing/old system of peer review judgements.

And table 6.6.6 found that a vast majority of the scientists (85.7%) considers peer review publications in eminent science journals are as important as commercialisation of knowledge and most of the scientists give importance to publications than patenting.

From the reading of the data from the above mentioned tables one would infer that Indian scientists still give priority to the old social contract of science, though there is a trend of transformation among them.

6.7 Organisational Structure

There are many changes going on in the institutional level. Most of the research institutions are having Technology Transfer units. It is a new culture of research institutions and universities in the Indian setting.

6.7.1 Scientists' Perception of the Organisational Setting of the Institutions

In order to know the scientists' perception on Organisational setting the present question was asked:

Is the present organisational structure of your institute/university is conducive to your research work?

Table 6.7.1 Scientists' Perception of Organisational Setting

Name of the Institution	Yes		No	
	Nos.	%	Nos.	%
JNU	12	80%	3	20%
IIT	4	100%		
NII	4	100%		
ICGEB	4	100%		
NIPGR	1	100%		
Total	25	89.9%	3	10.1%

Source: data from the questionnaire.

Due to the emergence of globalisation the organisational structure has changed very much and the university and research institute of the 1980s is different from the present structure. Inorder to know the satisfaction of the scientists regarding their organisational set up the present question were asked. And it is clear from the table that around 89.9% of the scientists stated that they are satisfied with the present organisational structure. Many of them have argued that the basic facilities of their respective institutes are satisfactory and expressed that there is much scope for improvement. All the institutes which is part of the present study is elite and advanced institutes, hence there is good facilities.

A scientist from JNU expressed:

> *Yes, the present organizational structure is conducive to my research. It is true that there are limitations. But when you compare with other institutes in India its far better, but still scope for improvement*

Similarly another professor from JNU argued:

> *...Yes, but partly. In India we have very disorganized infrastructure and no support to maintenance strictly whatever we have, scientific research requires a strong continuous support of infrastructure like electricity, water supply etc. which most of the university in India cannot promise to keep it up, this uncertainty disturbs the repeated production of quality research in the university, JNU is not exception of this either.....*

One can interpret from the table and statements that even though there are limitations in their organisational structure the scientists are satisfied with their academic milieu. Compared to many Indian universities and institutes these scientists are having good academic environment interms of infrastructure accessibility of materials, funding etc. Perhaps that is the reason why they satisfied with their organisational structure.

6.7.2 Changes in the Organisational Structure

It is obvious that changes happened in the field of higher education in general and scientific research in particular. The traditional nature of university research has undergone a drastic change with the emergence of globalisation and liberalisation. As we have discussed in erstwhile table scientists/professors now have to play multiple roles like fund raisers, patent managers, firm owners, and research director of the teams etc. We have seen many cases from the field work. For instance one scientist from NII expressed that:

> *....I don't undertake any laboratory research now. I take care of patents and technology transfer; facilitate institutional (India and abroad) collaborations and multi-task in various other areas.....*

Nowadays it is an accepted norm among the scientists. University professors are consultants to various firms. Some scientists whom the researcher interviewed were consultants to various private biotech firms.

In order to understand the changes taken place in the organisational structure in detail the scientists were asked a qualitative open-ended question:

What kind of changes has taken place in the organisational structure of your institute/university compared to earlier days?

A Senior Professor of JNU expressed:

> *....The major change is the attitude of the scientific faculties, they are no longer accepting the disorganisation, Government of India is keen to financially support research in advanced field and allocate sufficient fund for research and support the younger faculties more than ever.....*

Similarly a junior scientist from NIPGR stated:

> *Over the past decade, we've had easier access to funds and international quality equipment, much more funding and convenience of spending, independence in deciding objectives and strategy, and, liberation of thought in work etc*

Likewise a scientist from NII explained:

> *.....We have state of the art equipments, we have funds both intramural and extramural to buy consumable for the research and the most important is that the atmosphere is very conducive to do good work........*

Similarly another Scientist from NII remarked:

> *...Several changes for good i.e.; uniform basic funding for all investigators/ scientists; improved infrastructure; funding to PhD Scholars to attend scientific conferences abroad....*

A Research Scientist from JNU stated:

> *....Infrastructural facilities have improved tremendously. The project funding has also increased. Importantly, networking with other academic institutes has increased.....*

Likewise a senior scientist and group leader of a research team from ICGEB expressed:

> *Within each group all the scientists have been given independence to do their work within the broad area of research activity. They can take their own students and research projects*

However, an eminent biotechnologist from JNU viewed:

> *...Financial power has increased a lot. In the starting point the principal investigator used to get Rs. 5000 only. Now it is doubled. The Dean of the school used to get only Rs. 5,000. Now it is 50,000. You can see the changes. Earlier there was only one committee for all the centres/schools. It was a big problem. It used to take too much time to get the things done. Now every school has its own committee and it made easy to purchase the equipments. But still there is scope for improvement JNU has a project section. It's very hard to get the things done easily. Its very difficult to go to Bank and it takes too much time to get a cheque cashed. Why don't JNU ask a bank to start their branch only to deal with Project section and why don't appoint trained chartered accountant to look into these things. We should use the recent developments in science and technology for these day-to-day activities. The time we spend for these bureaucratic procedures perhaps can spend for doing good science...*

One would infer from the above discussed statements that majority of the scientists are satisfied with their organisational structure. They have stated that there are many changes happened in their organisational setting. Majority of the scientists were argued that infrastructure development and availability of funding are the main changes happened with their respective institutions. Scientists are accepting the fact that there are drastic changes happened to them and academic freedom is another important change happened to them. We can read from these statements that the nature of science from a Mode 1 knowledge production to a Mode 2 knowledge production has happened. The examples are multiple roles of scientists, funding from various sources, academic freedom, networking, international collaboration etc. All these show a changing social system of science.

6.7.3 Institutional Support for the Commercialisation of Knowledge

In order to know the institutional support of the scientists to commercialise their knowledge the respondents were asked to tick their preference on a five point scale:

How much importance your institute/ organisation gives for commercialization of knowledge or patent? (Please tick the appropriate item).

5 – Highly Important, 4 – Important, 3- Moderate, 2- Little, 1- No Important.

Table 6.7.3 Scientists on Institutional Support for the Commercialisation of Knowledge

Institute	Highly Important (5)	Important (4)	Moderate (3)	Little (2)	No Important (1)	Total
JNU	-	6 (40%)	7 (46.7%)	2 (13.3%)	-	15
IIT	-	3 (75%)	1 (25%)	-	-	4
NII	2 (50%)	2 (50%)	-	-	-	4
ICGEB	1 (25%)	2 (50%)	1 (25%)			4
NIPGR	-	-	1 (100%)			1
Total	3 (10.71%)	13 (46.43%)	10 (35.71%)	2 (7.15%)	-	28

Source: data from questionnaire

It is clear from the table that 46.43% of the scientists feel that their institute gives *importance* to commercialisation of knowledge and only 10.71% of the scientists felt that their institute gives *high importance* to commercialisation. The 35.71% of the scientists subscribe to the view that their institute gives *moderate* importance to commercialisation and merely 7.15% of the scientists feel that their institute is giving *little importance* to patenting. Not a single scientist says that their institute gives *no importance* to commercialisation of knowledge Most of the scientist from IIT (75%), NII (50%), ICGEB (50%) stated that their institutes are giving due importance to commercialisation or technology transfer. However, only 40% of the scientists from JNU expressed the same answer. The institutional mechanism of the technology transfer in research institutes and IITs are different of a university setting like JNU. For instance in IIT Delhi they have a different unit for the transfer of technology, called Industrial Research and Development Unit. The IRD unit is very active in giving concrete shape to IIT's policies regarding patent issues. Through IRD cell of IIT Delhi is actively involved in collaborative programmes with research projects are under operation with institutes/organisations of Belgium, European Commission, France, Germany, Italy, Japan, Poland, Sweden, Switzerland, and USA. The IRD unit is responsible to provide administrative support and project management for the different types of projects undertaken by faculty members.

The Technology Business Incubator (TBI) has been in active operation, in the Institute since the year 2000. The TBI is conceived, programmed and implemented by the Foundation for Innovation and Technology Transfer (FITT), the industry interface unit of the Institute. FITT is giving all kind of support from legal advice to technology transfer.

NII, ICGEB and NIPGR also have Patent Cells and Technology Transfer units. Through that the scientists are getting proper guidance on technology transfer.

JNU recently started the Intellectual Property Management Cell. Through IPM cell they give proper guidance and help to patent the inventions and give legal advice. They have a legal advisor (patent lawyer), a sociologist of science besides scientists in the IPM cell. Because it is a newly started venture it is not that active as its counterparts in other institutes which we discussed above.

The discussion reveals that even though scientists are not fully satisfied with the institutional support for the commercialisation of knowledge, they are happy with the present environment. We have also seen that almost all the institutes/university have their own technology transfer unit. Some are really old and some are new, some are very much active in technology transfer and patenting and some not that active. Anyhow one thing is clear from the discussion is that there is a new trend of scientific research by establishing these institutional mechanisms is coming up. The institutes/universities are doing research and they also having institutional mechanism to transfer their technology. Even though we cannot call it as an emergence of an entrepreneurial science culture, but partly there is a shift towards economic benefits.

6.8 Mathew Effect in Science: Scientists' Perception.

Mathew effect in science means, the cumulative advantage of more prestigious or elderly scientists. The eminent scientists get disproportionately great credit for their contributions to science while relatively unknown scientists tend to get disproportionately little credit for comparable contributions.[10]

In order to explore the scientits' perception of the Mathew effect in science the present statement were given:

> *"Scientific contribution will have greater visibility in the community of scientists when it is introduced by a scientist of high rank/big institutes than when it is introduced by one who has not yet made his mark."* Do you agree?

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[10] R.K Merton. 1973. *The Sociology of Science: Theoretical and Empirical Investigations*. Chicago: University of Chicago Press. p.443.

Table 6.8 Scientists' Perception of Mathew Effect in Science

Name of the Institution	Yes		No	
	Nos.	%	Nos.	%
JNU	5	33.3%	10	66.7%
IIT	3	75%	1	25%
NII	2	50%	2	50%
ICGEB	2	50%	2	50%
NIPGR	-		1	100%
Total	12	43%	16	57%

Source: data from the questionnaire.

It is clear from the table that 43% of the scientists feel that still Mathew effect is there in the practice of science, but a majority (57%) of the scientists disagrees with the statement.

A senior professor* from JNU stated:

> *...Science is independent of person and country, it is a method and process to convert the natural queries and experiences into information and then knowledge. Charles Darwin's voyage has been a superb model of this. Recent impacts in science have been contributed by small and underdeveloped countries too. Several major breakthroughs in science have come from junior scientists working in the field....*

Similarly another junior scientist from NIPGR expressed:

> *These days, visibility does not depend on nationality as it did earlier. The journal you publish in, together with the quality of your work, decides your citation and scientific impact*

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* Did her PhD and Post Doctoral degrees from USA.

However, another professor from JNU remarked:

> *...As long as your research is path breaking it will get recognized. Yes, many times if a big scientist introduces the contribution it is immediately recognized. Watson and Crick were not big scientists when they announced the DNA structure.....*

A senior well known biotechnologist from JNU viewed:

> *.....If your science is good it will be received by the people working in the area. Most of the reviewers look for the evidence without doubt. Some times in hurry some scientists claim more than they discover, then the reviewer will not accept it. Then these scientists used to say I am from a developing country, say India or from an unknown Institute, that's why they have rejected my paper. This is really sad. You know scientific journals never accept/reject the papers. They will give criticisms, suggestions etc. And as we all know Indians are good in exaggerating the things. Actually international reviewers are unbiased. We cannot question their credibility.....*

Even though many of the scientists disagree with the existence of Mathew effect in science, 43% of the scientists were agreed that Mathew effect is still in practice.

A professor from JNU stated:

> *I agree that scientific contributions will have greater visibility if it is introduced by a scientist from European universities/institutes. It is difficult to get acceptance if you are from a third world country like India*

One can interpret from the table and statements that even though the Mathew effect is still in the field of scientific research its relevance has decreased very much throughout the decades. As we have seen from the table that majority (57%) of the scientists were clearly stated that nationality, experience, institutional background etc. does not matter if the work is original. With the emergence of the globalisation and liberalisation the scientific research is more globalised and application oriented unlike the earlier bureaucratic and stratified system of science. Here the scientists irrespective of nationality, experience etc. are getting due importance. What matters are their research results .One can argue that Mathew effect in science has lost its importance in this new social contract of science.

6.9 Scientists' Perception of the Globalisation and the Changing Role of University

It is a known fact that with the coming of globalization the role of universities has changed in many ways. In order to explore the perception of scientists on globalisation of research the present question were asked:

Do you think with the coming of globalization the hegemonic role of universities/ institutes in knowledge production has changed?

Table 6.9 Globalisation and the Changing role of Universities

Name of the Institution	Yes		No	
	Nos.	%	Nos.	%
JNU	9	60%	6	40%
IIT	3	75%	1	25%
NII	2	50%	2	50%
ICGEB	3	75%	1	25%
NIPGR	1	100%		
Total	18	64.29%	10	35.71%

Source: data from the questionnaire.

The table clearly reflects that a good percentage (64.29%) of scientists feel that with the coming of globalization the role of university has changed. Only 35.71% of the scientists think that there is no such change of universities due to globalization. The university's goals have changed now because of globalization. It is very much global now. A good example is, many European students are coming to various universities/ institutes in India to be part of the academic perform, both as regular students and as casual students and many Indian students are also going to various European universities for the regular programmes or exchange programme. Though the latter is not a new phenomenon but the former is very much new in India. It's all because of the phenomenon of globalization.

A senior professor from JNU stated:

> *....Yes, there are many changes. Universities has to become responsible not only to produce it's own country's future human resource and knowledge power but will be responsible for shaping the whole world, the name 'University' comes to be a real truth. It is a need to create awareness that we are global citizen and responsible for global changes, so required to plan resources and teaching methods under the new situation when interdisciplinary knowledge is a must, even breaking the wall between humanities and science. There are changes ahead in the field of managements of the universities funded by private and government, some will have to deal with the requirements in the immediate skillset whereas some to mentor future human resource....*

Similarly a scientist from NII remarked:

> *Universities/Institutes has become sensitive to needs of society and hence more and more knowledge has started percolating*

Likewise another Research Scientist from JNU viewed:

> *.....With the passage of globalization, modernity and the information age, universities are in search of new identities all over the world. Changes in the education are visible like boundaries between different research areas are diminishing as the research areas are becoming interdisciplinary....*

A senior professor from IIT expressed:

> *The main change due to globalization is that private research centres and R & D of industries are also engaged in research in frontier areas*

Another senior professor from JNU remarked:

> *....It is true that globalization has changed the face of traditional university. For instance the scientists from the US universities have started their own companies. But still knowledge production is part of universities only, not of industries...*

However a scientist from NIPGR argued:

> *Due to globalisation more courses springing up for application based subjects – where students are not taught any basics. And worse – there is a severe shortage of sufficiently qualified teachers in the new subjects*

It is clear from the above discussed statements that the scientists accepted the changing role of universities in a globalized era. Many of the scientists were infavour of the changes happened in the university structure. Many of the scientists argued that the traditional nature of disciplinary science has changed into interdisciplinary research and majority of the scientists accepted the role of private funding and institutes I n this globalized era. A good number of scientists say that given though there are many transformation happened to universities due to the coming up of globalisation, still the role of producing knowledge is with the universities only. The role of university as a knowledge producing factory is still relevant. All these throws light on the emergence of a new nature of university system and it is clear that Indian university/ institutions have also entered into the world of new social contract of universities.

6.10 Scientists' Perceptions of the Public Participation in Science

Nowotny etal., (2001) argued that one outcome of the changes in science is that the sites at which problems are formulated and negotiated have moved from their previous institutional locations in government, industry and universities in to the *Agora* – the public space in which the media is increasingly active, and in which contextualisation occurs. What emerges is a more nuanced, more sociologically sensitive epistemology which is more resilient than the hard core of autonomous self-referential epistemology which scientists have struggled to articulate and to defend. The conception of science has find room for the wide range of people who engage in material scientific activities and are linked in concrete ways to other social spaces in the *agora* that go far beyond laboratory. The knowledge now is socially robust. The activity of science needs legitimacy from various non-scientific actors includes laymen.

In order to know the perceptions of scientists towards the nature of emerging trend of science as a socially robust knowledge, and to know the perception of scientists towards the consideration of social demands into scientific research, the following question was asked:

Do you think it is necessary to take into account the social demands enters the research process, influencing the problem formulation, implementation and evaluation phases?

In response to the question a vast majority of the scientists agreed that it is necessary to take into account the social demands enters the research process influencing the problem formulation, implementation and evaluation phases. The 78.57% of the scientists feel it is necessary to consider the social demands and only a 21.43% of the scientists disagree with it. It shows that the perception of scientists on public participation has changed. The present day scientists are not like the one in the past, whose concept of science was an individual endeavor.

In order to explore more on the issue of public participation of science the following statement was given:

"Scientists require 'legitimacy' from the non-scientific actors like, government NGOs, consumers, laymen etc." What is your comment on this?

When the scientists were given the present statement their response was quite different from the earlier responses on social demands in scientific research. Majority (42.86%) of the scientists feel that scientists does not requires legitimacy from the non-scientific actors. It shows the existence of the old concept of science as a special activity among the scientists. Even though the attitude of scientists towards the participation of non-scientific actors in research has changed as we have seen in table in the last section, but the hegemonic concept of science as a special expertise or knowledge still exists among the Indian scientists. Only 35.7% of the scientists feel scientists requires legitimacy from the non-scientific actors.

As a senior scientist from NII remarked:

> *.....At the end of the day we are answerable to the society at large. We should be able to articulate our scientific problems in such a way that laymen should be able to understand and appreciate our effects.....*

Similarly a senior professor from JNU remarked:

> *....Scientists like all others require legitimacy from the funding agency and society, the rules and ethics are to be followed the same....*

Likewise a research scientist from JNU argued:

> *Certain areas of research like promoting sustainable development through innovative research projects should be designed to involve societal actors and aim at the combined knowledge generation and at influencing societal developments into the direction of sustainable development*

Whereas another scientist from NII stated:

> *....One should not be bothered what others say if they are not in position to judge your work.....*

Similarly a junior professor from JNU stated:

> *....All great discoveries in science were not made because they were legitimized by society. Great science is driven by the curiosity of a scientist and an open mind and the scientist should be left alone to do that......*

Likewise a scientist from NIPGR expressed:

> *...Consumers and laymen are not fit to decide. There must always be a committee of scientific peers to convey the laymen's concerns in a proper manner...*

Above two kinds of statements on the public participation of science are discussed and one would infer from the discussion that even though the scientists' attitude towards public has changed but still there exists a hegemony of scientists. This can be observed from the above discussion. Many scientists have the opinion that public cannot understand scientific expertise so there is no meaning of including laymen as part of scientific research. Many argued that laymen are not fit to decide what research they need. It seems scientists of India don't want to make public participation in their research. Scientists have the belief that whatever they are doing is going to benefit public only so there is no point to consider laymen's views before starting research or finalizing the research agenda or project. One can say from this discussion that the concept of *Agora* is not that relevant in the Indian setting, because scientists haven't developed that notion and even the public does not have the proper understanding of the expertise which the scientists are working on.

From a sociological analysis we can say that the western concept of *Agora* or public participation of science is not relevant to Indian setting and it is difficult to use the framework in a society which is entirely different from the western society. Public participation of science is possible in the European setting because of the universal education or 'massification of education'and the development and accessibility of media. Public can participate and discuss about an issue, for example GM foods, because they have the basic knowledge of the problem. The Indian case is different, where the number of illiterates is very high and majority of the Indians are living in the rural areas. The accessibility of mass media is very poor in the rural areas. The basic problem is lack of awareness on an issue. In order to participate or discuss about a scientific problem there should be a basic understanding of that problem. Otherwise only for the sake of participating does not make any sense. Even though there are many NGOs and government organizations working on public understanding of science and scientific communication their work haven't reached the needy yet. Perhaps by giving proper awareness and high literacy the problem can be solved. So it is true that the concept of *Agora* or public legitimacy has limitations. So it is clear from the discussion that the concepts of Agora/Public participation of science has less relevance in the Indian setting because of many sociological reasons.

6. 11 Scientists and University Patenting in India

The Government of India plans to introduce a Public Funded R and D Projects (Protection of Intellectual Property) Bill. If it is enacted, it would enable and encourage recipients of government funding to patent and license the results of their research. This in turn, would provide incentives for those recipients to work with industry players to commercialise the basic research, turning it into products and services that benefit the population at large, driving economic growth, employment, foreign direct investment, and tax revenues. The Bill, if enacted, will spur economic development in the technology sector by creating a system that facilitates commercialisation of government funded research leading to new products and services for consumers and businesses and resulting economic growth. It does by establishing the general rule that recipients of government funding can patent resulting inventions, and licenses them to businesses.

The opponents of the Bill came with various criticisms. Some of the important criticisms are i) patenting the inventions results in an additional "tax" that citizens have to pay to use inventions they have already paid for with their taxes, ii) If research institutions can patent government, funded inventions and provide exclusive licenses to private sector entities, then the government loses control over the inventions and there is no guarantee that they will be commercialized, iii) The proposed legislation will change the focus of *university research* from academic inquiries towards commercial pursuits, reducing the amount of pure basic research being conducted, iv) The proposed legislation merely imitates U.S. law (Bay Dole Act) and will increase the IP stranglehold on innovation.[11] These are some of the criticisms of the proposed bill.

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[11] The researcher participated in a panel discussion on Public Funded R & D (Protection, Utilization and Regulation of Intellectual Property) Bill, presided by Mr. Kabil Sibal, the Hon.Minister for Science and Technology, Government of India and S.K. Brahmachari, Chief of CSIR, held on 16th Oct. 2008, FICCI, New Delhi.

In order to explore the scientists' perception on this bill, the present question was asked:

The government of India is planning to introduce 'Public Funded R and D (Protection, Utilization, and Regulation of IP) Bill. What is your opinion on this bill?

In response to the question a vast majority of 89.29% of the scientists feel that the Bill is the need of the hour. The scientists are very much supportive of the proposed bill. It indicates the scientists changing attitude from research is only for the sake of research. Only 10.71% of the scientists are of the opinion that bill is not good in the Indian context. It is clear from the discussion that majority of the scientists are having positive attitudes towards the bill. Many of the scientists argued that the patenting bill, if it enacted will make researchers in university to be productive and accountable.

A senior scientist from ICGEB stated:

> *The bill is most appropriate. Indian Universities/Institutes should be allowed to get patent from the public funded research. The scientist should be aware of the importance of his/her own work. In case something can be used for the benefit of the country the work in the universities is supported by public fund and if a scientist can give back economically to the Government; it will be his valuable contribution in addition to generating new knowledge*

Similarly a scientist from NII expressed:

> *....It is a good idea. If any research done by any scientist has commercial implications, it would be a good idea to get a patent. Such kind of incentives promotes excitement not only among the scientists involved but also among the students. If any monetary gains come out of such patent, university, scientist and research scholars all should share the money....*

Likewise a senior professor from JNU stated:

> *...It would help in emphasizing the pre eminent role of universities as centres for generating knowledge and would also help the universities and scientists financially....*

Another scientist from IIT remarked:

> *It is a good initiative. Many quality researches from universities remain enclosed within the pursuit of scientific publications. While in the absence of public funded R & D Bill, these research inputs are utilized by foreign researchers to patent a product, Indian scientists in spite of giving intellectual input gets barred from getting the returns*

Another Senior Professor from JNU viewed:

> *....I have not read the bill completely yet. But I think there should be ownership for the inventor. Government should allow the inventor to create companies like in USA. Government can collect tax from this. I am arguing for this....*

However a research scientist from JNU stated:

> *The bill in the present form has some ambiguities. Currently researchers in some autonomous institutions can commercialize their research, the patent rights are largely held by the Government. If a dispute on the ownership arises, there is no law to protect the rights of the researchers. The bill however says researchers have to make an attempt to commercialize the research in 90 days after formally disclosing the findings. It they fail, the rights will go to the government. Quite absurd!*

From the above discussion it is clear that Indian scientists are very much supportive of the proposed university patenting Bill. Only a 10.71% of the scientists didn't support the proposed bill. One would infer from the discussion that Indian scientists have positive attitude towards the proposed bill on University Patenting, i.e. *Pubic Funded R & D (Protection, Utilization, and Regulation of Intellectual Property) Bill.*

From the sociology of science perspective it is necessary to analyse the scientists' perceptions of the after effects of the commercialisation of university research. In order to explore that the present question were asked:

Don't you think the proposed legislation will change the focus of university research from academic inquiries towards commercial pursuits, reducing the amount of pure research being conducted?

In response to the question a majority of 82.14% of the scientists says that the proposed bill will not reduce the development of pure sciences .They believe that the proposed legislation won't change the focus of university research from academic inquiries towards commercial pursuits. Only a 17.86% of the scientists are of the opinion that the proposed bill be affecting pure science research.

A senior professor from JNU argued:

> *No, it requires high amount of quality basic research developed in the lab to translate them into applied research, also commercial research is highly accountable and not many researcher will be interested to pursue that time bound work. Actually the proposed Bill legislation will increase the accountability in research funding which is presently almost none*

Though scientists are in favour of the proposed legislation, they feel that the legislation does not reduce the importance of basic research. Many scientists argued that they need quality basic research to do applied research. Although the scientists have a positive attitude towards the bill they don't think that the proposed Bill will change the focus of university research from academic inquiries towards commercial pursuits and they don't think it will reduce the importance of basic research. Here too the hidden existence of old contract of science is felt, where the importance of basic science research is high.

Conclusion

The major objective of the present study *'to explore the relevance of old and new social contract to the field of biotechnology through the orientation of scientists in Delhi region'* is discussed in this chapter. The chapter analysed the statements and opinions of scientists on various issues. The chapter confirmed that there are limitations in the emerging social contract of science when it applied to Indian setting. It is also confirmed that some aspects of old ethos of science still hold relevance in the Indian setting. It explained in detail various components of *Mode 2* knowledge production like, flexibility in research, collaborative research, transdisciplinarity, changing role of scientists etc., and proved that Indian biotechnologists have accepted the norms of new social contract of science, though not fully. And it discussed the relevance of the old contract of science, such as the norm of communism, importance of publications, existing peer review system, basic research etc. and proved that some aspects of old contract of science still holds relevance in the Indian setting. It also discussed changes in the organisational structure of scientists, institutional support of commercialisation of knowledge, globalization of science, Mathew effect, participation of science etc. It also confirmed that the emerging concepts of *agora/* public participation of science have less importance in the Indian social milieu.

Another important theme discussed in this chapter is the perception of the Indian scientists towards the proposed new bill on university patenting in India. It is confirmed that majority of the scientists are in favour of the proposed Bill. In sum there is a basic change in the orientation of scientists from advancing knowledge to commercialisation of research. Although not that radical change like its European counterparts, the discussion confirmed that Indian biotechnologists are doing research in a *Mode 2* or *Post academic* research environment.

Chapter 7

Conclusion

The present study is conducted to understand the relevance of the old and new social contract of science in the context of Biotechnology in the Delhi region, India. It is true that the nature of the system of science is said to be in transformation phase. It is evident from the various European and some East Asian countries that old contract between science and society which is generally guided by Mertonian ethos of science is losing its relevance in the context of emerging globalisation phenomenon particularly with the rise of private and corporate investments in science and especially in biotechnology. Bruno Latour had rightly pointed out that in the last century and a half scientific development has been breath taking. But the understanding of this progress has dramatically changed. It is characterized by the transition from the *culture of science* to the *culture of research.*[1] Krishna's studies in the Indian context have also finds the change from science as *part of culture* to *part of commerce*[2]. However, this does not mean that the existing or the *old* social contract is 'dead' in the context of the emerging *new* one. The former continues to draw its relevance to draw its relevance for a number of societal tradition bound factors. However this depends on the context and place.

In the old contract, science was expected to produce *reliable* knowledge, and communicate its discoveries to society. The new contract ensures that scientific knowledge is *socially robust* and its production is both transparent and participative. In the old contract, science is very much homogeneous and disciplinary in nature. But in the new contract it is heterogeneous and transdisciplinary in nature.As we explored in earlier chapters the old nature of science was very much rigid in character, but the new one is very much flexible. Research activities now transcend the immediate context of application, anticipate and engage reflexively with further entanglements,

1 Bruno Latour. 1998. From the World of Science to the World of Research. *Science*: 280. p.208.
2 Krishna V V.2007. Globalisation and Changing Social Contract between Science and Society :Some Implications. Lecture delivered at the Asian Studies Centre, University of Pittsburgh, 22nd October, USA.

consequences and impacts it generates. The old image of science as a personal activity does no longer exist. The new contract of science is possible only with collaborative research and the extension of the research sites. The present study reveals that among the biotechnologists in the Delhi region ,national and international collaboration is an accepted norm .The practice of some of the norms of new contract like flexibility of research,transdisciplinary research etc are practised among the biotechnologists in the Delhi region.

The present study to a large extent confirms that the orientation of the scientists in Delhi region, India is different from the European counterparts, where entrepreneurial science is an accepted norm. Indian scientists still have a psychological inclination towards the old system of science and research.

However, the empirical study confirms that some components of the new social contract of science like flexibility in research, collaborative research, changing role of scientists etc. is very much relevant in the Indian setting. Majority of the scientists have the opinion that all the above mentioned components are very necessary part of the present day research in science. It is also true that all those components of new social contract of science are not applicable in the Indian setting. The present empirical study confirmed that majority of the scientists are doing some sort of collaborative research because they believed that collaboration is must to do research, especially in the field of biotechnology. It shows the changing nature of science from an individual endeavour to a team work. The first hypothesis of the study, *to some extent biotechnologists in the Delhi region have accepted the norms of new contract of science,* is confirmed here.

The analysis of the empirical study also revealed that some aspects of the old contract of science or Mertonian ethos are very much relevant in the Indian setting. The study indicates that majority of the scientists believed in the old model of reward system. University as a place for teaching and advancing knowledge is still important to the Indian scientists. Majority has the opinion that university should give more importance to basic research, which is one of the important characteristic of the old contract of science.

From the empirical study it is clear that the old system of peer review is very much acceptable to Indian scientists .Majority of them believe in the old system of *peer review*. One important finding arising out of the present study is that although scientists now do seem to be positively oriented to commercialisation of knowledge, they continue to assign equally high importance to publications compared to patenting. It showed that Indian scientists are still attached to some components of the old contract of science like publications, reward system, etc. The second hypothesis of the present study, *some components of the old social contract like peer review publication, reward system etc. are still relevant in the Indian setting* is confirmed here.

Regarding the perception of scientist towards the organisational structure, most of them are satisfied with the organisational structure. However, many of them had opinion that there is room for further improvement. It also noticed that many changes have taken place in the organisational structure. For example IPM Cells, technology transfer units, incubators etc are started in many institutions. However, most of them stated that infrastructure development and availability of funding are the main changes that have taken place in their institutions. They have also a feel that compared to earlier periods there are more academic freedom is now. All these facts perhaps indicate the emergence of a new contract of science.

The study observed the emerging concepts of *Agora* or public participation of science has limitations in the Indian context. The majority of the scientists have the impression that legitimacy from the non-scientific actors is not essential. Even though some of them argued that it is necessary to take into account the social expectations during the research process, they don't want any kind of participation from the public. Perhaps perception of scientists on the public participation of science is negative. The study indicates that the concept of *Agora/* public participation is not completely applicable in a developing country like India. In order to develop an *Agora* one has to improve the awareness level of the public through the massification of education like in the West. Without the massification of education and awareness the idea of Agora or public participation would be a utopian concept in the Indian setting. The third hypothesis of the study, *the emerging concepts of Agora/ public participation of science has limitations in the Indian context* is confirmed here.

Sardana and Krishna's study on the applicability of *Triple Helix* in the Delhi region found that almost all public sector research institutes and universities had links with other institutes/universities either at national or international level, but there were hardly any formal partnerships with a company in the Delhi region[3]. It means the bilateral linkages and partnerships-between government and public sector research institutions, including universities is more relevant and meaningful than tripartite relationships. The present study also confirmed that all the features of new contract of science are not relevant in the Indian context. At the same time it is also clear from the study that many of the characteristics of the old contract of science are also losing their relevance in the Indian setting. There exists a mixture of the both old and new contract of science in India. Some components of the old and new contract of science are going together in the Indian context and perhaps growing simultaneously

Another important finding raised out of the study is that the majority of the scientists are very much supportive of the new proposed bill on university patenting in India. The Government of India is planning to introduce a Public Funded R&D Projects (Protection, Utilization and Regulation of Intellectual Property) Bill. The Bill, if enacted, would enable and encourage recipients of government –funding to patent and license the results of their research. This, in turn, would provide incentives for those recipients to work with industry players to commercialise the basic research, turning it into products and services that benefit the population at large, driving economic growth, employment, foreign direct investment, and tax revenues. The basic objective of the proposed Bill is to enable the research institutions to patent government- funded inventions. Once research institutions have the right to patent inventions resulting from the government funding, they can then license them to business and receive royalties that fund could support the further research and education and enabling businesses to invest in commercialising the research.

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3 Deepak Sardana and V.V Krishna.2006.Government, University and Industry Relations: the Case of Biotechnology in Delhi Region. *Science, Technology & Society* 11(2):p 369

The study shows that the scientists supported the Bill and they are of the opinion that the Bill is the need of the hour. It shows the changing inclination of scientists towards the notion of 'science as a private good or market good'. Although, the scientists support the Bill they argued that the implementation of the Bill won't affect the importance of pure science research. According to them, university patenting does not mean that the nature of knowledge is going to be a market good, but it will give encouragement to the scientists by accepting their invention. Hence it is clear from the study that the scientists are supportive of the public funded R&D (Protection, Utilization and Regulation of Intellectual Property) Bill. The empirical study confirmed the fourth and the last hypothesis of the present study, *Indian biotechnologists have positive attitude towards the new proposed Bill on University patenting in India.*

The study reveals that all characteristics of new contract of science are not relevant in the Indian context and it also confirms that all those traditional Mertonian notion of science too are not relevant in the Indian setting. Some components of the new contract of science and some of the old contract are go side by side in the Indian setting .The study theorises that in the Indian context there exists a hybrid form of scientific research, where some features of the old contract of science and some characteristics of the new contract of science co-exist.. Unlike the European counterparts, where all the components of the New contract of science are an ongoing practice, the Indian situation is quite different. It still gives importance to some of the features of old system of science too. A hybrid form of the *Old* and *New* contract of science is more evident from the Indian setting. However it is clear from the study that only few features of the Old contarct of science like reward system, peer review, high importance to publications et; are relevant in the Indian setting, but many features of New contract of science like collaborative research,transdisciplinary research, flexibility in research etc; are gradually accepted and relevant in the Indian setting. In sum, the scientific research in India, particularly biotechnological research is in transformation from a *Mode 1/academic science culture* to a *Mode 2/Post academic science culture.*

Bibliography

Books

Ben-David, Joseph. 1979. *The Scientist's Role in Society: A Comparative Study.* New Jersey: Prentice-Hall, Inc.

Bernal, J.D. 1946. *The Social Function of Science.* London: George Routledge & Sons Ltd.

Bernal, J.D. 1969. *Science in History* (Vol.1). Harmondsworth: Penguin Books.

Blume, Stuart S., ed. 1977. *Perspectives in the Sociology of Science.* New York: John Wiley & Sons.

Bush, Vennevar. 1945. *Science: The Endless Frontier.* Washington, D.C.: Public Affairs Press.

Cardwell, D.S.L. 1957. *The Organisation of Science in England.* London: Heinemann.

Chaturvedi, Sachin and Rao, S.R., eds. 2004 *Biotechnology and Development: Challenges and Opportunities for Asia.* New Delhi: Academic Foundation.

Cotgrove, Stephen and Box, Steven. 1970. *Science, Industry and Society: Studies in the Sociology of Science.* London: George Allen and Unwin Ltd.

Cozzens, S.E, Healey P, Rip, Arie and Ziman, John eds. 1990. *The Research System in Transition.* New York: Kluwer Academic Publishers.

Dear, Peter. 2001. *Revolutionizing the Sciences: European Knowledge and Its Ambitions, 1500-1700.* Hampshire: Palgrave.

Einstein, Albert. 1935. *The World As I See It.* London: John Lane.

Erickson, Mark. 2005. *Science, Culture and Society: Understanding the Science in the Twenty-First Century.* Cambridge: Polity Press.

Etzkowitz, Henry, Schuler Jnr. E., and Gulbrandsen, M. 2000. "The Evolution of the Entrepreneurial University". In Jacob, M., Hellstorm, T. eds. *The Future of Knowledge Production in the Academy.* Buckingham: Open University Press, pp.40-60.

Etzkowitz, Henry. 2002. *MIT and the Rise of Entrepreneurial Science.* London: Routledge.

Feuer, L. 1963. *The Scientific Intellectual.* London: Basic Books.

Fuller, Steve. 2000. *The Governance of Science: Ideology and the Future of the Open Society.* Buckingham: Open University Press.

Fuller, Steve. 2006. *The Philosophy of Science and Technology Studies.* New York: Routledge.

Fuller, Steve. 2007 *New Frontiers in Science and Technology Studies.* Cambridge: Polity Press.

Gaston, J. 1978. *The Reward System in British and American Science.* New York: Wiley – Inter Science.

Geiger, R.L. 2004. *Knowledge and Money: Research Universities and the Paradox of the Marketplace.* Stanford: Stanford University Press.

Geuna, Aldo, Salter, A.J. and Steinmueller, W.E. 2003. *Science and Innovation: Re-thinking the Rationale for Funding and Governance.* Northampton, M.A.: Edward Elgar Publishing.

Gibbons, Michael and Wittrock, Bjorn; ed. 1985. *Science as a Commodity: Threats to the Open Community of Scholars.* Essex: Longman Group Limited.

Gibbons, Michael, Limoges, C, Nowotny, H, Schwartzman, S, Scott, P, and Trow, M. 1994. *The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies.* London: Sage.

Gibbons, M, Limoges, C, Nowotny, H, Schwartzman, S; Scott, P, and Trow, M. 2005. "Evolution of Knowledge Production". In Smith, Mark J., eds. Philosophy and Methodology of the Social Sciences – Vol.III, *Scientific Knowledge as a Social Product.* London: Sage, pp.169-200.

Gillispie, Charles. 1990. *The Edge of Objectivity: An Essay in the History of Scientific Ideas.* Princeton: Princeton University Press.

Govind, Madhav. 2006. *Sociology of Science: Normative Dimensions, Community Life and Cultural Orientation of Scientists.* New Delhi: Anmol Publications.

Haberman, Jurgen. 1989. *The Structural Transformation of the Public Sphere: An Inquiry into a Category of Bourgeoisie Society.* Cambridge: Polity Press.

Hacket, Edward J., Amsterdamska, Olga; Lynch, Michael and Wajcman, Judy; eds. 2008. *The Handbook of Science and Technology Studies*, 3rd edn. Massachussetts: MIT Press.

Hughes, Thomas P. 1998. *Rescuing Prometheus.* New York: Pantheon Books.

Ilyin, Viktor and Kalinkin, Anatoli. 1985. *The Nature of Science: An Epistemological Analysis*. Moscow: Progress Publishers.

Irwin, Alan. 1995. *Citizen Science: A Study of People, Expertise and Sustainable Development*. London: Routledge.

Knorr-Cetina, K.D. 1981. *The Manufacture of Knowledge: An Essay on the Constructivist and Contextual Nature of Science*. Oxford: Pergamon Press.

Kumar, Deepak. 2006. *Science and the Raj: A Study of British India*. New Delhi: Oxford University Press.

Leach, Melissa; Scoones, Ian and Wynne, Brian. 2007. *Science and Citizens: Globalisation and the Challenge of Engagement*. New Delhi: Orient Longman.

Lyotard, Jean-Francois. 1979. *The Postmodern Condition: A Report on Knowledge*. Manchester: Manchester University Press.

Mallick, Sambit. 2008. Changing practices in/ of Science: The Context of Intellectual Property Rights in India. *Scientific Commons* 3: 1-12.

Mallick, Sambit. 2009. Review Article/ The Political Economy of Agricultural Biotechnology in India. *Social Scientist* 37(3-4): 52-63.

Manheim, Karl. 1929. *Ideology and Utopia*. New York: Harcourt, Brace.

Marshall, Gordon. 2005. *Oxford Dictionary of Sociology*. New York: Oxford University Press.

Merton, Robert K. 1968. *Social Theory and Social Structure*. Glencoe: Free Press.

Merton, Robert K. 1973. *The Sociology of Science: Theoretical and Empirical Investigations*. Chicago: The University of Chicago Press.

Merton, Robert K. 1996. *On Social Structure and Science*. Chicago: The University of Chicago Press.

Nowotny, Helga, Scott, Peter and Gibbons, Michael. 2001. *Re-Thinking Science: Knowledge and the Public in an Age of Uncertainty*. Cambridge: Polity Press.

Parsons, Talcott. 1951. *The Social System*. Glencoe: Free Press.

Pelz, Donald C and Andrews, Frank M. 1966. *Scientists in Organizations: Productive Climates for Research and Development*. New York: John Wiley and Sons, Inc.

Philips, Bernard. 1982. *Social Research Strategy and Tactics*. London: Macmillan Publishing Co.

Pledge, H.I. 1947. *Science since 1500*. London: H.M. Stationary Office.

Price, Derek J.De Solla. 1963. *Little Science, Big Science*. New York: Columbia University Press.

Radhika, Ramasubban. 1977. "Towards a Relevant Sociology of Science for India". In Blume, ed. *Perspectives in the Sociology of Science*. New York: John Wiley and Sons. pp.155-193.

Ravetz, J.R. 1971. *Scientific Knowledge and Its Social Problems*. Oxford: Clarendon Press.

Ravetz, J.R. 1973. "Tragedy in the History of Science. In Teich, M. and Young, R., ed. *Changing Perspective in the History of Science*. London: Heinemann.

Rose, Hilary and Rose, Steven. 1969. *Science and Society*. London: The Penguin Press.

Shapin, Steven. 1996. *The Scientific Revolution*. Chicago: The University of Chicago Press.

Singh, H.K.1978. *Science and Our Age*. New Delhi: Allied Publishers.

Sismondo, Sergio. 2004. *An Introduction to Science and Technology Studies*. Oxford: Blackwell.

Sklair, Leslie, I.L. 1973. *Organized Knowledge: A Sociological View of Science and Technology*. London: Hart Davis, MacGibbon.

Slaughter, Sheila and Leslie. 1997. *Academic Capitalism: Politics, Policies and the Entrepreneurial University*. Baltimore: The John Hopkins University Press.

Snow, C.P. 2006. *The Two Cultures*. Cambridge: Cambridge University Press.

Sprat, Thomas. 1959. *History of the Royal Society*. London: Routledge.

Stehr, Nico. 1978. "The Ethos of Science Revisited". In: Jerry Gaston ed. *The Sociology of Science*. San Francisco, CA: Jossey-Bass.

Stehr, Nico. 2005. *Knowledge Politics*. London: Paradigm Publishers.

Storer, Norman W. 1966. *The Social System of Science*. New York: Holt, Rinehart and Winston.

Uberoi, J.P.S. 1991 *Science and Culture* (3rd edn.). New Delhi: Oxford University Press.

Viswanathan, Shiv. 1985. *Organisation of Science: The Making of an Industrial Laboratory*. New Delhi: Oxford University Press.

Viswanathan, Shiv. 2007. "The Rise of Industrial Research". In Habib, Irfan S and Raina, Dhruv eds.*Social History of Science in Colonial India*. New Delhi: Oxford University.

Wagner, Wendy E. and McGarity, Thomas O. 2008. *Bending Science: How Special Interests Corrupt Public Health Research*. Harvard: Harvard University Press.

Web, M.D. 2008. *Webster's New World Medical Dictionary* (3rd edn.). New Jersey: Wiley Publishing Inc.

Weber, Max. 1989. "Science as a Vocation". In Lassman, P., Valody, I., and Martins, H. ed. *Max Weber's 'Science as a Vocation'*. London: Unwin Hyman. pp.3-31.

Whitehead, A.N. 1938. *Science and the Modern World*. Harmondsworth: Penguin Books.

Wilson, John T. 1983. *Academic Science, Higher Education and the Federal Government, 1950-1983*. Chicago: The University of Chicago Press.

Woolgar, Steve. 1988. *Science: The Very Idea*. London: Tavistock Publications.

Ziman, John. 1968. *Public Knowledge*. Cambridge: Cambridge University Press.

Ziman, John. 1976. *The Force of Knowledge: The Scientific Dimension of Society*. Cambridge: Cambridge University Press.

Ziman, John. 1978. *Reliable Knowledge: An Exploration of the Grounds for Belief in Science*. Cambridge: Cambridge University Press.

Ziman, John. 1984. *An Introduction to Science Studies: The Philosophical and Social Aspects of Science and Technology*. Cambridge: Cambridge University Press.

Ziman, John. 2000. *Real Science: What It Is, and What It Means*. Cambridge: Cambridge University Press.

Articles

Arocena, Rodrigo and Sutz, Judith. 2001. Changing Knowledge Production and Latin American Universities. *Research Policy* 30: 1221-1234.

Berman, Elizabeth Popp. 2008. Why did Universities Start Patenting?: Institution-Building and the Road to the Bayh-Dole Act. *Social Studies of Science* 38(6): 835-871.

Boarman, Craig P. 2008. University Research Centres and the Composition of Research Collaborations. *Research Policy* 37: 900-913.

Broesterhuizen E and Rip, Arie. 1984. *No PLACE for CUDOS?. EASST Newsletter* 3(3): 5-8.

Bud, Robert. 1991. Biotechnology in the Twentieth Century. *Social Studies of Science* 21: 416-418.

Bush, Vennevar. 1945. The Endless Frontier. *Transactions of the Kansas Academy of Sciences* 48(3): 231-264.

Cannavo, Leonardo. 1997. Sociological Models of Scientific Knowledge. *International Sociology* 12(4): 475-496.

Chaturvedi, Sachin. 2005. Developments in Biotechnology: International Initiatives, Status in India and Agenda before Developing Countries. *Science, Technology & Society* 8(1): 73-99.

Chubin, Daryl E. 1985. Open Science and Closed Science: Tradeoffs in a Democracy. *Science, Technology & Human Values* 10(2): 73-81.

Coban, Aykut. 2008. Genomic Information and the Public-Private Imbalance. *Capital & Class* 94: 71-105.

Cole, Stephen. 2004. Merton's Contribution to the Sociology of Science. *Social Studies of Science* 34(6): 829-844.

Cook-Deegan, Robert. 2007. The Science Commons in Health Research: Structure, Function and Value. *Journal of Technology Transfer* 32: 133-156.

Cotgrove, Stephen. 1970. The Sociology of Science and Technology. *British Journal of Sociology* 31(1): 1-13.

Crompton, Helen. 2007. Mode 2 Knowledge Production: Evidence from Orphan Drug Networks. *Science and Public Policy* 34(3): 199-211.

Desai, Pranav N. 2005. Challenges of Agro-Biotechnologies, Intellectual Property Rights and Globalization. *Asian Biotechnology and Development Review* 7(2): 91-107.

Dickson, David. 2000. Science and Its Public: The Need for a Third Way. *Social Studies of Science* 30(6): 917-923.

Dingle, H. 1949. Science and Professor Bernal. *Science Progress* 146: 50-61.

England, Merton J. 1976. Dr.Bush Writes a Report. *Science* 191 (4222): 41-47.

Etzkowitz, Henry and Leydesdorff, L. 1998. The Endless Transition: A "Triple Helix" of University-Industry-Government Relations. *Minerva* 36(31): 203-208.

Etzkowitz, Henry and Leydesdorff, L. 2000. The Dynamics of Innovation: From National Systems and "Mode 2" to a Triple Helix of University-Industry-Government Relations. *Research Policy* 29(2): 109-123.

Fabrizio, Kira R. 2008. Commercialising the Laboratories: Faculty Patenting and the Open Science Environment. *Research Policy* 37: 914-931.

Fan, Peilei. 2008. The rise of the Indian Biotech Industry and Innovative Domestic Companies. *International Journal of Technology and Globalization* 4(2): 148-169.

Frodeman, Robert and Mitcham, Carl. 2000. Beyond the Social Contract Myth. *Issues in Science and Technology*, Publication of Institute of Medicine, University of Texas at Dallas. Available at http://www.issues.org/16.4/p_frodeman.htm. (Accessed on September 10, 2008).

Fischer, Frank and Mandell, Alan. 2009. Michael Polanyi's Republic of Science: The Tacit Dimension. *Science as Culture* 18(1): 23-46.

Funtowicz, Silvio and Ravetz, Jerry. 1993. Science for the Post-normal Age. *Futures* 25: 735-755.

Funtowicz, S. and Craye, M.; Slujis, Jeroen Van de. 2005. A Reflexive Approach to dealing with Uncertainties in Environmental Health Risk Science and Policy. *International Journal of Risk Assessment and Management* 5(2): 216-236.

Gallopin, G.C., Funtowicz, S., O'Connor, Martin and Ravetz, Jerry. 2001. Science for the Twenty First Century: From Social Contract to the Scientific Core. *International Journal of Social Science*, UNESCO 168: 219-229.

Gaskell, George, 2004. Science Policy and Society: The British Debate Over GM Agriculture. *Current Opinion In Biotechnology* 15: 241-245.

Gibbons, Michael. 1999. Science's New Social Contract with Society. *Nature* 402 (C81): 11-18.

Gulbrandsen, Magnus and Langfeldt, Liv. 2009. In Search of 'Mode 2': The Nature of Knowledge Production in Norway. *Minerva* 42 (3): 237-250.

Haribabu, E. 1991. A Large Community but Few Peers: A Study of the Scientific Community. *Sociological Bulletin* 40 (1 & 2): 78-87.

Haribabu, E. 1999. Scientific Knowledge in India: From Public Resource to Intellectual Property. *Sociological Bulletin* 48 (1 & 2): 217-233.

Haribabu, E. 2004. Interests and Meanings: The Socio-Technical Process of Application of Biotechnology to Crop Improvement in India. *International Journal of Biotechnology* 6(1): 65-78.

Hessels, Laurens K and Lente, Harro Van. 2008. Re-thinking New Knowledge Production: A Literature Review and A Research Agenda. *Research Policy* 37: 740-760.

Hucks, Diana M. and Katz, J.S. 1996. Where is Science Going?. *Science, Technology & Human Values* 21(4): 379-406.

Jasanoff, Sheila. 2004. Science and Citizen: A New Synergy. *Science and Public Policy* 31(2): 90-94.

Jong, Simcha. 2008. Academic Organisation and New Industrial Fields: Berkeley and Stanford and the Rise of Biotechnology. *Research Policy* 37: 1267-1281.

Kellogg, David. 2006. Towards a Post-Academic Science Policy: Scientific Communication and the Collapse of the Mertonian Norms. *International Journal of Communications Law & Policy*, Autumn Issue.

Konde, Viren. 2008. Biotechnology in India: Public-Private Partnerships. *Journal of Commercial Biotechnology* 14(1): 43-55.

Krishna, V.V., Waast, Roland and Gaillard, Jacques. 2000. The Changing Structure of Science in Developing Countries. *Science, Technology & Society* 5(2): 209-224.

Krishna, V.V. 2001. Reflections on the Changing Status of Academic Science in India. *International Journal of Social Science*, UNESCO 168: 231-245.

Krishna, V.V. 2001. Changing Policy Cultures, Phases and Trends in Science and Technology in India. *Science and Public Policy* 28(3): 179-194.

Latour, Bruno. 1998. From the World of Science to the World of Research? *Science* 280: 208-9.

Law, John. 2008. On Sociology and STS. *The Sociological Review* 56(4): 623-649.

Lee, Sooho. 2005. New Production of Knowledge on Scientific Productivity. *Social Studies of Science* 35(5): 703-720.

Lee, Yang S. 1996. Technology Transfer and the Research University: A Search for the Boundaries of University-Industry Collaboration. *Research Policy* 25: 843-863.

Locke, Simon. 2001. Sociology and the Public Understanding of Science: From Rationalization to Rhetoric. *British Journal of Sociology* 52(1): 1-18.

Lubchenco, Jane. 1998. Entering the Century of the Environment: A New Social Contract for Science. *Science* 279: 491-497.

Maasen, Sabine. 2006. Transdisciplinarity: A New Mode of Governing Science?. *Science and Public Policy* 33 (6): 399-410.

Mansfield, Edwin. 1996. Modern University: Contributor to Industrial Innovation and Recipient of Industrial R & D Support?. *Research Policy* 25: 1047-1058.

Mashelkar, R.A. 2002. Economics of Knowledge. *Current Science*. Available at http://www.ias.ac.in/currsci/jul25/articles14.htm. [Accessed on September 26, 2008].

Mehta, Anita. 2008. Science Research in India: Universities, Research Institutes and Everything In-between. *Economic and Political Weekly* XLIII (41): 67-69.

Merton, Robert K. 1938. Science, Technology and Society in the Seventeenth Century England. *Osiris* 4: 360-632.

Mulkay, Michael. 1980. Sociology of Science in the West. *Current Sociology* 28(3): 1-116.

Nelson, Richard R. 2001. Observations on the Post-Bayh-Dole Rise of Patenting at American Universities. *Journal of Technology Transfer* 26: 13-19.

Nowotny, Helga. 1999. The Place of People in Our Knowledge. *European Review* 7: 247-62.

Nowotny, Helga. 2000. Transgressive Competence: The Changing Narrative of Expertise. *European Journal of Social Theory* 3(1): 5-21.

Nowotony, Helga. 2000. The Production of Knowledge Beyond the Academy and the Market: A Reply to Dominique Pestre. *Science, Technology & Society* 5(2): 183-194.

Nowotny, Helga, Scott, Peter and Gibbons, Michael. 2003. Mode 2 Revisited: The New Production of Knowledge. *Minerva* 41(3): 179-194.

Nowotny, Helga. 2003. Democratising Expertise and Socially Robust Knowledge. *Science and Public Policy* 30(2): 151-156.

Nowotny, Helga. 2006. Real Science is Excellent Science – How to Interpret Post-Academic Science, Mode 2 and the ERC. *Journal of Science Communication* 5(4): 1824-1929.

Oliver, Amalya. 2004. Biotechnology Entrepreneurial Scientists and Their Collaboration. *Research Policy* 33: 583-597.

Packer, Kathryn and Webster, Andrew. 1992. Patenting Culture in Science: Re-inventing the Scientific Wheel of Credibility. *Science, Technology & Human Values* 21(4): 427-453.

Parthasarathy, Ashok. 1969. Sociology of Science in Developing Countries: The Indian Experience. *Economic and Political Weekly* 4(31): 1277-1280.

Pestre, Dominique. 2000. The Production of Knowledge between Academies and Markets: A Historical Reading of the Book 'The New Production of Knowledge'. *Science, Technology & Society* 5(2): 169-181.

Pestre, Dominique. 2003. Regimes of Knowledge Production in Society: Towards a more Political and Social Reading. *Minerva* 41: 245-261.

Polanyi, Michael. 1962. The Republic of Science: Its Political and Economic Theory. *Minerva* 1(1): 54-73.

Richardson, Alan. 2004. R.K.Merton and the Philosophy of Science. *Social Studies of Science* 34(6): 855-858.

Rip, Arie. 2004. Strategic Research, Post-modern Universities and Research Training. *Higher Education Policy* 17(2): 153-166.

Rodriguez, Victor. 2007. Merton and Ziman's modes of Science: The Case of Biological and Similar Material Transfer Agreements. *Science and Public Policy* 34(5): 355-363.

Rudolf, Peter Seidl and Longo, W.P. 1999. Comments on the Application of the Triple Helix of Innovation to the Developing Countries. *Science and Public Policy* 26(2): 137-139.

Sampat, Bhaven N.2006. Patenting and US Academic Research in the 20th Century: The World Before and After Bayh-Dole. *Research Policy* 35: 772-789.

Sardana, Deepak and Krishna, V.V. 2006. Government, University and Industry Relations: The Case of Biotechnology in the Delhi Region. *Science, Technology & Society* 11(2): 351-372.

Schiller, Daniel and Brimble, Peter. 2009. Capacity Building for University Industry Linkages in Developing Countries: The Case of the Thai Higher Education Development Project. *Science, Technology & Society* 14(1): 59-92.

Scoones, Ian. 2002. Biotech Science, Biotech Business: Current Challenges and Future Prospects. *Economic and Political Weekly* 37(27): 2725-2732.

Scott, John. 2007. From Professor to 'Knowledge Worker': Politics of the Academic Profession. *Minerva* 45(2): 205-215.

Shills, Edward. 1970. The Profession of Science. *The Advancement of Science*. 24: 469-80.

Shin, Terry. 2002. The Triple Helix and New Production of Knowledge: Pre-packaged thinking on Science and Technology. *Social Studies of Science* 32(4): 599-614.

Sismondo, Sergio. 2009. Ghosts in the Machine: Publication Planning in the Medical Sciences. *Social Studies of Science* 39(2): 171-198.

Slaughter, Sheila and Rhoades, Gary. 2005. From "Endless Frontier" to "Basic Science for the Use": Social Contracts between Science and Society. *Science, Technology and Human Values* 30(4): 536-572.

Strathern, Marilyin. 2003. Re-describing Society. *Minerva* 41(3), 263-276.

Stuart, Toby E and Ding, Waverly W. 2006. When Do Scientists Become Entrepreneurs? The Social Structural Antecedents of Commercial Activity in the Academic Life Sciences. *American Journal of Sociology* 112 (1): 97-144.

Vavakova, Blanka. 1998. The New Social Contract Between Governments, Universities and Society: Has the Old One Failed. *Minerva* 36(3), 209-228.

Vessuri, Hebe. 2000. Mode 2 or the Emblematic Disestablishment of Science: A View from the Edge. *Science, Technology & Society* 5(2): 195-202.

Wagner, Cynthia K. 1998. Biotechnology in Mexico: Placing Science in the Service of Business. *Technology In Society* 20: 61-73.

Walstad, Allan. 2002. On Science as a Free Market. *Perspective On Science* 9(3): 324-332.

Weingart, P. 1997. From Finalization to Mode 2: Old Wine in New Bottles? *Social Science Information* 36(4): 591-613.

Williams, Kevin. 2008. Troubling the Concept of the 'Academic Profession' in 21st Century Higher Education. *Higher Education* 56: 533-544.

Wofsy, Leon. 1986. Biotechnology and the University. *The Journal of Higher Education* 57(5): 477-492.

Ziman, John. 1981. What are the Options? Social Determinants of Personal Research Plans. *Minerva* 19: 1-42.

Ziman, John. 1996. Is Science Losing Its Objectivity? *Nature* 382: 751-754.

Ziman, John. 2003. Non-instrumental Roles of Science. *Science and Engineering Ethics* 9(1): 17-27.

Presented Papers/ Lectures

Baltimore, D. 1992. "On Doing Science in the Modern World". Tanner Lecture Delivered in the University of Cambridge, UK.

Bruce, Donald M. 2001. "A Social Contract for Biotechnology – Shared Visions for Risky Technologies?". Paper presented at EUR-SAFE 3: The Congress of the European Society for Agriculture and Food Ethics, 3-5 October, in Florence.

Cameron, Hugh. 2000. "Public Research and Intellectual Property Rights". Workshop on the Management of Intellectual Property Rights from Public Research, 11th December, OECD, in Paris.

Friedman, Geoffrey. 2006. "Referendum Science and the New Social Contract: A Case Study of California's Stem Cell Research Model". Paper presented at the Townsend Centre for the Humanities, GROUP Research Team, University of California, Berkeley, USA.

Fuller, Steve. 2007. "Universities in a Globalizing World: Where Do We Go From Here". Special Lecture delivered at the Centre for Studies in Science Policy, JNU, 1st November, in New Delhi.

Gibbons, Michael. 1998. "Higher Education Relevance in the 21st Century". Paper presented at the UNESCO World Conference on Higher Education, 5-9 October, in Washington.

Gibbons, Michael. 1999. "Engagement with the Community: The Emergence of a New Social Contract Between Society and Science". Presentation to the Community Engagement Workshop, Griffith University at Queensland.

Ibsen, Alexander Z. 2007. "Towards a Sociology of Patents". Paper presented to the annual meeting of the American Sociological Association, January in New York.

Jasanoff, Sheila. 2006. "Experiments Without Borders: Biology in the Labs of Life". BIOS Annual Lecture at the London School of Economics, 15th June in London.

Krishna, V.V. 2007. "Globalisation and the Changing Social Contract Between Science and Society: Some Implications". Lecture delivered at the Asian Studies Centre, University of Pittsburgh, 22nd October, USA.

Krishna, V.V. 2009. "Globalisation and Changing Social Contract Between Science and Society: Some Implications. Lecture at the Department of Sociology, NTU, 20 February, Singapore.

Menon, M.G.K. 1973. "Science and Society". Patel Memorial Lectures, India International Centre, 12-13 February, in New Delhi.

Rip, Arie. 2007. "A Changing Social Contract Between Science and Society". Paper presented to the Conference 'Responsible Research in Europe: Science and Its Publics', 24-25 June, in Munich.

Sunder Rajan, Kaushik. 2009. "Intellectual Property, Pharmaceutical Logics and Ideologies of Innovation". Paper presented to the Law and Social Sciences Network Conference, JNU, 9th January, in New Delhi.

Thomas, Renny. 2008. "Social Contract between Science and Society: The Sociological Analysis of a Scenario". Paper presented to the Annual Meeting of the Indian Sociological Association, 27-29 December, in Jaipur, Rajasthan.

Wilder, Richard. 2008. Global Experience on Technology Transfer: Lessons for India. FICCI Seminar on Public Funded R&D (Protection, Utilization and Regulation of Intellectual Property) Bill, 2007, October 16, in New Delhi.

Wynne, Brian. 2008. "Changing Relations between Science and Society". Paper presented at the Department of Science and Technology Studies, University of Utrecht, 16th April, Netherlands.

Thesis/ Dissertations

George, G.S. 1979. *Scientists in an Organisational Setting: A Case Study of the Indian Agricultural Research Institute (IARI).* M.Phil. Dissertation, Centre for the Study of Social Systems, JNU, New Delhi

Govind, Madhav. 2002. *Narrative Dimensions, Community Life and Cultural Orientation of Scientists in National Physical Laboratory, Delhi and Indian Institute of Science, Bangalore.* Ph.D. Thesis, Centre for the Study of Social Systems, JNU, New Delhi.

Krishna, V.V. 1985. *Scientists in Laboratories: A Comparative Study of Organisation of Science and Goal Orientation of Scientists in CSIRO (Australia) and CSIR (India) Institutions.* Ph.D. Thesis, Department of Sociology, University of Wollongong, Australia.

Sardana, Deepak. 2002. *Triple Helix: University, Industry and Government Partnerships: A Case of Biotechnology Sector in Delhi Region.* M.Phil. Dissertation, Centre for Studies in Science Policy, JNU, New Delhi.

Viswanathan, Shiv. 1980. *Scientists in Organisations.* Ph.D. Thesis, Department of Sociology, University of Delhi, New Delhi.

Reports

DBT Annual Report, 2008.

JNU Annual Report, 2007.

JNU Annual Report, 2008.

Report of the World Conference on Science: Science for the Twenty-First Century: A New Commitment, 2000. London: UNESCO.

Websites

www.dbtindia.nic.in

www.dst.gov.in

www.icgeb.res.in

www.iitd.ac.in

www.jnu.ac.in

www.nii.res.in

www.nipgr.res.in

Appendix-1

Questionnaire for Biotechnologists

Changing Social Contract between Science and Society: Exploring the Case of Biotechnology in India

1. How many years have you been in biotechnological research?

2. Are you still in the same area of specialisation or have you changed your area over the period of time?

Yes/No

3. What is your present area of specialisation or research?

4. What is the applicability of your current research?

5. Do you share your research findings with fellow scientists freely and without the feeling of fear?

Yes/No

If No, why?

6. Do you believe in the old model of reward system like awards, honorary editorship of journals, *eponymy* (the practice of affixing the name of the scientist to all or part of what he has found)?

Yes/No

7. Do you think science is primarily a disinterested search for truth and only secondarily a means of earning a livelihood?

Yes/No

8. Scientific contribution will have greater visibility in the community of scientists when it is introduced by a scientist of high rank/big institutes than when it is introduced by one who has not yet made his mark (junior scientists, scientists from non-European countries etc.).Do you agree?

Agree/Disagree

If disagree, why?

9. Is the present organisational structure of your institute/department is conducive to your research work?

Yes/No

10. What kind of changes has taken place in the organisational structure of your Institute/University compared to earlier days?

(Please give your comments)

11. Have you done any combined or collaborative research?

Yes/No

12. If yes, what kind of collaboration? (Please tick appropriate items)

a.Collaborating with scientists/researchers from universities/institutes outside India (International Collaboration)

b.Collaborating with scientists from Indian universities/Institutes.

c.Collaboratin with Indian Industry

d.Collaboration with MNCs.

13. Have you done any project/s with scientists from various disciplines (Transdisciplinary work)?

Yes/No

If Yes, Please Specify?

14. Do you think university should be a place for only teaching and advancing knowledge?

Yes/No

15. Do you think universities/research institutes should give more importance to basic research (like Physics, Chemistry, Maths and Biology.) only?

Yes/No

16. Do you think with the coming of globalisation the hegemonic role of universities/institutes in knowledge production has changed?

Yes/no

17. If so, what kind of changes do you see?

18. The present research in biological research is transdisciplinary in nature. Do you agree? (Please give your comments)

19. Do you work for a project with scientists from various agencies, like non-university institutes, government agencies, industrial laboratories, think tanks, consultancies, etc?(specify)

Yes/No

20. Do you believe in the existing system of 'peer review' judgements?

Yes/No

21. Do you think that the 'peer review' judgements by the peers in your discipline are adequate? Or do you think there should be a different kind of peer-review based on various additional criteria? (Please specify)

22. How do you communicate about your research with fellow scientists?

1. Through conferences/meetings

2. Through peer-review publications

3. Through multiple networks (like, through IT) i.e., e-mail, video conferencing etc.

4. Personal meeting (Informal).

23. Do you think because of patenting, the number of publications (journal, books) has declined?

Yes/No

24. Among the following, which one is more important for you?

a. Publications

b.Patenting

c.Equal importance to publication and patenting

25. How much importance would you give to the following?

(5-Highly Important, 4-Important, 3-Moderate, 2-Little, 1-No Important) (Please tick appropriate items)

a. Exploration and adding to systematic knowledge: 5/4/3/2/1

b. Patenting: 5/4/3/2/1

c. Designing of products /kits etc.,:5/4/3/2/1

d. Solving a problem for a client (like industry, firms etc):5/4/3/2/1

26. How much importance your institute/organisation gives for commercialisation of knowledge or patent? (Please tick the appropriate item)

(5-Highly important, 4-Important, 3-Moderate, 2-little, 1-No important)

27. Do you think there is conflict between commercialisation of research, patenting and publication of research results?

Yes/No

28. Do you think that peer review publications in eminent science journals are as important as commercialisation of knowledge?

Yes/No

If No, which is given more importance?

29. Compared to the earlier period do you think Professors now have to perform multiple roles like fund raising, publicity agents, Firm owners, and research director of a team of researchers?

Yes/No

30. Is any of your students/research scholars are involved in any kind of collaborations with firms, industry, think tanks or working as consultants?

Yes/No

If yes, please Specify?

31. The Government of India is planning to introduce 'Public Funded R&D (Protection, Utilization, and Regulation of Intellectual Property) Bill'. What is your opinion on this Bill?

32. Don't you think the proposed legislation will change the focus of university research from Academic inquiries towards Commercial pursuits, reducing the amount of pure research being conducted?

Yes/No

33. USA enacted the Bayh- Dole Act in 1980 to allow the patenting of university (public funded) research. As a consequence universities received thousands of patents; many of them have been commercially successfully. Do you think Indian Universities should be allowed to get patent for their research? (Please specify)

Yes/No

If Yes, why? (Please specify)

34. Do you think it is necessary to take into account the social demands enters the research process, influencing the problem formulation, implementation and evaluation phases?

Yes/No

35." Scientists requires 'legitimacy' from the non-scientific actors like Funding agency, government, NGOs, consumers, laymen etc." What is your comment on this? (Please Specify)

THANKS FOR YOUR KIND COOPERATION

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Appendix-2

List of Scientists Selected/ Interviewed* in the Study

- **Jawaharlal Nehru University**

- Prof. Rakesh Bhatnagar*, Professor, School of Biotechnology.
- Prof. Rajiv Bhat, Professor, SBT.
- Prof. Neera Bhalla Sarin, Professor, School of Life Sciences
- Prof. K.C. Upadhyaya, Professor, SLS.
- Prof. Indira Ghosh, Professor and Dean, School of Information Technology.
- Dr. Rakesh K. Tyagi, Dean, Special Centre for Molecular Medicine.
- Dr. Suman Kumar Dhar, Associate Professor, SCMM.
- Dr. K. Natarajan, Associate Professor, SLS.
- Dr. K.J. Mukerjee*, Associate Professor, SBT.
- Dr. Jaishree Paul, Research Scientist, SLS.
- Dr. Rohini Muthuswani, Assistant Professor, SLS
- Dr. S.S. Maitra, Assistant Professor, SBT
- Dr. Shyamala Maitreyi Rajala, Assistant Professor, SBT.
- Dr. Swati Tiwari, Assistant Professor, SBT.
- Dr. Saima Aijaz, Assistant Professor, SCMM.

- **Indian Institute of Technology (DBEB)**

- Prof. J.K. Deb *, Professor

- Prof. T.R. Sreekrishnan, Professor
- Dr. Biswajit Kundu, Assistant Professor
- Dr. Shilpi Sharma, Assistant Professor.

> **National Institute of Immunology**

- Dr. Ravi Dhar*, Staff Scientist and advisor of Patents and Technology Transfer, Facilitator of institutional collaboration (India and abroad).
- Dr. Agam Prasad Singh, Staff Scientist
- Dr. Vinay Kumar Nandiccori, Staff Scientist.
- Dr. Rajni Rani, Staff Scientist.

> **ICGEB**

- Prof. Sudhir Kumar Sopory, group leader, Plant Biology: Plant Molecular Biology.
- Prof. V.S. Chauhan, group leader, Mammalian Biology: Malaria.
- Prof. Raj Kamal Bhatnagar, group leader, Plant Biology: Insect Resistance.
- Prof. Navin Khanna*, group leader: Mammalian Biology: Recombinant Gene Products.

> **NIPGR**

- Dr. Gitanjali Yadav, Staff Scientist.

Appendix-3

A Brief Profile of the Institutions

I. Jawaharlal Nehru University (JNU)

The present study selected scientists from four Schools/ Centres of JNU.

- *School of Biotechnology (SBT)*

School of Biotechnology, JNU was rated the best biotech school in the country in India's top 20 Biotech Schools Survey conducted by *Bio Spectrum* in November 2005. It ranked very high on infrastructure and industry interaction scores.

The current areas of research activities as per faculty specialization are as follows: Immunology, Molecular Biology of Infectious diseases, Molecular Biology and Genetic Engineering, Transcription Control and Gene Regulation, Protein Folding and Stability, Molecular Virology, Cancer Biology, Molecular Cell Biology, Optimization of Recombinant Protein Production, Structural Biology and Bioinformatics, Biochemical Engineering.

- *School of Life Sciences (SLS)*

The SLS came into existence during 1970-71. Since its inception, it has been a premier multi-disciplinary research and teaching department in the country. The school has followed innovative teaching and research programmes in different areas of modern biology. With a main focus on Cell and Molecular Biology, SLS has built reputed research programmes in Regulation of Gene Expression, Plant Physiology and Biotechnology, Genetics, Functional Genomics, Molecular Biophysics and Structural Biology, Immunology, Radiation Biology and Neurophysiology using both plants and animals as model systems for these studies. The future plans and projections of the school are to develop centralized facilities for Genomics and Proteomics, Molecular Biophysics, Structural and Systems Biology. Facilities for intensive research and teaching on genetic technologies (transgenomics, genetic variability etc.) involving microbes, plants, animals and humans have to be strengthened. The School's Central Instrumentation Facility (CIF), whibh is providing the bore support for research activities, is unique of its kind. The SLS has been recognized by the UGC as an important centre with an integrated programme of teaching and research in diverse aspects of modern biology. It is the only school in the country where integrated interdisciplinary programmes in modern biology for research and teaching are followed. In recognition of the school's commitment to providing instruction in Life Sciences, the UGC rated the school as a Centre of Excellence under the COSIST programme

- *School of Information Technology (SIT)*

The SIT was established in the university to carry out academic related activities in the broad area of Information Technology (IT). The academic programme is currently focused on the core area of Computational and Systems Biology. In the School of Information Technology the Centre for Computational Biology and Bioinformatics (CCBB) is supported by the Department of Biotechnology (Govt. of India) for academic and research activities and has been identified as a Centre of Excellence in Bioinformatics. A major characteristic of SIT is its emphasis on inter-disciplinary research. This is also reflected in the research expertise of the faculty who come from various backgrounds such as Physics, Chemistry, Biology, Statistics and Computer Science and carry out research in diverse fields such as Comparative Genomics, Structural biology and in Silico drug design, data mining and analysis of large scale biological data, biophysics, systems biology, robotics and artificial intelligence.

- *Special Centre for Molecular Medicine (SCMM)*

The discipline of Molecular Medicine is a newly emerging area of biomedical sciences contributing to the understanding, prevention and cure of human diseases. The SCMM at JNU is the first of its kind in India.

The objective of the SCMM is to foster teaching and research activities in the study of human diseases with the application of advanced tools of molecular and cell biology. The SCMM has planned its academic programmes to play a major role in training young scientists, clinical and non-clinical, keen to pursue careers in basic medical research. The thrust areas of the centre are: Metabolic Disorders, Infectious Diseases, and Diagnostics

II. IIT-Delhi

- *Department of Biochemical Engineering and Biotechnology (DBEB)*

The DBEB at IIT-Delhi has a unique place in the development of biochemical engineering discipline in India. The department took an early note of the significant role that was to be played by biochemical engineers and biotechnologists in future industrial development of biotechnology related processes and products by initiating this activity in 1968. At present the department provides a model for an integrated approach towards education as well as research and development of various bioprocesses. The main objectives of the department as follows:

1) Training students and developing expertise in bio-chemical engineering, biotechnology at the PG and Doctorate levels.

2) Research and Development of various microbial and enzyme system and developing understanding of biological/ biochemical phenomena underlying such systems.

3) Engineering analysis and optimal design of various biological systems and processes.

4) Transfer of knowledge through seminars, symposia and short-term refresher courses of national and international levels.

5) Undertake industrial consultancy jobs to solve the specific problems of bioprocess industries.

III. National Institute of Immunology (NII)

The NII is an autonomous institute supported by the DBT, Government of India, started in 1988. The institute is committed to advanced research addressing the basic mechanisms involved in body's defence, host-pathogen interactions and related areas with a view to contribute to the creation of an internationally competitive intellectual knowledge base as a sustainable source of innovative futuristic modalities of potential use in health care.

NII has steadily worked at furthering knowledge of the molecular mechanisms of interaction between the biological systems and their environment while searching for new intervention modalities to combat mortality and morbidity as well as enhancing national competence in modern biology research. The major areas of research at NII are Immunity and Infection, Gene Regulation, Molecular Design and Reproduction and Development.

IV. International Centre for Genetic Engineering and Biotechnology (ICGEB)

The ICGEB is an international organisation whose statutes were signed by 26 countries under the form of an international treaty in 1994. The institution is structured in two components located in Trieste, Italy, and in New Delhi, India. It is an autonomous, international, intergovernmental organization supported by the United Nations Industrial Development Organization (UNIDO). It is dedicated to advanced research and training in molecular biology and biotechnology with special regard to the needs of the developing world. The main research areas of ICGEB, New Delhi labs focus on mammalian and plant biology. Biomedical projects are pursued in virology, structural biology and in the field of Malaria both in basic research and vaccine and drug development of technologies for bio pharmaceuticals and for diagnosis of infectious diseases.

V. National Institute of Plant Genome Research (NIPGR)

The NIPGR is a premier institution for plant genomic research. It has been established by the DBT, Govt. of India, to coincide with the 50^{th} anniversary of India's independence as well as birth anniversary of Dr.J.C.Bose in 1998. The institute has already placed India among the major contributors to plant genomics. Genomics research is providing bridges between different branches of natural sciences and as a result it has been logarithmic growth over last two decades. The ongoing research programmes of NIPGR aim of nutritional, structural and functional genomics of various plant systems with the ultimate goal to manipulate plant genes to breed improved varieties of crop plants.