Course: Science, Technology and Society

Professor: Sambit Mallick

Department: Humanities and Social Sciences

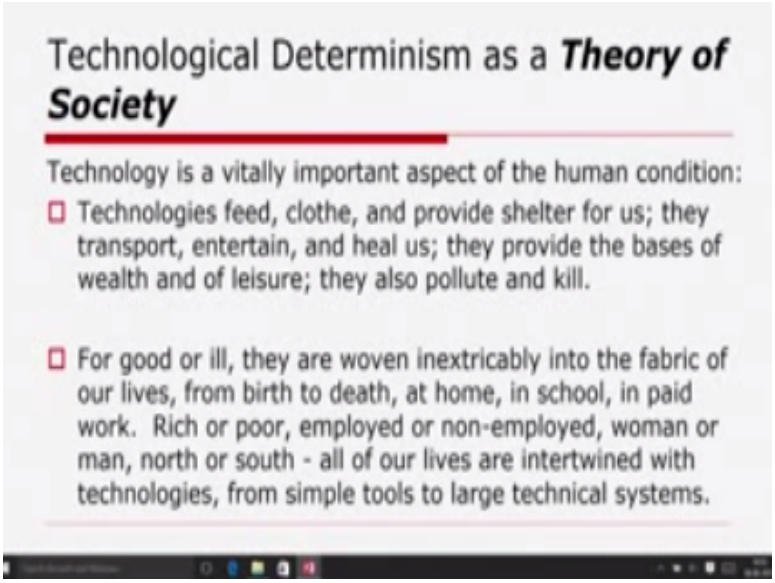
Institute: IIT Guwahati

Week: 09 (Social Shaping of Technology II)

Lecture: 25 (Donald MacKenzie and Judy Wajcman I)

Staying on with the social shaping of technology, we are trying to locate or historically STS scholars have been trying to locate technology as a by-product of social, economic, cultural and political formation. Till now what we have discussed? We have discussed technology, political construal of technological systems, Do artifacts of politics?, in the form of the construction of New York bridge, that is how we also gave the examples from India that the way public roads are designed in India, they have become anti-pedestrian today. We have also discussed Layton junior's technology as knowledge, we also have discussed how Thomas Alva Edison invented , electric bulb in a certain social and economic and political context, cultural context.

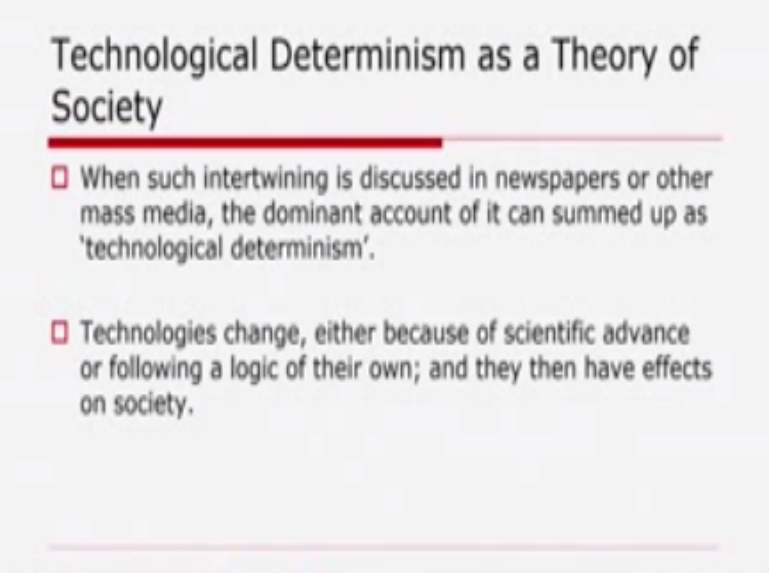
Now, through the works of Donald MacKenzie and Judy Wajcman, its reflections on technological determinism as well as social determination, whether technology is neutral or not or social changes are always determined by the development of technology or not, we are going to see. Let us start with technological determinism as a theory of society and then we will also see whether technological determinism as a theory of technology, we will also see does science shape technology. By providing different examples, we will try to locate the evolution of technology in the context of social history of technology, by taking the cue from social history of technological systems.



We all know that technology is a vitally important aspect of the human condition, technologies feed, clothe and provide shelter for all of us, they transport, entertain and heal us, they provide the basis of wealth and of leisure, they also pollute and kill. If you look at the way technologies have been used, technologies have been used to increase agricultural production, technologies have been used to make our garments possible, technologies have been used to provide shelter for us, technologies help us in transport and communication, in entertainment, in providing medicines, technologies also provide us with the basis of wealth and also of leisure or entertainment. But at the same time, technologies also are responsible for the kind of pollution, the kind of adverse effects that we have.

If you slightly recall the earlier lectures, that we discussed in the context of Langdon Winner's article on "Do Artifacts Have Politics?", that we are not going to judge technology in terms of efficiency, productivity or positive and negative environmental side effects, but we are going to examine technology in the context of the ways a specific technology embodies power and authority. The question of liberty, the question of justice, the question of equality, they assume greater significance when we look at the political, social, economic, cultural, construal of technological pharmacy. For good or ill, technologies are often woven inextricably into the fabric of our lives from birth to death, at home, in school, in paid work and so on.

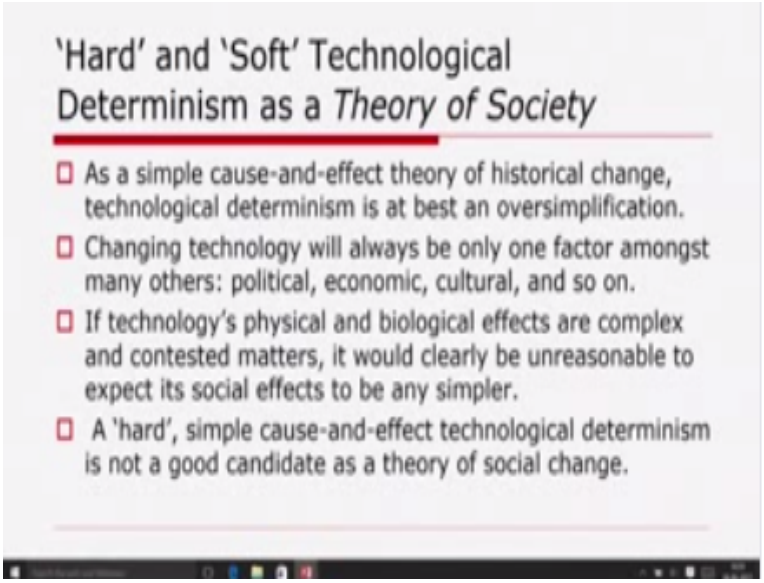
Rich or poor, employed or non-employed, woman or man, north or south, all of our lives are intertwined with technologies from simple tools to large technical systems.



And when such intertwining is discussed in newspapers or other mass media, the dominant account of it can be summed up as 'technological determinism.' We have already discussed what is technological determinism, social, political, economic changes may be attributed to the changes in technologies.

Then technology changes our social formation, economic formation, political formation, cultural formation, ideological formation. this is technological determinism. Technologies change either because of scientific advance or following the logic of their own and they have the effects on society.

Then if I say that technologies develop on their own, it has an internal logic of development of its own, then it is an internalist account of the development of technology. That is what we have discussed in the initial lectures, but how is it conceived of being influenced by external factors will be discussed in the lectures to follow. We have started the discussion, in fact, technology as a product of our social formation.



suppose if I if you look at this, the development of computer technology, for example, is often seen as following a logic, the development of computer technology for example, is often seen as following trajectories that are close to natural laws. The most famous being Moore's law describing how the number of components on a state of the art microchip doubles in a fixed predictable period of time. originally a year, now people think that we conceptualize it in a period of 18 months, one and a half years.

This key technical underpinning of modernity fuels an information and communication technology revolution that numerous experts tell or numerous pandits tell is changing and will change the way we live. This is important. when we look at this, that here one thing is technological determinism, that technology changes our economic, social, political, cultural formation or it determines our society. And one more thing, we are also talking about modernity, modernity as a part of, , what are the constituent, what may be the constituents of modernity, -, holism or totality, reflexivity, rationality and social movements. We have already discussed this and whenever we are talking about modernity, our mind always takes us to European modernity. That is a kind of modernity, we live in a world of multiple modernities, alternative modernities. When we look at this, the technological determinism as a theory of society, there are hard and soft technological determinisms as a theory of society.

Technological determinism contains a partial truth. Technology matters, no doubt about it. It matters not just to the material conditions of our lives and to our biological and physical environment, that much is obvious, but to the way we live together socially.

Lynn White's articles, , he famously attributed the coming about of feudal society or society dominated by an aristocracy of warriors endowed with land to the invention and diffusion to western and such ownership and control over land to the invention and diffusion to western Europe. Prior to that, fighting on horseback was limited by the risk of falling off. , we can go on, , White's count is better read as parable than as real history.

Among the Franks, the star off may have caused feudalism, but it had no such effect, say Anglo-Saxon England prior to the Norman conquest. We can go on, , if you look at history of technology as such. Changing technological determinism, , changing technology will always be one factor among many others, political, economic, cultural and so on.

As a simple cause and effect theory of historical change, technological determinism is at best an oversimplification. If I say, no, technology is the cause, social change is the effect, political change, economic change is the effect, I think it amounts to oversimplification. Changing technology will always be only one factor amongst many others, may be political, economic, cultural and so on.

If technology's physical and biological effects are complex and contested matters, it would clearly be unreasonable to expect its social effects to be any simpler. Now, let us see how, what we mean by hard and soft technological determinism as a theory of society. A hard simple cause and effect technological determinism is not a good candidate as a theory of social change.

, technology's social effects are complex and contingent in not to say that it has no social effects. We are not saying that, no, technologies do not have any social effect, but the failure of a hard technological determinism does not rule out a soft determinism. For example, Langdon Winner undermines the notion that technologies are the, are in themselves neutral.

There is a soft technological data. Langdon Winner, , his reflections are one of the most thoughtful attempts to undermine the notion that technologies are in themselves neutral, that all that matters is the way societies choose to use them. the way Winner argues that technologies can be inherently political.

We have already discussed this. This is so, Winner says in two senses, . We have already discussed.

First, technologies can be designed consciously or unconsciously to open certain social options and close others. Thus, Winner claims, , New York builder Robert Moses designed road systems to facilitate the travel of certain types of people and to hinder that of others. , against New York bridge was constructed by keeping the non-entry of the blacks and the poor, , it reflects a deep rooted racial prejudice and class bias on the part of the designer himself, Robert Moses himself.

Secondly, Winner argues that not only can particular design features of technologies be political, but some technologies , in their entirety are political. Even if it is mistaken to see technologies as requiring particular patterns of social relations to go along with them, some technologies are in given social circumstances more compatible with some social relations than with others. Hence, Winner argues that on the basis of energy supply around nuclear technology that requires plutonium may enhance pressure for stronger states or violence to prevent its theft and thus erode traditional civil liberties.

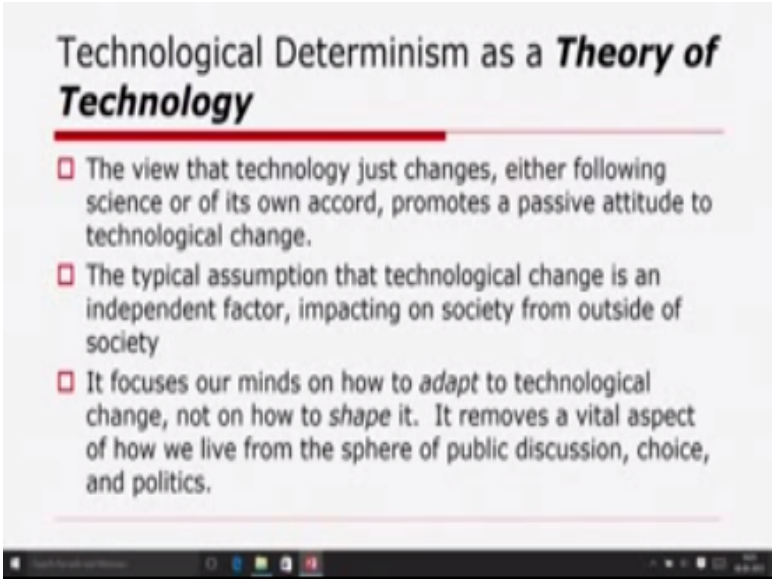
That is why whenever , we try to examine technology, , we should not try to examine technology only in terms of efficiency and productivity and positive and negative environmental side effects, but the way a specific technology embodies power and authority and within that the way power and authority are deeply embedded , in the development of a technology or technological system, we must look at the, the way civil liberties are sabotaged. This particular claim may be wrong, . Natural uranium shows no sign of running out as it appeared at, it might when Winner wrote this article and the relatively modest recycling of spent fuel has to date lead to no restrictions on civil liberties, but the general form of the argument demands attention.

In adopting a technology, we may be opting for far more economically, politically, even culturally as well as technically than appears at first sight because hard technological determinism is an oversimplified theory of technological change and, and as a consequence of which social change, discovering in advance what the more might be is very difficult and predictions are in consequence often of being, but the difficulty of the task is not reason for avoiding it, it is challenging whether, to go ahead with such kind of notion or whether to

challenge. Even if the challenge is a difficult exercise, we must not avoid challenging it, we must not avoid making an exercise of it. n what we have discussed? technological determinism as a theory of society, and then hard and soft technological determinism as a theory of society and now technological determinism as a theory of technology.

That is why you will find , even today some engineers, scientists, even social scientists, if you look at you will find that they think that, , technology develops on its own. There, and the view, as a theory of society, technological determinism is asking a good question, albeit often providing an oversimplified answer. Where we part company with it more decisively is, is in its aspect as a theory of technology, in its typical assumption that, technological change is an independent factor impacting on society from outside of society.

So, to speak, , then , we are going back to the linear model of the relationship between science, technology and society, where we said, you know, science leads to the development of technology, technology leads to the development of society. And this is a very common way of, thinking, but to our minds a mistaken one.



The view, that technology just changes either following science or of its own accord promotes a passive attitude to technological change.

, if a proponent of linear model of the relationship between science, technology and society suggests that, no, technology changes because of changes in science or technology changes

just because of its own internal dynamic, it promotes , such conceptions, such views promote a passive attitude to technological change. , such typical assumption that technological change is an independent factor impacting on society from outside of society, then it focuses our minds on how to adapt to technological change, not on how to shape it. Then whenever some change occurs, we always say that let us adapt to such technological changes.

But STS scholars, we always try to do, as a student of STS, I must say that we, always try to shape a particular technology to suit our needs, to suit our demands, not to adapt to that technological change. That is why both are important. When it focuses our minds on how to adapt to technological change, not on how to shape it, it removes a vital aspect of how we live from the sphere of public discussion, choice, , selection and politics.

That is why I said earlier that selection is based on cultural relevance. , when we go ahead with public discussion, choice or selection and political formation, very often people think that, no, let us adapt to technological changes, but, it is it is equally important how to shape a specific technology to suit our demands. Then, t if you, if you look at this, then what we find that precisely because technological determinism is partly right, as a theory of society, , when I say this, , technology matters not just physically and biologically, but also to our human relations to each other.

Its deficiency as a theory of technology impoverishes the political life of our society. In one of the most influential recent works of social theory, for example, Ulrich Beck, both diagnoses and calls for reflexive modernization, , which apparently opaque phase, , this apparently opaque phase encodes several linked notions, but the one that is crucial here is the idea that instead of modernization or progress, being a modernization and or progress, being a process that just happens to societies, it should become a process that is actively and democratically set. , Ulrich Beck's work resonates with the remarkably successful attempt of the German Green Party to bring into the heart of the political process, the activities and goals of citizens initiatives of investigative journalists, of radical engineers and of the environmentalist, women's and peace movements, , environmental movements, human rights movements, women's movements and so on.

As a vitally important part of progress, technological change is a key aspect of what our societies need actively to shape rather than passively to respond to. , if we always try to adapt

to technological change, we, we passively respond to that technology. If we try to shape a particular technology, then what we do, or rather our societies' need actively shape it, then the way technology is set to suit our demands, suit our needs and it will, then, it will be more inclusive in the context of public discussion, the way we are going to choose or select and in the context of political formation.

, often efforts to develop a politics of technology are seen as anti-technology, as an attempt to impose upon technology rigid negative political controls. The prevalence of that misconception and this is a misconception that people think that no, no, no, if you talk about the politics of technology, it is essentially anti-technological, it is rigid, it is a negative thought, too much of political control we do not want in the context of technological development, but the prevalence of, that misconception is our reason for including here and extract from the work Donna Haraway's work on this, kind of misconception, who has become perhaps the most influential feminist commentator on science and technology. Her dance, playful, poetic and occasionally oblique prose is sometimes misunderstood as an attack on science and technology, but, but we see it in a different light.

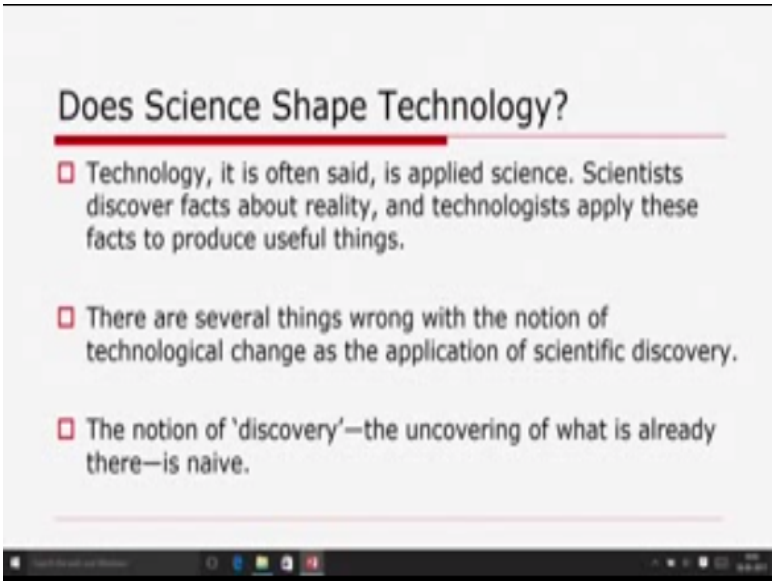
She is sharply critical of those who reject technology in favor of a return to a mythical natural state and she argues instead for an embracing of the positive potential for science and technology. When, we try to bring about a critique to technology, our intention is, our purpose is not to go back to those, that theological stage or metaphysical stage , as recently has been seen in the context of fundamentalism, rise of fundamentalism across the continents, but , we are not trying to , go back to those mythical world or mythical natural state, but , what Donna Haraway tried to do, what she argues that , we must embrace the positive potential of science and technology. Of course, there is much in those spheres she should wish to see change, but she argues that she eschews an eco-feminist celebration of women's spiritual closeness to an unpolluted nature, famously and provocatively preferring to be a "cyborg" a cybernetic organism such as an animal with a human made implant than an eco-feminist goddess.

Donna Haraway, , she is trying to rephrase an old theme, , the liberatory potential, the, kind of potential to achieve liberty of science and technology. In the passage from her work, , that Mackenzie and Wajcman tried to select, that she notes that great power of science and technology to create, she notes the great power of science and technology to create new

meanings and new entities to make new worlds, while critical of many aspects of the way this happens such as the wholesale extending of private property, that is, patenting to life forms. , we are going to discuss this in the context of science policies in India, , what are the criteria of attaining patents? One, novelty, second, non-obviousness, third, utility, , industrial utility, that is how we try to make a shift from invention to innovation, , that is what we have already discussed in the context of , Layton Jr's article.

even in the context of Edison's electric light, , the way Edison and his close associates tried to make a shift from invention to innovation, innovation essentially involves marketization, commercialization, industrial utility. , Donna Haraway, while critical of many aspects of the way, that this happens such as the wholesale extending of private property, that is, patenting to life forms, , in the context of agriculture, in the context of medicine and so on, she warns that any purist rejection of the unnatural hybrid entities produced by biotechnology, admitting at one point her frank pleasure at the introduction into tomatoes of a gene from flounders, which live in cold seas, that enables the tomato to produce a protein that slows, that slows freezing. She revels in the very difficulty of predicting what technology's effects will be, the lively unfixed and unfixing practices of science and technology produces surprises, which just might be good ones, that is what she tried to reflect.

Now, what we have discussed till now? We have discussed till now technological determinism as a theory of society, hard and soft technological determinism as a theory of society and technological determinism as a theory of technology. technology changes just because of either changes in science or technology changes because of an internal dynamic. , how? Then, if we say that technology changes because of changes in science, then let us see, does science shape technology? Clearly, any efficacious politics of technology, any systematic attempt to ensure that the surprises are indeed good ones needs an understanding of technological change.



Let us, begin to sketch an outline of such an understanding by tackling the most obvious force shaping technology, that is, scientific change people very often say. Technology is often said, that technology is applied science. Scientists discover facts t, about reality and technologists apply these facts to produce useful things.

This is a, standard notion about the relationship between science and technology, scientists discover facts about reality and technologists apply these facts to produce useful things. As we have already discussed that this view of technological change is a key underpinning of popular forms of technological determinism.

There are several things wrong with the notion of technological change as the application of scientific discovery. That if I say that technology changes because of changes in science, this is also misnomer at , many times if you look at the history of science and technology. First, , , there are several things wrong with the notion of technological change as the application of scientific discovery.

Then first the notion of discovery itself, the uncovering of what is already there is naive. Scientists, are of course, in constant intimate dialogue with the real material world, but they are active participants in that dialogue , bringing to it conceptual schema, experimental traditions, intellectual investments, ways of understanding the world models and metaphors, some drawn from the wider society and so on. Furthermore, science and technology have by no means always been closely connected activities.

Looking backwards is tricky because people in previous times did not operate with our notions of science and technology as Meyer in 1976 put it. There is some controversy among historians who have studied the issue, but it can be concluded that before the latter part of the 19th century, the contribution of activities we would now think of as science to what we could call technology was often marginal. Then, when people in previous times did not operate with our notions of science and technology, suppose the water wheel, the plough, the spinning wheel, the spinning genie, even the steam engine, these crucial inventions were in no real sense the application of pre-existing science.

That is why if you look at the steam engine for example, steam engine is a part of technological formation, technological system, but steam engine was first invented and then we came to understand the laws of thermodynamics. This is very important to understand that is why technology also direct, technology also changes the direction of basic research, science. If we say that no technology is always applied science, science also can be applied technology.

That is the relationship between science and technology is dialectical in nature. That is why when we started these lectures that I said technology always predates modern science. That is a political economy approach, that is a historical sociological perspective, that is a philosophical and anthropological perspective on the relationship between science and technology.

That is a materialist view about science and technology. People very often say that science is prior, but the history of science and technology suggests that no technology always predates modern science. That is why when we say laws of thermodynamics, laws of thermodynamics never led us to the invention of steam engine.

Rather the invention of steam engine led us to our understanding of the laws of thermodynamics. That is why the relationship between science and technology is dialectical in nature. Such hierarchical relationship, the hierarchical relationship, linear relationship between science and technology is not sustainable today, is untenable.

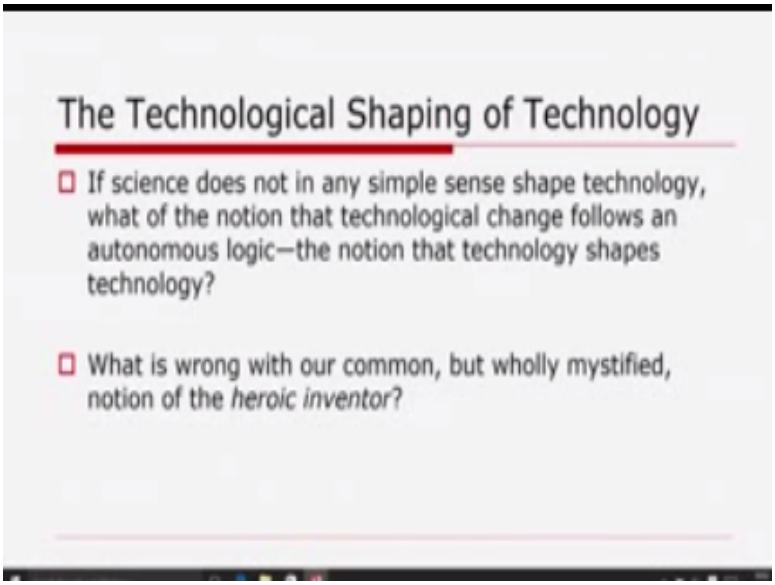
Then, if you look at these things, for example, steam engine, such crucial invention was in no real sense the application of pre-existing science. rhetoric about the contribution of science to technology, there was in plenty, but the rhetoric often bore little relation to the modest reality of that contribution and needs to be interpreted differently. If you look at Steven Shapin's works, you will find out. internalism-externalism debate within history of science. It is important, science and technology. Where science and technology are connected as they increasingly have been since the second half of the 19th century, it is mistaken to see the connection between them as one in which technology is one-sidedly dependent on science.

Technology has arguably contributed as much to science, as science also has contributed as much to technology. Think of the great dependence of science on the computer without which some modern scientific specialties could scarcely have come into existence. Most recently where technology draws on science, the nature of that relation is not one of the technologists passively deducing the implications of a scientific argument.

Technology as the word's etymology reminds us is knowledge as well as artifacts and the knowledge deployed by engineers is far from just applied science or engineer turned historian Vincenti demonstrates. Walter Vincent in 1990, said that no, do not think that technology is just applied science. Technology is a combination of both knowledge as well as artifacts.

That is why we discussed not only technology as a part of artifact, but also it is a part of knowledge in the context of both Langdon Winner as well as Layton Jr. Engineers use science, they seek from science resources to help them solve the problems they have, to achieve the goals towards which they are working. These problems and goals are at least as important in explaining what they do as the science that is available for them to use. Now, let us come to the technological shaping of technology.

, first we started with this technological determinism as a theory of society. Then, hard and soft technological determinism as a theory of society.



Then, technological determinism as a theory of technology. Then, does science shape technology? Then, technological shaping of technology. If science does not in any simple sense shape technology, what of the notion that technological change follows an autonomous logic, the notion that technology shapes technology.

To understand the force of this argument, it is necessary to see what is wrong with our common, but wholly mystified notion of the heroic inventor. , according to the notion of heroic inventor, great inventions occur when in a flash of genius, a radically new idea presents itself almost ready formed in the inventor's mind. This way of thinking is reinforced by popular histories of technology in which to each device is attached a precise date and a particular man.

Few indeed there are women in the stereotyped lists to whom the inspired invention belongs. One important attack on this, , , there are many critiques to such l, so called inspirational notion of invention. One important attack on this inspirational notion of invention was mounted by the group of American writers, most importantly William Ogburn, who from the 1920s onwards set themselves the task of constructing a sociology of technology.

In a 1922 article, Ogburn and his collaborator Dorothy Thomas argued that far from being the, result of unpredictable flashes of inspiration, inventions were inevitable. , , the, once the necessary constituent cultural elements are present, an invention must occur such as given the boat and the steam engine, is not the steam boat inevitable? , this is very important.

Even we can go on, , , they regard, , Ogburn and Dorothy Thomas, they regarded it , as a crucial evidence for the inevitability of invention that a great many inventions were in fact made independently by more than one person. That is why we looked at Edison and his close associates, Edison, Nussle, Zilsel, Zilsel and so on. Not the, least of the difficulties of this position is that apparent inventions of the same thing turn out on closer inspection to be of importantly different things.

A solidly based critique of the inspirational notion of invention can, however, be constructed directly drawing on the work of writers such as Ogburn's contemporary Usher, his colleague Gilfillan and more recently historians of technology like Thomas P. Hughes. Hughes work is of particular relevance because much of it focuses on classic inventor, great inventor figures such as Thomas Edison credited with the invention of among other things, the gramophone and the electric light bulb and Elmer's Perry famed for his work on the narrow compass and the marine and aircraft automatic pilot. Hughes has no interest in disparaging, the, the, the achievements of those he writes about.

Indeed, he has the greatest respect for them, but his work demonstrates that invention is not a matter of, an invention is not a matter of 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 namely Edison and electricity. That is why Edison once said, no it is 99 percent in what is an invention? Invention involves 99 percent perspiration and, and 1 percent inspiration.

, when, when an invention occurs, it occurs in a particular, in a specific social context. Largely, it is a matter of the minute and painstaking modification of existing technology. It is a creative and imaginative process, but the imagination lies above all in seeing ways in which existing devices , can be improved and in extending the scope of techniques successful in one area into new areas.

Then a vitally, important type of technology, technical change altogether escapes our conventional notion of invention. Technical change is often a perpetual accretion of little details, probably having neither beginning, completion nor definable limits of process. Gilfen saw at work in the gradual evolution of the sea, this process is normally anonymous,

certainly not heroic inventor figures and often skilled craft workers without formal technical or scientific trend.

It is probably best seen as a process of collective learning rather than individual innovation. That is why whenever we talk about science, science should not be individualized or that is why we always try to bring about a critique to patents that you know science is a collective endeavor. That is why science must be kept at the public domain.

Learning by doing in making things and what Rosenberg calls learning by using feedback from experience of use into both the design and way of operating things are both of extreme practical importance. Small changes, little changes may add up to eventually considerable changes in design, productivity and effectiveness. New technology typically emerges not from flushes of disembodied inspiration, but from existing technology by a process of gradual change to and new combinations of that, that existing technology.

Even what we might with some justification want to call revolutions in technology often turn out to have been long in the making. Constant's important study, how he wrote of the change in aircraft propulsion from the propeller to the jet shows this clearly. Revolutionary as it was in the context of aircraft propulsion, the turbo jet built upon a long tradition of work on water and gas turbines.

Existing technology is an important precondition of new technology. That is why whenever we talk about new technology, we just cannot say that it is apriori in nature. What is apriori? A priory means prior to experience, prior to imprecision. That is what we have discussed in the context of methods of science. That if we say that something is prior to experience, that new technology is not like that. New technology is an important precondition, rather new technology is conditioned by an existing technology.

That is why existing technology is an important precondition of new technology. Existing technology provides the basis of devices and techniques to be modified and is a rich set of intellectual resources available for imaginative use in new settings. But is it the only force shaping new technology? No, it cannot be.

We would say that it is not and would argue that this can be seen by examining the two most plausible attempts to claim that existing technology is more than just a precondition of new technology, but is an active shaping force in its development. These attempts focus around the ideas of technological paradigm and technological system. The idea of technological paradigm is an important extension of Kuhnian idea of scientific paradigm.

If you slightly recall Kuhnian paradigm, say paradigmatic shifts in the context of scientific revolutions, we are trying to extend Kuhnian model of paradigmatic shifts in the context of scientific revolutions to technological paradigm. In Kuhn's work, paradigm has two meanings, two main meanings which are interrelated, but distinguishable. In the more basic sense, the paradigm is an exemplar, a particular scientific problem solution that is accepted as successful and which becomes the basis for future work.

Thus, Newton's explanation of the refraction of light in terms of forces acting on particles he believed light to consist in formed a paradigm for much subsequent work in optics. Researchers sought to produce similar explanations for other optical phenomena. The paradigm in this first sense of exemplar plays a crucial part in the paradigm in the second more famous wider sense of the entire constellation of beliefs, values, techniques and so on shared by the members of a given scientific community.

The discussion on paradigms in technology, Kuhn discussed scientific paradigms, paradigms within science. Now, we are trying to extend that to capture technological paradigms, paradigms within technology. The discussion on paradigms in technology has been less profound than it might have been because it has tended to focus on the second meaning of paradigm.

What was that second meaning? entire constellation of beliefs, values, techniques and so on shared by the members of a given scientific community. That is why Kuhn also mentioned, consensus by scientific community. Then, then if I say the discussion on paradigms in technology has been less profound than it might have been because it has tended to focus on the second meaning of the paradigm.

entire constellation of beliefs, values, techniques and so on shared by the members of a given scientific community. That the second meaning of paradigm despite Kuhn's explicit

statement that the first meaning is philosophically deeper. That the paradigm is an exemplar, a particular scientific problem solution that is accepted as successful and which becomes the basis for future work.

But there is no doubt that the concept of paradigm applied to technological change does point us towards important phenomena. Particular technical achievements have played a crucial role as exemplars, as models for further development. In the field of missile technology for example, the German V-2 missile played this role in early post war American and Soviet missile development.

Because technological knowledge cannot always be reduced to a set of verbal rules, the presence of a concrete exemplar is a vital resource for thought. The Americans possessed actual German built V-2s as well as most of the design team. Though Soviets painstakingly constructed with help from some of the designers replicas of the original missile.

I am just quoting from Odway and Shaw in 1979 “to a significant extent the V-2 formed the model from which further ballistic missiles were derived by conscious modifications.” If we find technologists operating with a paradigm, taking one technical achievement and modeling future work on that achievement, it becomes tempting to treat this as somehow self-explaining and discuss it in terms of mechanical analogies such as following a technical trajectory. This is what Giovanni Dossi pointed out in 1982.

But to do this would be to miss perhaps the most fundamental point of Kuhn's concept of paradigm. What was that? Now, the paradigm is not a rule that can be followed mechanically, but a resource to be used. It is not a methodological canon , which can be followed mechanically, but a, but it is a resource to be used, to be utilized.

There will always be more than one way of using a resource of developing the paradigm. Indeed groups of technologists in different circumstances often develop the same paradigm differently. American and Soviet missile designers for example, developed significantly different missiles despite their sad use of the V2 as a departure point.

Where this does not happen, where there is congruity in the development and extension of a paradigm, this stands equally in need of some kind of explanation. Just how much can be

hidden for by considering the further development of a paradigm as simply a technological trajectory following an internal logic emerges from another study by Hughes in 1969. Here, the trajectory being considered is that of successive processes for synthesizing chemicals by hydrogenation, combination with hydrogen at high temperatures and pressures over catalysts.

Hughes examines the trajectory of this work in the German chemical form IG Farben and and its predecessors. Beginning with the paradigm instance of the Haber Bosch process for the synthesis of ammonium, the company moved on to the synthesis of wood alcohol and finally, of gasoline from coal. A natural trajectory indeed, but, one that outside the form including most consequentially the German states of the German states need for work time independence from external sources of raw materials.

In America, the chemical giant DuPont adopted synthetic processes for the production of ammonia and wood alcohol, but did not in that very different environment find the step to the synthesis of gasoline natural. In Germany, moving to gasoline synthesis involved greater and greater links between Farben and the Nazi state links which eventually led 23 executives of Farben to the dock in the Nuremberg war time tribunals. If you look at the second world war situation, you will find the idea of technological system has been used in the history of technology.

More widely than that of technological paradigm and thus the characteristics of explanations framed in its terms are more evident. Now, let us follow its usage by Thomas P Hughes who makes it in many ways the central theme of his studies of technology. Typically and increasingly technologies come not in the form of separate isolated devices, but as part of a whole , as part of a system.

An automatic washing machine can work only if integrated into the systems of electricity supply, water supply and drainage. A missile to take another example is itself an ordered system of counterparts, warhead, guidance, control, propulsion and also part of a wider system of launch equipment and command and control networks. The need for a part to integrate into the whole imposes major constraints on how that part should be designed.

That is what we have discussed in the context of Edison and the and his electric light in the invention of electric. The integration of technologies into systems gives rise to a particular

pattern of innovation and focusing of innovation on perceived reverse salience is a phenomenon of great generality. while this is an important way in which technology or technological system shapes technology, does it imply that only technology shapes technology? Hughes answer is no and the reason for that answer is of considerable importance.

A technological system like an electric light and power network is never merely technical. Its real world functioning has technical, economic, organizational, political and even cultural aspects. Of these aspects, the most important one is economic and perhaps for this reason what Donald Mackenzie and Judy Wajcman suggest that no the economic shaping of technology, the economic shaping is social shaping in the lectures to follow we are going to discuss.

Thank you.