CHAPTER 1
APPROACHES TO TECHNOLOGY AND MEDICAL TECHNOLOGY

This chapter reviews the approaches to the study of technology, and the studies of medical technology. The first section looks at the approaches to technology. It discusses three approaches – the dominant technological determinism framework, the social shaping of technology approach, and the social construction of technology framework. The second section looks at the studies of medical technology.

SECTION I Approaches to Technology

Since World War II there has been a large amount of writing on science, technology, and on medicine. Science and Technology Studies (STS) has since become an established discipline. Vessuri identifies two broad components in these studies of science and technology, and of a tension between these two streams (Vessuri 1996). On one hand is the disciplinary approach, linked to the traditional academic disciplines of sociology, economics, history, anthropology and political science. For instance, historians of science, of technology and of medicine have revealed much about the origins and developments in these fields. Within sociology the sociology of scientific knowledge (SSK) is now a specialized area of study, and since the 1980s the methods developed in this area are being applied to studies of technology. There has also been a lot of writing by feminists on technology and medicine, especially on reproductive technologies and their impact on women's lives. The other stream in studies of science and technology, as pointed out by her, is the problem approach, which is forced upon us by the very dynamic of technical, scientific and social change. According to Vessuri this approach is a rich source of inspiration. Not only does it foster the renewal of research agendas, thus putting new demands upon the traditional disciplines. It also helps practitioners in this broad work front 'to participate in the political and social debate of the contemporary technological society in which we live and in which their transformations are not only a source of joy, but also of suffering' (Vessuri 1996).

1.1.1 Technological determinism is the single, most influential theory regarding the relationship between technology and society, and remains the dominant perspective guiding much of the studies of technology. This is the view that technological development occurs according to some naturally given logic; that technology is an independent factor, is autonomous and that it impinges on society from outside. Further, it is believed that technology is the primary causal agent in social change; that changes in technology cause social changes – social structures evolve by adapting to technological change.
In its strongest version, the theory claims that change in technology is the most important cause of change in society. In other words, the proponents of technological determinism view technology (and science) as asocial institutions, whose development is driven by the unfolding of their own internal logic. An associated view is that there is no distinction between science and technology: advances in science are considered to lead to its applications, namely that technology is nothing but 'applied science'. The traditional linear model of technical innovation/development in this TD perspective considers/describes technologies as 'applied science', emerging through a sequential flow from basic science, through applied R & D, to commercial production and use/consumption. The invention-innovation-diffusion processes are conceived as separate stages in an essentially linear process. At the 'invention' stage technologies are presumed to arise as 'fixed' or 'black-box' solutions. These established artifacts then diffuse through the marketplace to have 'impacts' upon society, work organization, production systems, and so on.

Scientific knowledge itself is regarded as a collection of objective, neutral statements about the natural and social world. Such neutral knowledge can be used in different ways, put to either good purposes or destructive ones. All science and technology are looked upon as objective and neutral instruments of cultural, social and economic progress and development (the notion of scientism). In this view, therefore, the scientific and technological capacities are linked to the development and economic success of a country. It is argued/constantly stressed, especially in 'developing' countries like India, that science and technology be harnessed for the growth and development of a nation.

Most studies of science and technology are conducted within this TD framework – technologies are taken for granted and studies seek to assess their social impacts. Studies are undertaken for policy purposes of feeding into decisions taken by government, to enhance/improve industrial production. So we have policy-related studies, as well as economic models and analysis of technical innovations and change, of science and technology (S & T) infrastructure and capacity, of research and development (R & D) capacities and expenditures.

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2 Leo Marx discusses the transformation in the idea of technology, on one hand, and in the ideology of progress, on the other. At one time innovations in science and in the mechanic arts were regarded as necessary, yet necessarily insufficient means of achieving general progress, which was conceived as a more just, more peaceful and less hierarchical society based on the consent of the governed. This republican idea of progress got transformed over time, where progress came to be construed as improved technology, where improvements in technical means became an end in itself, and there was a tendency to bypass moral and political goals. In other words, what is called as the technocratic idea of progress, which is considered to be characteristic of corporate capitalism. Within this idea there was a 'reification' of technology in the late nineteenth and early twentieth centuries, and technology came to be invested with a host of metaphysical properties and potencies, and as an autonomous agent of social change (Marx 1994).
relating it to economic concepts of productivity, performance and competitiveness, cost-benefit analysis of technologies, of transfer of technology from developed to developing countries, and so on. Furthermore, as S & T are looked upon as following their own autonomous logic, and then having effects on society, studies have also tended to concentrate on the effects, on the impact of technology on society and descriptions of “how technology has changed the way we do many things”, namely - technology shaping society. Descriptive historiographies of how many technical inventions came about and of individuals associated with them are also available.

In the aftermath of World War II, and especially during the Cold-War period and after the Vietnam War, there arose a lot of concern about science and technology, and their effects. What is notable is that several well-known physicists and other scientists became involved in political activities aimed at educating the public about what would be involved in a war with nuclear/hydrogen bombs. Concerns were raised since the 1930s from several quarters, such as by Marxist scientists, and by the Campaign for Nuclear Disarmament, Bulletin of the Atomic Scientists. The dominant perspective then, as now, was the “use-abuse” model of science and of technology, referred to earlier. The Russell-Einstein Manifesto, by Bertrand Russell and Albert Einstein, released on 9th July 1955, was signed by several other scientists of those times, such as Max Born, Leopeald Infeld, Linus Pauling, Joseph Rotblat, Frederic Joliot-Curie and others. It called upon scientists to “assemble in conference to appraise the perils that have arisen as a result of the development of weapons of mass destruction...”. The scientists spoke as “members of the species Man”, whose continued existence, they felt, was in doubt. They felt that the world then was full of conflicts; and overshadowing all minor conflicts was the titanic struggle between Communism and anti-Communism, between the East and the West. In their view everybody needed to think about “what steps can be taken to prevent a military contest of which the issue must be disastrous to all parties” (The Russell-Einstein Manifesto on www.pugwash.org/about/manifesto). This Manifesto became the inspiration for the first Pugwash Conference on Science and World Affairs held in 1957. The Pugwash Conference has since become a symbol of the social and moral duty of scientists to promote debate and reflection on the ethical obligations of scientists in taking responsibility for their work, among other things.

The sociological studies of science were guided largely by what is known as the Mertonian paradigm, concerned with the study of the normative structure of science and how it functioned as an institution, and of scientists’ norms, career patterns and the reward system in science. Then came Robert Kuhn’s theory on “structure of scientific revolutions”, about “normal” science as a “tradition-bound” “puzzle-solving exercise”, which on occasions tends “to go astray”. When it does, when the “normal” science can no longer explain “anomalies that subvert the existing
tradition of scientific practice', then begin the extraordinary investigations that lead the profession to a new set of commitments, a new basis of practice, a new 'paradigm'. These extraordinary episodes, when a shift of professional commitment occurs, are what Kuhn called 'scientific revolutions' (Kuhn 1970).

Socially, the 1960s was the period of several movements, including the radical science movement. The dominant 'use-abuse' understanding of science and technology was found to be inadequate on many counts, and there arose critiques from several quarters, such as from the anti-war movement, the organised left, and the women's health movement. Radical political critiques of science appeared in the 1960s and 1970s, wherein the neutrality of science was under question; the role of science and technology in imperialism, in exploitation of workers, in racism, in war and in oppression, became matters of central concern. There were also feminist critiques of science, and the women's health movement came up with feminist critiques of medicine. There were groups like the British Society for Social Responsibility in Science and Science for People, as well as magazines like Science for People, Science for the People and Radical Science Journal. As pointed out by Martin, in that period, 'a critique of science was seen as a part of a critique of society.' The emphasis was on political economy, especially an analysis of capitalism' (Martin 1993). There were calls and movements for alternative technologies, such as for 'appropriate' technology and 'intermediate' technology. There was also opposition to ideologies of a 'technological imperative', which suggested that particular paths of technological change were inevitable.

1.1.2 Several critical perspectives on technology emerged in the 1970s from Marxist labour process debates about production. It was felt that while study of effects of technology was a valid and extremely important area of concern, however, it leaves a prior and more important question unaddressed, nay unasked. And that is 'what has brought about, shaped the technology whose effects/impact are being studied? What has caused and is causing the technological changes whose effects are being experienced by society?' Questions such as: how, to what extent, and in what ways does the society we live in affect the kind of technology we produce, what role does society play in the shaping of the technologies we have, which were seldom asked, started to be posed.

MacKenzie and Wajcman argued for "at least equal time for the study of the 'effect of society on technology' ", to study this issue also more seriously and systematically (MacKenzie and Wajcman 1985). They pointed out some consequences of this shift. When one looks at effects of technology on society then one tends to pose questions like, 'How can society adapt to changing
technology?" In this case we take technological change as 'a given, as an independent factor, and think through our social actions as a range of passive responses'. The controversies that take place then are technological in name only: they are rather 'post-technological' because in them technology is found already completely frozen into particular moulds'. Instead if we ask 'what role does society play in shaping technology'...then the latter ceases to be an independent factor, an unknown factor, dropping out of the blue and making us accept it or reject it. Our technology, like our economy or our political system, then becomes a social product, a characteristic of how we live. Essentially it implies that we view technology not as something that has suddenly 'appeared', but as something that has been developed and produced by certain individuals or groups of individuals, as a product of human relations and actions. Alongside narrowly 'technical' considerations, a range of 'social' factors affect which options are selected, thus influencing the content of technologies and their social implications. Simply put, the 'social shaping of technology' perspective as it was broadly referred to (SST), proposed that in the early stages of development of technologies choices could be made between alternative processes. The choices/final products are shaped by interests - economic, social and political - of individuals, groups and institutions involved. By SST is meant that a range of 'social' and 'economic' factors as well as narrowly 'technical' considerations pattern/aff ect the design and implementation of technology.

The central theme in the 'social shaping of technology' perspective then was a critique of the existing notion of technological determinism - of the assumption that technological change is autonomous, 'outside' of the society in which it takes place, that 'science shapes technology'. It arose as a critique of the existing deterministic traditions, which did not problematize technological change, but limited the scope of enquiry to monitoring the social adjustments that it considered as being required by technological progress. The social shaping perspective drew upon several existing works and studies of those times, on the history and sociology of science and technology, which gave fresh insights and information about these areas. It was shown then that science itself was affected in profound ways by the society in which it takes place; not only were the models and images used in scientific theories drawn from the wider society; social and political considerations had entered into scientists' evaluations of different theories as true or false. Even the level of 'fact', the process of experiment and observation - was social, and different groups of scientists in different circumstances had been shown to produce radically different 'facts'. Secondly, it was also increasingly realized that science and technology were not always closely connected activities; people did not operate with notions of what in modern times came to be known as 'science' and 'technology'. Even in modern times the connection between science and technology was not one-sided - technology has contributed as much to
science, as science had to technology. It was also shown that invention was not a matter of a sudden flash of inspiration from which a new device emerges ‘ready made’; largely it is a matter of the minute and painstaking modification of existing technology. It was also pointed out that the conventional notion of invention failed to take note of one important type of technical change – that which was often ‘a perpetual accretion of little details........probably having neither beginning, completion nor definable limits’, such as in the gradual evolution of the ship (Gilfillan cited in MacKenzie and Wajcman 1985 p 10). The authors of such a process of invention are normally anonymous, and often skilled craft workers, without formal technical or scientific training; technical change, therefore, is probably best seen as a process of collective learning rather than individual innovation. New technology then emerges, not from flashes of sudden inspiration, but from existing technology, by a process of gradual change to, and new combinations of, that existing technology.

While attempts were made to extend Kuhn’s idea of the scientific paradigm in the idea of a technological paradigm, the idea of technological systems was used more in studies of technology. It was argued that increasingly technologies were being made not as separate, isolated devices, but as part of a whole, as part of a system – such as an automatic washing machine, which can work only if integrated into the systems of electricity supply, water supply and drainage. Similarly so with missile systems – which need to be part of a wider system of launch equipment and control networks. This need for a part to integrate into the whole imposes major constraints on how a part should be designed. The best example of this was Hughes’ study of the invention of the electric bulb by Edison (discussed later).

1.1.3 The following paragraphs look at some of the types of studies of technology that were then available or had been carried out, and the perspectives that subsequently emerged on the relationship between society and technology, which gave rise to the social shaping of technology perspective.

Marxist labour process theory was applied in analyzing changes in the technology of production. Several studies were published of how the requirements/considerations of capitalist production (such as of economy, of efficiency, of profitability, of control over labour process) have shaped the outcome where choices in technology have existed. Mackenzie and Wajcman have brought together several such studies by different authors (MacKenzie and Wajcman 1985). Such as Bruland’s study of industrial conflict as the source of development of the automatic spinning mule, and Noble’s work on choice of numerical control as against record playback for automating machine-tool production.
David Noble, in his case-study of the development of a 'successful' and a 'failed' technology, looked at the automation of machine tool production. It could have proceeded along two possible ways – record playback and numerical control (Noble 1985). By reconstruction of the 'failed' and 'lost alternative' of record playback, Noble showed that automation did not have to proceed the way it did. The form of automation resulted from deliberate selection, arising from the social relations of production. Numerical control (NC) prevailed for technical and economic reasons, as well as for reasons of managerial power and engineering ideology. With almost unlimited military finance MIT scientists designed a system that was far too expensive and complex for commercial application in the metal industry. Noble argues that it was the complementary interests of the technical, managerial and military communities (management, Air Force and MIT) that ultimately shaped the technology and not its inherent technical superiority. Air Force requirements for highly sophisticated machining of complex parts were beyond the capacity of record playback method; NC also held the promise of reducing the labour costs of toolmakers, machinists and pattern-makers; additionally, it placed the control of machines, and hence of production, in the hands of the management, as against record playback, which depended on skilled shop-floor workers. Lastly, cultural values also played an important role – 'the culture of engineers' in which the most automated is seen to be the most 'advanced', and in which human factors (in production) are seen as sources of human error to be eliminated. There is also a fascination with computers and the most automated techniques. NC was a symbol of the computer age, of power, and of remote control of the automatic factory. Furthermore, Noble's case-study also shows that 'the managerial process of decision making in industrial innovation deserves special attention. This goes not only for industrial corporations, but also for politicians, government bureaucracies and all individuals and bodies who have a say in shaping technical innovations' (Braun 1992).

In his study of the invention of the electric bulb by Edison, Hughes argued that at times technological decisions are also economic decisions. As mentioned earlier, the integration of technologies into systems gives rise to a particular pattern of innovation that Hughes describes as 'reverse salients'. According to him innumerable inventions and technological developments result from efforts to correct reverse salients. The concept of reverse salient makes sense only if the technological system is seen as oriented to a specific goal. In many cases a system goal normally implies economic goals, about reducing costs, increasing profits. For instance in electricity supply systems, whether public or private, those who have run them have been concerned above all with costs, profits and losses. The reverse salient is the 'inefficient or uneconomical component and for many practical purposes inefficient means uneconomical. So technological reasoning and economic reasoning are often inseparable'. Using this framework
Hughes argues that Edison designed the bulb not as an isolated device, but as part of the system of electricity generation and distribution and utility systems (Hughes 1985). For the system of generation, distribution and utility of electricity to be successful, not only did the price have to be low, it also had to compete with existing gas-based lighting systems. According to Hughes such needs of the system are clearly to be seen in the design of the bulb.

Cowan's study of the development and promotion, in the 1920s in the US, of the electric refrigerator as against the gas-based refrigerator was yet another exploration of the forces that lead to the 'success' of some machines and 'failure' of others (Cowan 1985a). The gas-absorption refrigerator had the advantage of not requiring an electric motor; it had no moving parts, was virtually silent, had fairly low operating parts, and was potentially easy to maintain. The technical deficiencies then were negligible, and would probably have been smoothened out in a short time. Cowan shows how the companies working on the gas-based refrigerator, which was not technically inferior, lacked the large sums of money, skilled personnel, aggressive marketing, and co-operation of the electric utility companies that were deployed by large companies such as Kelvinator, General Electric and Westinghouse in developing and promoting the electric refrigerator. (GE by then was an enormous corporation with vast resources and had interests in every aspect of the electrical industry in the US, from design of large electricity generation plants to manufacture of bulbs). The manufacturers of gas refrigerators, such as Servel, could not 'succeed' against the superior economic power of GE and the other electrical corporations. Cowan concludes that the 'success' of the electric refrigerator was as much economic and social as technical; its development was encouraged by a few companies that could draw upon vast financial and technical resources. Comparable resources and support could not be harnessed for gas-based refrigeration.

According to Winner 'technological change expresses a panoply of human motives, not the least of which is the desire of some to have dominion over others, even though it may require an occasional sacrifice of cost cutting and some violence to the norm of getting more from less' (Winner 1985, p 29). He gives the example of the introduction, in reaper manufacturing, of pneumatic molding machines, a relatively new and untested innovation, in the 1880s in Chicago. This new machine actually produced inferior products at a higher cost than the existing process, and could be operated by unskilled labour. Still they were introduced in a foundry in Chicago. At that time the owner of the foundry was engaged in a battle with the National Union of Iron Molders; the use of the new machines led to 'weeding out' the 'bad elements', namely, the skilled workers who were organizing unions then in Chicago. The machines were abandoned after three years. But by then they had served the purpose of destruction of the union. According to Winner,
this technical invention cannot be understood outside the context of the workers’ attempts to organize and police repression of the labour movement of Chicago in that period.

It was also shown that economic calculations do not always explain technological development, and that the sponsoring of technical innovation by the state has been of great significance. The single most important way that the state has shaped technology has been through its sponsoring of military technology. Like international economic competition, war and the threat of one have also acted to bring about technological change. Through case studies of nuclear power, air transport and electronics several scholars showed how military concerns have shaped ‘civilian’ technology – such as work on military jets influencing civilian jet liners of the post war period and crucial military support for the development of semi-conductor electronics.

In the same period (1970s-1980s) feminist analyses gave rise to several new perspectives on the social shaping of technology. It was argued by feminists that gender was as much an important factor as class in shaping the organisation of work that emerged from technological change. Cowan pointed out that three characteristics of women as workers should be of signal importance in any discussion on rates of technological change – the fact that they worked for less, that many jobs were not open to them because of sex typing, and that they were regarded as transient members of the workforce, and therefore difficult to organize and unionize. ‘We are accustomed to thinking about the price and availability of labour as one of the key determinants of rate of changes in any given industry or locality, but we are not accustomed to thinking of the price and availability of labour as determined by the sex of the labourers (Cowan 1985b p 53; Cockburn 1985). Cowan cites two case studies to illustrate her point about how the sex of the workers interacts with technological change. One is on technological change in the cigar industry in New York, in the mid-later nineteenth century, where women workers were employed to break the strikes by skilled male workers, by shifting to home-based work by women, as well as by deploying simple molding tools that could be operated by them. The other is on the garment sewing industry where technological change seems to be fairly static on account of availability of female machine operators. Yet another general point raised was that ‘technology is both the social property and one of the formative processes of men’ (Cockburn 1985 p 22). In the typical gender division of labour some activities performed by women involve considerable skill, manual dexterity and computation, such as knitting. However, these activities are not normally defined as technologies.

Feminist historians of technology, who were concerned about the impact of technology on women’s lives, undertook much of the early work on domestic technology (Cowan 1985b; Doorly
It was argued that an important influence in this area has been the way society is organised – the social prevalence of the single-family household, with its assumption of the essentially unaided female homemaker, and association with privacy and autonomy, has profoundly structured the forms of domestic technology that have become available. 'Few tools in our society are designed for communal (or shared) ownership. If they were designed for sharing, rather than for individual use, we believe they would change structurally, mechanically and in material composition' (Papanek and Hennessey, in MacKenzie and Wajcman 1985, p 21). There were studies of the technology of leisure – video recorders and video games – and of the massive technological changes in the American homes in the early 20th century. Cowan pointed out 'rather than household tasks being eased or eliminated, mechanization gave rise to a whole range of new tasks. Although not as physically burdensome, these jobs were as time-consuming as the jobs they had replaced' (Cowan 1985b p 177). The feminist interest in domestic technologies is traced to the debates about housework as a key source of women's oppression (Wajcman 2000).

Winner in an article entitled 'Do Artifacts have Politics?' added another dimension to the studies in the social shaping perspective, namely the theory of technological politics (Winner 1985). According to him while an understanding of the social considerations shaping technology is important, this is not to say that the actual technical artifacts do not matter at all. Winner draws attention to the momentum of large-scale socio-technical systems, and discusses the theory of technological politics that takes technical artifacts seriously, and identifies certain technologies as political phenomenon in themselves. He considers this perspective, which focuses attention on 'the things themselves', a necessary complement, and not a replacement, to social shaping of technology theories. According to him 'If our moral and political language for evaluating technology includes only categories having to do with tools and uses, if it does not include attention to the meaning of the designs and arrangements of our artifacts, then we will be blinded to much that is intellectually and practically crucial'. Sometimes the design/arrangements of technological artifacts/systems is such that it leads to certain consequences, while closing some others. The design maybe consciously chosen for its effect; or maybe made without giving much thought to the consequences. 'The things we call 'technologies' are ways of building order in our world. Many technical devices and systems important in everyday life contain possibilities for many different ways of ordering human activity. Consciously or not, deliberately or inadvertently, societies choose structures for technologies that influence how people are going to work, communicate, travel, consume, and so forth, over a very long time. In the processes by which structuring decisions are made different people are differently situated and possess unequal degrees of power as well as unequal levels of
awareness. By far the greatest latitude of choice exists the very first time a particular instrument, system, or technique is introduced. Because choices tend to become strongly fixed in material equipment, economic investment, and social habit, the original flexibility vanishes for all practical purposes once the initial commitments are made. In that sense technological innovations are similar to legislative acts of political foundings that establish a framework for public order that will endure over many generations. For that reason, the same careful attention one would give to the rules, roles, and relationships of politics must also be given to such things as the building of highways, the creation of television networks, and the tailoring of seemingly insignificant features on new machines. The issues that divide or unite people in society are settled not only in the institutions and practices of politics proper, but also, and less obviously, in tangible arrangements of steel and concrete, wires and transistors, nuts and bolts (Winner 1985 p 30). With several examples he elaborates on the ways in which artifacts can 'contain' political properties. First are instances in which the invention, design or arrangement of a specific technical device or system becomes a way of settling an issue in a particular community - such as certain forms of industrial mechanization. However, to recognize the political dimensions in the shapes of technologies, one need not look for conscious conspiracies or malicious intentions. For instance: during the 1970s it became evident that the ways in which machines, buses, buildings, plumbing fixtures, and so on were designed, it was impossible for many handicapped persons to move around freely, a condition which excluded them from public life. In this case such designs arose more from neglect than from any deliberate intention. Second are instances of what can be called inherently political technologies, which may or may not require, or are strongly compatible with particular kinds of political relationships. Here he cites the work on risks of nuclear power. According to one observer 'if you accept nuclear power plants, you also accept a technoscientific-industrial-military elite' (Winner 1985 p 31). Another hazard is that the operational requirements of such a technical system, requiring use of plutonium, may influence the nature of public life, because the measures needed to safeguard from plutonium theft involve the sacrifice of civil liberties. Finally, Winner says, to pay attention to the technical objects does not mean that we can ignore the contexts in which the objects are situated – the study of specific technical systems and their history helps us to understand which technologies and which contexts have become important to us and why.

Cowan proposed that research strategies in the sociology of technology needed to focus on the 'consumption junction' – namely the potential or actual consumer of an artifact. According to Cowan, a large number of 'relevant social groups' are involved in the success or failure of a given technology. Such as the craftsmen or engineers who maybe responsible for the innovation, to managers who make decisions about the innovation, to the production experts/manufacturers who
must transform the innovation into an artifact, to the people who must distribute, market and sell it, to the government machinery that regulates technology, and finally the people who will use/consume the artifact. Any one of these groups, or an individual acting within the context of his/her group identity, or a combination of these groups, or some group not thought of, can influence the success or failure of the artifact. She used this framework to look at the history of home heating and cooking systems in the USA (Cowan 1987).

Thus we see that the 'social shaping of technology' perspective posed a challenge to the technological determinism perspective; it attempted to encompass the many different levels and forms, by which social relations affected/interacted with technology and technological change. Not only capitalist considerations of profit and productivity, and the other needs of an industrialized capitalist society, such as the role and needs of the state, the emergence of the nuclear family, the gender division in labour and housework, all were identified as factors having a significant role in technological change. Most of the studies in this framework took into account the prevailing broad economic and social climate of the Cold War period, such as the building up of the military-industrial complex, attacks on organized labour and the technocratic values that were influential among the technical professionals. By drawing attention to both, the content of technologies and the processes of technical innovation and technical change, they showed that technology does not develop merely according to an inner technical logic, but is a social product, patterned by the condition of its creation and use.

1.1.4 Several others talked of the possible political functions of technologies in society. It was argued that the notions regarding value-neutrality of science and technology, derived from the philosophy of 'scientism', according to which the scientific approach was objective and therefore the only worthwhile approach to any problem. In such a 'scientific approach' technologies and techniques are perceived to be science-based, and hence apolitical, neutral. This tends to promote a passive acceptance of the technologies that 'appear' in society and have certain effects. Dickson, for instance, argued that the idea of technological neutrality was a myth, an 'ideological disguise', used to legitimate the continuing power of the dominant class (Dickson 1974). According to him technology has a political nature and function in contemporary society. He viewed technology not as a heterogeneous set of machines, but as 'an abstract concept embracing both the tools and machines used by a society and the relations between them implied by this use' (p 17). His thesis was that technology is a social institution, like the legal or educational system, and technological innovation and development are essentially political processes. In a material sense technology sustains and promotes the political system within which it has been developed. At the same time it acts in a symbolic manner to support the legitimating ideology of this system.
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- namely, the interpretation of this society, of the world around it and of its position in it. Both these factors play an important role in determining the nature of technology itself. He suggests that the social relations of production become incorporated in the technology of a society, and that technology and social relations reinforce each other in a somewhat dialectical fashion, at both a material and an ideological level. *Such a view of technology implies that one can explain the nature of technology developed by a particular society only by relating it to the patterns of production, consumption and social activity, in general, which maintain the interests of the dominant sections of that society. The latter can ensure that technology develops in such a way as to lead to their control, dominance in society. The form of technology in contemporary society derives from what he terms the 'ideology of industrialization', which is a political ideology of control. It enables, for instance, employers to use assembly-line production techniques as a means of maintaining hierarchical relations in the factory; television to be used as a means of centrally controlling public information and entertainment; 'built-in obsolescence' as a means of manipulating consumer choice to stimulate the flow of market commodities.*

In examining the historical development of technology, Dickson suggests that technological innovation is also a political process. In the early stages of capitalism, for example, innovation was used directly as one of the means by which the capitalist strengthened control over the activities of the work force. Subsequently, innovation has become institutionalised into 'research and development', an essential component in the economic machinery of contemporary capitalist states. Such institutionalisation promotes the notion of technical innovation as an objective, technical response to particular circumstances. In Dickson's view, in reality, the purpose of most R & D is determined by economic considerations of increased efficiency, economic growth, rationalisation and competitiveness, as well as of technical solutions to social needs.

1.1.5 The *social construction of technology* perspective (SCOT) emerged in the 1980s, and has gained ground among historians and sociologists studying technology and society. Much of the recent feminist literature, which is on reproductive technologies and information technologies, is also informed by social constructivist perspectives (Wajcman 2000).

The social construction of technology perspective began as a research programme for studying *the development of technological artifacts and systems*, one that contributed to a greater understanding of the social processes involved in technological development, 'while respecting the seamless web character of technology and society'. It argued for *an integrated approach to the social study of science and technology*, in specific the *social constructivist* approach that extended the sociology of scientific knowledge approach, established since the 1970s in the
sociology of science, into the realm of technology (in other words the *social construction of facts and artifacts*). The sociology of *scientific knowledge*, in turn was an extension of the sociology of knowledge to the study of the so-called 'hard sciences'. In contrast to the earlier work in the sociology of science in the Mertonian framework, the sociology of scientific knowledge looked at the actual content of scientific ideas, theories and experiments, and was referred to as the 'strong programme' in the sociology of scientific knowledge (SSK). The two central tenets in this approach are: one that all knowledge and knowledge claims are to be treated as being socially constructed - *that is all explanations for the genesis, acceptance and rejection of knowledge claims are sought in the domain of the social world than in the natural-world*. Secondly: in investigating the causes of beliefs sociologists should be impartial to the truth or falsity of the beliefs, namely differing explanations should not be sought for what is taken to be a scientific 'truth' and what is considered a 'scientific falsehood'. Such beliefs should be explained symmetrically. While there were differences among the researchers in this area regarding the best place to locate the empirical research on the processes of construction of scientific knowledge (should it be the laboratory, or a scientific controversy, or the scientific publication), and the methodological strategy, there was widespread agreement that scientific knowledge can be, and had been shown to be, socially constituted. These approaches came to be known as the 'social constructivist' approach. What the studies in this genre attempted to show was that there was nothing epistemologically superior about the nature of scientific knowledge; it was merely one in a whole series of knowledge cultures. The explanation for the success and failure of knowledge systems lay in the sociological arena, and was not an epistemological task.

The Empirical Programme of Relativism (EPOR) was one approach in this social constructivist perspective, which focused on the empirical study of contemporary scientific developments, and the study in particular of scientific controversies. The key concepts in the EPOR are: *interpretative flexibility* of scientific findings, namely: scientific findings are open to more than one interpretation. In other words it must be shown that different interpretations of nature are available to scientists and hence that nature alone does not determine the outcome to scientific debate. While the interpretative flexibility can be recovered in certain circumstances, by and large such flexibility soon disappears in science, and a consensus emerges as to what the 'truth' is in that particular instance. The study of scientific developments in EPOR therefore entails demonstrating the interpretative flexibility of scientific findings, and identifying the social mechanisms that limit this interpretative flexibility, leading to the termination 'or closure' of scientific controversies, and the emergence of a consensus.
When the SCOT approach began to take shape its proponents discarded most of the then existing approaches to technology advocated by historians, philosophers and economists. It was argued by the proponents of SCOT that both science and technology are socially constructed cultures and that the boundary between them is a matter for social negotiation and represents no underlying distinction. The metaphor of the *seamless web* was used to characterize the nature of actual process of technological development, wherein there are no distinctions between the technical, social, economic and political aspects of technological development.

Notwithstanding some important differences within the social construction of technology perspective, it tries to explain how technological artifacts/technologies are developed, are ‘constructed’ by social processes. An artifact - such as a bicycle for instance - is not ‘invented’, but ‘developed’ through a social process in which user groups influence the subsequent development of prototypes. Each prototype of an artifact poses certain problems to its users and the solution of these problems, incorporating/adapted to their needs, is what is designated as ‘social shaping’ by users. This social construction perspective, therefore, looks at how technological products are developed/shaped through various social interactions, how particular devices, designs and social constituencies prevail within the alternatives available at a given time. In studying the origins and dynamics of technological innovation, the researchers look at the *interpretative flexibility* of technical artifacts and their uses. Namely: that people in different situations interpret the meaning of a particular machine or design of an instrument in different ways. People may use the same kind of artifact for widely different purposes, and the meanings attached to a particular artifact and its uses can also vary widely.

The social construction of technology perspective also proposed that in analyzing technological development ‘failed’ innovations were just as important as the successful ones, and that the history of technology should consider artifacts that were ‘failures’ on the same footing with those that were ‘successes’. Such a historical investigation should not glorify the ‘successes’, but understand the reasons for the ‘success’ of some technologies and ‘failure’ of others. In order to do this all the possible technological solutions that had been offered, say for a given social problem, need to be tracked down and examined, in the context of the time period in which the choices were being made.

There are three main approaches in this SCOT perspective. The first, the social constructivist approach, extends the EPOR to studies of technological developments. One of the central tenets of this approach is the claim that technological artifacts are open to sociological analysis, not just in the context of their usage, but also with respect to their design and technical content. They
entail micro-studies of R&D laboratories, in which the interpretative flexibility of the artifact under study must be shown – that there is flexibility in how people think or interpret artifacts, as well in how artifacts are designed. There is not just one possible way or one best way of designing an artifact. The studies may also entail locating the "relevant social groups" involved in the development of a particular technological device, or process or system; each of these groups may have a different interpretation of the artifact and the associated problems, thus demonstrating interpretative flexibility. Finally the studies entail looking at mechanisms for stabilization of an artifact and the "disappearance" of problems. The studies look at how people act in different ways to achieve their purposes within the process of development, and of the processes through which the people concerned make judgments about the value of their representations.

The second approach, largely adopted by Thomas Hughes, used a "systems" metaphor, to look at the different, but interlocking elements of physical artifacts, institutions and their environment, and attempts to offer an integration of the technical, social, economic and political aspects in technological development (Hughes 1987). According to Hughes technological systems are both socially constructed and society shaping; and contain messy, complex, problem-solving components. The components in a technological system include the physical artifacts (such as transformers, transmission lines and so on in electric power systems), organizations (such as manufacturing firms, investment companies, research and training programmes, legislation and regulations, and so on), and natural resources as well, such as coal mines. Each of these "artifacts", these components of the system, interacts with the other artifacts, all of which contribute directly or through other components, to the common system goal. If one component is removed from the system, or if its characteristics change, the other artifacts/components will alter characteristics accordingly. The key concepts in this approach are those of the "reverse salient" and "critical problem", used to characterize the features of the system on which attention is focused during the innovation (explained earlier in 2.1.3). Through these concepts a link is established between the micro- and macro-levels of analysis.

The third approach, associated with the work of Callon extends the "systems" approach by breaking down the distinction between human actors and natural phenomena (Callon 1987). Both are treated as elements in "actor networks" and no distinctions are made between the animate and inanimate elements, between individuals and organizations; the concept of "actors" includes all the heterogeneous entities in a system or network. Such as electrons, catalysts, accumulators, users, researchers, manufacturers and government agencies making regulations that affect technology, and others. According to Callon all these elements, or "actors", interact through networks and are tested by the actors who innovate to create a coherent actor world. In addition,
Callon suggests that it is not possible to distinguish during the process of technological innovation phases that are distinctly technical or scientific from those guided by economic (social) logic. The conventional belief is that in the initial phase of innovation the problems to be solved are basically technical, and that the economic, social, political or cultural considerations come into the picture only at a later stage. However, Callon says, this distinction is never so clear – right from the start the technical and social considerations are inextricably bound up into an ‘organic whole’ (Callon 1987 p 84); such heterogeneity and complexity are not progressively introduced along the way, they are all present from the beginning. Therefore, Callon makes no distinction between the social and the technology, between the inside and outside in the development of technology. ‘Sociological, techno-scientific and economic analyses are all permanently interwoven in a seamless web’ (Callon 1987 p 84). Using the case-study of the innovation of the electric vehicle in France, Callon further proposes that the study of technology itself can be transformed into a sociological tool of analysis.

A common feature of all these approaches within SCOT is the emphasis on ‘thick description’ – that is looking carefully into what is considered as the ‘black box of technology’, of historical and contemporary technology to see what it contains. In other words, it means looking closely at the content and the actual dynamics of technical development/change, at artifacts and varieties of technical knowledge in question, and at the social actors whose activities affect their development.

1.1.6 The major contribution of the social constructivist perspective in the sociology of science, as pointed out both by its proponents and critiques, has been to question the normative view of science and scientific practice. However, we see that earlier critiques of science and technology, and studies in the social shaping of technology perspective had raised such issues, albeit in a different manner and with different goals and intentions.

There have been several critiques of the limitations of the constructivist approach in the sociology of science. Such a mode of analysis does not move beyond the micro-sociological level of analysis, and has contributed little to the understanding of the interface between science, technology and society. In fact it has little of value to say about these matters. According to Baber one of the ‘unintended consequences’ of the proliferation of studies in this relativist/constructivist SSK genre has been a total neglect of ‘the constitutive historical question of the sociology of science: what explains the origins of modern science in the seventeenth century and its ascendance in four centuries to a position of cognitive monopoly over certain spheres of decisions?’ (Baber 1998), and the neglect of the comparative historical and
civilizational perspective pioneered by the English biologist Joseph Needham. Some, like Yearley (1988) have pointed out that while there has been a great change in our understanding of science, the increase in understanding has been achieved at the cost of specialization.

Martin characterizes the developments in the critique of science as 'the taming of science studies by its academic context'. According to Martin as sociological treatments of scientific knowledge and theory about the practice of science has become more sophisticated, it has become less accessible to scientists and activists, more insular, more disconnected from the early concerns about the human impact of science and crucial social issues (Martin 1993). From a critique of science for scientists it has moved towards a critique of science for sociologists; science studies has become the study of science as it is, as it is serving society; the radical critique and development of alternatives 'have been pushed to the wayside'. In his view much of the professional academic work in the social studies of science can be seen as 'a process of taking over the insights of the radical critics, recasting them in an academic and sanitized mold, and pursuing the dilemmas internal to the resulting intellectual terrain'. While this process of academization has not necessarily been a conscious process, however, those critics with a more open political agenda are given little acknowledgement. It has led to antiseptic concerns about 'interests' at the micro-level, at the personal level, such as the manner by which scientists persuade each other about what is a fact, or how they pursue career advancement, and about the discourse, and the epistemological basis for the knowledge of the sociologists who are studying scientists. As pointed out by Martin, a critique should not only be epistemologically sophisticated, it also needs to be socially relevant, and self-critical about its method and social location.

1.1.7 As with the social constructivist perspective in science studies, in studying technological change the SCOT approach has its usefulness. Like the SST approach, it is an important counter to the notion that one need not understand what goes on inside the 'black box' of technical development, in how technical knowledge is created, and that one should be merely interested in the inputs and outputs of the black box. As pointed out by Winner, it offers clear guidance for undertaking case studies of technological innovations (Winner 1993). In fact there have been several case studies using this approach such as on the development of bicycles, Bakelite, missile guidance systems, electric vehicles, networks of electrical power generation and distribution, expert systems in computer science, and the medical ultrasound scanner.

The most useful contribution has been the revelation that technological innovation is a multi-centred complex process, and not the autonomous, unilinear progression as depicted by earlier
works within the TD approach. These case studies in the social constructivist approach have revealed the spectrum of possible technological choices, alternatives, and branching points within patterns sometimes thought to be necessary, and showed that there is conflict, disagreement and consensus formation around some choices of great importance. In other words 'social constructivist interpretations of technology emphasize contingency and choice, rather than forces of necessity in the history of technology' (Winner 1993, p 367). Social constructivist studies have also been helpful at questioning the arbitrary distinctions drawn between the social and technical sphere.

However, the narrow and a-historical approach of the social construction of technology perspective has also been subject to critical appraisal from several quarters (as with the sociology of scientific knowledge perspective). In a sharp and acerbic article Winner writes, ‘advances along this line of inquiry take place at a significant cost: a willingness to disregard important questions about technology and human experience, questions very much alive in other theoretical approaches’ (Winner 1993 p 368). According to Winner, there is a tendency in SCOT – explicit or implicit- to be dismissive about the works of a whole range of earlier thinkers who have written about the origins and significance of modern technology – such as Lewis Mumford, Jacques Ellul, Ivan Illich, Marx and Engels, and other historians, sociologists and economists writing on technology. Winner goes on to say that ‘here is a social construction of knowledge that seeks to depict earlier and contemporary approaches as outmoded or dead’ (Winner 1993 p 367). Lack of attention to social consequences of technical choice, of technical change, little concern for the ways in which technologies transform social relations and personal experiences; why such innovations matter in the broader social context, such issues are not of concern. While we know about the relevant social actors involved in the development of technology, we do not know about those groups that have been left out, that have no voice, but will be affected by the technology. Similarly, while we know about the decisions/choices that were made, we do not know about potentially important possibilities that were never considered at all for debate and choice. Furthermore, by focussing on the immediate interests, actions and solutions of specific groups/actors, this approach disregards the possibility that there may be deeper processes located elsewhere in society, which may not be visible. Yet another problem is the lack of an evaluative stance, which might help people judge the possibilities that the technological choices present. The social constructivist works provide a limited and sanitized view, devoid of any critical standpoint that might contribute to substantive debates about the political and environmental dimensions of technological choice. In other words, it lacks any theoretical or practical position on technology and human well being at all. According to Winner, the stance of ‘relativism and interpretive flexibility’ amounts to moral and political indifference as regards the status quo and its ills and
injustices. Given the significance of technical phenomena for contemporary human societies, and the historical concerns regarding the role and effects of technology in modern societies, and the frequency with which technology arises as a crucial issue for commitment, such a stance is extremely unhelpful.

Vergragt attempts to overcome the limitations of SCOT and the actor-network approaches by focusing on study of industrial research laboratories (Vergragt 1988). He points out that industrial research laboratories are the sites where important decisions are taken and choices made with respect to future innovations and products. It is the site of creation of new technological products and processes, through the deployment of scientific methods and theories. Within the industrial research laboratory scientific knowledge, technical expertise, economic considerations, marketing skills, all are combined to create products and processes, which incorporate modern science and which can be profitably sold on the market, and which perpetuate the economic power of the 'innovating firm'. Many such products and processes have led to several transformations in societies as we know it. Hence it is important to not only study impact of technologies, but also the processes that shape them and the possibilities for enhancing public influence over these processes. This is not to say that it is technologies which change/shape society. Behind this is the view that there exist power relationships and interests inside and outside the firm, and innovations themselves are susceptible to wider political and economic influences. So a study of the social shaping of industrial innovations, of how scientific facts are 'constructed' in industrial research laboratories, and how these processes of 'construction' are influenced by corporate and other interests is useful.

Several others have pointed to the a-structural approach of SCOT to technology development and its neglect of the wider social context. Klein and Kleinman elaborate on the methodological and explanatory difficulties that arise with this approach, and point to the importance of structural concepts in technology development. According to them, SCOT implicitly assumes that the relevant social groups involved in technology development are equal and that all are present in the design process. The systematic asymmetries of power and how these power differences are rooted in the structural features of social life, all these remain largely invisible. There is no explanation for how consensus develops in development of technologies, or why the meanings of some groups had greater relevance than that of others and how differences were resolved (or suppressed). In other words, what is it that enables one group's interpretation to be embodied in the artifact? Using concepts from organisational analysis and political economy, they argue for the importance of structural concepts to understanding technological development. The structural characteristics of potentially relevant social groups can give us an idea of their likely impact on
the development of artifacts. For instance: the internal structure of social groups maybe such that it allows the elite factions to impose their own meanings on the artifact. All other things being equal, the capacity of one social group to shape artifact development will be enhanced the greater its access to economic resources and to shape policy outcomes (Klein and Kleinman 2002). In a similar vein Blume points out that in the social construction approach the social groups emerge from thin air (Blume 1992). There is little sense of the fact that technological innovation and change take place within social structures. According to Blume these structures not only define the relations of the concerned groups to existing artifacts, they also have (unequal) influence over their future development. For instance: in practice a patient’s experience with diagnostic equipment does not have the same significance for its future as does the assessment of the physician using it. ‘In writing the histories of the technological developments, we must characterize the actions of the principal actors both in terms of the objectives they seek to attain and of the strategies that they adopt’ (Blume 1992 p 62). According to Blume, organized technological innovation is one of the most powerful forces of change in a society that sustains it to the hilt, both economically and ideologically, and technology-in-society is a major challenge and transcends the theoretical specifications of the individual social science disciplines such as economics and sociology. There is need for a theoretical perspective in which technical and economic activities are embedded in, and interact with, a more complex social structure. According to him there is need of a perspective that draws both on sociology and on economics; it is not enough to join together bits and pieces taken from the two.

Even before such critiques appeared Russell not only offered a very substantive and far-reaching criticism of SCOT. He also outlined an alternative conceptual framework for the study of technologies as social products (Russell 1986). Responding to Pinch and Bijker’s proposal for an integrated social constructivist approach to sociology of scientific and technological knowledge, Russell agrees that there are problems with the conventional ‘black box’ treatment, and linear models of innovation, and descriptive historiographies of technology, and that there is a need to give the study of technologies as social products a coherent theoretical underpinning. However, he does not agree with the approach of transfer of the concepts of sociology of science to technology, as it implies ignoring basic differences between the two, of one as an activity and the other as products. He argues that it is inappropriate to transfer the approach and concepts of sociology of science to technology. Russell discusses in some detail the analytical inadequacies in the concepts of social constructivism, namely relativism, interpretative flexibility, evolutionary model of innovation and closure.

(i) The evolutionary model of variation and selection among technologies suggests that a full range of technological options appears, either somehow spontaneously generated or from a
process of conception which implicitly needs no social analysis. It concentrates on only a part of
the genesis of technology – that of adoption of specific features that exist in the conceptual or
prototype stage, and still shields from analysis what comes before them. For instance: it looks at
how a choice was made between several different forms of bicycles, but not why these were the
only possibilities presented to the users, or how these possibilities themselves came about in the
first place. However, in most contexts, the control of research and design processes by certain
interests means that only a limited number of trajectories are accepted as ‘progress’, that some
criteria for ‘improvement’ are taken as given and others are ignored, that ‘needs’ are interpreted,
and thus that many options never surface for ‘selection’ in a conscious, informed manner. Such a
selection may take place by tangible institutional or financial means, or subtly through the
training and ideology of personnel. Russell suggests that there is need to identify historical
alternatives if we are to explain or understand a development or how we might have influenced
that process. However, we must also recognize that many may have been lost in conception. So
they will not have been visible to the groups outside the design process, or even to the designers
themselves. So a focus on ‘technological controversy’ will miss these aspects of social shaping of
technology. There is need, therefore, to scrutinize the whole process of technology development,
demonstrating and explaining the different points of access of each group to it and its plausibility,
to counter technological determinism.

(ii) With respect to relativism he says that attention needs to be given not only to the
processes by which technical arguments are settled, but also to the very content of the technical
arguments. For instance: in case of a major technological project, the outcome is decided not just
by the relative technical merits of the contending arguments. It needs explanation in terms of
how and where the dispute was conducted, access to information and so on. However, while
doing this one should also pay attention to how the very content of the technical arguments are
shaped by social influence. For example, criteria such as efficiency, cost-benefit, risk-assessment
and other techniques employed in disputes over technological projects embody specific ways of
defining problems, assumptions and judgments. These may predetermine outcomes and make it
futile to challenge them within their terms of reference. Secondly, he says, it is easy to slip from
relativism as a method each view of social reality as equally valid, into relativism as a position on
conflicting viewpoints, which leads to political neutrality. According to Russell ‘to counter a
scientistic notion of facts, and its corollary that establishing these facts does, and should,
determine the action taken, we do not need to adopt a neutrality, which holds each view of social
reality as equally valid’. To transcend this situation (which in his view is a false dichotomy)
requires that one starts with a political commitment to demonstrating the possibilities of
alternative technologies for alternative goals, and to open up the process of technological
development to sections of society denied access to it, rather than with some academic motivations.

(iii) The other weakness of the SCOT approach, as pointed out by Russell, is its inadequate conception of social structure. More than identifying and describing the social groups, they need to be located in a structural and historical context. We need to be aware of their relations to not only the technology, but also to other sections of society, their economic, political and ideological constraints and influences. It is this structural relationship that largely determines their relationship to each technology that they conceive and develop, or are confronted with. Whereas, Pinch and Bijker’s conception creates an impression that social groups are isolated from each other and are all equally powerful. The concept of ‘relevant social groups’ is also not quite simple in reality. It is possible that some groups may not be visible at all, because they had no voice in the process, or they were indifferent to the options presented; whatever the case the reasons need to be known. Second, is the problem of ‘over-aggregation’ – public statements of one organization or group can mask significant internal divisions on the issue. Thirdly, it is possible for certain groups or sections to secure their interests without actually participating directly in the dispute over a technology.

(iv) There are also problems with ‘interpretative flexibility’ in explaining the outcome of technological development and adoption. An explanation of technological change must show not only what different social groups think about an artifact, but also what they are able to do about it – their differential abilities to influence the outcome. This again relates to the issue of social groups. Not only do their objectives need to be related to their social location, but also the resources of knowledge and power with which they can bring about change to suit their objectives. Not to do so is to legitimize existing patterns of control and deny the possibility of change. Finally, the concept of ‘closure’ from the sociology of scientific knowledge in describing the outcome is inappropriate for technology. Its use in case of technology refers to the stabilization of an artifact and the disappearance of associated problems. This implies that technology is being treated as a knowledge system, and technological disputes are settled as in scientific ones. The context in which scientific disputes are settled, through communication and debate, selection of areas for research and through ideology in theory itself, is different from that of technological systems. Technologies are material products with material results, and are not pure knowledge. Use of ‘success’ to describe adoption of technologies is also problematic; its use can be misleading. It connotes consensus and acceptance of the innovation, which may not be so in reality. Some group, as mentioned earlier, may not have been consulted, or need not accept that meaning that ‘succeeds’, or may not see ‘the problem as being solved’.
Russell proposes that the social processes producing technologies should be situated in, introduced into an established framework – that provided by a broadly Marxist form of radical social analysis. In his view while the treatment of technology in radical social analysis has been limited in focus, still it promises greater explanatory power in wider contexts, and especially the ability to relate objectives, actions, choices and outcomes at the micro-level to broader social structures and processes. Furthermore, it also demonstrates possibilities of changing the course of technology to suit different objectives. A significant point raised by Russell, which was also raised by Winner, is the need to have an understanding of the sphere in which a technology is, or could be, developed and introduced. This should not be construed as not having a framework applicable to all technologies; rather it is to recognize the fundamental differences in relationships shaping different technologies, such as bicycles, a machine tool, a domestic appliance, a military aircraft, and so on; to avoid unwarranted generalization from failure to see the specificity of a context; and at the same time to appreciate that unification in a theory of technology cannot come about through its abstraction, but only through a coherent model of the society in which different technologies are embedded (emphasis in original) (Russell 1986).

Russell believes that there is a fair amount of work, empirical, exploratory and controversial, which can usefully inform an analysis of political processes behind technologies. But there is little work on technologies even as given entities, leave alone addressing their content. He discusses the contribution of the studies of technology done within the labour process theory – on the technology of production, and being extended to non-manufacturing activities. He points out that we also need to confront the role of technology in individual and collective consumption. In this sphere we need to analyze the influence that consumer groups (not homogenous) have over the nature of goods and services offered, and conversely the means by which the providers of these goods can manipulate the consumption and change its forms. So a critical analysis of technology has to address the concepts of ‘choice’, ‘market’, ‘need’ and so on. Additionally, as we move away from groups and contexts which fit neatly into the fundamental Marxist categories, the analysis gets more complex, with a wider range of groups and different types of interaction between them. In his view, the emerging critiques in political science and policy studies need to be extended and adapted for technologies and the issues surrounding them.

Yearley advocates a ‘moderate constructionism’ approach, which combines ‘a social construction view and a political economy view’. According to him ‘science and technology are not mere social constructions; but constructions they are all the same’ (Yearley 1988). Furthermore, he extends the sociological vision to an examination of the role of science and technology in the underdeveloped world, located within the broader academic concepts of
underdevelopment. The political economy perspective draws attention to the larger institutional structures to understand how the development of scientific and technical knowledge is influenced by economic and political priorities. Yearley argues that such priorities can clearly specify what sorts of science are pursued, whether nuclear physics or organic chemistry (or biotechnology) receives most funding and staff. Other potential branches may not receive any attention if they offer no commercial results or other rewards to researchers. An example is that of the so-called orphan drugs, which may benefit only very few people affected by rare diseases, but would not be commercially viable. Another example he cites is that of the glamour attached to cancer research, or plentiful funding in the U.S. for work on the strategic defence initiative. In other words, his central argument is that scientific knowledge is being filtered and selected by commercial and political considerations. It may even be the case that scientific knowledge is being withheld for political-economic reasons. Such an approach thus shows that there is no single route along which scientific knowledge 'advances', that it is inextricably linked to the social and economic context. So what is considered as a neutral, value-free knowledge can be regarded as a 'construction', or at best a permutation according to Yearley, based on political, commercial and personal considerations. Extending this to technology development means that one technical artefact, design or technical procedure has been chosen over another not only for technical reasons, but also for economic or political ones. Two examples of such social shaping of technology are discussed by him.

1.1.8 Thus we see that the sociology of technology has seen the emergence of the 'social shaping of technology' approach (SST) and the SCOT approach. Together, they offer a more realistic understanding of the process of technological change than the mainstream, technocratic, TD approaches of technological progress and its 'impact' on society.

SST should not be considered synonymous, or should not be confused with, the social construction of technology approach or even with the general sociological study of technology. It is true that both SST and SCOT are concerned with explaining the social processes of the conception, invention, design and development of technology, all of which embody particular social relations, with explaining how social processes, forces and structures relate to technology and give rise to particular technologies, and with developing critiques of notions of technological determinism. They attempt to show how technologies are created not by lone inventors, but by a combination of social processes and social forces. However, there are significant differences between the two.
Our review of literature indicates that the origins of the SST approach lie in the long-standing critiques, since the 1960s and 1970s, of science and technology and of the deterministic approaches to their study (see section 1.1.2). The social construction approaches emerged later, and concentrate on the micro-level, and within which fall the social constructivist approach, the actor-network and the systems approaches. Several researchers have pointed out the limitations of this micro-perspective, and have attempted to articulate a more comprehensive framework, that incorporates the specific with the larger social processes.

In a review of the research in the 1990s that looks at the social shaping of technology, Williams and Edge conceptualize SST as a ‘broad church’, in which a variety of scholars with differing concerns and intellectual traditions find a meeting point (Williams and Edge 1996). What is common to all is their questioning and critique of the traditional deterministic conceptions of technology, the ‘linear model’ of innovation, and the limited scope of the enquiry to monitoring the ‘impacts’ of technology. Research within the SST approach has problematized the processes of technical innovation and of technological change, to reveal and analyse the socio-economic patterns embedded in them, as well as in the content/character of technology. Research in the SST approach views science and technology not as standing outside or above society, but as areas of social activity, subject to social forces and amenable to social analysis, and thus open to social intervention. In their review Williams and Edge discuss how SST emerged through a critique of TD, and goes beyond simplistic social determinism, to grasp the complexity of the socio-economic processes involved in technological innovation. Such research explores a range of factors – organizational, political, economic and cultural – which pattern the design/form of technology, as well as the direction of technological innovation, and the process of implementation of technology.

According to Williams and Edge, central to SST is the concept that there are ‘choices’ – not necessarily conscious – inherent in both the design of individual artifacts and systems, and in the direction of innovation programmes. Different routes are available potentially leading to different technological outcomes. These choices could have different implications for society and for particular social groups.

Mackay and Gillespie make suggestions for extending the SST approach (Mackay and Gillespie 1992). They argue that ‘the SST approach tends to assume that once one has looked at the social origins of technological change one will have explained everything of importance. To suggest that once a technology is produced, or even sold, it reaches the end of its social shaping, however, is to ignore both its marketing and how the technology comes to be used or
They look upon technology not solely as a process of design but as a product of three conceptually different spheres: conception, invention, development and design; marketing; and appropriation by users. In their view not enough attention is given to the role of ideology as a social force behind design and development. For instance: there is need to relate occupational ideologies to the technological product. Secondly, marketing plays an important role: not only does it inform design, but also plays a part in constructing demand.

In an exploration of the implications of the work on social shaping of technology for technology policy and management, Russell and Williams have reviewed the developments in SST through the 1990s (Russell and Williams 2002). Like Williams and Edge, they also point out that SST is not a single, well-defined theory and that it includes distinctively different approaches and concepts, and the issues studied have ranged widely across types of technology, stages of the innovation process and domains of use. However, what all of them have in common is an attempt to demonstrate social influence on the direction of technological change. There has been substantial growth and development through the 1990s, and a 'bewildering proliferation of frameworks, concepts and general claims' in the field. Yet there is extensive common ground between seemingly contrasting approaches. Among the broad themes and trends that they identify in SST are:

- **An increasing integration of insights from a variety of currents of technology studies** - not only from the largely historical and sociological frameworks around which the SST work was launched in the 1980s, but also from innovation studies based in evolutionary economics - and from more general social theory.

- **Further development of ideas on the situated, socio-technical, and systemic character of technologies**, including the co-production of technology and social change.

- A continuous emphasis on the contingent and unpredictable nature of socio-technical processes and outcomes.

- **An extension of the focus of research `downstream'** from design and development, to use and appropriation.

- A **wider conception of the terrain of innovation and of relevant groups and sites;** and

- A **greater emphasis on cultural aspects of technology**, particularly the role of meanings and values attached to technologies, and the shaping of knowledge in and about technology.

Russell and Williams elaborate on two key trends: the notion of co-production of technologies and social change, and on the extension of social shaping analyses downstream, to use and appropriation of technologies, in order to draw out the implications for policy making and
management of technologies. *Co-production of technology and social change* describes the conceptualization of the association between social and technological change. Many SST studies have rejected the terminology of technology and society as separate spheres, which interact. New general terms have been introduced to stress that both technology and social arrangements develop as part of the same process - that technology and organizations co-evolve, are co-produced, are *mutually constitutive* – and that technological entities are always combinations of social and technical elements, from their inception to their final outcomes. (for example – Hughes’ metaphor of *seamless web*, Bijker’s notion of *socio-technical ensembles*, networks of heterogeneous elements as in the actor-network theory, notion of *socio-technical landscapes* by others). SST studies have started looking beyond design and development of technologies, -at the commercial shaping of technologies, and at suppliers and users of technologies, focusing on areas such as processes of selection, acquisition and appropriation of technologies in specific contexts; the extent of innovation as technologies diffuse and are used; the relations and strategies of developers and users in shaping the locus and control of innovative activity. For instance: the process of acquisition is much more complex than the conventional one of a technology being replaced by a self-evidently better one. Users or purchasers of technology for organizations are guided and constrained by a complex combination of objectives, priorities, criteria and regulatory constraints, as well as values, pressures, images and associations. Secondly: innovation studies have demonstrated the varied strategies of suppliers towards downstream shaping, and the complex industry structures which develop from these. Industry structure in many areas is thus much more complex than that of a simple one of suppliers, users and markets. For some technologies, there have developed chains of intermediaries – retailers, IT professionals, managers, organizers of trials and so on – who play a key role in not only adapting the technology (to local knowledge of the organization) and allowing the diffusion, but also help users understand possibilities and formulate requirements, and mediate between suppliers and users. Each of these chains is subject to a variety of pressures towards integration or separation. It is being recognized that a range of actors, other than manufacturers are involved. Users, competing suppliers and suppliers of complementary products participate in developing markets. Where there is no existing market for a `new technology’ the `market’ may have to be created to go with the products if suppliers are to realize its commercial potential (Williams 2006). This implies diffusion of the knowledge required to understand the utility of new products and how to use them. So mapping the industry structures becomes crucial to understanding the shaping of technologies.

In recent times SST has been strongly influenced by concern with technology policy. Public technology policies based on the linear models of TD are now seen as unhelpful because of their
division of innovation into separate phases. SST has drawn attention to the close and reciprocal interactions between these stages, and the transformation of technologies between their initial conception and eventual application, has helped draw attention to the role of the user and supplier. It has been claimed that SST could help to broaden technology policy agendas and make them more pro-active, rather than merely conduct the conventional retrospective cost-benefit analyses of technologies that have been developed and are already in use. This approach allows exploration of the possible implications of different choices during technological development. SST work has extended its focus 'outwards' to incorporate analysis of physical and organizational infrastructures, of industrial policies, of regulation and taxation, etc, in shaping technologies. In this context they talk of constructive technology assessment (CTA). CTA acknowledges that development necessarily involves multiple actors, and that effective assessment and redirection requires input from them. It therefore envisages continuous interaction between policy makers or regulators and developers, and advocates integration of an iterative assessment into design and development phases as well as in implementation.

In more recent times there have been calls for 'a critical, yet constructive engagement' with new technologies, to look at the 'cultural politics' of technology (Sorenson 2004). It is felt that technology is not just a negative force to be checked, but also a positive force to be made use of. According to this view, a strictly critical attitude may make us overlook possibilities that are not considered, whereas too constructive an engagement may induce too optimistic a view. There is need to take on the positive and negative potentials of technology.

Over the 1990s Feenberg has drawn from and assimilated the advances in technology studies, as well as the lessons from the fall of the Soviet Union in the 1980s. He gives a positive thrust to technology studies, by articulating a theoretical-philosophical approach to technology in the context of modernity. He shows how the existing cultural studies and constructivist sociology and history have shed new light on technology. However, they have so disaggregated the question of technology as to deprive it of any philosophical significance. Such analyses have been unproductive because they remain at an abstract level and leave everything as it is. They do not have any implications for technological development, the actual foundation of modernity. Such technology studies have become a matter for specialized research. Such studies minimize the top down control of technical rationalization, such as by corporations. What is needed is a "critical theory of technology" – a critique that enters into the life of the technical systems that can reveal unexplored possibilities. He attempts to bridge technology studies with modernity theories, and develop a theory of democratic technological change that would allow reshaping of modern technological society. Feenberg sees no distinction between technology and culture in
modernity. Rationality, according to him, is not an alternative to culture. Rather "rationality in its modern technical form mediates cultural expression in ways that can in principle realize a wide range of values. The poverty of actual techno-culture must be traced not to the essence of technology but to other dimensions of our society, such as the economic forces that dominate technical development, design and the media (Feenberg 2003). One of the important features of Feenberg's theory is what he calls technical codes. The design that a given technology takes is shaped by social actors. However, not all actors have the same amount of influence in this process. Those groups whose worldview determines what is normal and real and rational have a greater say in the designs of technology than those of non-dominant ones. As a result, the technologies/designs that one actually sees are not necessarily the single most efficient and rational ones, but instead those which from among a group of potential designs, best reflect the hegemonic beliefs and values of the dominant group. Feenberg calls these dominant designs as technical codes. The invisibility of these technical codes makes them appear as normal even though they are not. Given the pervasiveness of technology in modern societies, it has become a legislative political institution and therefore should be controlled democratically; rather than be left to a few privileged groups. Since technological development is contingent not just on reason but also on society, it ought to be democratized like other domains of social activity. Feenberg provides an outline of the nature of democratic politics of technology.

REFERENCES


SECTION II
STUDY OF MEDICAL TECHNOLOGY

One reason we are ambivalent about the effects of technology in general is that it is difficult to be clear about the consequences of particular kinds of technical innovation. Take, for example, modern advances in medicine and social hygiene. This is perhaps the most widely admired realm of science-based technological advances; nonetheless it is often said today that those alleged advances are as much a curse as a blessing.

On reflection, however, such inconclusive assessments seem crude and ahistorical. They suffer from a presentist fallacy like that which casts doubt on the results of much public opinion polling. It is illusory to suppose that we can isolate for analysis the immediate, direct responses to specific innovations. Invariably people’s responses to the new—to changes effected by, say, a specific technical innovation—are mediated by older attitudes. Whatever their apparent spontaneity, such responses usually prove to have been shaped by significant meanings, values, and beliefs that stem from the past. A group’s responses to an instance of medical progress cannot be understood from the historical context, or apart from the expectations generated by the belief that modern technology is the driving force of progress.

Leo Marx (1994)

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3 In: The Idea of “Technology” and Postmodern Pessimism, In: Does Technology Drive History? The Dilemma of Technological Determinism by Merritt Roe Smith & Leo Marx (eds), The MIT Press, Massachusetts.
1.2 Approaches to Medical Technology

1.2.1 Definition of medical technology

Over the 20th century the term 'technology' has come to represent simultaneously an artifact/device/machine, a specialised form of theoretical knowledge or expertise, a distinctive mental style and a unique set of skills and practices. In fact, it is felt that 'technology' is identified less closely with the material or artifactual aspect, and is much more an abstract, inclusive concept denoting the inter-penetration of the machine with certain kind of knowledge, practices and organisational styles. In keeping with this concept of technology, the term medical technology is an (abstract) inclusive term that denotes the set of procedures, techniques, drugs, devices, equipment and facilities used by healthcare professionals in delivery of medical care; it includes the organisational and supportive systems within which such care is delivered. Although it is not explicitly stated, this commonly used definition, or characterization, of medical technology, is that of the Office of Technology Assessment, USA (OTA 1976). Medical technology is also used to refer simply to the instruments and equipment used by medical professionals in delivery of medical care (used in this thesis also - namely, equipment-embodied technology). One also comes across terms such as 'hard' and 'soft' technologies, which is basically a modification of the OTA definition, where 'hard' technology refers to equipment-embodied technology, such as instruments, machines and devices, while 'soft' technology refers to organizational and financing mechanisms. Working definitions of 'medical device' have been formulated in European countries and the US largely for regulatory purposes, and are more specific and limiting. A medical device is any instrument, apparatus, appliance, machine, implant or other similar article that is intended for use in the diagnosis of disease or other conditions, or investigation, monitoring, cure, mitigation, treatment or prevention of disease, or intended to affect/modify the structure or function of the human body, and which does not achieve any of its intended purposes through pharmacological, immunological or metabolic means.

By the above all-inclusive OTA definition, almost all of modern medicine qualifies as medical technology. (In fact some sociological studies look upon aspects of medical practice such as medical records or the doctor-patient interaction as medical technology). This problem is not unique to medical technology; rather, different people define the word 'technology' itself differently. While technology is generally used to denote 'artifacts', increasingly it is used to denote processes for producing artifacts, knowledge about artifacts and processes, and even systems for organization and control. However, the latter components – knowledge and forms of organizations are important and general distinguishing features of human societies themselves,
which may use/employ certain forms of technological artifacts. To include them under technology can be problematic, to say the least.

1.2.2 There is voluminous literature describing the history of developments in modern medicine and medical technology. Much of this work is on specific innovations, such as specific vaccines or techniques and so on, or on the person(s) associated with these inventions and innovations. These works are concerned more with the specificities of the disease, or the activities of the individuals involved, and the interest in the technology is incidental.

However, the historical account of Reiser on the process of introduction of several technologies in the 'art and practice of medicine' during the past four centuries, in Europe and North America, and the responses of the medical profession, is an exception. He provides detailed and well-researched descriptions of the origin and development of some instruments/techniques (such as the stethoscope, thermometer, microscope, sphygmomanometer, and clinical laboratory tests) and on the processes by which a technical advance got accepted or rejected by the medical profession (Reiser 1978). Some of the important features regarding the introduction of technologies into medicine during the nineteenth century that emerge from Reiser's work are:

(i) The work of experimenting, individual researchers and medical practitioners led to the development of most instruments.

(ii) The process of introduction and acceptance of technologies into medical practice was a long-drawn out process, due to the (iii) limitations of the innovation, and the subsequent process of refinements; (iv) all technical innovations were greeted with caution, and even skepticism or opposition by sections of the medical profession. Concern with technology, about its overuse/indiscriminate use existed within the medical profession much before it became widespread. (v) Elaborate research on the subject was conducted by the concerned researchers, and comprehensive treatises were published in support of the concerned technology. For instance: Wunderlich, who was working on the usefulness of the thermometer in the 1850s, made a large number of observations on body temperature, and compiled observations on almost 25,000 patients.

The acceptance and regular use of instruments such as the thermometer and sphygmomanometer took place over more than a hundred years. The thermometer was not accepted for a very long time because of lack of comprehensive information regarding the value of temperature recordings in health and illness.—Instruments for measuring temperature changes began to be designed since the late 15th century (with Galileo being one of the pioneers in the area). For nearly a hundred years since then its use was hindered due to prolonged dispute
concerning its accuracy. Despite improvements in the instrument it was not taken up by physicians because of lack of comprehensive information regarding the value of the temperature recordings. Later on (1870s-1880s) the concern was that by attaching too much importance to the thermometer readings doctors might fail to adequately explore the other circumstances of illness, the object of therapy becoming only a reduction of the temperature. This problem grew during the 1890s, when drugs that could reduce fever became widely used. This sometimes led one to neglect other signs and to misdiagnose or inadequately treat the patient’s fever. Doubts about the value of thermometer readings also arose when flaws were found in the thermometer that even reputable manufacturers produced. In the US some physicians attributed the problem to competition in business and the absence of a correct standard by which to set the instruments, as well as of a scientific institution to verify the accuracy of the instrument.

Similarly, the development and introduction of the sphygmomanometer, for measurement of blood pressure, was characterized by debates over the advantages and limitations of observations based on the sensory organs, and those based on instruments. An extremely important and relevant issue was raised by the French physician, Marey, who himself designed one sphygmograph in 1860, which met with a better reception than its predecessors. Marey and subsequent investigators warned that the character of normal circulation and the variations in the normal pulse study required further study, before sphygmographic evidence of disease could be relied upon. Physicians needed to understand the influence on the patient, and thus on the tracing of work, eating, heat and emotion, and were cautioned about the imperfect knowledge of the relation between the tracings and the physiological disorders they were supposed to indicate. It took several more decades until the blood pressure instrument was satisfactory enough for use.

Reiser concludes that in modern medicine diagnostic judgments based on ‘subjective’ evidence (such as the patient’s own sensation, physician’s observations) are being supplemented by those based on ‘objective’ evidence provided by laboratory procedures and mechanical and electronic devices. He points out the resulting gains and potential losses to the patient, the physician as well as to society. He also discusses the reliability of the evidence so produced, as well as the hazards involved in their unquestioning acceptance. In addition, by looking at how technologies altered the methods of diagnosis and, in turn, the patient-doctor relationship, as well as provision of medical care and treatment, Reiser’s work throws up several useful dimensions/insights regarding the use of technology in present-day medicine.

Reiser’s account reveals that the routine practice and organisation of early-twentieth century medicine was slow and cautious in changing and in accommodating the new ways of representing
and understanding disease that were being made possible. It indicates also that *medical technology has been a contentious issue within the medical profession right since its introduction.*

Beginning in the seventeenth century, the introduction and acceptance of medical technologies has been a long-drawn out process, marked by tension/contestation between the proponents and opponents of the concerned technique/technology. One of the reasons for this was the reservations about or opposition to machine-generated data from sections of the medical profession. In part this was related to the other reason, namely the limitations of the technique/technology itself and the time taken in its refinement. *According to Reiser, in the late nineteenth and early twentieth centuries, by which time technologies like the x-ray and the clinical laboratory had started becoming widespread, two movements developed within the medical profession. These raised important questions about the uncritical reliance of medicine on technologically generated facts.* The first attempted to reverse the growing neglect of the patients’ views, his/her history and description of symptoms; and emphasized that they constituted important evidence and should be carefully considered by the doctor in evaluating illness. The second emphasized that *all techniques used to gather and evaluate medical evidence, including those based on technology, were liable to significant error.* In different ways both groups have raised doubts about the wisdom of over-reliance on information obtained by technology. They also urged physicians to explore their own attitudes towards illness and ways of reaching medical judgments.

1.2.3 There was a proliferation of medical technologies in the early part of the 20th century, beginning in the post World War I period, and there were alterations in practically every facet of healthcare (see chapter 2 –Review of literature in public health). Medical technology in general and assessment of its social and economic impact in particular, became a major policy concern in the 1970s and 1980s in the industrialized countries of the West. Medical technologies had acquired a bad name by the mid-1980s (many charged it with being ‘extravagant and irrelevant’).

Perusal of medical literature of the first half of the twentieth century shows that there were debates about and concern within the medical profession about the tendency for (over) dependence on technology, over its possible gains and losses to medicine. The delegation of responsibility for diagnosis to technical experts raised basic moral problems for twentieth-century medicine (Reiser 1978 p 171). For instance, Tinsley Harrison, a well-known American clinician and author of medical text-books, noted ‘the present-day tendency towards a five-minute history followed by a five-day barrage of special tests in the hope that the diagnostic rabbit may suddenly emerge from the laboratory hat’ (cited in Reiser 1978, p 158). In 1910 the English physician and
bacteriologist Wright expressed concerns over the use of bacteriological tests by physicians who lacked thorough education in bacteriology, as also the implications of the fact that the field was relatively young and new bacteriological discoveries were being made. The concern continued within later physicians, who realized that many doctors ordering laboratory tests had little working experience with the wide range of techniques used to analyze specimens or the criteria used by laboratory workers to make judgments. Without this knowledge they could not adequately subject laboratory evidence to medical scrutiny. George Pickering, English clinician and professor of medicine, commented in 1955 that 'To rely on data, the nature of which one does not understand, is the first step in losing intellectual honesty. The doctor is peculiarly vulnerable to a loss of this kind. And the loss naturally leaves him and his patients poorer' (Reiser 1978 p 173).

In the 1950s the hazards of hospitalization were acknowledged and the term "disease of medical progress" was used and some doctors documented the 'disturbing incidence of medical misfires'. In a Presidential address before the Association of American Physicians in 1975, Rogers dwelt on the 'dilemmas posed by the expanding capacity for intervention in human disease'. He discusses some of the problems, such as the financial burdens for the patients, the 'worrisome incidence' of iatrogenic diseases and the tendency for specialization among physicians (Rogers 1975). In his view there was need to sensibly restrain technology and the curiosity of the medical professionals and their desire to be thorough. So he calls for technologic restraint coupled with discrimination in the use of the 'powerful tools we now have at our command', and to adopt 'a patient-oriented approach to problems rather than a problem-oriented approach to the patient'.

An important issue that was sought to be raised in some way or the other was that of limitations of technologically generated evidence. During the nineteenth century some physicians had been troubled by the faulty data that could be produced by mechanical flaws in their instruments and by differences in the perceptions of observers who viewed the same data. These problems were not comprehensively investigated until the early twentieth century when several empirical studies appeared concerning sources of error in measurement, observer variation and the issue of misinterpretation of data generated by machines. It was pointed out that 'facts obtained from the laboratory are in one sense no more objective that those collected at the bedside – both types of evidence must be interpreted by the human mind. Instruments are only powerful transmitters. Essentially all data are subjective: in all observations an opinion is registered at the same time that a fact is recorded' (Reiser 1978 p 183).
It thus emerges that the reliance of medicine on technology has been questioned from within the medical profession itself. The works of medical professionals, especially those like Cochrane and McKeown, raised considerable doubts about the efficacy of many medical procedures in general. It became increasingly clear that clinical research was not organized to provide definitive information on the effectiveness of existing or new clinical procedures. It also emerged that in the real world of health care scientific evaluation of efficacy and safety of medical technologies was often not done. New equipment, procedures or systems got adopted often without adequate knowledge of, or concern for, their relative effectiveness or efficiency, and safety. They also pointed to the problems associated with evaluation and regulation of medical technologies once they have been adopted, particularly regarding costs and benefits. There was recognition that it was not an easy, simple task. There was need to distinguish between improper use of existing technology, and the process by which new technologies were developed, introduced and diffused into the health care system.

There were plenty of other studies and analyses of the issues thrown up by the presence and use of technologies. These ranged from evaluation by medical professionals of the so-called 'technical aspects' such as the clinical usefulness and their efficacy, to a large number of studies undertaken from a policy angle. The latter looked at adoption/diffusion of certain technologies, nature of the growth and demand for these procedures, operating costs, patterns of utilization, of effect of ownership of facilities on utilization, of abuse/misuse by physicians, impact on cost of medical care, and role of government policies and programmes in their acquisition, and on planning and financing for these services.

The sociological studies pointed to several issues associated with availability and use of medical technologies. Medical technologies were considered to have:

- affected the epidemiology of mortality, morbidity and disability;
- brought about changes in patient/consumer expectations and thereby, in utilization of healthcare;
- altered the organization and financing of hospital services;
- altered the scope and content of medical work and medical curriculum, and the balance of status among medical workers.

(see volume edited by McKinlay 1982).

The issue that dominated all discussions on medical technology was that medical technology contributed to the 'worrisome problem of inflation in healthcare cost' (McKinlay 1982 p ix).
much-cited work in this regard was the document of the US National Center for Health Services Research, 'Medical Technology: The Culprit Behind Health Care Costs'? A general consensus emerged that medical technologies are expensive to acquire and maintain, and substantially contribute to increasing the costs of health care in a number of ways. As discussed in a later section, controlling the increasing costs of healthcare had become a major policy issue by the late 1970s, especially in the US. The mechanism of re-imbursement of medical expenses was considered to be the major cause of the explosive use in the increase of medical technologies. It was argued that the extent of insurance (whether private or social) and the methods of payment promoted the adoption of expensive hospital technologies and inhibited the adoption of preventive, rehabilitative and ambulatory ones.

1.2.4 Since the 1970s medical technology assessment/technology assessment in health care has developed into an independent area of study. There is substantial literature on impact of medical technology in the industrialized countries of the West, a large proportion of it on the impact of medical technology on cost of healthcare and on regulatory mechanisms. We see that they constitute important case-studies of diffusion of medical technology, and give critical insights into several issues thrown up by their presence and utilization. This section looks at some of these important studies on medical technology and highlights the issues of relevance.

1.2.4 A

Introduction of CT scanning in 1970s - concern over high cost of 'high-technology' – genesis of regulations and policies regarding medical technology

Availability of technologies and their widespread adoption and use in North America and Europe led to national policies and legislation to regulate the cost, development and diffusion of technologies, as well as cost containment measures by hospitals. Additionally measures for technology assessment were instituted. Specifically, the extremely rapid diffusion of the CT-scanner in USA and Britain in the mid-1970s, despite lack of adequate information on its efficacy and effectiveness, gave rise to questions about costs of technology. Governments started expressing concern at the cost implications of this 'promising', yet far from proven technology.

The Office of Technology Assessment (OTA) in the US undertook a policy-oriented study in the 1970s on the use of cost-benefit/cost-effectiveness analysis (CBA/CEA) to evaluate medical technologies (OTA 1981). As part of this study case studies of several technologies were also conducted to assess the costs and benefits of medical technology. This covered technologies such as: the artificial heart, automated clinical analyzers, CT-scanning, gastro-intestinal endoscopy, neo-natal intensive care, breast cancer surgery, end-stage renal disease interventions, cervical
cancer screening, orthopedic joint implants, etc. One case study in this series, by Wagner, on economic evaluation of CT-scanning explores the feasibility of cost-benefit analysis and cost-effectiveness analysis of diagnostic procedures (OTA 1981). According to Wagner, when applied to diagnostic procedures, the purpose of economic analysis was to provide information on two related questions: under what circumstances should the diagnostic procedure be performed? How much investment in capacity to perform the procedure is justified? A procedure will be of undisputed and obvious value for some groups of patients. The important question for resource allocation is not whether the diagnostic procedure or equipment concerned is justified or whether it lowers or raises health costs; but how the procedure should be used in the practice of medicine. Only by knowing the costs and effects of treating each group of patients with the procedure is it possible to know whether there is too much or too little capacity to perform the procedure in any community. Wagner argues that the conceptual, methodological and data problems inherent in answering the first question often create such inaccurate and unreliable results that the economic evaluation is generally not worthwhile. She concludes that there are many methodological and conceptual problems in applying the standard cost-benefit analysis and cost-effectiveness analyses to diagnostic technologies.

As part of this same study reports were also prepared of the mechanisms for managing the diffusion and use of medical technologies in several European countries, Canada, Japan and Australia (OTA 1980).

Stocking and Morrison undertook a case-study of whole-body CT-scanning in the UK, as an example to initiate discussion on the whole process of technology assessment, on how a new technology should be assessed, how the introduction of a new technology should be managed, and on future developments and implications (Stocking and Morrison 1978). Among the issues that emerged, an important one was that technology assessment was not a simple matter of putting together data on cost-effectiveness and making a ‘once and for all’ decision in the light of evidence. When a technology is evaluated it is not enough to compare its usefulness with that of another existing technology or healthcare. Explicit recognition must be given to effects of future developments and arrangements must be made for continuing evaluation and monitoring of these technologies, as developments take place. Although completely unforeseen developments cannot be ruled out, yet it is possible to make some forecasts about the future based on the ideas and developments already being worked upon. Yet another important issue was that of resource allocation and choice of priorities. If only a limited rate of growth is possible, then the adoption of/investment in one technology may mean that another has to be foregone, or that funds may not be available for new buildings or staff, or for an increased emphasis on health education and
prevention. This raised the question - what sort of health service do we want and what sort of technologies would be appropriate for it; what are the relative priorities for prevention, for acute care, for cure and care of chronic problems. This study also addresses the issue of effect of regulations on industry. In times of economic constraint it is very hard for policymakers to justify large expenditures on new technologies. This poses a dilemma for British industry, as exclusive concentration on the UK market would lead to only limited sales, so that an innovation has to be taken overseas to achieve profits. These difficulties maybe a disincentive to industry to invest in development of new medical technologies. In this context they say that the entrepreneurial basis of industry is not necessarily a sound way to produce the most desirable medical technologies. A 'laissez-faire' approach tends to result in the production of very sophisticated machines, often very costly, which may not meet the most important technological needs of the NHS. It is suggested that ways of interaction between industry and healthcare technology users have to be explored, so that industry can respond to the needs. There is need for close interaction between manufacturers and NHS during development, and even subsequently, as new generations of machines are produced. Modifications in design can be made and it maybe possible that intervention during development may persuade manufacturers to produce a cheaper, simpler machine for general use than the currently favoured sophisticated, costly machines. There could be more intervention by the users to produce 'appropriate technology'. Hence there were reservations about the feasibility and usefulness of conventional economic evaluations of medical procedures and technologies.

The implications of some of these regulatory measures were analyzed by Iglehart (1982) and Wagner and Zubkoff (1982). According to Mechanic measures for regulating and rationing technology affected the organization and financing of health care services, and as a consequence led to increased bureaucratization of the health services (Mechanic 1982).

In an editorial with the provocative title Taming High Technology Smith sheds light on the outcome, in the US and in Britain, of efforts to institute formal mechanisms to evaluate expensive new techniques technology and making the best use of them. It was thought that the following actions were needed to achieve this: (i) Some means of identifying those technologies, whether new of already in use, that can be shown consistently to improve clinical outcome. (ii) For those shown to be effective, clear and specific indications need to be defined for its use. (iii) Estimate scale of provision if the patients who stand to benefit are to get the technology without delay. (iv) Economic appraisal comparing the concerned technology with alternatives, as well as with technologies for other problems (such as between dialysis and heart surgery). (v) Hospital specialists whose decision-making determines the use of technologies should have up-to-date
information on the balance between risks and benefits, and take decisions accordingly (Smith 1984). According to Smith there were two practical problems in implementing this scheme. One was doctors’ notion of their clinical freedom. It was rejected by the American Medical Association on these grounds. In Britain however doctors recognized that budgets are finite and ways had to be found of allocating resources among specialties. So ‘external forces’, as Smith calls them, led to the realization that expensive techniques need to controlled and rationed on the basis of their relative worth. The second big problem was that many expensive technologies are marketed. Manufacturers of high technology equipment employ salesmen to promote its use. The kind of assessment envisaged conflicted with these commercial interests. That this was so was borne out by the fact that in the US the National Centre for Health Care Technology was aborted because “its promise of success so threatened certain vested interests that it became a target for abolition and Congress yielded to these lobbies” (Jennett quoted in Smith 1984).

Jennett raises some issues pertaining to the cost of technology (Jennett 1986 pp 114-134). According to him while there is a plethora of literature on the cost of medical care/economics of health, yet no clear messages, not even about the nature of problems. He characterizes high technology as being complex and expensive, and as a result its availability is restricted. Jennett’s argument was that high technology medicine (HTM) has often been misapplied in two ways. Firstly, criteria for their use are rarely defined sufficiently, and even if they are, clinicians ignore them. As a result, doctors may not know about their effectiveness; or even if they know still they maybe applied inappropriately, as in unnecessary use and overuse. Secondly, there are no criteria for how the scale of provision – such as how many body scanners should be made available, and so on.

Jennett poses the question: what are the elements of cost in high-technology medicine (HTM), and proposes that the breakdown of activities in financial terms provides a useful means of analyzing the components of cost associated with certain technological procedures, and of comparing expenditure on technology with that on other components of health care. He says that it is the initial capital cost of equipment like dialysis machines and CT scanners that attracts attention (and public donations for these in UK). However, not only is high technology expensive per se, but it also tends to generate expenditure on ancillary items and services, such as consumables, maintenance and staff -that maybe individually relatively low cost. Irrespective of extent or intensity of use of the machines, certain running costs have to be met. For instance: in the laboratory where automated equipment might be expected to have reduced the bench work of technicians, the main cost of tests is still technician time. Similarly, in the clinical setting new technology frequently means especially skilled staff being employed exclusively for the use and
maintenance of the equipment. For instance: in case of hospital dialysis and of intensive care (care of both patients and machines by nurses), the main revenue cost was that of highly trained nurses. He cites studies of intensive care costing in the US, which drew attention to the inadequacies of aggregating costs. One study showed that equipment accounted for less than 5 per cent, while ancillary services accounted for two-thirds of the expenditure. Another study showed these ancillary services to consist of laboratory services, drugs, x-rays, inhalational therapy and some supplies. Furthermore, there were considerable variations in the use of resources by different types of patient who were all charged similar day rates. Low-risk monitoring only patients are cheaper and bring down means cost per case. However, even if the cost per case is modest, or is reduced, the consequence of developing a method that appears to confer a marked advantage is that it is used on more patients than before; therefore total expenditure increases. He cites another study, which showed that not more than 15 per cent of the annual increase in hospital costs could be attributed to the acquisition and first year running costs of all new equipment (big and small). According to this study the main way to limit expenditure on technology was to reduce the aggregate of smaller items, particular the more routine kinds of laboratory tests and x-rays. Jennett computes the relative costs to the Health Authority (in UK), and shows that the local community drug bill exceeded the total costs of salaries, equipment and consumables on laboratories, diagnostic and therapeutic radiology, plus other equipment, plus cardiac surgery, i.e. all the high technology costs (Jennett 1986 p 123). It is essential, therefore, before formulating schemes to cut costs, to know where the expenditure is on a large enough scale to do so. Because certain procedures have high capital or unit costs it should not be assumed that they are unjustified. They maybe more beneficial for their cost than the aggregate of expenditure on large numbers of inexpensive, but ineffective, items of medical care. However, it is not very easy to also assign a monetary value to benefits as it is to costs. Despite all the problems and complexities of cost-benefit analysis of medical technologies, Jennett says that the effort should not be abandoned. He suggests that in this case the role of cost-effectiveness analysis should be to reduce the cost of procedures that are clinically appropriate.

Regulatory mechanisms and relevant policies were introduced in various European countries in the 1980s to control introduction and diffusion of expensive medical technologies. Stocking gives an overview of these mechanisms and their effectiveness (Stocking 1988a). It emerged that a wide variety of mechanisms existed and that these depended on the health systems of the respective countries. According to Stocking, if we take full technology assessment to include:

1. monitoring emerging or existing technologies which might require evaluation;
2. ensuring that appropriate clinical trials, cost-effectiveness studies and other research activities are undertaken; and
3. drawing all the information together and disseminating the information to all appropriate groups in the health and government systems; then, 

no European country had a body which carries out all these activities in a systematic way. However, there exist bodies in various countries, which take up particular aspects (Stocking 1988b).

Foote provides a review of the policies in the US that directly and indirectly affected the medical device industry (Foote 1992). According to her medical device innovations are deeply embedded in the broad debates about health policy. She labels ‘the insatiable demand, fed by a profusion of new technologies and the profits they represent, as the medical arms race’. From her review of how policies and regulations have affected medical device innovation and distribution (either by promoting or inhibiting), she concludes that innovation flourished in the 1950s and 1960s because the dominant policies promoted both discovery of new products and their widespread distribution. Despite safety and cost-control policies in the 1970s and 1980s the momentum of innovation was sustained, partly because these policies were relatively unsuccessful and regulation was not fully implemented as intended. She says that one must recognize the limits of medical device technology to cure all ills and the limits of public policy to solve social problems. According to her, wise policy must address the larger moral questions of how we want to live and how we want to die; which are difficult questions that are avoided.

According to Banta several areas in technology assessment needed attention. For instance: with respect to diffusion he says that it is adoption of innovations that has been studied much more than extent and pattern of use (Banta 1981). In a review of issues facing biomedical innovations Banta suggests that even if the rising costs of medical care are controlled, the other concerns about medical technology are real and are likely to continue. Hence there is need to understand the process of research, development and diffusion (which includes adoption and subsequent use) of medical technology.

1.2.4B Diffusion of medical technologies

The diffusion/adoption of medical innovations in healthcare organizations, especially hospitals, is an important area of study. The trends in the adoption of new hospital technologies was reviewed by Russell (1976). Greer has reviewed some diffusion studies of medical innovations and discusses some of their inadequacies and weaknesses (Greer 1982). Majority of them use the classical theory of diffusion that explains adoption of innovations by individuals, and according to her there are limitations in applying this classical theory to organizational adoption of innovations. Secondly, theorizing was based on studies of diffusion of procedures and
programmes among organizations; there were no studies of diffusion of 'hard' medical technologies, such as equipment. She discusses the usefulness of organizational and political analysis in studying diffusions. According to her little attention has been given to political aspects of decision-making in health organizations. She discusses Krause's scheme for studying innovations, which as she points out, has not been well developed, in spite of its intellectual importance. Krause (1971) suggested that manufacturing corporations were particularly active in their efforts to promote the adoption of equipment and other products. The promotion of an innovation by a corporation was negatively related to the enthusiasm of health professionals. The less sponsorship elsewhere, the greater the efforts of the producing corporations to "sell" the innovation themselves. However, Krause argued that corporations normally act in coalition with other health interests, which include medical research physicians who wanted to undertake "frontier research", and others who desired the prestige that had come to be attached to advanced technology. He further suggested that non-teaching hospitals and community physicians were influenced by the manufacturing corporations and teaching hospitals, but lacked necessary information on the effectiveness of innovations. Thus he viewed non-university hospitals as the major victims of unscrupulous salesmen. They end up paying for prestigious equipment for which they have neither the patient volume, nor the staff to maintain (Krause 1971, in Greer 1982). Greer also cites a study by Roos of the decision-making process within hospitals regarding consolidation of their laboratories. In this study the rational economical explanations did not explain the decisions made. Roos argues that in general adoption of innovations was a function of political and technological events, which affected hospitals; and of the performance satisfactions and dissatisfactions of groups within the hospitals (Roos 1974, cited in Greer 1982).

One of the explanations forwarded for expansion of medical technologies in hospitals is that it is a result of professional dominance, a result of preferences of doctors translated into organizational policies. Greer's study to examine the participation of physicians in actual technology decisions reveals a more complex picture. It does not support the hypothesis of professional dominance as the principal dynamic pushing expansion of technology in community hospitals in the US. This study focused on community hospitals and consisted of 378 focused interviews with physicians, hospital administrators, including chief executive officers, nurses and technicians (Greer 1984). According to Greer there are different reasons for acquisition of technology by hospitals, depending on the objectives of the hospitals and their ownership pattern, whether it is a government or teaching hospital, and so on. It appears that to ask which of the two prevails — medical or administrative — in technology-acquisition decisions is a wrong

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4 This situation has changed since the introduction of so-called 'high-tech' imaging equipment such as the CT-scanner, MRI and ultrasound scanner.
question. Such decisions arise not from a single-decision process wherein different categories of physicians pit their resources against those of other physicians, administrators and trustees. Rather there are three different systems, operating largely independently of one another. These three tiers have different operating norms and criteria, different participants, and are called into action by different technologies having different organizational implications. These three systems are: the medical-individualistic system; the fiscal-managerial system and the strategic-institutional systems. The traditional views of hospital domination by concerns of clinical medicine are thus greatly complicated by (separable) concerns with the fiscal-managerial management of the growth and development of the institution.

McKinlay adopts an organizational-political approach to study the way in which medical innovations (diagnostic techniques, surgical procedures and medical interventions) become part of established medical procedure. He uses a 'career' approach to the diffusion of medical innovations. Based on a review of a large number of studies of diffusion and careful examination of the 'careers' of several different types of well-known and 'popular' innovations, he considers it useful to break the diffusion process into seven distinct stages, from that of 'promising report' to 'standard procedure'. According to him the concept of a 'career' is merely a methodological tool ('heuristic device') used to highlight particular issues and possible points of intervention. It does not mean that every innovation passes through each of the stages in the exact order. It is a useful approach, which 'enables one to break fairly complex social behaviour and political processes into a manageable form, identifies possible points of intervention, and bestows a semblance of order on the present chaotic state of diffusion studies. Therein, however, lies a major disadvantage: it suggests that more order and coherence exist than is actually the case.' Among the technologies whose diffusion is examined are electronic fetal monitoring, CT - scanning, coronary artery bypass surgery (CABG) and cardiac care units (CCUs), and some anti-cancer agents. McKinlay cites Banta on diffusion of CT-scanning, a technology that diffused extremely rapidly even while it was being developed and occupied centre-stage through the 1970s, and continues to do so:

'Despite more than five years of experience with CT-scanning, its usefulness and ultimate place in medical care are largely unknown. The development and diffusion of CT-scanners took place without formal and detailed proof of their safety and efficacy. The evidence existing today did not come from well-designed, prospective clinical trials, but from analyses of clinical experience. However, this evidence is restricted almost entirely to assessing diagnostic accuracy and usefulness, and gives little indication of the effects of CT scanning on therapy planning or on patient outcome' (Banta 1980).
The results of an extensive review, by two respected surgeons, of 150 different reports of surgical measures for coronary heart disease are also presented by McKinlay. It showed that the medical 'evidence' for CABG consisted entirely of observational reports (such as retrospective studies, case reports, clinical experience, follow-up studies). Secondly, while the superiority of randomized controlled trial was recognized, still there was not a single such trial among these studies. Proposals for prospective RCTs were alluded to with the hope that such studies could provide answers to the many questions that were still not completely resolved. Thus interestingly, these reports never really place the issue of the effectiveness beyond dispute.

What emerges from McKinlay's review is that the worth of a medical innovation seems to be settled 'not by rigorous, formal evaluation of their efficacy and effectiveness, but by the sheer volume of observational reports'. These studies are frequently initiated and conducted by the parties who have been involved in the initial stages of the innovation – namely in the initial research and subsequent mobilising/organising support for it. Such as the manufacturers, professionals and hospitals, who may have a vested interest in uncovering a beneficial outcome for the innovation. According to McKinlay it seems reasonable to argue that the success of an innovation has little to do with its intrinsic worth, but is dependent upon the power of the interests that sponsor and maintain it, despite the absence or inadequacy of empirical support. McKinlay proposes that there is need to move beyond such superficial levels as that of holding physicians or the medical establishment responsible for all the problems besetting medicine and the healthcare system, and to look at the activities of hospitals, physicians and a range of other interests, in relation to more basic structural processes that impinge upon them.

McKinlay uses this approach to analyse the diffusion of medical technology in New Zealand in relation to several structural problems afflicting the country's medical system, within the broader context of its overall fiscal crisis. According to him it is macroeconomic factors that determine the very nature and range of policy options available. This study therefore begins by reviewing the structural problems in the country's economy, describes and highlights some aspects of the overall medical care system and then examines some aspects of medical technology, with specific examples (McKinlay 1980). He relates the influx of high technology to the medical care system, which is marked by oversupply of hospital beds and physicians; unchecked and expanding private facilities secured through government-financed capital loans, various subsidy schemes and other benefits; and the medical establishment's ability to steer the state. He identifies the following typical sequence in the introduction of high technologies in the country: through aggressive marketing and sales efforts, multinationals that are constantly
producing new technologies, encourage the medical establishment to demand the latest and most sophisticated technology. For a physician to be unfamiliar with or lacking access to such technology is considered deficient, unprofessional and even negligent. For a hospital to be without this technology means that it is undermining its competitive position. Hence 'keeping up-to-date' is a must. Additional local demand is fostered through powerful community groups, such as Lions Clubs. Either local community groups raise funds for various technologies and then donate them to the public health system. Or they influence the formal decision-making authorities by bringing pressure through their political representatives, or local media efforts. Eventually the state purchases, underwrites or subsidizes the new technology or service. In the case of technology the government pays the corporation that manufactures the hardware with its export earnings. McKinlay points out that in this process no attention is given to demonstration of effectiveness. He says 'the administrative rule of thumb in New Zealand (and most other countries) is that an intervention of service is presumed to be effective until it is shown to be ineffective'. Even if it has been demonstrated to be ineffective, it is retained because of the power of the interests that become associated with, or even dependent, on it. These are the factors leading to proliferation of unevaluated high technology.

2.2.4C Provision of medical technology – Issue of Re-use of medical devices

Self-referral and physician ownership of diagnostic and treatment facilities, and the ensuing 'conflict of interest' has been another important issue in the discussions on medical technology. There were studies on whether physician ownership gave rise to increased use. Research indicated that physician-owned facilities generated significantly higher rates of use and costs than independently owned facilities. The higher concentration of physician-owned MRI facilities in one region (California) increased rates of use above that for the rest of the country (all studies cited in Swedlow et al 1992). A study of diagnostic imaging showed that physicians who referred patients to facilities of which they were owners charged 4.4 to 7.5 times more per episode of care than other physicians (Hillman et al 1990). A study on patterns of use of three services, including MRI, by physicians indicated that patients were referred to these services more often by physicians who owned such facilities than by those who referred patients to independent facilities (Swedlow et al 1992). Studies indicate that, in general, an increased concentration of providers tends to lead to increased rates of use.

Few studies raised the issue of how the way it is made available to the public can affect/dilute the potential for benefit of a technique/technology. An example is the study of pacemaker implantation. In fact it has raised some major policy issues with economic implications: re-use of
pace-makers, allegations of excessive implantation and the issue of what constitutes the most efficient system for providing patients with pacemakers (Bronzino et al 1990). Protocols for re-use of pacemakers have been developed in several countries, although it was not approved in the USA. All the corporations that market pacemaker in the USA have lobbied with the government against pacemaker re-cycling on the grounds that product quality control cannot be maintained for re-used machines. However, a statistical analysis in Europe of a sample of over 2000 patient records in whom re-cycled pacemakers were used showed no difference in performance of re-cycled and new ones. On the contrary, the data suggested that re-cycled ones perform better. While the manufacturers would be aware of these evidences their opposition to recycling was probably more to do with its effect on the sales. In late 80-early 90s in the USA over 200,000 new pacemakers were being implanted annually, each costing about US $ 3000. The sale of pacemakers thus constituted about 600 million-dollar business. It was estimated that re-cycling would reduce the demand for new gadgets by 10-20 per cent, cutting the market by between 60-120 million dollars annually. Re-cycling costs appear to be considerably less than the price of a new unit.

In 1979 in the US a public interest research group published a report asserting that 35 percent of all pacemaker implantation that took place in a city between 1978-1979 were unnecessary from a clinical perspective. It argued that hospitals were using the procedure to generate revenues, whereas drug-based therapies that were less debilitating and less expensive could have been used. An independent review by the state concluded that 1.5 per cent of all patients received a pacemaker they did not need at all.

In countries such as Britain and Germany, which have national health services, in areas with heavy population densities special pacemaker centres have been set up. These centres handle all implantation. The objective is to reduce costs and improve quality of services by spreading the overhead costs associated with expensive equipment, specialized personnel, etc., over large number of patients and thus providing low-cost care. In the USA most hospitals offer implant services, often relying on manufacturers for monitoring and re-programming services. This is considered to be the effect of a system in which hospitals explicitly compete for patients and therefore need to offer the widest possible range of services. Such alternative systems for implantation and subsequent patient care indicate the effect of the structure of health care delivery systems on provision of costly technologies, and that some degree of central planning may work by improving delivery and reducing costs of health care benefits associated with some technologies.
Re-use of pacemakers and other disposable medical supplies, such as cardiac and coronary angioplasty catheters, is a standard, scientific and carefully monitored practice in hospitals in many parts of the world and in India as well (Anon 1996). Many hospitals have long set up critical procedures to salvage equipment, render them safe through various well-documented procedures, tested them for quality and offered them for re-use at a fraction of the cost of new equipment. It seems to be the practice in private hospitals too, which say they offer patients a 'choice' in the matter. Early dialysers were re-usable, but as the market increased manufacturers introduced the 'disposable' haemo-dialyser and labeled it 'for single use only'. To cut costs many hospitals cleaned these using the same techniques they had used for the earlier models and found them to be effective. Despite extensive data supporting medical benefits of 're-use' manufacturers still label the product 'for single use only'. Requests by medical researchers in the USA to manufacturers for data in this regard were met with only references to possible risks. In India in 1996 the dean of the KEM Hospital Mumbai, issued a directive to stop re-use of sterilized, 'disposable' equipment. Among the reasons cited for this move were legal liability, prevention of infections such as AIDS/hepatitis B and ethical considerations. Which are quite tenuous, as there is no law or judgement so far that defines which medical instruments can or cannot be used. Further the manufacturers' instructions for single use does not constitute scientific proof that re-use is detrimental. And the dean admitted that no complaints had arisen following re-use. The resistance to re-use and pressure from manufacturers to stop it gives an idea of the interests of non-medical parties such as the industry in adoption and use medical innovations.

There are other observations on role of industry in influencing specific government policies and programmes in provision of technology (Greenberg 1978, Kolata 1980). Empirical studies support the view that under certain competitive market conditions and because of inherent difficulties in assessing their costs and benefits, technologies provided scope for physicians to overuse medical procedures and thus contribute to increase in costs. Their high cost, combined with their discretionary use, make them prone to abuse/misuse and incorrect use.

Despite several observations on role of industry in influencing government policies and programmes in provision of medical technology, the role/behaviour of the medical-equipment industry, and its interaction with the medical profession and influence on medical practice have not been adequately addressed.

2.2.4D There are also writings covering ethical and moral issues arising out of availability of technologies such as life-extending (Dutton 1992), and reproductive technologies (Mallik 2003).
In general changes in the mortality and morbidity patterns were attributed to availability of technology. According to Gruenberg technology had changed the situation (regarding mortality and morbidity) 'by reducing mortality and adding years to sick rather than to healthy lives'. He argues that the 'net effect of successful technical innovations used in disease control has been to raise the prevalence of certain chronic diseases and disability by prolonging their average duration'. This, according to him, represents the failures of our success (Gruenberg 1982).

With so much being written about the economic and social impact of medical technology, and of ways to evaluate it that one feels that the field must be fairly advanced and that a lot is known about medical technology. Yet, several authors pointed out that 'nothing clearly emerges about the nature of the problems regarding medical technology, nor how they can be resolved' (Jennett 1986). According to Wagner and Zubkoff, 'there are still major gaps in what we know about the real impact of technology on social costs and benefits, and on the efficacy of medical procedures' (Wagner and Zubkoff 1982). Banta pointed out that there was incomplete coverage of new and existing technologies, and that no country had yet succeeded in developing a coherent system for assessing health care technology (Banta and Luce 1993).

2.2.5 Sociological studies of medical technology

We find that there is plenty of work on respectively, history and sociology of medicine and of technology, and on impact of medical technology on provision of healthcare and on medical practice. Yet, it is said that there are not enough sociological studies of medical technology (Tone 2002). Elston locates the emergence of sociological inquiries into medical practice, medical science and specific medical technologies around the 1980s and provides an overview of the context and content of these inquiries (Elston 1997). According to her some of the developments responsible for these sociological studies are:

1. Emergence/Resurgence of epidemic infectious diseases since early 1980s. There is a large, heterogenous body of work, from sociological dimension into HIV/AIDS and related tuberculosis epidemics, as well as into associated research activities, scientific response to this epidemic.

2. Emergence of molecular biology and rapid growth of molecular genetics, and its application to human disease and health-related bio-technologies.

3. Restructuring of health services or health sector reforms undertaken in many parts of the world. A related issue is that of increasing costs of health care in many countries.
Timmermans and Berg provide a clearer picture, which shows that medical technology has been an important area of study. According to them medical technology has been recognized as a central issue in the sociology of health and illness. They provide a review of studies of medical technologies published in the journal *Sociology of Health & Illness* in the previous 25 years (Timmermans and Berg 2003). According to them these studies fall into three theoretical perspectives: technological determinism (TD) social essentialism and technology-in-practice.

In their view, at a time when social problems-social deviance was a fashionable area, medicine was viewed by many as an institution of social control. Medical technologies were analysed as providing healthcare providers with effective tools to coerce others into approved healthy lifestyles and helped to minimized patient compliance issues. These were some reasons why medical professionals were attracted to technologies. There was a focus on the then controversial technologies such as brain surgery, behaviour modification and human genetics. The review looks at a couple of studies in the TD genre, on use of psycho-pharmacology drugs and the metered dose inhaler (MDI). In the former the use of technology (drugs that are aggressively promoted by a powerful drug industry) by doctors is analyzed as a means of exercising social control over deviant behaviour. Similarly, the MDI is seen as a solution to the problems in prescribing ephedrine (which is potentially dangerous), and allows the doctor to ensure compliance by and control over asthma patients. Also cited is a study on new reproductive technologies as propelling and perpetrating patriarchal control over women. As Timmermans and Berg point out, these analyses come under the technological determinism framework, in which technology is assigned the central position and looked upon as the dominant moving force in society. This perspective attributes great explanatory power to technology and assumes that technology’s overall effect has been harmful. They are critical of such technologically determinist positions. In their view TD is profoundly anti-sociological as it presumes that the political logic of domination is internal to the technology; it ignores completely the human/political agency of doctors and patients, of culture, interest groups and users; or rather it is assumed that the political agency of individuals is to a large extent curtailed by the technological momentum. While medical technologies are seen to extend the apparently clear-cut interests of some group, how exactly these interests enter into the technology and how their operation exerts the effects is often left out of discussion. In the opinion of Timmermans and Berg TD in medical sociology is not usually about analyzing medical technology, ultimately it is about constructing a symbolic case against medical hegemony. Hence attention has been given largely to controversial innovative technologies threatening to disturb the social order. The reviewers point out that the technologically determinist ‘dehumanization’ argument in death and dying could be reversed. In emergency departments dying might fulfil the criterion of ‘dignified’
dying because of the presence of resuscitation technologies. The resuscitation protocols offer a short respite in the sudden dying process, that allows the staff to informs and prepare relatives and friends for the possibility of impending death. Terminal care in general depends on the extensive use of less-controversial technologies such as pain medication and special mattresses that reduce the likelihood of bedsores. Timmermans and Berg conclude that it would be good 'to retire' the TD perspective once and for all.

The other extreme to TD has been a form of social essentialism, where medical technologies are viewed as tools (catalysts) that generate interactions or meanings, but do not act, affect or evolve themselves. The key feature of social essentialism is that technology is a passive device or a blank slate, to be interpreted and/or rendered meaningful by social interpretations. As they point out, social constructivist ideas form the theoretical underpinning of social essentialism, whereby medical technologies are viewed as influential instruments to be mobilized by social actors and imbued with meaning. According to Timmermans and Berg 'while such empirical analyses purport to be about medical technology, they are not. They are about patient compliance, illness narratives, caring and curing, sick roles and illness experiences, ideologies of disability, gender and race, etc' (Timmermans and Berg 2003 p 102). All the topics traditionally of interest to sociologists have been projected on to medical technology, but what is typical of the technology is left unexplored. For instance: there are sociological studies of how technologies affect patients' feelings of vulnerability and their autonomy, or how they lift patients' spirits and courage, and help re-assure patients, or help staff maintain professional composure, about the social impact of the technologies on disability. There are some analyses on how technologies perpetuate a particular therapeutic ethos, arguing that the same issue could and would have been treated differently in a different culture or at another historical juncture. Such an analysis emphasizes how technologies facilitate the reduction of a rich illness experience to a more narrow medicalised disease. The more critical version of the social essentialism analysis tries to show 'how categories of knowledge are used in power relationships', how interest groups select technologies in order to assure the continued hegemony of the medical-industrial complex. The technology is considered to absorb and reflect social and political meanings. Timmermans and Berg conclude that social essentialism tells us about sociological pre-occupations, but glosses over what is technological in medical technologies. They contrast this with the social construction of technology perspective, which entails an ethnographic-historical study of the actual content of the technology, its development and use, to explain the success or failure of technological artifacts.
Traditional medical sociological studies thus, according to these reviewers, either overestimated or under-estimated the power of technologies. The technology-in-practice analyses of medical technologies emerged in the 1990s in medical sociology, and has been influenced by the developments in the interdisciplinary field of science and technology studies (STS). These analyses attempt a more dynamic view of medical technologies. In this approach technologies are embedded in relations of other tools, practices, groups, professionals and patients, and it is through their location in these networks and interactions with them that treatment, or any other action is possible in healthcare. The general purpose of this approach is to gauge what technologies do, on the different worlds that techniques contain and imply. What becomes a relevant 'social', 'technological', or other category in the development or usage of technology depends on how it is transformed during technological practice; technology is constituted by others and in turn constitutes the actions of others. They cite the example of Pasveer's study of x-ray imaging, which shows that x-rays became effective only after standardization of the x-ray equipment and photographic materials, after the training of physicians, construction of boundaries between normal and pathological, and stabilization of links between x-ray images and other diagnostic tests. Technology-in-practice uses a broad definition of technologies, covering the entire range of medical technologies, including the managerial instruments such as patient records.

Criticisms of medical technology have emerged from some women's groups, and from disabled persons. These sections view medical technology as an instrument of professional control over their bodies and lives, and/or a means of distorting/intruding into their normal bodily experiences of giving birth, or growing old, or a barrier to acceptance of physical differences between people. There is also the notion of patients' rights, in keeping with the view of patients as 'consumers' of health care. Many of these studies do not move beyond the level of the doctor and the medical profession, and blame largely the profession for all the woes and problems of technology.

2.2.5 Given the dominance of the technological determinism perspective, it is not surprising that, there are hardly any studies on how technologies are developed and produced, McKinlay's attention to development of medical innovations being an exception. In fact the very question has not been addressed adequately, except for passing/tangential references to the possible influence of commercial manufacturing on development of medical innovations. We see that Technology Assessment (TA) addresses the 'problems' that arise after the technology had become well established.
Since the 1980s, with the growing influence of the social constructivist approach in sociology of technological innovations, the development of medical technology started to be addressed. Two studies, both of development of medical imaging technologies, are available within the social construction of technology genre. Yoxen’s case study of development of medical images describes some of the early stages in the early development of the ultrasound scanner. *The primary concern of the study is with the process of image-generation* — with the search for that form of representation wherein three-dimensional forms can be rendered as two-dimensional images. At the time of this case study scientific images were considered to be a special kind of construction, arrived at by schematizing, geometrizing, and highlighting salient features from a mass of detail. Through images generated by specific operations, Nature was rendered (emphasis in original) in ways that highlighted certain features of interest. For such images to be relied on as evidence there must be general agreement as to their value and reliability, and there must exist a set of procedures for generating them. With this understanding *Yoxen looked at the formation of a medical consensus that ultrasound images have value*. *His case study addresses specifically the differing ways, in the 1940s and 1950s, of generating two-dimensional images using high-frequency waves (ultrasonic waves)* (Yoxen 1987). It limits itself to the inventive activity of various medical men, assisted by scientists and engineers around the time of II World War. According to him even after fifteen years of development, when the scanning machines could be said to work, there remained considerable skepticism about the comparative value of these images. What then began was a process of enrollment of doctors, developing the view that their clinical judgments could be strengthened by relying on images generated through the work of others. He does not address the obvious issue of the process of enrollment, even though he feels that it is a question fundamental to the evolution of many medical technologies. The quality and reliability of the images was seen as a major problem, and attention turned to the question of how to standardize the equipment. As far as developing ultrasound for diagnosis in obstetrics was concerned, there were several problems. Firstly, in the 1950s the problems of producing clinically useful images were considerable, and second, moving into the clinical setting was helpful, although it exposed women and their babies to a highly experimental research technology. In Britain funds for the development of the machine by Smiths Industries, were made available Scottish Hospitals Endowment Trust, and later when Smiths Industries withdrew, the National Research Development Corporation took an interest.

Several issues of significance emerge from Yoxen’s account. One is that there were a variety of approaches to the technical and representational problems of using sound to visualize internal organs. Different groups pursued different strategies and explored the utility of different forms of graphic representations, although a common aim was improved diagnosis — the basic challenge
The other is by Blume of the development of imaging technologies. Blume finds the social construction of technology framework inadequate, as mentioned in the preceding section. Blume also adopts the notion of `career` in his comparative study of development of four major imaging technologies (x-ray, ultrasound, CT-scanning and MRI). However, he explicitly differentiates his notion of `career` from what he considers as McKinlay’s `ironic account` of careers of medical innovations (Blume 1992 p 68). His comparative analysis is built around the concepts of: an inter-organisational structure between the radiological profession and the manufacturing industry; career as a means to denote the various phases such as those of exploration, development, and diffusion and evaluation; and problematization or simply the research process by which the technology takes shape. In his account of each of the above technologies he begins with the research work which has thrown up ideas with potential, the subsequent response of the researcher to the ideas in terms of mobilising resources and support for the idea and the manner in which the research questions are then posed, how the models that were developed were tested and promoted among the medical profession and the role of state agencies in the entire process. By comparing the `careers` of x-ray (an immensely `successful` technology) and thermography (an `unsuccessful, unglamorous technology`) he gives an idea of what goes into making a technology `useful` or otherwise. In the process he draws attention to several features of innovation that are
not given attention to, but play a crucial role in innovation and diffusion. Such as: the fact that several possibilities exist regarding technologies, of the preferences and work of diverse actors in shaping the outcome, development of shared interests between sellers and buyers, the actions of the principal actors both in terms of the objectives they seek to attain and of the strategies that they adopt, such as post-sales contacts of the industry in form of servicing of hospital equipment. His observations lead him to conclude that 'the structure of relations that have developed between radiologists and the firms supplying instruments to them is in some sense vital to subsequent innovation processes in diagnostic imaging' (p 54). He argues that 'not the structure of production alone, but the structure of use as well, and the relations between the two exert crucial influence on the innovation process' (p 261). Blume refers to the military-industrial complex in the context of development of mutually beneficial interests between sellers and buyers in some contexts, such as between the radiology profession and the x-ray manufacturing industry.

2.2.6 Within the conventional definition of medical technology another area that has received a lot of attention is that of production and use of therapeutic drugs and pharmaceuticals. There is considerable literature on the emergence and activities of this industry, on research and development of new drugs, on pricing mechanisms, international trade, interaction of the pharmaceutical industry with the medical profession, its influence on policy and regulations, and other aspects.

Two studies concerning production of therapeutic drugs and pharmaceuticals furnish useful perspectives. Liebnau's business history account of the evolution of the pharmaceutical industry in the late nineteenth-early twentieth century reveals the interaction of technology, business and medicine (Liebnau 1987). He makes the following observations in his study, with respect to three distinct contexts. Firstly, in relation to the history of medicine it provides a perspective on the producers and manipulators of therapeutics. The industry also employed many physicians and medical scientists whose influence on the companies themselves was as significant as the impact of the industry on medical practice. Secondly, his study sheds light on medicine and technology. According to Liebnau, the medical industry must be viewed, together with the hospital, as a major source of medical technology. It was also the originator of the technique in that it provided new therapies and devised new methods by which to use them. Thirdly, he relates his work to the

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5 The American President Eisenhower used this notion of a 'military-industrial complex', in which shared interests between buyers and sellers can override the opposition of interests implied by a price mechanism. It suggests a common interest in increasing the size of the market and the rate of innovation, and in preserving the autonomy of the market from external control or regulation. An analogous phrase medical-industrial complex has been used by several observers to characterize the (American) medical system and its relationship with industry.
history of technology and business, to the development of new industrial sectors and of science-based industry, and the particular problems of marketing esoteric products to consumers who are ill-informed about the forefront of development.

Davis (1997) has studied the production of pharmaceuticals as a system comprising a dynamic network of relationships. The individual (as patient/consumer), the doctor, the state, the media and the industry are all part of this system. However, according to Davis, from a policy perspective the fundamental dynamics are provided by the economic actors, namely the industry, the state, third-party payers, professional organizations, and even consumer and user organizations. The fundamental axes are: profit generation and competitive survival within the industry, fiscal balance and macro-economic management for the state, risk management and budgetary viability among provider organizations and financial access for the consumers. Even within this network of economic relationships it is the industry that plays the central, formative and most strategic role. Driven by the constant search for profit and survival, it enters into a dynamic set of relationships with other actors. The pharmaceutical market place is highly competitive and the manufacturers strive for long-term survival through scientific innovation, advances in production technology, marketing programmes and organizational restructuring. The process of innovation, production and distribution runs along fully industrial lines and there is high level of regulatory, professional and scientific involvement. In promoting their products individual companies enter into relationships with professionals and their organizations. A fifth to a quarter of industry costs are devoted to such marketing and promotion. They also work through the media and lobby with the government. At a strategic level, industry associations have negotiating relationships with the state and state agencies over prices, subsidies, cost containment, co-payments, etc that impinge upon the profitability of the industry. In most cases companies rely on magnifying marginal attributes in order to differentiate their products from that of others in the market. Much that passes for product innovation represents change at the margin and claims made during marketing and promotion cannot be taken as demonstration of therapeutic innovation. In recent times the innovation and research activity has taken a new form, where companies are establishing exclusive arrangements with relevant university departments and research institutes and by gaining access to the discoveries of small biotechnology research firms. According to Davis, the major fallout of this preoccupation with profitability is that the growth of the industry has not been in consonance with the needs of the people. For instance: production of essential drugs for malaria, tuberculosis, etc., falls short of the need. Whereas, the market is flooded with non-essential, irrational and at times even hazardous drugs. Thus Davis' study of the modern pharmaceutical industry also shows that the production of therapeutic drugs is entwined with the industrial and medical system, in which the
state plays an important role. Davis too states that this field provides a good example of the interaction between the medical professional, the industry, the state, the media and the patient. In his account the actors involved in production of pharmaceuticals have a concrete identity and are not faceless entities, simply referred to as ‘actors’ (in the name of objectivity). It is explicit about who makes the critical decisions about resource allocation, especially investment in new techniques, facilities, and geographical locations, who decides what goods are to be marketed, and how they will be produced, and who profits, and so on.

Taken together, these works on the development of imaging technologies and of pharmaceuticals, can be considered to complement each other in drawing inferences about the process of development and adoption of medical innovations. It emerges that the development and adoption of innovations are not as straightforward, objective or neutral a process as it is conventionally assumed or made out to be. Several factors, social and economic, along with the technical possibilities, influence the development of technologies. What we find is that the actual process by which development and adoption of innovations takes place inevitably involves not only individuals with certain interests and inclinations, but also groups and organizations with their set of interests. It emerges that it is a fairly complex process, in which along with the medical profession, the industry plays a vital role in not just manufacture, but in development of innovations and their adoption as well. The state too influences this process in various direct and indirect ways.

REFERENCES


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The actions taken at this time had far-reaching implications for public health. A "political medicine," with status equal to that of political economy in shaping public policy, failed to develop. The public health field, along with medicine more generally, achieved significant autonomy, yet it did so by sacrificing the claim to speak with authority on many social issues.

From time to time since the days of Chadwick and Farr, questions have arisen about how "social" medicine should be (and equally about what issues and actions a social medicine involves or implies). Throughout this century, many public health leaders have urged the importance of social determinants of illness and health. Yet I fear that little of that concern has stuck to become part of the mainstream or core of public health. I have trouble shrugging off that dead hand, according to which issues of economic justice or violence (domestic, local, international) belong to one category with one set of institutions, and medical issues belong to another. Perhaps the "social" is too amorphous, ill-defined or diffuse, but I think we are also trapped by the inertia of a history that informs both professional culture and expectations among the public at large. In that history, the drama of the conquest of epidemic disease has loomed largest. In medical histories (and even in histories of public health), the matter of hunger and overwork as medical problems is often ignored, treated as marginal, or regarded as a recognition of the 20th century. I find a visit to the Sadler witnesses exhilarating because they represent a time when medical professionals did not have to apologize for thinking that social policy affected public health. The split that Chadwick and Farr had effected had not yet taken place.

- Christopher Hamlin while dwelling on the formative period of modern public health in Great Britain in the 1830s and 1840s.

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