Ten Paradoxes of Technology: An Introduction to the Critical Theory of Technology

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Preface

In recent years, the industrial revolution has gone global in a big way. The so-called "postindustrial society" has "made in China" written all over it. Rates of growth in major undeveloped countries have skyrocketed as they take over manufacturing for the entire world. But the results are far from reassuring. The dark side of all this progress is increasing inequality and environmental crisis.

Since World War II, we in the developed world have considered ourselves to be living on islands of modernity in a global economy headed toward universal prosperity. We assume that we are destined to pull the developing world into modernity just as the peasants of England and France were once pulled into the modernity of their day by Manchester, London and Paris.

But the modern economy is too resource and energy intensive to be viable with additional billions of participants. An evolutionary process of regulation and technological innovation has begun that is supposed to protect the atmosphere and reduce waste, but it seems too slow off the mark to prevent significant climate change and drastically rising fuel costs. The expansion of the modern sector of the world economy is likely to slow as it meets these and other environmental obstacles.

Meanwhile, trends among the excluded in the developing world are unfavorable. Three scourges threaten the stability of the older ways of life that until now sustained the huge populations not yet admitted to modernity: armed conflict, especially in Africa, organized criminality as a response to widespread unemployment, and official corruption, which causes waste and public health catastrophes, and provokes political violence in response. The rapid incorporation of the excluded into modernity could counter these growing trends, but in fact we face an increasingly steep slope as we work toward that goal.

The predictable outcome of this situation is an ever greater divide between a more slowly growing modern sector and disintegrating premodern economies reorganized around various dysfunctional alternatives that cannot be integrated to a modern society. In the worst case scenario the excluded disrupt the stability and security required by modern economies and the world begins to fall back rather than continuing the present trend. Even if that does not happen, the historical analogy with the developed world seems likely to fail as billions of people remain excluded far into the future.

This all too plausible pessimistic diagnosis should set us thinking about where we have gone wrong. What we call a modern economy is not the result of careful and intelligent planning. It is the outcome of a great many forces, including political decisions and cultural and economic trends often reinforced by advertising and evolving social arrangements. For a time a Panglossian neoliberal ideology consecrated the outcome. We lived in "the best of all (economically) possible worlds." Recent events cast doubt on the wisdom of the chaotic historical process to which we owe the present configuration of our economy.

But awareness that our society is a kind of accident suggests possibilities that go well beyond environmental protection and banking regulation. We can begin to imagine a better and more purposeful design of modern life that would improve on the one we have inherited. Such a *remodernization* would reduce pollution and waste and overcome the divide between rich and poor. It would enable progress to continue along a different track from the current crisis ridden one.

For that imagined alternative to become reality, the technological base of modern societies must be transformed. Whether this is possible depends very much on the nature of technology. From a deterministic point of view, the path of development has already been traced out by the advanced societies and no deviation from that path is likely to succeed. But if this is true, poor countries such as China and India are doomed to make huge and wasteful expenditures providing universal access to the automobile since automotive technology played a major role in Western development.

In the West, social criticism and scholarly research in the sociology and history of technology has freed us from naïve faith in the inevitability of our own path of development. Yet deterministic assumptions are alive and well where it counts, among the elites who decide development policy. Intellectuals in the developing world are increasingly sceptical of these policies as economic crisis and the overwhelming evidence of exclusion and pollution send up warning signs that are hard to ignore. The governments themselves begin to be open to new ideas and critical viewpoints.

Change is coming. The task for students of technology is to articulate the philosophical and sociological basis of that change and to argue for a more democratic and humane path of development than has prevailed in the past.

This task has been taken up by scholars and rural development experts in Brazil. The Social Technology Network addresses the limitations of neo-liberal development strategies with new ideas adapted to the situation of the tens of millions of the excluded.

The first chapter of this book is an expanded version of a lecture delivered in 2009 in Brasilia to the international conference of the Social Technology Network. The lecture challenged standard views of technology with ten "paradoxes" reflecting what we have learned in recent years in science and technology studies and philosophy of technology. The social constructivist turn in technology studies lies in the background of this lecture.

The second chapter combines two lectures presented to the WTMC seminar in 2008. The seminar is a yearly event that brings together many of the doctoral students in science and technology studies (STS) in Holland, one of the principle centers of work in this field. I was asked by the organizers to introduce myself in my first lecture and this set me off on a semi-autobiographical exercise that is reproduced here as an accessible entry into the critical theory of technology. In this lecture I describe my own experiences as an "agent" in the technical sphere.

The third chapter consists of four lectures delivered in 2010 at the University of Brasilia to a class that included students from several disciplines and a number of rural development specialists. These lectures opened a course in philosophy of technology which continued after my departure under the leadership of several Brazilian scholars. The course aimed to counter the influence of technocratic ideas about development with a critical approach that would empower the students to think and act independently in their increasingly technological society.

Chapter four is based on a lecture presented in an early form to the World Social Forum in Belem do Para in 2008, and more fully elaborated in 2009 for a conference organized by the University of Quilmès at the Ministry of Science and Technology in Buenos Aires. This lecture attempts to distinguish science and technology in terms of the different political strategies appropriate for social responsiveness in each case. The distinction is necessary because of the frequent confusion on the left between regulation of technology and management of scientific research.

The context of these lectures is important for understanding them. The issues are not merely academic. The study of technology concerns the future of modernity as an innovative form of life with a still uncertain grip on global development. Faced with the dual crises of exclusion and the environment, we should be engaged in a process of social experimentation leading to a new understanding of progress. But far too little is being done.

Occasional innovations such as the Grameen Bank attract momentary attention and offer hope. In Latin America and India movements for social technology bring engineers and teachers together with local communities in the search for sustainable technical solutions to local problems. The proliferation of workers' cooperatives in Argentina after the economic crisis there deserves study and support. On an entirely different score, the unprecedented spread of music education throughout Venezuelan schools is a fascinating example of the power of relatively inexpensive cultural activity to transform lives. But there is nowhere near the focus on these innovations that is devoted to projects with powerful commercial sponsors and beneficiaries.

The practical obstacles to overcome are enormous and the intellectual resources still relatively scarce. Science and technology studies and philosophy of technology can make a contribution to freeing us from the failing illusions of modernization theory and neoliberalism. That is my purpose in publishing these lectures.

I would like to thank those who helped organize my lectures, Sally Wyatt, Larissa Barros, Ricardo Neder, Frédéric Sultan, and Fernando Tula Molina. I would also like to thank the Fundação Banco do Brasil for supporting my stay in Brazil, and the strike committee of University of Brasilia for permitting my class to go forward during a labor action.

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Chapter One
Ten paradoxes of Technology

This paper presents a philosophy of technology. It draws on what we have learnt in the last 30 years as we abandoned old Heideggerian and positivist notions and faced the real world of technology. It turns out that most of our common sense ideas about technology are wrong. This is why I have put my ten propositions in the form of paradoxes, although I use the word loosely here to refer to the counter-intuitive nature of much of what we know about technology.

1. *The paradox of the parts and the whole.* Paraphrasing one of Martin Heidegger's most provocative reflections on animal life, we can ask whether birds fly because they have wings or have wings because they fly.[1] The question seems silly but it offers an original point of entry for reflection on technology and development.

Birds appear to be equipped with wings and it is this that explains their ability to fly. This is the obvious common sense answer to Heidegger's question. But this answer has implications that are less than obvious. Although our intuitions tell us birds belong in the air, our language seems to say that they are separate from the environment on which they act and even separate from the "equipment" they use to cope with that environment. Birds *use* wings to fly in something like the way in which we humans use airplanes.

Pursuing the analogy we could say that if birds did not have wings they would be just as earthbound as were humans before the Wright brothers—or was it Santos Dumont —invented the airplane. But this makes no sense. Although there are a few species of flightless birds, most birds could not survive without flying. Flying is not just something birds do; it is their very being.

A better analogy to birds' flight would be human speech. Although speechless humans do exist, they lack an essential aspect of what it is to be human. Speech is not properly understood as a tool humans use to communicate because without it they are not fully human. Speech, like flight for birds, is essential in a way tools are not. One can pick up and put down a tool, but humans can no more abandon speech than birds can abandon flight.

Pushed to the extreme the common sense answer to Heidegger's puzzling question breaks down. Of course we usually do not fall into such absurdities when talking about animals, but the misleading implications of ordinary language do reflect our inadequate common sense understanding of technology. This has consequences I will discuss in the rest of this paper.

Heidegger's second option, that birds have wings because they fly, challenges us in a different way. It seems absurd on the face of it. How can birds fly unless they have wings? So flying cannot be the cause of wings unless an effect can precede a cause.

If we are going to make any sense of Heidegger's point we need to reformulate it in less paradoxical language. Here is what he really means. Birds belong to a specific niche in the environment. That niche consists of treetops in which to dwell, insects to eat, and so on. It is only available to a specific type of animal with a specific type of body. Flying, as a necessary property of an organism that occupies this particular niche, requires wings rather than the other way around as common sense would have it.

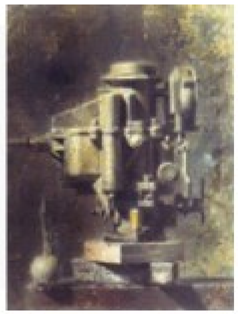
This is a holistic conception of the relation of the animal to its environment. We are not to think of birds, insects and trees as fully separate things but rather as forming a system in which each relates essentially to the other. But this is not an organic whole the parts of which are so intimately connected they can only be separated by destroying the organism. In the case of an animal and its niche, separation is possible at least temporarily, although it threatens the survival of the animal and perhaps of other elements of the environment dependent on it.

These relationships are bit like those of a part of a machine to the whole machine. The part can be separated from the whole but it then loses its function. A tire that has been removed from a car continues to be a tire but it cannot do the things tires are meant to do. Following Heidegger's thought, it is easy to see that the form and even the existence of tires such as we know them depends on the whole car they are destined to serve. And the reciprocal also holds: care and tire are mutually interdependent. The car is not just assembled from pre-existing parts since the nature of the parts is derived from the design of the car and vice versa. The car does not ride on the road because it has tires. Rather, the tires belong to the car because the car rides on the road.

I will call this *the paradox of the parts and the whole. The appar-*

[1] Heidegger, Martin, *The Fundamental Concepts of Metaphysics*, trans. W. McNeill and N. Walker. Bloomington and Indianapolis: Indiana University Press, 1995, part II, chap. 4.

ent origin of complex wholes lies in their parts but, paradoxical though it seems, in reality the parts find their origin in the whole to which they belong. I want to illustrate this paradox with two images, each of which exemplifies the two answers to Heidegger's question in graphic terms.

The first of these images shows a carburetor in a manufacturer's catalogue. As you can see it is a wonder of sharp edged surfaces and smooth curves in cold, shiny steel. It is completely separate from its environment and fulfills the dream of reason, the dream of pure order. Now look at this second image by the painter Walter Murch. We are once again in the presence of a carburetor, but this time it is portrayed as a warm and fuzzy object that blurs into the air around it. It is compared subtly with a sprouting onion over to the left which establishes a scale that contradicts its strangely monumental aspect. This is a romantic rather than a rationalistic image. It hints at the history and the connectedness of the thing rather than emphasizing its engineering perfection.

Which image is truer to life? I prefer Murch's which I used as cover art for a book called *Questioning Technology*.[2] Murch sets us thinking about technology's complexity, the environment in which it functions, the history out of which it arises, rather than answering the question in advance with a nod to its supposedly pure rationality.

Examples that confirm the point are easy to find. A technology imported or imitated from a developed country is implanted in a new environment in a less developed country. It is expected that it will perform in the same way everywhere, that it is not a local phenomenon bound to a particular history and environment. In this respect technologies differ from such rooted phenomena as customs or language. Difficult though it be to transfer Western industrial technology to a poor country, it is far easier than importing such things as a different cuisine or different relations between men and women or a different language. So we say that technology is universal in contrast to these particular and local features.

And this is usually correct to a considerable extent. Of course it makes no sense to send tractors to farmers who have no access to gasoline. Such gross mistakes are occasionally made but for the most part the problems are more subtle and are often overlooked for a long time. For example, industrial pollutants that were evacuated safely by a good sewage system in a rich country may poison wells in a new, much poorer, locale. Differences in culture too pose problems. The keyboards of the typewriters and computers Japan imported from the West could not represent its written language. Before a technical adaptation was found some Japanese concluded that modernization would require the adoption of English!

Good sewage systems and Roman alphabets form a niche essential to the proper functioning of these technologies just like the water in which fish swim. Technologies resemble animals in belonging to a specific niche in a specific society. They do not work well, if at all, outside that context. But the fact that technologies can be detached from their appropriate niche means they can be imported without bringing along all the contextual elements necessary for their proper functioning. Technologies can be plucked from the environment in which they originated and dropped into a new environment without afterthoughts. But this can be a formula for disaster.

Consider the adoption of the private automobile by China as a primary means of transportation. In February 2009 auto sales in China surpassed those in the United States for the first time. China is now the largest market for private cars in the whole world. This is not surprising given the size of China's population. But for that very same reason it was foolish to commit so many resources to the automobile. Automobiles are a very inefficient means of transportation. They consume a great deal of fuel for every passenger mile driven. China is so big that its participation in oil markets will eventually push prices up to the point where the private automobile will become unaffordable to operate. Meanwhile, China will have built its cities around automotive transportation with consequences that will be very expensive to reverse. Mistakes such as this occur because policymakers fail to realize the dependence of the parts on the whole. In this they resemble ordinary people everywhere in modern societies. Our common sense misleads us into imagining that technologies can stand alone.

[2] Feenberg, Andrew (1999). *Questioning Technology*. New York: Routledge.

2. *The paradox of the obvious.* Why do we think like this? Why does common sense tend to validate the first of the two images I have presented? I find the answer to these questions in another paradox which I will call *the paradox of the obvious.* Here is a general formulation: *what is most obvious is most hidden.* An amusing corollary dramatizes the point: fish do not know that they are wet. Now, I may be wrong about fish but I suspect that the last thing they think about is the medium of their existence, water, the niche to which they are so perfectly adapted. A fish out of water quickly dies but it is difficult to imagine fish enjoying a bath. Water is what fish take for granted just as we human beings take air for granted. We know that we are wet because water is not our natural medium. It exists for us in contrast to air. But like fish who do not know they are wet, we do not think about the air we breath.

We have many other experiences in which the obvious withdraws from view. For example, when we watch a movie we quickly lose sight of the screen as a screen. We forget that all the action takes place in the same spot at a certain distance in front of us on a flat surface. A spectator unable to ignore the obvious would fail to foreground the action of the film and would remain disturbingly conscious of the screen. The medium recedes into the background and what we notice in the foreground are the effects it makes possible. This explains why we see the possession of wings as the adequate explanation of flying and why it looks to us like machines are composed of independent parts.

3. *The paradox of the origin.* Our forgetfulness also blinds us to the history of technical objects. These objects differ from ordinary things and people in the way they relate to time. This person, that book, the tree behind our house all have a past and that past can be read on his wrinkled and smiling face, the dog-eared pages of the book, the stump of the branch that broke from the tree in the last storm. In such cases, the presence of the past in the present seems to us unremarkable.

But technologies seem disconnected from their past. We usually have no idea where they came from, how they developed, the conditions under which the decisions were made that determined their features. They seem self-sufficient in their rational functioning. An adequate explanation of any given device appears to consist in tracing the causal connections between its parts.

In reality there is just as much history to an electric toaster or a nuclear power plant as there is to persons, books, and trees. No device emerged full blown from the logic of its functioning. Every process of development is fraught with contingencies, choices, alternative possibilities. The perfecting of the technical object obliterates the traces of the labor of its construction and the social forces that were in play as its design was fixed. It is this process that adjusts the object to its niche and so the occlusion of its history contributes to the forgetfulness of the whole to which it belongs. I call this *the paradox of the origin: behind everything rational there lies a forgotten history.*

Here is an example with which we are all familiar. What could be more rational than lighted exit signs and outward opening doors in theatres? Yet in the United States these simple life saving devices were not mandated by any law or regulation until the famous Iroquois Theatre fire in Chicago in 1903. Some 600 people died trying to find and open the exits. Thereafter cities all over the country introduced strict safety regulations. Today we do not take much notice of exit signs and doors and certainly few theatre goers have an idea of their origin. We think, if we think at all, that they are surely there as useful precautions. But the history shows that this is not the full explanation. A contingent fact, a particular incident, lies behind the logic of theatre design.

4. *The paradox of the frame.* There is a corollary of the paradox of the origin. I call this *fourth paradox, the paradox of the frame* and formulate it as follows: *efficiency does not explain success, success explains efficiency*. This is counter-intuitive. Our common sense tells us that technologies succeed because they are good at doing their job. Efficiency is the measure of their worth and explains why they are chosen from among the many possible alternatives. But the history of technology tells a different story.

Often at the beginning of a line of development none of the alternatives work very well by the standards of a later time when one of them has enjoyed many generations of innovation and improvement. When we look back from the standpoint of the improved device we are fooled into thinking its obvious superiority explains its success. But that superiority results from the original choice that privileged the successful technology over the alternatives and not vice versa. So what does explain that choice?

Again, the history of technology helps. It shows that many different criteria are applied by the social actors who have the power to make the choice. Sometimes economic criteria prevail, sometimes technical criteria such as the “fit” of the device with other technologies in the environment, sometimes social or political requirements of one sort or another. In other words, there is no general rule under which paths of development can be explained. Explanation by efficiency is a little like explaining the presence of pictures in a museum by the fact that they all have frames. Of course all technologies must be more or less efficient, but that does not explain why they are present in our technical environment. In each case only a study of the contingent circumstances of success and failure tells the true story.

5. *The paradox of action*. This brings me to my fifth paradox which I call *the paradox of action*. I think of this as a metaphoric corollary of Newton's Third Law of motion. Newton's law states that for every action there is an equal and opposite reaction. This law is verified every time two billiard balls bounce off each other. My corollary applies this model to human behavior. It most obviously applies in interpersonal relations where anger evokes anger, kindness kindness, and so on. Every one of our acts returns to us in some form as feedback from the Other. But this means that *in acting we become the object of action*.

In more formal philosophical language the paradox of action says that human beings can only act on a system to which they themselves belong. Because we belong to the system any change we make in it affects us too. This is the practical significance of our existence as embodied and social beings. Through our body and our social belonging we participate in a world of causal powers and meanings we do not fully control. We are exposed through our body to the laws of nature. And we are born into a cultural world we largely take as given. In short, we are finite beings. Our finitude shows up in the Newtonian reciprocity of action and reaction.

But technical action appears to be non-Newtonian, an exception to the rule of reciprocity. When we act technically on an object there seems to be very little feedback to us, certainly nothing proportionate to our impact on the object. But this is an illusion, the illusion of technique. It blinds us to three reciprocities of technical action. These are causal side effects of technology, changes in the meaning of our world and in our own identity.

It is only when we narrowly define the relevant zone of action that we appear to be independent of the objects on which we act technically. In context, action always conforms to my version of Newton's law and comes back to affect the actor. The illusion of independence arises from the nature of technical action which dissipates or defers causal feedback from the object. Indeed, the whole point of technology is to change the world more than the actor. It is no accident that the gun harms the rabbit but not the hunter, that the hammer transforms the stack of lumber but not the carpenter. Tools are designed to focus power outward, on the world, while protecting the tool user from that equal and opposite reaction Newton proclaimed.

But Newton cannot be defied for long. In one way or another the reaction will manifest itself. In the case of pollution all one need do to identify the reaction is to enlarge the context in space and time and wait for the chickens to come home to roost. Barry Commoner's ecological corollary of Newton's law declares that "Everything goes somewhere." Indeed, all the poisons produced by industry end up in someone's backyard even if it takes years to notice. As technology grows more powerful its negative side effects become more difficult to ignore and finally it is impossible to ignore the dangers they create.

This observation brings us back to our first three paradoxes. The paradox of the parts and the whole states the importance of the niche or context. That niche must include a way of absorbing the impact of the technology, including its waste products. But attention to this aspect of technology is obscured by a narrow conception of technical action. The paradox of the obvious works against recognizing this connection. The feedback that is invisible in the immediate zone of action becomes visible when a wider or longer range view is available. The paradox of the origin wipes the slate clean and obscures the history in which past feedback influenced current designs.

In modern society technologies are perceived as purely instrumental and separate from their past, the environment in which they function, and their operator, like those wings that cause birds to fly. But these apparent separations hide essential aspects of technology as we have seen. I have called ignorance of this principle the illusion of technology.

This illusion is less of a problem in traditional societies. There craft knowledge and everyday experience are in constant communication. The lessons learned from using technical devices are absorbed into the craft tradition where they limit and control technical activity. From a modern standpoint this appears to be an obstacle to development, but there may be wisdom in restraint. Certainly our recent experience with technologies such as nuclear weapons and toxic chemicals indicate a need for restraint.

But this is not the way most modern technology has developed. Under capitalism control of technology is no longer in the hands of craftsmen but is transferred to the owners of enterprise and their agents. Capitalist enterprise is unusual among social institutions in having a very narrow goal—profit—and the freedom to pursue that goal without regard for consequences. Once technology has been delivered over to such an institution, the lessons of experience are ignored. Workers, users of technology, victims of its side effects, all are silenced throughout the industrialization process. Technological development can proceed without regard for the more remote aspects of its own context. This makes possible the development of sophisticated technical disciplines and very rapid progress but with unfortunate side effects. In communist countries, this same pattern prevailed under government control where the goal assigned to state enterprises—meeting a quota—was similarly narrow.

Instead of correcting the illusion of technology, modern societies take that illusion for reality. They imagine they can act on the world without consequence for themselves. But only God can act on objects from outside the world, outside the system on which He acts. All human action, including technical action, exposes the actor. The illusion of godlike power is dangerous.

When Robert Oppenheimer witnessed the explosion of the first atom bomb a quotation from Baghavad-Gita flashed through his mind: "I have become death, the shatterer of worlds." But soon he was attempting to negotiate disarmament with Moscow. He realized the shatterer could be shattered. Presumably Shiva, the God of death, does not have to worry about the Russians.

Our actions not only come back to us through causal feedback, they also change the meaning of our world. The most dramatic examples of such transformations of meaning occur around new technologies of transportation and communication. Railroads and later automobiles and airplanes have radically diminished the experience of distance. Regions once remote were suddenly made close by these technologies. The spatial coordinates of our lives, what we mean by “far” and “near,” are completely different from what it was for all of human history before these inventions were introduced. Added to these changes, electronic communication has radical consequences as a multicultural world gradually emerges from the monocultures of old. Ordinary people now know more about foreign lands and cultures from movies, encounters with immigrants, and tourism than all but a few adventurers and colonial administrators a century ago. What is more, such familiar distinctions as those between public and private, work and home, are subverted as new technology brings the office into domestic spaces and extrudes creative activities and private fantasies into public arenas.

Even the meaning of nature is subject to technological transformation. Take amniocentesis, for example. It allows the sex of the fetus to be identified early in pregnancy. Relatively few parents abort fetuses because of their sex, but the fact that this is possible at all transforms an act of God into a human choice. What formerly was a matter of luck can now be planned. Even choosing not to use the information has become a choice in favor of "nature" whereas before no choice was involved. Our society is now capable of technologizing reproduction and has thus changed its meaning for everyone, including those who do not use the technology.

6. *The paradox of the means*. The paradox of action also holds in the case of identity. The hunter kills a rabbit with his gun and all he feels is a little pressure from the kickback of the weapon. But the rabbit is dead. There is an obvious disproportion between the effect of the action on the actor and his object. But the action does have significant consequences for the hunter. His identity is determined by his acts. That is to say, he is a hunter insofar as he hunts. This reverse action of technology on identity is true of everyone’s productive activity in one way or another. In sum, you are what you do.

Consumer society has brought the question of identity to the fore in another way. The technologies we use in daily life, such as automobiles, Ipods, mobile phones, signify us as the kind of people we are. We now “wear” our technologies just as we wear clothes and jewelry, as forms of self-presentation. Today, not only are you what you do, but even more emphatically you are what you use.

These observations suggest *a sixth paradox of the means* which follows directly from the paradox of action: *the means are the end*. There is a weaker version of this paradox with which everyone is familiar. It is obvious that means and ends are not completely independent of each other. Common sense tells us not to expect much good to come of using bad means even if the ends we have in view are benign. But my formulation is more radical. The point is not that means and ends are related, but that they are in fact one and the same over a wide range of technological issues. By this I mean that the changes in meaning and identity discussed above are often the most important effect of technological change, and not its ostensible purpose.

Consider the example of the automobile. Automobile ownership involves far more than transportation. It symbolizes the owner’s status. In poor countries, it has an even greater symbolic charge than in rich ones, signifying the achievement of modernity and its vision of a rich and fulfilling life. It cannot be said in such cases that the means are separate from the ends. Possession of the means is already an end in itself because identity is at stake in the relation to technology.

7. *The paradox of complexity*. This brings me to *a seventh paradox of complexity* which can be succinctly stated as: *Simplification complicates*. This corollary of the paradox of action flows from the nature of technology. As we have seen technologies can be removed from their context and transferred to alien locales. But more profoundly considered, technology is in some sense already decontextualized even before it is transferred, even in its normal setting. By this I mean that creating a technology involves abstracting the useful aspects of materials from their natural connections. This constitutes a radical simplification of those materials, so radical in fact that it must be compensated by a recontextualization in a new technological niche where we find them transformed in a finished and working device. But the recontextualization is not always completely successful.

Here is an example. To make the paper on which this lecture is printed, trees were removed from their place in the ecology of the forest as they were reduced to simplified raw materials. They were then transformed to become useful in a new context, the context of contemporary writing practices. That new context brought with it all sorts of constraints such as size, thickness, compatibility with current printers, and so on. We recognize the paper as belonging to this new context.

But the process of decontextualizing and recontextualizing technical objects sometimes results in unexpected problems. In the case in point, paper making employs dangerous chemicals and its poorly regulated pursuit causes air pollution and immense harm to rivers and their inhabitants. In sum, in simplifying, technological projects such as paper making produce new complications.

This is why context matters. Ignorance of context is especially prevalent in developing societies that receive a great deal of transferred technology. Blindness to context and consequence is the rule in such cases. Technologies adapted to one world disrupt another world. These complications become the occasion for popular reactions and protests as they impinge on the health and well being of ordinary people. This proposition is tested over and over in one developing society after another. Where popular reaction leading to correctives is effectively suppressed, as it was in the Soviet Union, the consequences of development can be catastrophic: severe chemical pollution of the air, water and soil, extensive radioactive contamination, and declining fertility and life expectancy.

8. *The paradox of value and fact*. As it grows more powerful and pervasive, it becomes more and more difficult to insulate technology from feedback from the underlying population. Workers, users, victims, and potential victims all have their say at some point. Their feedback, provoked by maladaptation, negative side effects or unrealized technical potential, leads to interventions that constrain development and orient its path.

Once mobilized to protect themselves, protesters attempt to impose the lessons of experience with technologies on the technical experts who possess the knowledge necessary to build working devices in a modern society. It appears superficially that two separate things, technical knowledge and everyday experience interact in a clash of opposites. Technical experts sometimes decry what they think of as ideological interference with their pure and objective knowledge of nature. They protest that values and desires must not be allowed to muddy the waters of fact and truth. Protesters may make the corresponding error and denounce the experts in general while nevertheless employing their technology constantly in everyday life.

But in fact technical knowledge and experience are complementary rather than opposed. Technical knowledge is incomplete without the input from experience that corrects its oversights and simplifications. Public protests indirectly reveal the complications unintentionally caused by those simplifications, i.e. aspects of nature so far overlooked by the experts.

Protests work by formulating values and priorities. Demand for such things as safety, health, skilled employment, recreational resources, aesthetically pleasing cities testify to the failure of technology to adequately incorporate all the constraints of its environment. Eventually those values will be incorporated into improved technical designs and the conflict between the public and its experts will die down. Indeed, in years to come the technical experts will forget the politics behind their reformed designs and when new demands appear will defend them as a product of pure and objective knowledge of nature!

Values cannot enter technology without being translated into technological language. Simply wishing away inconvenient technical limitations will not work. The results of such a voluntaristic approach are disastrous as the Chinese discovered in the Cultural Revolution. For something useful to come out of public interventions, experts must figure out how to formulate values as viable technical specifications. When that is accomplished a new version of the contested technologies can be produced that is responsive its context. In the process values are translated into technical facts and the technology fits more smoothly into its niche.

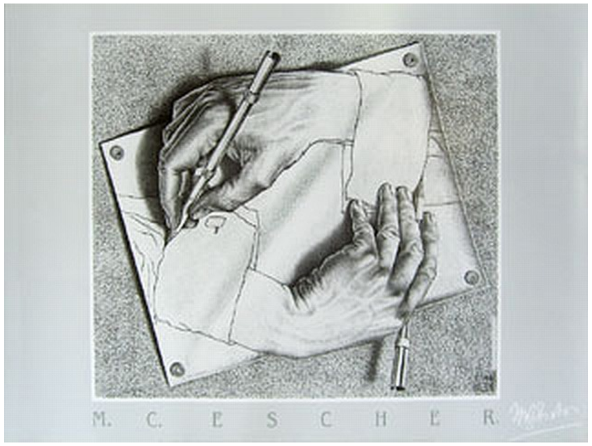
The structure of this process is a consequences of a technology cut off to a considerable extent from the experience of those who live with it and use it. But the experience of users and victims of technology eventually influences the technical codes that preside over design. Early examples emerge in the labor movement around health and safety at work. Later, such issues as food safety and environmental pollution signal the widening circle of affected publics. Today, as we have seen, such interactions are becoming routine and new groups emerge frequently as "worlds" change in response to technological change. This overall dynamic of technological change closes the circle described in the paradox of action: what goes around comes around. And because we have experience and are capable of reflecting on it, we can change our technologies to safeguard ourselves and to support the new activities they make possible.

Sometimes the problem is not the harm technology does but the good it might do if only it were reconfigured to meet unmet demands. This case is exemplified by the Internet. It was created by the US military to test a new type of networked computer time sharing. But a graduate student came up with the idea of networking not only the computers but also their users and introduced email. Since then one generation of users after another has developed and explored new ideas for social interaction on the Internet. Home pages were followed by web forums and web forums by social sites dedicated to music sharing and photography. These sites were integrated into blogs and now social sites such as Myspace and Facebook have emerged, pulling together many social resources. At each stage programmers have worked to accommodate the new demands of users with the corresponding technical solutions. This is a process repeated endlessly as technologies develop.

This leads my to my *eighth paradox*, which I will call *the paradox of value and fact: values are the facts of the future*. Values are not the opposite of facts, subjective desires with no basis in reality. Values express aspects of reality that have not yet been incorporated into the taken for granted technical environment. That environment was shaped by the values that presided over its creation. Technologies are the crystallized expression of those values. New values open up established designs for revision.

9. *The democratic paradox*. Social groups form around the technologies that mediate their relations, make possible their common identity and shape their experience. We all belong to many such groups. Some are defined social categories and the salience of technology to their experience is obvious. A worker in a factory, a nurse in a hospital, a truck driver in his truck, are all members of communities that exist through the technologies they employ. Consumers and victims of the side effects of technology form latent groups that surface when their members become aware of the shared reasons for their problems. The politics of technology grows out of these technical mediations that underlie the many social groups that make up society. Such encounters between the individuals and the technologies that connect them proliferate with consequences of all sorts. Social identities and worlds emerge together and form the backbone of a modern society.

In the technology studies literature, this is called the "co-construction" of technology and society. The examples cited here show this "co-construction" resulting in ever tighter feedback loops, like the "Drawing Hands" in M. C. Escher's famous print of that name. I want to use this image to discuss the underlying structure of the technology-society relationship.



Escher's self-drawing hands are emblematic of the concept of the "strange loop" or "entangled hierarchy" introduced by Douglas Hofstadter in his book *Gödel, Escher, Bach*.[3] The strange loop arises when moving up or down a logical hierarchy leads paradoxically back to the starting point. A logical hierarchy in this sense can include a relationship between actors and their objects, such as seeing and being seen or

[3] Hofstadter, Douglas (1979). *Godel, Escher, Bach*. New York: Basic Books.

talking and listening. The active side stands at the top and the passive side at the bottom of these hierarchies.

The famous liar's paradox is an example of a strange loop in which top and bottom trade places. Like all statements, the statement "This sentence is false" refers to an object. The statement itself is the actor at the top of the hierarchy. But the object to which it refers is also itself and in describing itself as false it reverses the direction of action. When one claims that something is false that claim is the actor and what it describes as false is the object. But that object is itself. Now the sentence is only true if it is false and false if it is true. A strange loop indeed!

In the Escher print, the paradox is illustrated in a visible form. The hierarchy of "drawing subject" and "drawn object" is "entangled" by the fact that each hand plays both functions with respect to the other. If we say the hand on the right is at the top of the hierarchy, drawing the hand on the left, we come up against the fact that the hand on the left draws the hand on the right and so is also located at the top level. Thus neither hand is at the top or both are, which is contradictory.

On Hofstadter's terms, the relation between technology and society is an entangled hierarchy. Insofar as social groups are constituted by the technical links that associate their members, their status is that of the "drawn" object in Escher's scheme. But they react back on those links in terms of their experience, "drawing" that which draws them. Once formed and conscious of their identity, technologically mediated groups influence technical design through their choices and protests. This feedback from society to technology constitutes *the democratic paradox*: *the public is constituted by the technologies that bind it together but in turn it transforms the technologies that constitute it.* Neither society nor technology can be understood in isolation from each other because neither has a stable identity or form.

This paradox is endemic to democracy in general. Self-rule is an entangled hierarchy. As the French revolutionary Saint-Just put it, “the people is a submissive monarch and a free subject.” Over the centuries since the democratic paradox was first enacted, its reach has extended from basic political issues of civil order and defense to embrace social issues such as marriage, education, and health care.

The process of extending democracy to technology began with the labor movement. It called attention to the contradiction between democratic ideology and the tyranny of the factory. This was the first expression of a politics of technology at a time when technical mediation was still confined to a single sector of society. The dream of control of the economy by those who build it with their brains and hands has never been fully realized. But today, around the many issues raised by technology, something very much like that dream is revived in new forms. Those who demand environmentally compatible production, a medical system more responsive to patient needs, a free and public Internet, and many other democratic reforms of technology, follow in the footsteps of the socialist movement whether they know it or not. They are broadening democratic claims to cover the whole social terrain incorporated into the technological system.

10. *The paradox of conquest.* Hofstadter's scheme has a limitation that does not apply in the case of technology. The strange loop is never more than a partial subsystem in a consistent, objectively conceived universe. Hofstadter evades ultimate paradox by positing an "inviolate level" of strictly hierarchical relations above the strange loop that makes it possible. He calls this level "inviolate" because it is not logically entangled with the entangled hierarchy it creates. The person who says "This sentence is false" is not entangled in the paradox she announces. In the case of the Escher drawing, the paradox only exists because of the unparadoxical activity of the actual printmaker Escher who drew it in the ordinary way without himself being drawn by anyone.

The notion of an inviolate level has its place in logic but not in life in a technological society. In fact the illusion of technique is precisely defined by this notion. This illusion gives rise to the popular belief that through technology we “conquer” nature. But human beings are natural beings and so the project of conquest is inherently paradoxical. This *tenth paradox of conquest* was succinctly formulated in another context by F. Scott Fitzgerald: *the victor belongs to the spoils.* The conqueror of nature is despoiled by its own violent assault. This paradox has two implications. On the one hand, when “humanity” conquers nature, it merely arms some humans with more effective means to exploit and oppress other humans who, as natural beings, are among the conquered subjects. On the other hand, as we have seen, actions that harm the natural environment come back to haunt the perpetrators in the form of pollution or other negative feedback from the system to which both conqueror and conquered belong. In sum, the things we as a society do to nature are also things we do to ourselves.

In reality there is no inviolate level, no equivalent of "Escher" in the real world of co-construction, no godlike agent creating technology and society from the outside. All the creative activity takes place in a world that is itself created by that activity. Only in our fantasies do we transcend the strange loops of technology and experience. In the real world there is no escape from the logic of finitude.

Conclusion. The ten paradoxes form a philosophy of technology that is remote from current views but corresponds more nearly to experiences we have with increasing frequency. In rich countries the Internet and the environment are the two domains in which the paradoxes are most obviously at work. The many disorders of development illustrate their relevance in the rest of the world. Everywhere technology reveals its true nature as it emerges from the cultural ghetto in which it was confined until recently. Today technological issues routinely appear on the front pages of the newspapers. Fewer and fewer people imagine they can be left to the experts to decide. This is the occasion for the radical change in our understanding of technology. The institutionalized abstractions of the corporations and the technical professions are no longer the only standpoint from which to understand technology. Now it is more and more in the foreground of our everyday activities and provokes renewed philosophical reflection.

Here in conclusion is the list of the ten paradoxes. Let us hope they soon cease to feel paradoxical and become the new common sense.

1. The paradox of the parts and the whole: The apparent origin of complex wholes lies in their parts but in reality the parts find their origin in the whole to which they belong.
2. The paradox of the obvious: What is most obvious is most hidden.
3. The paradox of the origin: behind everything rational there lies a forgotten history.
4. The paradox of the frame: Efficiency does not explain success, success explains efficiency.
5. The paradox of action: In acting we become the object of action.
6. The paradox of the means: The means are the end.
7. The paradox of complexity: Simplification complicates.
8. The paradox of value and fact: Values are the facts of the future.
9. The democratic paradox: The public is constituted by the technologies that bind it together but in turn it transforms the technologies that constitute it.
10. The paradox of conquest: The victor belongs to the spoils.

Chapter Two

Encountering Technology

Starting at the Beginning

I was born in New York City during World War II. My father was a prominent theoretical physicist who studied quantum mechanics in Germany and returned to the US where he participated in the revolutionary scientific developments of the 1930s and 40s. I grew up surrounded by scientists and their apparatuses. Cyclotrons and nuclear reactors were part of my childhood. I have fond memories of visiting "the lab" where the glassblower made toys for me and where later I worked for a summer entering mysterious numbers into an adding machine. I am a rare student of science and technology who was actually raised on the subject.

This gives me a somewhat different perspective than the currently fashionable emphasis on the ordinariness of scientific research. I have always known that science was a human activity – it went on in my house – and yet the scientists I knew believed science to be significantly different from most other human activities. Recent attempts to iron out the differences with a relativistic epistemology seem quite artificial and unconvincing. Science is surely not "pure," but relativism is essentially irrelevant, not much different from the claim that Bach's music is relative to his time. The point is obvious and gives rise to interesting research, but it is ultimately trivial: the music remains, irreducible to the circumstances of its creation. Scientific truths have a similar status as products of supreme crafts that transcend the ordinary events from which they arise.

On a less elevated note, science, especially experimental science, involves a great deal of technical cleverness. Perhaps this is why throughout my childhood I was encouraged to be clever. I was sent to carpentry school as a small boy and learnt to make little tables and wastebaskets under the direction of a very stern old carpenter. Innocently enacting an outdated cliché, I took apart clocks and machines and learned to handle chemicals, use a microscope, make a crystal radio, and suchlike.

On a visit to Hiroshima I was shocked by the realization that the atom bomb which had destroyed the city was a product of the very cleverness I was encouraged to develop as a boy, applied by brilliant scientists and engineers. Truly, cleverness is the greatest human power but not the greatest achievement. After the War, Hans Bethe bemoaned the fact that he and his colleagues at Los Alamos had been clever rather than wise. The course of 20th century technological advance certainly proves him right.

By the time I reached college, I was mainly interested in literature and philosophy. The writings of René Girard and Gabriel Marcel had a tremendous influence on me. I studied Husserl, Heidegger and Western Marxism. This was the early 1960s and the United States still lay under the pall of McCarthyism. The oppressive social and political conformism of the times is unimaginable today. Culture and critique were totally marginal in this environment. I longed to escape America for Europe and spent several years studying at the Sorbonne. But this hybrid identity posed a problem: how to find an authentic relation to my two traditions. Technology appeared to hold the answer in so far as it was a particular achievement of the America in which I was raised, questioned in interesting ways in the Europe where I had studied. This intersection determined my lifelong interest in philosophy of technology.

At first I approached the issue of technology through the concept of dystopia. The elimination of political opposition in advanced industrial society is an effect of technology, both its gigantic productivity and the ideology of progress that accompanies it. In the 1960s it seemed we were headed for *Brave New World*. Marcuse was the thinker of this moment. But paradoxically the dystopian perspective provoked mass opposition in the new left and the counterculture. By the late 1960s the system confronted a significant challenge.

I was studying in France in 1968 with Lucien Goldmann and Jacques Derrida when the most powerful new left movement of the decade broke out and I suddenly found myself at the center of a revolution. During May of that year a student revolt was the catalyst for a general strike that shut down the entire country. The French government came close to collapsing and only the loyalty of the troops saved it.

This movement seemed to me to be the end of dystopia and the beginning of a new type of socialism. In 1968 we fought for a general democratization of economic and technical institutions, not the system that prevailed in communist countries at that time. We substituted the idea of self-management for the orthodox Marxist concept of socialism.[4]

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[4] See http://edocs.lib.sfu.ca/projects/mai68/ . I also co-authored a book on the May Events containing many translated documents: Feenberg, A. & Freed-

Although the French government still confronted a traditional opposition and was still judged in terms of utopian aspirations it could not hope to meet, France was well on the way to an American style consumer society. And yet it came quite close to a revolutionary transformation under an ideological banner emphasizing solidarity, democracy, and social control over economic and technical institutions. I came out of this movement convinced that there must be a way of reformulating Marxist theory to account for this unprecedented revolt in an advanced capitalist society. I wrote a first book on the early Marx and Lukács in search of resources in the Marxist tradition for interpreting this new situation.[5]

From Lukács I learned to distinguish rationality as a cognitive procedure from rationality as a cultural form. This distinction is fundamental to understanding the "great divide" that separates modernity from premodernity without falling into conservative and ethnocentric self-congratulation. The ability to reason belongs to the genetic heritage of all normal human beings and all cultures exhibit its effects in various ways. But modern scientific-technical rationality, as a specific type of rationality, uniquely emphasizes unusual procedures such as quantification which are not common to all cultures. When these procedures are instituted collectively in technologies, bureaucracies, and markets, a wholly new type of society is created. This society is legitimated ideologically by its rational grounds rather than by narrative myths, and that too is new. Critique must break through the illusion of rational necessity that is the ideological foundation of the system.

Lukács introduced the term reification in the sense in which it has been widely used ever since to refer to the process in which human relations are objectified as things. He understood this process as the production of the social world in a rational form, subject to laws such as those of political economy, and technically manipulable. The relation of the worker to the machine is the model of practice in a law-governed social world. The rational system is autonomous, self-acting, and requires only tending from human agents. The worker cannot change the logic of the machine, only position himself correctly in front of it. Lukács generalized from this example to understand the structure of practice in every area in advanced capitalism. The entrepreneur on the stock market, the employee in the bureaucracy, the intellectual in the discipline, all accept the law of their reified institution and attempt to manipulate it to advantage. But Lukács believed the working class was capable of coming together, recognizing its own role in creating the reified society, and transforming it.

How did Lukács explain the unique cognitive and political potential of the working class? He argued that the type of rationality exemplified by capitalist economics and technology would meet an immanent limit. Rational forms which pretended to autonomy came up against their intrinsic link to a content that overflowed them on all sides. This content was the life process of the members of the society, shaped but not fulfilled by the forms. As Lukács explained, a formal economic category such as wages appears to the businessman as a variable in calculations of profit and loss but from the worker's perspective its quantitative ups and downs are of vital significance for concrete health and happiness. Lukács believed that workers could penetrate the reified veil of the economy on the basis of their experience of the limit of the forms, and uncover potentialities blocked by capitalism.

Of course, by 1968 and certainly by now the traditional Marxist representation of the working class no longer corresponded to reality. But the general idea of a dereification of rational forms, the translation of fixed and frozen institutions back into the processes of human relations from which they arose seemed to be verified by the May Events. The slogans "Everything is Possible" and "All Power to the Imagination" flowed directly from this dereifying impulse.

It was on these terms that I understood or perhaps misunderstood the early work of those in the field of science and technology studies with whom I soon became acquainted. They offered empirical support to the critique of scientism, determinism, and the ideology of progress begun by Lukács and the Frankfurt school long before. And they also placed technology in a central position as a mediation in the process of human relations, both shaping that process and shaped by it.[6]

My rather idiosyncratic appropriation of STS generalized from Lukács's argument to construct a new theory of technical politics. The problem was still the one Lukács posed of the critical force of the consciousness of dominated groups in technically mediated institutions.

man, J. (2001). *When Poetry Ruled the Streets: The May Events of 1968.* Albany: SUNY Press.

[5] Feenberg, Andrew (1986). *Lukács, Marx, and the Sources of Critical Theory*. New York: Oxford Univ. Press.

[6] This is an argument made with particular force by Bruno Latour. See, for example, Latour, Bruno (1992). "Where Are the Missing Masses? The Sociology of a Few Mundane Artifacts," in Bijker, W. and Law, J., eds., *Shaping Technology/Building Society: Studies in Sociotechnical Change.* Cambridge, Mass: MIT Press.

Once those caught up in the technical networks of the society realize their own collective role in creating and sustaining those networks, they can criticize and change them. This is not a romantic return to the immediate, to emotion versus reason, but rather a dialectical passage through the rationalized forms to an alternative configuration of the networks they make possible. These insights helped me to see the theoretical interest of my own involvements in technical politics, which I'll sketch next.

I should warn you that I'm not a sociologist or anthropologist. The concrete cases I've studied were not chosen out of simple curiosity or for their scholarly significance. They have all grown out of my experience as an insider in various unusual organizations. Since I have always been situated within the field of my study, I have a point of view. I have not so much "followed the actors" in Latour's phrase, as acted, and reflected on the results from my situated vantage point. I can't say whether this is more of an advantage or disadvantage, but I know it is a condition of my own ability to gain insight and do research. In what follows I would like to describe the involvements that served as a background to my theoretical work. These are matters from which we normally abstract in writing up our research, the "backstage" apparatus hidden from the audience. It occurred to me that it would be interesting to bring it forward for once to see what it looks like in the light of day.

I will discuss three cases. They concern medical research on human subjects, online education, and computer networking in France. All three cases have in common a polarity between a technocratic and a democratic logic. In each case I have been involved in democratic initiatives. As you'll see the strategy emerging from these cases does not oppose human beings to machines, but rather attempts to incorporate underserved human needs into the technical codes that preside over design. In these cases a narrowed range is a condition for the exercise of elite power through the technical network. Democratic interventions aim at widening that range and reducing asymmetries of power. Thus the "question of technology" in these cases is not about a substantive characteristic of technology as such but rather concerns the image of the human each technical system presupposes and shapes through the needs it serves. But let me turn now to the cases.

Three Case Histories

1. *Controversy in Medicine*. I was politically active until the late 70s when the American left finally succeeded in committing suicide, a temptation it had had trouble resisting for several years. I still felt like an activist even though my energy no longer had any obvious political outlet. A neurologist of my acquaintance invited me to help him create a medical research foundation to study an incurable disease. The Center for Neurologic Study hoped to find a cure for ALS ("Lou Gehrig's Disease") through drug trials organized with particular attention to patient rights. There is still no effective treatment for this poorly understood disease, and most patients die within a few years of diagnosis. The doctor primarily responsible for the Center had already begun holding patient meetings to inform patients about their illness and to promote the exchange of social support and ideas for symptomatic treatments. These patient meetings promised a favorable scene on which to obtain the informed consent required for legitimate experimentation. Through these meetings we organized patients to participate collectively and vicariously in medical experiments with the intention of empowering them with both knowledge and enhanced care.[7]

I studied medical ethics and medical sociology as we worked on developing our innovative experimental system. I gradually came to realize that we were engaged with the same issues that had interested me in socialism. The medical system is a vast technical institution in which individual patients are all too often lost. This is particularly true of experimental medicine which patients sometimes confuse with standard treatment and invest with unrealistic expectations. Yet patient demand for experimentation in the case of incurable fatal disease is very strong. The hope of cure needs to be tempered by a sense of the slow progress of science, but that makes it more difficult to recruit patients and requires a great deal of time and effort to educate them. We felt this challenge was worth meeting out of respect for patients' rights.

It may be difficult to realize now just how innovative we were. Normally, patients have little contact with those who share their disease. They are connected only indirectly by the medical institutions to which they report for treatment. Talcott Parsons described what he called the "sick role" as an informal exchange in which patients are exempted from socially useful performance on condition of seeking a cure. As part of the "deal," the sick role isolates patients to prevent them from forming a deviant social group. But this description makes no sense for victims of chronic incurable diseases. Furthermore, ex-

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[7] The Center for Neurologic Study web page is located at http://www.cnsonline.org . An article I wrote for CNS is available at http://www.cnsonline.org/www/docs/dublin.html .

perimentation on patients confined to the traditional sick role easily slips over into exploitation. It is unrealistic to expect isolated and poorly educated patients to exercise their freedom and preserve their dignity in the face of an enticing invitation to experimental participation.

Medicine recognized this problem in a backhanded way by restricting opportunities to participate to a bare statistically significant minimum, paternalistically protecting patients such as ours who had no other hope than experimental treatment. We responded to their demand while addressing the ethical issue. Patients can only offer truly free and informed consent as members of an organized group, educated to understand the experiments to which they are recruited. We designed our program accordingly.

We were unable to obtain support for our innovative work with patients. In fact we were ridiculed by the Muscular Dystrophy Association (MDA) to which we applied for funding for research on ethical experimentation. But the Karolinska institute in Sweden made a supply of interferon available to us and MDA did offer support for treating patients with it.[8] Patients heard lectures by several scientists explaining the experiment. I gave a lecture to eliminate any confusion between experimentation and standard treatment. Eventually we established dosages and the procedure for delivery of the medication and went on to attempt to cure one particularly brave patient, but without success. I took away from this experience a strong sense of the indifference of the medical institution to patients like the ones we were trying to help.

Some years later as AIDS ravaged the gay community the issues which we had confronted re-emerged to startling effect. Unlike our patients, who were politically unorganized and helpless, the gay community had been engaged in a civil rights struggle before the disease struck. Organized resistance to the standard practice of experimental medicine shocked the medical community. Scientists and physicians discovered patients who refused to occupy the sick role. An organization called Act Up engaged in noisy protests at scientific conferences and meanwhile patients met and educated themselves about the nature of the disease and the science behind the proposed cures.

These protests resulted in significant changes in the technical organization of experimental medicine. For example, to be eligible for some drug trials patients had to have no previous experience with treatment. These "clean" patients were presumably best able to give accurate scientific results. Consider the inhumanity of offering a patient with an incurable fatal disease one and only one chance of cure. Obviously the scientists who designed such studies were not ill intentioned. But equally obviously they had not thought through the human implications of their preferred technical design.

Here is a second example. The “gold standard” in medical experimentation is the double blinded controlled trial. This requires extraordinary cooperation from patients. Some will take placebos and will only discover that fact at the end of the experiment. Their efforts as experimental subjects may benefit science and humanity, but not themselves, whereas those taking an effective new drug will also experience a personal benefit. But antagonism between the medical community and AIDS patients eroded the willingness to sacrifice. Patients took their pills to a lab for analysis, and if they were on placebos they dropped out of the experiment. Experiences like these eventually convinced the medical community that it had to work with the AIDS movement rather than against it. The process of cooptation involved significant concessions on both sides.

I wrote a paper on this case based on the point of view I had evolved in my earlier experiences with ALS.[9] I focused on the politics of the research system. The system appeared to be a product of pure scientific rationality and as such inflexible in its design. This explains why scientists’ initial reactions to the AIDS movement were so negative. They thought that irrational patients were blocking the path to a cure for their own disease. But in reality many features of the research design were contingent and had no particular basis in a supposedly pure scientific rationality. Some aspects of their experiments were designed for the convenience of researchers or to “protect” patients. Others had scientific value but the price patients were asked to pay for participation was so high compliance required far more education and a far more collaborative environment than was normally available. Eventually the technical code of experimental medicine was altered under pressure from below. This greatly improved access to experimental treatments for patients with incurable disease. This is a good example of a democratic intervention into technology through protest and controversy.

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[8] One of several plausible hypotheses held that ALS was caused by a slow virus, the action of which might be blocked by interferon.

[9] See Feenberg, Andrew (1995). *Alternative Modernity: The Technical Turn in Philosophy and Social Theory*. Los Angeles: University of California Press, chap. 5.

In the article I wrote on this case, I attempted to establish the legitimacy of patient involvement in research design. This approach was incompatible with a scientistic standpoint in which patients would appear simply as objects. On that account patient intervention would be a breakdown in the research process, no different in principle from leaky equipment or a short circuit in the apparatus. I attacked this conception of medical research with a broad reference to Donna Haraway's notion of the cyborg. From her outlandish metaphor I extracted the point that I needed, namely, that the body as conceived in medicine is an abstraction from the person in interaction with the medical institution, and not a "natural" object in the same sense as bacteria or stars.

This observation was then supported by a review of studies in medical ethics and sociology highlighting the impact of symptomatic care, the placebo effect, and social support on medical outcomes. This literature demonstrates that the body conceived in mechanistic terms is only part of the story of health. But how to take into account the rest of the story? The answer cannot be to abandon medical science, the achievements of which are undeniable. Nor can patients await the completion of the scientific project. But in practice medical science proves not to be a closed system. Its openness is due in part to its still imperfect knowledge but also to a reason of principle: the patient is a conscious agent and not a passive object and therefore experience and understanding affect health.

Having established these ideas through the social science literature, I introduced several concepts with which to articulate a solution to the conundrum of the medical body. I defined "participant interests" in a non-essentialist framework as concerns flowing from enrolment in a technical system or network. Participant interests are thus not just preexisting facts about individuals or groups but arise from technical involvements. Such interests take three forms, first, as informal and scarcely articulated feelings, second, as purely objective facts known to researchers, and third, as articulated and socially recognized matters of concern. In technical politics the second modality is sometimes necessary to pass from the first to the third, that is to say, only by invoking scientific knowledge are participants able to recognize, clearly state, and gain acceptance for a conception of their own interests.

I introduced the concept of participant interests to explain how health related concerns ignored by the medical institution might provide a basis for patients to struggle over its configuration and procedures. These concerns are essentially communicative. They are underestimated by a medical establishment increasingly preoccupied by scientific and technical advances.

I introduced a second concept – the technical code – to explain the relationship between the discourse of medical science and that of patients. What appears as an interest to patients must be translated into scientific terms to enter the discipline of medicine. Otherwise, it remains extrinsic to medical practice, a mere environmental condition without properly medical significance. The technical code refers to an ideal typical construction the social researcher can use to trace the translations between social demands of patients and medical knowledge. With this concept, I could now describe at a high level of abstraction how we at the Center for Neurologic Study had translated patient complaints into a new experimental design, and how AIDS patients were able to modify experimental design to meet their needs. The model of translation explains the dynamic of many other technical systems under pressure from the social networks they institute.

We are clearly a long way from socialist revolution with this approach, and yet the basic idea of dereification persists. Today I would call these attempts to change the medical institution "democratic interventions" responding to the underserved interests of those caught up in its operations. To succeed in cases such as this, the democratic intervention must actualize the potential for group formation of patients with a common affliction and common relationship to medicine. We took members of a technical network unaware of their commonality, brought them together so that they achieved self-consciousness, and responded to shared interests ignored by the current configuration of the network to which they belonged. AIDS patients later carried this process through to the point where they were able to force changes on the whole medical community which we and our patient group were too weak to impose.

My article emphasizes the role of ethics in the technical code of medicine. According to the standard view in both medicine and philosophy, ethics is extrinsic to the scientific basis of medicine and concerns only the application of the science in a human context. But this is to reduce medical care to a technical intervention. Communicative interaction is also essential to medical care, especially in the case of experimentation. The subject of research is not an individual scientist nor even the scientific community, but a collective of scientists, doctors, and human "subjects" interacting according to an agreed on framework. The code that describes that framework is epistemological, technical and ethical at one and the same time. The ethical dimension can be ignored by cynical researchers in situations where subjects are weak and ill-informed but the future of research is jeopardized whenever human beings are treated like guinea pigs. Where researchers are conscientious and subjects strong and well informed, ethical, technical and epistemic procedures merge into a single complex that supplies knowledge and protects human dignity.

2. *Participatory Design in Education.* After several years working with this medical institute I moved to the Western Behavioral Sciences Institute (WBSI) where I once again became involved in technical politics.[10] In 1981 the Institute decided to create a distance learning system for executives based on a computer network. This had never been done before. The Internet was still closed to the public and e-mail was still new, used primarily in computer companies and a few university research departments.

In those days, distance learning meant sending printed materials to students who had no contact with each other or their teachers. We invented e-learning in order to add human interaction to distance learning. The technical infrastructure of our project was a mini computer running a computer conferencing program with which we communicated on a proprietary network using early personal computers and modems. We hired faculty from major universities, fascinated by the prospect of using a computer for the first time. We opened our program in January of 1982, but with only seven students because it was difficult to recruit for a program so innovative it was practically incomprehensible. The faculty sent out readings by mail, and our students discussed them online, generating hundreds of pages of transcripts each month. This communicative application of computer networking came as a surprise to both educators and computer people, although today it is fairly routine.

This experience put me in touch with leading people in industry and government. I recall being invited to lunch in the early 1980s by a vice president of one of the largest computer companies in the world. He asked my opinion on the future of computing. I thought to myself, if this guy doesn't know and is asking me, a student of Marcuse, to tell him, then no one knows! It became clear to me that technology was highly flexible and unpredictable and not at all like the image of the rigid system projected by the paradigm technologies of the 1930s that had shaped the vision of Heidegger and the Frankfurt school. In fact we were proving this point in practice. By creating the first online education program at a time when computers were understood as tools for calculating and filing data, we contributed to reinventing computer technology as a medium of communication.

But there were many problems. The normal way in which one learns to teach is by being taught. Most people who have studied in a classroom have no difficulty performing the basic rituals of teaching such as facing the class to speak, recognizing those who raise their hands, using a blackboard, and so on. But none of our teachers had ever been in an online classroom and so they had no idea what they were supposed to do. Neither did we. It took a while to figure out how to initiate discussion and build interaction online but eventually we devised a dialogic pedagogy. Students were impressed by successful online classes and spread the word about our program. We were moderately successful for 10 years but never attracted the large scale support we needed to make a major impact and meet our costs.

The complexity of the interfaces to the modems, networks, and asynchronous computer conferencing software then available posed another problem. For example, signing on required the punctilious execution of a whole page of commands. We had to convince executives who had never even typed to engage with this primitive equipment. We decided to program our own simplified interface to help the executives we were recruiting participate more actively. Like the Internet browser, this terminal software was intended to liberate the user from the command line. Our software automated routine tasks such as signing on and uploading messages, which could be composed off-line in a small editor we wrote for that purpose. The software also made it possible for us to implement short-term projects with the Commerce Department of the United States and various corporations.

The WBSI program provoked considerable interest in the business press and in universities in the English-speaking world and Scandinavia.[11] However, large-scale interest in online education only appeared at the end of the 1990s, during a crisis in university funding. Paradoxically what computer companies and college administrators understood by "online education" was quite different from our pioneering program. The meaning of the term slipped according to the best

[10] The WBSI website is located at: http://www.wbsi.org/wbsi/index.htm . See also, Feenberg, Andrew, "Building a Global Network: The WBSI Experience," in L. Harasim, ed., *Global Networks: Computerizing the International Community*, MIT Press, 1993, pp. 185-197.

[11] For example, Rowan, Roy (1983). "Executive Ed. at Computer U," *Fortune*, March 7.

principles of STS and I had an opportunity to watch interpretive flexibility in action. Where we had added communication to a traditional distance learning system that lacked it, the new advocates of online education hoped to automate education on the Internet, eliminating the existing interaction in the classroom.

Of course the ambition to automate education provoked instant faculty rage. I recall feeling targeted by colleagues who blamed me for this monstrous assault on their profession. I could only say, “It's not my fault, I lost control of my idea long ago.” David Noble, the Marxist historian of deskilling, became the principal critic of online education and he and I participated in several public debates on the virtues and vices of the new system.

These experiences led me to change my research focus. I attempted to place the issue of online education in the widest possible context. This had become necessary because I was fighting on two fronts, against humanists who dismissed all electronic mediation and technocrats who saw in it the promise of eliminating the teaching profession. Their values differed but their arguments converged in a deterministic conception of technology as a dehumanizing and commercially profitable alternative to traditional arrangements. At the same time, I felt it was important to enter into the technical details of the problem in order to secure the points made at the philosophical level. As a result, I discussed the question of online education at three very different levels of abstraction, philosophical, political, and technical.

The philosophical argument begins with Plato, who first contrasted the communicative characteristics of writing to speech and so began the tradition of media critique 2500 years ago. His critique echoes still in Martin Heidegger and Jean-François Lyotard who identify the digital encoding of information in computers as the source of their dehumanizing effects. This argument culminates finally in the attack on online education for substituting computers for humanistic understanding. But the notion that the use of computers will somehow bias language and learning toward the strictly technical is off the mark. The deterministic hypothesis on which this notion rests has been refuted in practice by the predominantly informal communicative usages of computer networks. To judge by the results users have had as much impact on computers as computers have had on users.

At the political level, I am interested in the struggle for control of the meaning of online education between actors with different agendas, either automation or electronic mediation of traditional education.[12] This case neatly illustrates the constructivist premise that the same basic equipment configured in different ways can support completely different social relations. Technical and social differences vary independently. Sometimes a slight technical tweak completely transforms the social meaning of a technology. Consider, for example, the role of sidewalk ramps in redefining the life possibilities of the handicapped. Sometimes, significant technical differences make very little social difference, as is the case with hybrid engines in cars.

This argument opens the question of the design of computer systems in education. So long as the computer as such is the problem, design is unimportant. But if the computer is innocent, at least of the charge of dehumanization, then everything depends on how the systems are put together. Automation is only one possible design agenda.

The automation of education responds to the industrial technical code, going back to the early 19th century. The transfer of skills from craftsmen to machines is an old pattern that underlies the industrial revolution and continues through the Taylorist and Fordist developments of the 20th century. The technical code of industrialism aims to centralize control of the workforce and to lessen labor costs by substituting machines tended by unskilled labor for skilled labor.

The previous attempt to automate education was Computer Aided Instruction, or CAI. CAI was delivered by the (ironically called) Plato system, and later by application programs running on personal computers. But it never offered a convincing substitute for live face-to-face instruction. At the end of the 1990s, we were led to believe that the new multimedia features of the Internet could provide a more realistic experience. The Internet promised simulated interaction and video delivery of canned lectures by “star” professors, adding a little life to the sterile programs of earlier CAI.

But would it really work? And if so, would it be desirable? Faculty were skeptical and not only because they feared losing their jobs. No one who has dealt with students’ questions believes current artificial intelligence is up to the task of anticipating and answering them. There are subtle interactions that make a difference in real classroom situations and these cannot be duplicated by videos and FAQs (“Frequently Asked Question” lists). Furthermore, informal and to some extent even formal human communication leaves it up to the par-

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[12] See Feenberg, A. (2002). *Transforming Technology*. Oxford: Oxford University Press, chap. 5.

ticipants to define the boundaries of relevance on the spot. These boundaries can be enlarged on occasion to include reflection on the communication process itself. Such meta-communicative practices are essential to our idea of freedom. They would be excluded by an automated system in which relevance was inscribed in software.

Our early experiment in online education was quite different. It was based entirely on human communication. At WBSI the computer offered a virtual meeting place rather than a simulacrum of the classroom. But online communication has its own limitations and problems. Its unusual pragmatics differ from their face-to-face equivalent through asynchronicity and the absence of paralinguistic signs. Again, actual experience teaching online informed my work, but I also drew on semiotics and conversation analysis for theoretical concepts useful for understanding this new communicative practice. This analysis brought out the dependence of group relations on characteristics of the technologies binding together the group.

Group activity is usually mediated by objects of some sort. The seminar requires its table around which to sit and games require boards or fields. But in online education the semantic flow is carried by the mediation and that has complex implications. We are here in territory explored by media theorists such as Marshall McLuhan. The medium is, if not the whole message, at least a significant part of it. But McLuhan could only observe patterns of electronic mediation in two cases, telephone communication between pairs of interlocutors and various types of one-way broadcasting. The computer network makes possible a third case: asynchronous online interaction in small groups. This new technology opens up a huge range of activities to electronic mediation that had formerly to take place in real time face-to-face encounters.

Small groups are the social settings of much white collar work, education, and a wide variety of social clubs and information exchanges. The social codes for all these activities are familiar and negotiating communication problems in face-to-face dialogue is relatively straightforward. But online group interaction is another story entirely. It is more difficult to work together under these unusual conditions and it requires skilled communicative leadership to accomplish complex goals, including educational goals. I developed a theory of "moderating" to isolate the specifically communicative aspects of online leadership.

As a student of science and technology it occurred to me that I should not merely write about online education but I should do something about it. I applied my own theory of the technical code to conceiving the technology corresponding to the pedagogical practice of our original program. I designed a piece of software and obtained a grant to implement my design in order to reinforce my argument against automation with a different kind of technical intervention. The "moderating functions" were incorporated into the software design in the hope that facilitating the work of discussion leaders would encourage teachers to take an active role in their online classes. This project still continues and has had modest success, although the main reason higher education has not been automated is the patent inadequacy of current technology to the task.[13]

My project is one of a great many that flourish in the educational field. Teachers working closely with programmers devise original solutions to the problem of achieving traditional pedagogical goals in a new environment. This is an example of "participatory design," and it represents a second type of democratic intervention.

3. *Hacking the Network.* My third case introduces yet another type of democratic intervention in a very different social context. In the mid 1980s I was invited by the French telecom to introduce computer conferencing to the Minitel system. I spent some time in France working on this project and learned a great deal about the Minitel in the process.

The Minitel is now a forgotten episode in the prehistory of the Internet. But it was a very important landmark in online communication, proving for the first time that a domestic computer network could reach a wide audience. What made the Minitel so successful was the free distribution of user friendly terminals that plugged into the phone system. Users did not need to know anything about computers to get up and running on the system. Entrepreneurs could easily hook up hosts and their revenues were guaranteed by the phone company which billed customers for each minute of online service. Six million terminals were distributed and the system proved both a social and economic success until it was finally eclipsed by the Internet.[14]

Although the Minitel was originally conceived to distribute information to households, the most exciting application was invented by hackers who broke into a news service to chat online in pursuit of friendship and dates. Very quickly other host services introduced programs to capture and collect revenue from this new flow of communi-

[13] The latest version of the software is described at http://www.geof.net/code/annotation/

[14] One can still get an idea of the Minitel system at http://www.minitel.fr .

cation. This was the first widespread public use of instant messaging. The asynchronous computer conferencing programs I was engaged to introduce would have enhanced communication on the system by supporting more complex interactions such as business meetings, classes, and other group activities. We were not successful but I do not think this was our fault. We encountered significant obstacles in the social environment and the design of the Minitel.

The main problem was the image of the system. The French educational system was far too stodgy to take up our innovation, but we had hoped that business would be interested. How wrong we were! The very design choices that made the Minitel acceptable to the public and suited it to placement in the home, diminished its credibility in a business context. The image problem was aggravated by "pink" messaging. Who could believe an electronic singles bar had promise as a venue for business meetings?

There was also a technical issue. I recall one incident that clarified the problem for me. The Minitel was conceived for consulting databases stored in videotext pages and accessed through hierarchical menus. The keyboard was designed by a telephone manufacturer to punch in the numbers of menu items, but this is not what communicating users of the system required. I wrote a short note on the keyboard for the directors of the telecom in the hope that a new terminal would be designed more suitable for typing and hence for professional communication. There was no response to my recommendation and soon I learned that the telecom was ashamed of the communication on its system since so much of it revolved around sex. They had inscribed informational usages in the Minitel hardware and had no intention of changing that even though the users had reinvented the technology around a new social form.

Once again I confronted the alternative: technocratic "rationality" versus communication as conceived by users. This alternative reflected different social visions of modernity, a vision focused on the narrowly conceived goals of organizations such as government agencies and businesses, and a vision focused on a broader range of human needs evident to users but not to the technocrats in charge of designing and implementing the system. I wrote an article about this contrast as manifested in the history of the Minitel.[15]

In my article I developed this contrast at several levels. My purpose was to show that one can trace an ideology "all the way down" in the sense that discursive expressions of social visions can be found reflected in details of technical design and vice versa. The identification of congruencies at all levels would verify the basic constructivist thesis that technology and society are not two separate domains but intricately imbricated. But it verifies this thesis in a rather different way from the usual STS formulations since it does not presuppose an individualist or empiricist methodology but instead treats social forces of many different types as equally "real."

I identified three main levels, at each of which alternatives appeared: social theories; social imaginaries, expressed in policies and popular sentiment; and technical specifications and practices. The first level includes various theories and critiques of post-industrial society. The second level includes the government policies that led to the creation of the Minitel system and the unexpected transformation that invested the technology with social and sexual connotations. The third level includes such design features as user friendliness, the keyboard, and the hacker initiative that introduced instant messaging. The argument shows how the technical code translates between levels and signifies the Minitel as a compromise between contrasting interpretations.

In this case the democratic intervention took the form not of a social movement or professional resistance, but the action of a few hackers. Yet that action would have been without significance had it not been seized on by millions of users. In this sense it can be said to be democratic. But in a deeper sense, democracy is at stake in any intervention into technology that enlarges the scope of human communication and serves a wider range of legitimate human needs than those represented by the technocracy.

What needs were served in the Minitel case? In one sense the answer is obvious. Users pursued friendship and sexual encounters. But the role of anonymity in this case raises interesting questions about post-industrial society. The increasing impersonality of rationalized interactions opens up a vast sphere of anonymity in everyday life. The efficiency of these official and economic transactions appears to validate this new social form. But the functional role of anonymous encounters does not exhaust their significance in the psychic life of the individuals. Rationalized interactions are not a perfect substitute for other more personal interactions in the lost communities of earlier times. The affective surplus shows up in longing for community and, more ominously, in fantasies of sex and violence in popular culture.

The Minitel was introduced to enhance post-industrial efficiency by enabling users to personalize anonymous requests for infor-

[15] Feenberg, A. (2010). *Between Reason and Experience.* MIT Press, chap. 5.

mation relevant to the pursuit of "rational" ends such as business or academic success. But unwittingly the technocrats also made it possible to personalize other less "rational" requests, among which the most urgently pressing in an atomized society concern human relations. Thus the system almost invited the hack to which it was submitted. In the process, its socio-technical form was altered: from a hierarchical system in which individuals connected individually to central hosts rich in informational content, it was effectively transformed into a commutative system in which everyone connected with everyone to communicate about personal affairs. Conceived as an electronic library accessed through the telephone network, the system took on the social form of the telephone network as well.

Critical Theory of Technology

These experiences brought me to the realization that most of the Marxism I had learned as a student did not apply to the world in which I was living. Toward the end of the 1980s I decided to write a book in which I would settle accounts with my past beliefs. This became *Critical Theory Of Technology,* published in 1991. The book was written on the cusp of the breakdown of communism. In fact the page proofs came back with a request that I eliminate "USSR" except as a historical reference. I had made the transition from Marxism to philosophy of technology just as the Communist world disappeared.

The lessons of my work with medicine and computers showed up in this book. These experiences demonstrated that issues Marx had associated with the factory had now spread throughout the society. David Noble and Harry Braverman had argued that deskilling was the social imperative central to industrial innovation. But Noble and Braverman were talking about factory work. The factory was no longer the sole locus of technical activity. We encountered the same pressures for deskilling and automation surrounding the introduction of the computer into education. Related problems appeared also in relation to online communication in France with the Minitel and in the US with the Internet. The contested shape of the online world testifies to the continuing differences between technical agendas corresponding to different interests and visions of life.

These differences are still the occasion for struggles, but struggles of a new type. In my book I generalized the Lukácsian theory to take account of the tension between technically rational forms and the life process of the individuals shaped by those forms in technical networks. The concept of participant interests generalized the earlier notion of class interest in response to this new situation. Technical politics meant the democratization of technological society, a theme that relates significantly to the socialist project without being precisely identical to any earlier doctrine.

Looking back on this book today, I find in it four fundamental ideas that continue throughout my work. I introduced the concept of "formal bias" to understand how a rational system could have discriminatory consequences. This is a difficult point since we normally think of bias as the result of irrational emotions, false ideas, and unjustified privileges. The theory of the bias of technology depended on an idea I originally found in Marx but which I refined with concepts drawn from STS.[16] Marx's critique of political economy showed that market rationality produces class inequality despite its appearance of fairness and reciprocity. STS could be interpreted to extend a similar idea to technical rationality. Like the market, devices serve everyone equally, but their design is accommodated to the interests and visions of specific actors, sometimes at the expense of other actors with less power.

The concept of formal bias depends on another fundamental idea drawn from STS. Technical disciplines describe the workings of technologies in causal terms drawn from natural science, but design is clearly underdetermined by the conformity of technologies to natural law. Social factors intervene in the selection of successful designs from among a wide range of possible configurations. The underdetermination of design leaves room for a variety of socially biased solutions to the problems of an industrial society, including, potentially, a socialist solution.

But unlike earlier Marxist arguments for the replacement of one system by another, the critique of formal bias leads to an additive pattern of gradual change. The addition of care to cure or communicative functions to informational functions parallels many similar episodes in the history of technology. Technologies are not unified works of art, fixed at their origin once and for all. Rather, they consist in layers of functionality that gradually accumulate in response to the demands of the different actors with the power to influence their design.

[16] See, for example, Pinch, Trevor and Bijker, Wiebe (1984). "The Social Construction of Facts and Artefacts: or How the Sociology of Science and the Sociology Technology Might Benefit Each Other," *Social Studies of Science*, vol. 14, 1984.

The French philosopher of technology Gilbert Simondon described two layering patterns.[17] On the one hand, functions can be served by separate structures, each new function requiring a new structure. This pattern results in undesirable complexity and inefficiency. Consider, for example, the catalytic converter, which responds to new environmental constraints with an expensive attachment to the exhaust system. On the other hand, the structures of the artifact may be reconfigured to perform multiple functions as new functions are added. This pattern, which Simondon calls "concretization," avoids needless complication and represents a progressive path of technological development. In my social appropriation of Simondon's concept, I emphasize the role of concretizing innovations in reconciling actors with different agendas.

The Center for Neurologic Study and the AIDS movement achieved concretizations in experimental design by seamlessly combining care and education with the search for new knowledge. Scientists and patients were reconciled in the new configuration. Computer conferencing is a concretization of transmission and filing technologies, combining in a single act sending messages and making them available to a user group. We designed terminal software in order to extend access to this system from the engineers who created it to executives with few computer skills, reconciling two very different types of users. A more serious conflict appeared at a later stage at the level of multimedia systems for education. The question concerned which of several alternatives was to serve as the core medium, text, as in our version of online education, or video, as in proposals for automation. It is still uncertain how this contest will play out. In the Minitel case the concretization was blocked at the keyboard. Although official actors and users could have been reconciled in a redesigned terminal suitable for both information retrieval and communication, this did not occur.

Concretizations are particularly important in environmental politics. They make it possible to address environmental regulations without degrading technical performance. Victims of pollution, workers employing polluting technologies, and users of their products are reconciled in innovative designs that reduce the environmental impact of production without raising costs excessively.

Since writing *Critical Theory Of Technology* I have written a number of other books on social aspects of technology in which I have examined everything from James Bond films to the Japanese game of go, from ecology to technical democracy. In each case I explore the themes I have laid out here in one or another setting. Most recently I have begun writing at greater length about Heidegger, Marcuse, and the early Marx and Lukács. I am trying to revive radical social theory of modernity around the theme of technology which has been ignored with few exceptions by major theorists.[18]

Now that I have briefly explained my personal trajectory and these three case histories, I need to address a final question that has surely occurred to you. Are the similarities between these three cases due to the subjective orientation of the researcher, or do they reflect a general polarity between technical elites and users? I believe that in fact modern societies have a common structure over a very wide range of institutions rooted in the history of capitalism. It is therefore not surprising that it reappears in each of the cases I studied. In an attempt to get beyond the traditional Marxist focus on economics, I have taken a fresh look at the imbrication of power and technology in Marx's theory of capitalism.

This phenomenon appears most clearly in the origins of the factory system. The factory appears in Marx's work as a system of technological domination, contradicting the standard deterministic view according to which industrialization was motivated entirely by the pursuit of efficiency and could not have developed otherwise. But determinism ignores the social dimension of the development, characterized by class tensions that orient it in a specific direction.

As leaders, capitalists are restrained minimally by society, for example by laws against theft and competitive pressures. Within the factory the owner is fairly free to act as he wishes. The capitalist's extraordinary freedom defines a new type of ownership, quite different from most earlier notions of property. For example, the owners of large estates were expected to fulfil religious, political and charitable obligations to their tenants. But the capitalist version of ownership imposes only narrow responsibilities. The owner is granted the *right of legitimate indifference* to his workers and to the community in which his factory is located. This is what I call "operational autonomy," the owner's right to make decisions without consulting any overriding normative considerations or constituencies. Note that operational

[17] Simondon, Gilbert (1958). *Du Mode d'Existence des Objets Techniques.* Paris: Aubier, chap. 1.

[18] See *Alternative Modernity, Questioning Technology, Transforming Technology, Heidegger and Marcuse, Between Reason and Experience.*

autonomy does not require private ownership. The same type of control may be exercised in a state owned or non-profit institution.

The power and indifference associated with operational autonomy has consequences for the progress of technology. Before factories were built, the textile trade in northern England was carried on through the putting out system. The capitalist supplied raw materials to village workers, each with his own cottage and tools, and returned later to pick up the finished goods which he then sold on markets in larger cities. The factory system shifted work from the family and the home to a central location owned by the capitalist. This new situation led to control problems. Supervision by business owners and their agents became necessary in order to prevent slacking off and theft. Once in charge of the work process capitalists imagined various improvements that resulted in a much more parcellized division of labor. Work was deskilled to eliminate the need to hire skilled males. Soon women and children displaced them at lesser cost.

The process was explained by Andrew Ure in 1835. He wrote, "By the infirmity of human nature it happens, that the more skilled the workman, the more self-willed and intractable he is apt to become, and of course, the less fit a component of a mechanical system, in which, by occasional irregularities, he may do great damage to the whole. The grand object therefore of the modern manufacturer is, through the union of capital and science, to reduce the task of his work people to the exercise of vigilance and dexterity."

Mechanization follows the manufacturing pattern. Some of the tasks divided between unskilled workers were assigned to machines. Control was also delegated to machines as we see especially in the case of the assembly line. According to Marx production achieves its fully capitalist form through the mechanization of industry and the adaptation of technology to the requirements of capitalism. Thus the industrial model is the result of a social process and the technology emerging from that process is class bound.

As inheritors of this history, contemporary capitalist and communist elites have an unusual degree of autonomy. Premodern rulers' were limited by custom and religion and their responsibilities to the community extended far beyond those of a modern corporation or government agency. Apart from markets and laws, these modern elites are subject to few constraints. But there is a more subtle intrinsic constraint arising from their hierarchical position in the organizations to which they belong: they must maintain that position in systems in which the subordinates have no intrinsic interest in their success.

The structure of top-down control that evolved under capitalism reflects this imperative of modern organization whether it be in the public or private sector. The forms of sociability that impose this pattern emerged with capitalist manufacturing which shattered the traditional structures and ethos of artisanal production. It continued with the bureaucratization of the state apparatus in both capitalist and communist countries. It has shaped the culture of the technical disciplines which serve the enterprise and the bureaucracy, and the technical codes in every field reflect these origins.

The requirement of what I call "operational autonomy" dictates the style of technological design characteristic of industrialism. The goal is to inscribe top down control in design and especially to perpetuate control over future technological choices. Such strategies prove "efficient" under the conditions that preside over their selection and implementation, closing the circle and giving the illusion of neutral technical rationality. For example, where profit is the measure of success, technologies such as the assembly line easily prove their worth. But were the success of a worker-owned enterprise measured in terms that reflected workers' interests, the boredom of assembly line work might be counted against it and another technology chosen. This approach shows how the formal rationality of the system is adapted to its social bias.

One of the great questions of our time concerns how far the technological system can evolve toward a more democratic configuration as its bias is challenged from below. The cases I have described are moderately encouraging. They have in common the effectiveness of user agency in the dynamic situation of the introduction or development of new and complex systems. In each case users widen the range of needs the system represents.

Our standard conception of politics today is inadequate because it does not recognize the political nature of such interventions. Politics is about war and peace, law and taxes, and is based on geographical representation. Today many of the most controversial issues that affect our lives involve technology but the affected "communities" belong to technical networks that stretch across political jurisdictions. The concept of politics needs to be revised to take account of this new situation.

Political theory has not yet made this adjustment. It has no answers to questions about technical representation. More worrisome still is its inability to grasp the anti-democratic implications of certain technological designs. Philosophical speculation on the nature of totalitarianism often overlooks the role of new techniques of surveillance, information management and communication in making possible the one party police state so disastrously prevalent in the 20th century. Instead the blame is laid at the feet of Plato and Rousseau! And few political theorists worry about the single most undemocratic feature of modern democracies, namely the use of broadcasting to spread lies and propaganda in the interests of established elites and their policies. Is the ambition of business to control the Internet an issue for democratic theory? It certainly should be although there is not much philosophical literature on this topic. Research in STS should address this situation and encourage a major reorientation of democratic theory.

I should say a few words in conclusion about the relation between my work and the mainstream of STS. I clearly do not belong to that mainstream although I have learned a great deal from the field. What I find especially important is the dereifying impulse that lies behind the attempt to bring science and technology back into the human world. But I am astonished by the ambitious claims made on behalf of STS by many of its prominent advocates. I'm thinking especially of Bruno Latour whose work I have followed with interest for many years. I sympathize with his intent to transcend the antinomies of culture and nature, subject and object and I have learned from him the inextricable association of people and things in the social process. But I do not believe the antinomies can be transcended by a new terminology and a new method of empirical research. What is more, the cost seems to be giving up the entire tradition of social theory. This is where I have real problems.

I do not believe the tradition is exhausted. There are rich analyses in the tradition and valuable concepts that we should develop further rather than junk. If I were to put my argument in Latour's terms, I would say that he has underestimated the methodological implications of one key difference between modernity and pre-modernity, namely the fantastic success of modern societies in converting "mediators" into "intermediaries," that is, in stabilizing certain key social relations in so many different ways that a "shorthand" for the results is not only perfectly adequate but essential to understanding.

Democratization involves destabilizing those relations in smaller or larger ways, a process that is almost impossible to conceive without acknowledging and criticizing the stability that has been achieved. This is why sociological concepts describing these stabilized relations, notions such as modernization, rationalization, capitalism, management, class, power, interest, ideology, propaganda, racism, are more important than ever.

Is it possible to work with these concepts without recapitulating what many in STS now see as the humanistic and essentialist mistakes of the past? I believe it is, that basic sociological concepts can be reconstructed in new ways. Indeed, sophisticated Marxist theorists such as Marx himself and the early Lukács undertook this task long before STS, albeit in a different theoretical context. In conclusion, consider the six concepts I have introduced here to formulate my own critical approach, rationality, participants interests, technical codes, operational autonomy, formal bias, and underdetermination.

1. *Rationality*: Rational procedures embodied in social institutions and technologies are distinguished by characteristics such as precision, standardization, and rules of equivalence. Rationality in this sense cannot be understood on the same terms as other social activities because its logical form makes possible unique achievements such as technical disciplines and the technologies based on them, large scale markets, etc. At a certain density these achievements give rise to modernity.

2. *Participant Interests*. These interests do not presuppose an essentialist definition of agents independent of their technical involvements but are relative to the networks in which the agents participate, either actively as users and workers or passively as victims of pollution or other side-effects.

3. *Technical Code*. This concept refers us to culturally and socially established regularities shaping the design of technologies and systems. Technical codes are secured at many levels -- ideological, normative, technical -- and therefore persist with great stability from one situation to another, one generation of technology to the next.

4. *Operational Autonomy*. The Foucauldian critique of power as a substantial attribute of individuals was anticipated long ago by certain aspects of Marx's work. Power is a function of the organization of the collective of workers and tools which distributes it more or less symmetrically. Operational autonomy is the highly asymmetrical distribution inscribed in the industrial technical code. It describes a system in which coordination requires top down control.

5. *Formal Bias*. This concept articulates the political implications of unequal control over technological design exercised by the relevant (and irrelevant) actors. With this concept it is possible to attribute socially specific "values" to technology without falling into essentialist condemnation of technology as such. Operational autonomy determines a bias that is strictly formal, dependent only on the structure of the collective and not on particular substantive interests, with the

exception of the interest in perpetuating operational autonomy itself.

6. *Underdetermination.* This concept makes it possible to explain the intersection of participant interests and the established technical disciplines in technically sound solutions to technical problems. Underdetermination makes room for structural constraints such as operational autonomy and actors' preferences, both in the form of technical codes and more punctual interventions in the design process.

These six concepts form a bridge between the methodological apparatus of STS and the insights of the critical tradition in social and political thought. They open the way from what Wiebe Bijker has called the "academic detour" of STS back to the main road of democratic political theory.

Chapter Three

Critical Theory and Philosophy of Technology

1. Democratization of Technology

After so many years of debate about nuclear weapons and, more recently, climate change it should be obvious that the future of humanity depends on technology. We are told that the experts have everything in hand, but this is increasingly dubious. On the contrary governments and the experts who advise them seem paralyzed by the challenges they face. Long-term considerations, no matter how well grounded scientifically, fade before the politics of the moment. And the best laid plans of the experts and their corporate and political masters often go awry.

Since we are in Brazil consider São Paulo traffic as an example of what can go wrong. This is a consequence of *successful* development. Surely we can do better. But the existing system has momentum and is backed by a dogmatism of quasi-papal proportions. Only significant public movements can divert the process onto new paths. This is precisely the agenda that I address here, and I call it *the democratization of technology.*

The basic principles of democracy are well known. They include voting in multiparty elections, the rights of minorities, and free discussion in the public sphere. Skeptics ask how any of this applies to technology. Can the general public make any sense out of issues involving difficult technical decisions? Who wants to listen to free discussion among incompetents? The answers are obviously "no" and "no one." We should leave technology to experts whose scientific knowledge of nature qualifies them and them alone to design our future.

Indeed, public discussion stops at nature's door. There's no debating mountains or sneezing. The sceptics treat technology as a quasi-natural phenomena. But this leads straight to technocracy. As technology penetrates ever more deeply into society, it depoliticizes more and more of social life. Issues are removed from the public sphere, where values guide decisions, and transferred to administrations where decisions are made on the basis of facts (and supposed facts.) Values no longer play a role. The normative dimension of politics is in the process of disappearing.

Philosophy calls this attitude toward technology "reification." In accordance with its Latin root, *res*, the word for thing, "reification" means treating a human or social relation as a thing subject to scientific explanation and technical control. The market was the first important instance of reification in this sense. In the 19th century it was widely assumed that the market was governed by laws like those of nature. Political interference was strictly excluded. But ever since the Great Depression we have dereified the market through massive government intervention. Economic crises are now treated as political challenges. But, ironically while the market was politicized, the technical sphere was reified and withdrawn from politics. This is the basis of the technocratic ideology which gains tremendous influence after World War II.

Today the reification of technology is frequently under attack. We are familiar with many cases in which the experts bend under public pressure of one sort or another. For example, environmental movements have stimulated innovations responding to new standards. The Internet offers another example of an important technology that is only very loosely controlled by government, business, and experts, and remarkably responsive to public concerns.

The implications of these public interventions are increasingly clear. We are gradually returning technology to the public sphere where it will be subject to normative considerations once again. We need a theory of democracy adapted to this new situation.

The available conceptual framework for understanding such cases is the so-called lay-expert dilemma. Experience with the defects and flaws of technological systems motivates public involvement. Lay people speak out and the experts respond. Out of these interactions between lay and expert improved systems may emerge.

Note that lay actors do not replace experts. Rather, where their relationship is healthy and constructive, they learn from each other, reflecting the *complementarity* of everyday experience and technical rationality. The tension between them is reduced by controversy and dialogue. This is the only way to avoid the catastrophic consequences of technocratic dogmatism revealed after the fall of the Soviet Union. Ordinary people were silenced there for generations, unable to protest obvious abuses of the environment and the human body, with the result that life expectancy is declining and large areas of the country are contaminated by radiation and other poisons.

These considerations on technology have implications for our understanding of the public sphere. What is considered a public issue, suitable for free discussion, has changed over time. Law and war were the most important issues for early democracies and little else qualified as a suitable subject of discussion. But the public sphere expanded throughout the 19th century to encompass excluded zones formerly attributed to nature or God. For example, slavery was abolished and marriage and education were removed from religious control and transferred to the secular authorities. Somewhat later at the end of the 19^{th} and beginning of the 20^{th} century governments begin to intervene in the economy removing it from the sphere of nature and placing it in the political sphere. Now we are witnessing a further broadening of the public sphere to incorporate another pseudo-natural domain, technology.

Radical social philosophers responded to this new situation in the 1960s and '70s. At first they adopted a position I call "left dystopianism," exemplified in the writings of Foucault and Marcuse, the two most prominent social critics in this period. They broke with the essentialism and determinism of most earlier notions of technology and introduced a historical perspective with the intent of opening up the future. Their critique of the idea of a singular scientific-technical civilization created a space for thinking about alternative technology and democratic social control.

These left dystopians shared the notion of technology as ideology, as *socially biased*. This is a controversial position that conflicts with the common sense view of technology as neutral. I will be exploring this notion throughout these lectures. Here is a cultural example that can serve as an entry into this way of thinking about technology.

Lauriston Sharpe describes the misadventure of a group of missionaries in the backwoods of Australia in the 1920s. They needed help at the mission and handed out steel axes to the locals as payment for services rendered. But these were aborigines whose economy and culture relied on stone axes made by male members of the community and loaned on occasion to women and children. Stone axes had great symbolic importance in the system of authority, the cosmology and the trade relations of the tribe. The arrival of freely available steel axes disrupted the culture and left the tribe demoralized and disoriented. Far from being a neutral tool, the stone axe was the bearer of a way of life and, to the surprise of the missionaries, so is a steel axe. What is true of particular tools in cases like this is also true of modern technical systems. The choice between systems determines social worlds.

In the work of Foucault and Marcuse these worlds are political. Technology establishes a new form of domination at the basis of modern life. Foucault argues that the development of new sciences of man in the 18^{th} and 19^{th} centuries required the imposition of technically rational structures on human beings. Science is not an innocent observer but depends on asymmetrical power relations subordinating the observed object to the observing subject. Criminology, for example, depends on prisons as the technical framework for exposing its objects to systematic observation. Science and technical control go hand in hand.

In Marcuse technology and technical thinking are shown to extend their reach into every aspect of life and thought, eventually blocking transcending critique of social institutions by reducing every discontent to a problem solvable on the terms of the existing system. Consider the example of the demand for "fair wages." This slogan is ambiguous, signifying on the one hand an increase of some sort and on the other hand a utopian demand for fairness. Modern business unionism systematically translates the slogan into a certain percentage while erasing the utopian implication that society could at some point in the future be truly "fair." The injustice of wage labor generally is reduced to a problem solved by minor changes that temporarily defuse class conflict.

The reduction of normative to technical issues, to what sociologists call "operational components," once hit home to me in the most personal way. When I was a student in the 1960s I came across an article quoting secret documents prepared by a committee of university professors, including one of my own. The professors were asked to advise the government on preventing student protest. The problem was literally formulated in terms of the operational components of protest and suggestions for solving it ranged from improving visiting hours in the dorms to reducing the pressure for grades. It never occurred to the committee to suggest ending the war in Vietnam because that was not a politically acceptable variable, an "operational component."

Foucault's and Marcuse's demystification of the apparently rational and necessary course of progress introduced political choice into the technological domain. For these philosophers different technological systems have different implications for human freedom. This view has a certain similarity to the common sense instrumental view of technology, but the emphasis here is on design and system configuration rather than simple use. For example, the instrumentalist does not question the significance of the automobile but simply notes that the driver is free to choose her destination. The critical theorist, by contrast, argues that the automobile is the basis of a particular urban design and other technologies of public transportation offer an alternative. Today we face the live issue of how to configure the Internet, as an advanced form of broadcasting or as the infrastructure of online community. I will return to this question later in these lectures.

In the 1970s and 80s technical politics became more and more common, slowly concretizing these themes. Environmentalism has banalized the notion that technology is subject to political control. In the medical field movements for natural childbirth and access to experimental AIDS drugs shattered the illusion of absolute medical authority. Technocracy lost much of its appeal too from the bizarre and ultimately unsuccessful attempt to frame the War in Vietnam as a technical problem American bombs could solve.

Its decline was accelerated by the emergence of a new paradigm of human relations to technology. The computer and especially the Internet create a space within which human beings interact with and even transform their technologies. This new paradigm replaced the old one based on technical macro-systems such as railroads, telephone networks, and electrical systems, which exclude most human initiative. As technical micro-politics became more common, critical approaches to technology gained increasing plausibility.

Despite their contribution to freeing up the imagination of the future, the early theories of Foucault, Marcuse and other similar thinkers lacked concreteness. They offered only very general accounts of agency to explain public challenges to technical systems. A lingering dystopian pathos gave their theories widespread popular appeal without actually explaining the new possibilities of action they inspired. It is to correct these methodological weaknesses that I devised the critical theory of technology, the subject of these lectures.

2. Rationality in the Critical Theory of Technology

In 1888 Edward Bellamy published *Looking Backward*, the most famous utopian novel of the 19th century. In 1932 Aldous Huxley published *Brave New World*, the most famous dystopian novel of the 20th century. What happened to transform 19th century optimism into 20th century pessimism? Why did the 19th century foresee utopia and the 20th century dystopia?

Utopian literature is usually dated from the 17th century. In the earliest versions individual and society are perfectly reconciled through a stoic ethos that reduces the competition for scarce resources that causes so much conflict in the real world. In Thomas More's *Utopia* for example the individuals eschew luxury, employing gold for plumbing rather than money. With Marx, utopia is reconceived as a historical potentiality. Reconciliation of individual and society will be possible in the future not through self-abnegation but through the end of scarcity. This Marxian vision is the background to Bellamy's utopia.

Bellamy's hero wakes up after sleeping for more than 100 years in the 20th century to find that American has become a socialist society. All the institutions are explained to him as rational, that is, both just and efficient. Adults are enrolled in an industrial army where they enjoy equal pay and are relieved of the most difficult and dangerous work by machines. The hardest jobs are accompanied by a shorter work week so as to recruit workers who value leisure without the need for financial incentives or coercion. The industrial army is commanded by experts of high moral character.

Everyday life and politics are not organized by the army nor are art, literature, science, invention, journalism, and religion. All these activities are pursued freely, without expert control, because they have no scientific basis and hence no use for expert management. Bellamy's utopia is a bipolar society combining collectivism and individualism in ideal proportions. But this is precisely what did *not* happen in the 20th century when the technical means were actually available to accomplish utopian ends.

Huxley's dystopia is also a rational society, extrapolated from mass manipulation by the emerging broadcast media and Ford's assembly line. His dystopia reconciles individual and society by eliminating individuality. Its rulers argue that all ills stem from the lack of fit between people and the division of labor. Human beings must therefore be reconstructed in mind and body to suit the tasks they are condemned to perform. People become technical objects in this scheme, their genetic heritage a raw material for the production of better adapted models of humanity. The alternative the novel proposes, or rather the dilemma it constructs, distinguishes technological domination from individualistic chaos, the one offering slavery and stability, the other freedom and catastrophe.

Both of these novels concern the radical consequences of total social rationalization. The comparison between them raises the question of the significance of rationality in a dramatic way. In my introductory remarks I emphasized the non-neutrality of technology and the role of values in technical choice. These novels presuppose something very much like that argument. In the one case technical and moral progress are conjoined while in the other technology is bound up indissolubly with domination. But neither of these fictions corresponds exactly with our contemporary situation.

The question the novels do not address is precisely how rationality is combined with values. Each novel posits an essential connection between technical advance and a specific value. This leaves little room for human agency in the technical sphere. But a new politics is emerging that responds to the failures of expertise through democratic interventions by ordinary people with consequences for the design of technologies and technical systems. A new understanding of rationality is needed to respond to the questions raised by this new technical politics.

The need is particularly urgent today since rationality is entangled in the paradox that Huxley identified in his novel. We have discovered that progress in technology, that is to say rationality in its most concrete form, leads not to freedom but to domination. A new elite arises to administer technically mediated institutions and this is not accidental to modernity, an effect of corruption or prejudice, but responds to the requirements of efficiency. Thus the division of modern societies into rulers and ruled is rooted in technological rationality itself. This is the context in which technical politics is lived as resistance to domination.

The fate of medicine is a case in point; it has been transformed from a craft based on the individual labor of doctors and nurses into a vast technical system administered through bureaucratic institutions and increasingly controlled by corporations and governments. As medicine becomes more technically effective, its patients become more and more like things, the objects of technique, and less and less like persons. The demand for more humane procedures put forward in different ways by pregnant women in the 1970s and AIDS patients a decade later restored communicative relations interrupted by the technocratic restructuring of medicine.

To understand such cases, the critique of technology must reverse the notion we inherit from the 18th century Enlightenment according to which rationality is essentially opposed to domination. On this view domination should recede as rationality advances. Thus philosophy claims at least part of the credit for the decline of feudal and religious superstitions and the institution of democracy in America and Europe.

Habermas calls this the "Enlightenment project." It was always questionable, but it seems to have failed disastrously in the last century. The "project" has been challenged historically by two critiques of rationality. On the one hand a romantic critique of reason itself calls for a retreat from rationality and all its works. On the other hand various forms of critical theory attempt to develop a "rational critique of rationality." These two styles of critique imply different politics and it is therefore important to distinguish them clearly.

Romantic resistance to reason as such begins in the late 18th century, accompanied by idealization of the past. Rousseau, for example, criticized the division of labor which, he claimed, enslaves modern human beings to a system they cannot control. He contrasted modern men unfavorably with the virtuous peasants of Republican Rome. We have poets, geometers, and physicians, he says, but no citizens, meaning that specialization has deprived the members of society of a vision of the whole and the ability to engage morally with its requirements. Later in the 19th century the standardization of products provoked aesthetic dissatisfaction with modernity. Ruskin criticized the disappearance of craft and the debasement of aesthetics in modern society. Modernity is not just unjust but also ugly. Kierkegaard attacked the loss of passion in modern life. Modern man, he charged, is incapable of commitment because he is always reflecting on his situation and calculating his chances. Balzac's antihero Vautrin declaims "J'appartiens à l'opposition qui s'appele la vie." This image of life versus mechanism captures the essence of the romantic critique.

Romantic critique appears to be verified by the 20th century catastrophe of reason. Wars, concentration camps, nuclear weapons, and now environmental disaster threaten the Enlightenment project. But this critique of reason does not lead to a constructive politics but rather to withdrawal from the public world. Furthermore, it is difficult to believe that the full content and significance of rationality is exhausted by the division of labor, standardization, accounting and mechanization. Surely reason has underexploited potentials that can be mobilized in a self-critical approach. This implies a distinction between technical rationality and critical rationality of the sort that is deployed in this lecture.

There are no ready concepts for talking about the paradox of rationality, the fact that the progress of technology has gone hand-in-hand with the progress of domination. That the existing technology favors this development is clear, but it is important to avoid an essentialist critique of technology as such. To understand the paradox without romantic subtexts we need a concept of *social* bias appropriate for the analysis of *rational* systems. This is a departure from the usual concept of bias which is closely associated with prejudice and discrimination. Racial discrimination in hiring is routinely described as biased in this sense.

But bias in a less familiar sense appears in other spheres as well. For example, many everyday objects are adapted to right-handed use. This too could be called a bias but it does not involve prejudice. Rather it is built into the design of the objects themselves. In this it resembles the kind of bias to which technology and other rational systems are susceptible.

In accordance with this distinction, critical theory of technology identifies two types of bias, which I call "substantive" and "formal" bias. The more familiar substantive bias is the object of Enlightenment critique. Eighteenth century philosophers were confronted with institutions that claimed legitimacy on the basis of stories about the past and religious tradition. Aristocratic privilege was justified by mythic origins such as participation in the crusades. Kings ruled in the name of God. Reason opposed these narrative myths behind religion, monarchy and feudalism. The Enlightenment judged according to facts and arguments and this judgment was fatal to the *ancien regime*. Much later a similar critique attacked racism and gender bias again in the name of rational ethical principles and scientific knowledge. I call the bias criticized in such cases "substantive" because it is based on pseudo-facts and prejudices. Substantive bias intrudes specific contents that motivate discrimination into domains that ought to be governed by rationality and justice.

Critique of substantive bias seems to imply the purity of reason as such. But things are not so simple. Although rational critique is justified relative to myths and prejudices, it is not without its own form of bias. A brief detour into Marx's critique of the market is useful for understanding this counter-intuitive form of bias.

The market appears rational but, strangely, its expansion leads to inequality. This inequality escapes Enlightenment critique because it is not justified by narrative myths but by the exchange of equivalents. In the mid-19th century two styles of critique emerged in response. The French anarchist philosopher Proudhon famously claimed that p*roperty is theft*. He argued that given the outcome property income cannot be the result of an equal exchange. Various theories of this sort appeared over the years, some arguing that capitalists charge more than goods are worth, others arguing that they pay workers less than their fair share. In either case, capitalism was treated as a fraud rather than as a coherent system. Such arguments usually led to an idealization of peasant small holding.

Marx was a more rigorous thinker. He realized that the critique of the market would have to begin with the fact of equal exchange rather than denying it. The origin of inequality would have to be found in the very rationality of the market. He proved this with an elaborate economic theory that I will not review here. His argument turns on the difference between the amount of wealth required to maintain the worker, which is more or less equivalent to his wages, and what he is capable of producing in the course of the working day, the length of which is set by the capitalist. Since the worker owns and sells his labor power, not the product of his labor, no violation of strict market exchange is involved in setting a workday long enough for the capitalist to make a profit. The injustice of the system is a result of the logic of the market.

With this argument Marx showed that rational systems can be biased by their social context and design and he extended this type of critique to technology as well. Technology too discriminates between rulers and ruled in technologically mediated institutions. This bias does not involve prejudice. A biased technology is still rational in the sense that it links cause and effect in useful patterns. No narrative myths or pseudo-facts obstruct its efficient functioning, and it is certainly free of prejudice. I call this a "formal" bias because it does not violate the formal norms such as control and efficiency under which technology is developed and employed. These norms do not specify a particular substantive goal but are apparently compatible with any goal the technology can be made to serve. However, we observe over and over in history that the pursuit of efficiency and control in fact favors particular social groups and their goals. Technology is not simply a neutral medium in which universal human needs are satisfied, but plays a specific social role in society. As we have seen, this was the case with deskilling through technical innovation.

There are two familiar ways in which rational systems and artifacts are biased. In the first place they require a context for their implementation and that context may have different implications for different individuals or social groups. Consider the case of maps. A map may be a perfect representation of the territory and in that sense highly rational, but it is useless until direction on the map is correlated with direction on the ground. Thus the map does not stand alone but must enter practical reality with a bias in the most neutral sense, an orientation. But a map may also embody a social bias, for example, in the case of early navigation when map-making was a necessary preliminary to the conquest of territory occupied by natives who themselves had no need of maps to get around.

The second way in which rational artifacts are biased is through their design as in the case of right handed tools. Design is shaped by many actors seeking rational solutions to the problems that concern them. Artifacts and systems reflect particular interests through the role of these actors in the design process. This does not make them irrational or inefficient but on the contrary is the way in which they are rational. I employ the concepts of “translation” and “technical code” to understand this apparent paradox.

Technologies are built according to general rules I call “technical codes.” These codes lie at the intersection of social demand and natural causality. Social demand is first formulated discursively, in a philosophical or ideological form. Technical codes translate such social discourse into design specifications. The sidewalk ramp is a good example. Until it was introduced, disability was considered a private problem. The interests of the disabled were not represented in the design of sidewalks which obstructed their movements at every crossing. Complaints about this situation were framed in terms of human rights. Once society accepted responsibility for the free movement of the disabled, the design of sidewalks translated the new right. Recognition of this right takes the form of a design specification.

Progress is defined relative to technical codes and not in absolute terms. Unsuccessful alternatives are rejected and forgotten, covered over by a kind of technological unconsciousness which makes it seem as though the chosen path of progress was inevitable and necessary all along. This is what gives rise to the illusion of pure technical rationality. That illusion obscures the imagination of future alternatives by granting existing technology an appearance of universality and necessity it cannot legitimately claim. The role of critical theory of technology is to demystify this appearance in order to open up the future.

3. The Contribution of Critical Theory

In this lecture I will explain the connection between the critical theory of technology as I have formulated it and the Critical Theory of the Frankfurt School. This focus will take us in two different directions. The first part considers the Frankfurt School’s reflections on the paradox of modern rationality, and its failure to resolve that paradox. The second part shows how critical theory of technology supplements the Frankfurt School’s critique of technology and helps to address its limitations.

The Frankfurt School was a group of unorthodox Marxist philosophers who founded their Institute for Social Research in Germany shortly before Hitler came to power. Theodor Adorno, Max Horkheimer, and Herbert Marcuse were critical of the Soviet version of communism. They believed that class consciousness had failed to emerge as Marx expected and that the opportunity for proletarian revolution had been missed. They did not despair completely but held out little hope for the future. The problems of modernity, they argued, were rooted in the very nature of rationality. The Frankfurt School focused on technology, as the concrete expression of flawed rationality, free from the illusions of traditional Marxism.

Like Bellamy, Marx believed technology had the potential to liberate humanity. His social analysis leads to faith in the emancipatory effect of a further rationalization process under the control of workers. Later Marxists simplified the argument and concluded that capitalism distorted a pure rationality waiting to emerge under socialism. They believed that progress would solve all the problems with technology.

When Lenin described communism as Soviets plus electricity, he announced a standard modernizing strategy. His government imported and imitated Western technology without much attention to local conditions including the political conditions created by the Soviets, or workers’ councils, that ostensibly held power. The result was the importation of operational autonomy along with the equipment, the design of which it had determined. “One-man management” soon became the mantra of Soviet development policy.

We have not seen the emergence of a pure and benign technological rationality under either capitalism or communism, but rather the generalization of technical mediation in the form which capitalism first gave it. Technology reaches medicine, entertainment, sports, education, and frames everyday life and belief. Power follows technology. The enrolment of everyone and everything on the planet in the system has made it possible to spread centralized administration from the factory to society at large. This is a catastrophic reversal of the expectations of the philosophers of the Enlightenment which Marx still hoped to fulfil through socialist revolution.

There are several possible responses to this situation. Traditional Marxists, liberals and neoliberals hold that modernization must continue until it finally fulfils its promise. The negative consequences so far endured are dismissed as contingent accidents along a path to utopia. Postmodernists despair in enlightenment and give up on reason altogether. The philosophers of the Frankfurt School offered a more complex response, a “dialectic of enlightenment” that recognized the catastrophe of modernity but also the promise of a rational society.

They shifted the emphasis of the Marxist argument. from social and economic relations between human beings to the relation of human beings to nature. Adorno and Horkheimer argued that the rational domination of nature leads eventually to the domination of some human beings by other human beings. Every advance of rationality in the struggle with nature is also an advance of domination in society. The Enlightenment project is thus more complex and fraught than it seems.

Horkheimer explained the problem in terms of the split between reason and value. He argued that reason is rooted in the preservation of life but in modern times it is reduced to a pure means, an instrument of power indifferent to life. Horkheimer distinguished accordingly between what he called “objective” and “subjective” reason. Objective reason contains a value within itself. Medicine is an example. It combines rational techniques based on science and experience with a commitment to healing. Until modern times this was the normal form in which reason was deployed in society. But with the emergence of a total civilization of technique reason becomes “subjective” in the sense that it responds to the will rather than to intrinsic purposes of some sort.

Marcuse argued that the of success subjective reason makes possible not only a generous material standard of living but also access to the cultural heritage of the human race, formerly available only to the wealthy. Advancing technology thus proves the obsolescence of class rule just as Marx supposed, but at the same time it provides the means for perpetuating the capitalist system indefinitely through “delivering the goods” and integrating the working class to consumer society. “Technological rationality” thus shatters the dream of Enlightenment. This is a radicalization of Weber's rationalization thesis culminating not in the iron cage of bureaucracy but in an iron cage of technology.

This radical critique does not convince Jürgen Habermas, the most prominent contemporary representative of the Frankfurt School. Habermas introduced communication theory and system theory into Critical Theory and turned it away from the radical critique of modernity toward the reform of the welfare state. He rejects what he considers the anti-modernism of Adorno, Horkheimer and Marcuse, the first generation of the Frankfurt School. They never explain the critical standard underlying their argument, nor do they propose a concrete reform program. According to Habermas this leaves a gaping normative deficit.

In his 1968 essay on “Technology and Science as Ideology,” Habermas addresses Marcuse’s version of the Frankfurt School’s argument.[19] He claims that Marcuse has two independent critiques of technology. The first critique follows the line taken by Adorno and Horkheimer in viewing technology as intrinsically dominating. This critique has a certain similarity to the romantic critique of rationality discussed earlier although Marcuse develops it in a unique way. The problem is not precisely the substantive bias of rationality condemned by romanticism, but rather the formalistic character of reason itself which has substantive consequences.

This puzzling distinction can be clarified by reference to premodern notions of rationality based on the cultivation of the potentialities of its materials. Traces of such notions persist among some practitioners of technical arts such as architecture and medicine. For Marcuse, the formal neutrality of modern reason, which derives from its mathematical construction of its objects, cancels its connection to potentialities and places it at the disposal of the powerful, ready to serve their subjective values. Frank Lloyd Wright attempted to situate his buildings harmoniously in the landscape, realizing its potential as a site, but the same engineering techniques he employed, freed from any such aesthetic concern, are also available to create steel and glass monstrosities cut off from any relation to nature. Marcuse argues for a social revolution in reason itself, incorporating humane values into its technological applications. Marcuse hoped for the fusion of aesthetic and technical rationality in a new version of objective reason.

Habermas rejects this view which he attributes to a “secret hope” in a communicative relationship to nature. He argues that nature cannot be liberated from the bonds of technology since technology is a generic achievement and not specific to any given society. As such it cannot be transformed by a change in social organization.

Habermas is more sympathetic to Marcuse's second critique. According to this critique the problem with technology is its universalization as a worldview or ideology influencing every aspect of life in modern society. Marcuse writes "When technics becomes the universal form of material production, it circumscribes an entire culture; it projects a historical totality-- a 'world.’” This is the Marcusean version of the technocracy thesis according to which experts have taken over and depoliticized public life. Self-expanding technology replaces moral considerations and debate. Habermas finds in this approach a way of

[19] Habermas, Jurgen (1970). Technology and Science as Ideology, in *Toward a Rational Society*, J. Shapiro, trans. Boston: Beacon Press.

separating the critique of technology as such from its use as a legitimating ideology.

Habermas's version of this argument is presented in the course of a critical discussion of Marxism. Where Marx distinguished productive forces and relations of production and identified the tensions between them that motivate class struggle, Habermas argues that class struggle has weakened in intensity as the issues that motivated it have taken on completely new forms. Thus it is necessary to recast the problems Marx addressed at a higher level.

Habermas substitutes his own more general categories, "purposive-rational action" and "communicative interaction," for Marx's forces and relations of production. Purposive-rational action is success and control oriented. The technical relation to nature is rational in this sense. It differs from communicative interaction which is based on the norms of ideal speech and aims at mutual understanding rather than technical success. The generic tension between the types of action involved in production and social relations now replaces the original Marxian problematic.

Habermas derives a normative ground from his theory of communication. He claims that we could not communicate without implicitly assuming that our interlocutors speak truly and sincerely. It is only against the background of such assumptions that we can identify deviations from ideal speech such as lying. Institutions based on communicative interaction such as the family and the public sphere thus have an intrinsic normative character.

These distinctions are the basis for a general theory of social organization. On the one hand every society has an institutional framework based on a system of meanings, practices and expectations established by communicative interaction. On the other hand societies have technical subsystems which contain the knowledge, practices, and artifacts that produce the goods required for survival. The balance between the technical and communicative dimensions varies in different forms of society, but the institutional framework was always predominant until modern times.

Habermas distinguishes two stages in the development of modernity in each of which a different technical subsystem intrudes on the institutional framework. In the first phase of bourgeois society the market penetrates everywhere and displaces the institutional framework as the determining instance of social life. So long as the market is interpreted as a quasi-natural phenomenon, it supports bourgeois hegemony. Exchange appears fair since equivalents are traded without coercion. The legitimacy of the ruling interests is established through their identification with the "laws" of the market.

This legitimation fades as governments begin to regulate markets in the 20th century. In the post-war period technology takes over where the market leaves off in organizing more and more social life. As a result, market legitimation gives way to technological legitimation. The institutional framework is increasingly subordinated to the conditions of economic and technical development. Legitimation now requires the identification of the ruling interests with the efficient functioning of the system. Depoliticization masks continuing domination and justifies a technocratic order. Normative concerns are increasingly evacuated as a dystopian logic takes over.

Habermas's early essay is an attempt to establish a critical but positive relationship to modernity. In the terminology of his later work, he postulates a double rationalization, both technical and communicative. The technical rationalization is of course familiar but Habermas treats progress in freedom, individuality, and democracy as belonging to a parallel communicative rationalization. He does not criticize modernity as such but rather the over-emphasis on technical rationalization under capitalism at the expense of communication. Critique should aim at furthering communicative rationalization rather than denouncing technology.

Habermas's later work improved on this theory. He realized that individual action orientations do not a society make. The real problem is coordination among many acting subjects. Habermas distinguished two different types of action coordination characterizing the domains of "lifeworld" and "system" that replace the "institutional framework" and "technical subsystem" of his earlier work. In the new theory coordination is achieved in different ways in each domain, through mutual understanding in the lifeworld and through systems such as the market without the need for much in the way of communicative interaction.

The concept of lifeworld is derived from phenomenology. In Heidegger it is identified with the "world" as a system of meanings implicit in the active relation to things. These meanings are "preconceptual" in the sense that they are prior to and make possible the articulation of meanings in language. Husserl uses the term "lifeworld" to refer to the everyday domain of meanings that underlies scientific conceptualization. Both thinkers draw our attention to meaning as the irreducible medium of experience. Habermas reformulates the concept to emphasize the social context in which meanings are generated and shared.

The lifeworld is essential to the reproduction of the individuals but it is incapable of managing the institutions of a large-scale modern society. For that purpose more impersonal and quasi-mechanical forms of interaction are required and these are made possible by systems of economic exchange and administration. The system concept employed here is derived from the sociology of Talcott Parsons. Parsons developed this concept by generalizing certain features of markets to other social domains. Systems in this sense are self-regulating structures of interaction that enable the achievement of individual goals. They require no collective agreement but only stripped-down and conventional communicative responses such as the typical dialogue involved in making a purchase. Modern society depends on the effectiveness of systems at unburdening the lifeworld of excessively complicated tasks.

Habermas's critique of technocracy can now be reconstructed in terms of these new distinctions. Technocracy is redefined as colonization of the lifeworld by the system. Habermas advocates increased social control of the system by decisions reached freely in the public sphere through communicative acts. But he abstracts completely from technology in this version of his theory. The term does not even appear in the index of his most important book, *The Theory of Communicative Action*. He focuses instead on the welfare state, multiculturalism, and deliberative democracy. He is concerned for example about legal intrusions into the family and ignores such technological intrusions as the medicalization of child birth. But technology is just as important as markets and administrations. It too functions as a system in coordinating action and it too causes many of the most important problems of modern societies. How can a critical theory of modern society omit from its agenda environmentalism, the Internet, economic development in poor countries, and the problem of democratization of technology?

Despite these limitations Habermas's theory is full of important insights some of which I have attempted to incorporate into a new version of critical theory of technology. Perhaps the most important of these insights is his methodological dualism. Habermas recognizes that modern societies operate in two principal worlds, a world of quasi-mechanical institutional interactions and a world structured around meanings and communicative understanding. Each world requires its own method of analysis.

Unfortunately there is an ambiguity in Habermas's application of this dualistic conception. In methodological discussions he tends to argue that the distinction is analytic. This means that system rationality and lifeworld meanings co-exist in all social institutions. The weight of the two types of action coordination differs in different institutions, but there is invariably considerable overlap. Sociologists who study organizations verify this approach whenever they show the dependence of formal structures on informal relationships, both of which are necessary to effective functioning. Similarly, economists who study the effects of taxation on incentives for spouses to work illustrate the penetration of system rationality into the family, an institution that is primarily the scene of communicative interaction. Although this interpretation gives a realistic picture of the workings of the various institutions, it makes for problems with the colonization thesis since the system and lifeworld always already interpenetrate each other.

Habermas wavers between this analytic approach and reifying the system and lifeworld as separate spheres. Then institutions are assigned to each sphere and it appears that, for example, the market and state administrations belong to one sphere and the family to another. The colonization thesis makes sense in this context since the colonizer and the colonized are distinct entities. But this is also the context in which the neutrality of the system makes its appearance in Habermas's argument. For, if the system is external to the lifeworld and its conflicts, then its structure is not controversial, only its reach.

This formulation eliminates the problematic of domination so central to the thinking of the first generation of the Frankfurt school. Social critique is reduced to boundary problems. Apparently, systems are alright in themselves and the only problem is their extent. Of course different groups might have different goals for the system, just as users of tools may have different goals, but goals are external to the self-enclosed instrumental rationality of the system. This leads Habermas to reject radical proposals for changing the internal structure of the system such as self-management. The system is surrendered to capital and the experts.

If Habermas accepts the neutrality thesis, this is because he has no concept of formal bias and hence no conceptual basis for criticizing systems in themselves that does not tip over into romantic rejection. Caught between the neutrality thesis and the "secret hopes" of romantic critique, Habermas is helpless to devise an adequate critical theory of modernity.

To escape these problems, it is necessary to stick rigorously to the idea that "system" and "lifeworld" are a crosscutting analytic distinction throughout all the institutions of modern society. Lifeworld and system are not social spheres but overlapping perspectives on the social world. I therefore propose what I call a double aspect theory of systems according to which they are traversed by the social conditions of their design and configuration. Such a theory can encompass technology along with the markets and administrations analyzed by Habermas.

The logic of this double aspect theory requires careful elaboration. Since system and lifeworld are not separate things, but different aspects of one and the same thing, they cannot interact causally. And yet they are not identical either. Analytically distinguished entities such as these entertain logical relationships of some sort. For example, the Pythagorean theorem explains the relations of the three sides of a right triangle. Similarly, the notion of form explains the relations of the parts of a work of art. The related entities—sides, colors, shapes—cannot exist separately and yet they are distinguishable. We grasp them through special concepts adapted to each case.

Hegel wrote a short essay called "Who Thinks Abstractly" that helps to clarify the relations between aspects in the case that concerns us.[20] His essay reverses the usual understanding of abstract and concrete. It is not the philosopher who thinks abstractly, but the ordinary person who summarizes a complex of relationships in a single trait. Abstraction is thus a synecdoche in which a part stands for the concrete whole. Hegel gives the example of the servant who is treated as merely a servant by a vulgar master, in contrast with the "French noble" who understands that his servant is a person with ideas and purposes just like himself and who relates to him accordingly.

The Habermasian conception of system suggests something similar. Consider market relations. Their communicative simplicity is made possible by abstracting economic exchange from the complex relations that surround it. We enter a store and relate to the clerk exclusively as a clerk, ignoring all other aspects of the clerk's being. This is abstraction in Hegel's sense. In a curious confirmation of Hegel's admiration for France, it is considered proper to first recognizes a French clerk as a person with an appropriate greeting. Only then is it polite to relate to the clerk as a clerk.

Systems generally can be considered abstractions from the wider whole of the lifeworld in which they are embedded. What is abstracted is the functional dimension of the lifeworld. Thus a clerk performs an economic function, just as a device performs a technical function. The functional dimension of persons and things is distinguishable but it is not self-subsistent. The clerk cannot be separated from the person who is a clerk, nor the device from the social world in which it serves its function.

An automobile, for example, has a transportation function served by various causal mechanisms, but it is also part of the lifeworld of its owner with a significance in terms of beauty, status, social behavior, its impact on urban design, and so on. Of course the abstract idea of the transportation function is useful and the causal mechanisms that serve it can be studied and perfected, but this does not nullify the social meaning of the automobile. In sum, a functional logic operates at the systemic level, abstracted from the meanings that circulate in the lifeworld.

I call this approach instrumentalization theory. In this theory the system level is called the "primary instrumentalization" and the lifeworld level the "secondary instrumentalization." As applied to technology the point of the distinction is to show the relation between two fundamental aspects of every functional artifact: causal structure and social significance.

The primary instrumentalization is an imaginative relationship to technical affordances. A simple example is grasping a stick in order to extend one's reach to a fruit hanging from a high branch. The action depends on causal perceptions and reasoning. All human beings and even some animals are capable of this. Modern technology assembles huge numbers of such affordances in coherent patterns to accomplish goals that go beyond any one individual's needs.

But the logic of such assemblages is not exclusively technical. It is true that it is constrained by causal principles: only an assemblage that "works" succeeds. But there are an infinite number of working combinations available. The secondary instrumentalization determines which ones are realized. At this level the affordances acquire meaning in their social context. This is the lifeworldly significance of the technical; it situates technology in the way of life to which it belongs.

Technological design combines both levels seamlessly and both are necessary. Apart from the simplest technical actions, the construction of a device is always a social act involving the secondary instrumentalization. Invention proceeds from curiosity and technical insight and is usually conditioned by some possible social demand that can be distilled into a notion of function. But unless the demand is sufficiently pressing and general, the invention falls by the wayside regardless of its technical elegance. The history of technology offers some famous examples of causal insights that found no place in the

[20] http://www.marxists.org/reference/archive/hegel/works/se/abstract.htm

society to which they belonged, for example the steam engine invented by Hero of Alexandria and the wheels used by the Aztecs only in toys. Consider too the example of the zipper. It was invented and reinvented over and over but even when perfected technically it waited long years before anyone would consent to wear it. Determining the meaning of the zipper was just as important as making it zip.

The instrumentalization theory offers a framework within which to analyze the imbrication of the technological system and the lifeworld. The two instrumentalizations refer to different aspects of artifacts and their users, but these are aspects only, not separate spheres able to exist independently of each other. This is crucial. Unlike Habermas's system and lifeworld, here the aspects each reflect the other on its own terms. But the fact that modern societies are able to abstract the functional level of artifacts and to construct technical disciplines on that basis masks their essential social dimension. The abstraction certainly has consequences—it makes modern technology possible—but it does not actually eliminate the social. Recall the example of the sidewalk ramp discussed earlier. The ramp's causal properties are describable in a specification on purely technical terms, but that specification is not purely technical; it represents the rights of the disabled technically. That is its significance in the lifeworld.

The instrumentalization theory draws on some of Habermas's insights to restore the focus on technology and the problem of domination of the first generation of the Frankfurt School without romantic afterthoughts. The theoretical context is different from both, to be sure, but the point of the new formulation is the same, to reconstruct a "rational critique of rationality" in confrontation with technocratic ideology.

The primary instrumentalization specifies those aspects of the technical relation to reality which contain the potential for domination. Functionalizing an object involves more than control; it requires that the object be broken out of its place in its world and stripped of connections to its environment. In the case of human beings the implications are obvious: to return to our example, the clerk is useful only insofar as he does not express his personality too freely from behind the counter. The assembly line worker is in a still tighter straightjacket, forced into a strictly limited role. Natural objects too are "dominated" in some sense where they are denied their own potential for growth and connection.

In their *Dialectic of Enlightenment,* Horkheimer and Adorno appear to condemn instrumental reason as such for harbouring these traits. Later qualifications were never elaborated into an alternative theory. Marcuse's argument is more developed. He understands that the potential for domination is not realized as a simple consequence of the deployment of technology, but reflects a specific social context. On his account something like what I have called the primary instrumentalization is value-neutral and hence available to serve in a project of domination. An ambiguity remains regarding whether the critique addresses substantive or formal dimensions of technological rationality.

I have reformulated this theory in a more socially concrete way. On my account, systems acquire a formal bias toward domination through a specific type of secondary instrumentalization which narrows the values they serve to exclude important contexts and consequences. This is what happened in the development of industrial technology under capitalism. But the secondary instrumentalization may also cancel or mitigate the potential for domination by orienting technology toward a broader range of social values. This is the outcome of democratic interventions into technology. Separating these two levels saves the theory from the dilemma of essentialist technophobia or naïve acceptance of the neutrality of technology which threaten it in the various formulations of the Frankfurt School. The key concept missing in all these formulations is the notion of formal bias, which makes possible a true critical theory of technology.

4. Critical Theory, Constructivism and the Internet

The thought of the Frankfurt School was elaborated during a long period of defeats for the left. Meanwhile, broadcasting and technical macro-systems offered dystopian paradigms of technology. Despite the evident exaggeration there is a large dose of truth in these philosophers' pessimistic conclusions.

Their most significant sociological contribution was the critique of mass society. The critique presupposed Kant's ideal of enlightenment formulated in the phrase *sapere audi*, "dare to know." This is the ideal of autonomous individuality basic to the notion of democratic citizenship and which Marx projected onto the working class as class consciousness. But instead of alert citizens or a self-conscious class 20th century societies are populated by atomized and homogenized masses. This is due to the surprising effectiveness of propaganda and advertising which no one could have foreseen in the 19th century. The new mechanisms of control mobilize whole populations through nationalism, racism and consumerism.

Adorno and Horkheimer argued that in the era of the mass media the commodity form penetrates cultural production to the core. Today's commodified cultural products are fundamentally different from earlier cultural artifacts, even those sold on markets. It used to be that art had its own canons and logic based on religious or artistic traditions. The sale of the work did not affect its inner form as profoundly as it does in the case of the contemporary culture industry. Its products are shaped in their most intimate details by the requirements of the market. It is this which determines the stereotyped characters, plots and images through which they communicate a conformist ideology. A new authoritarianism emerges in which accepting the facts established by power appears as the only rational response to "reality." This is the rationalization of consciousness itself; it destroys individuality and critical thought. But the counter ideal remains: democratic discussion between free individuals is still an imperative of critical reason.

This theory is limited by its historical context. Today it appears somewhat abstract and technophobic and as a result it is frequently dismissed by post-modernists enchanted by mass culture. A more serious problem for the theory is the emergence of new struggles which cast a different light on the role of technology in modern societies. As we've seen, environmental struggles, user agency on the Internet, and in medicine, and struggles around economic development in poor countries all testify to the fact that the "masses" have not been incorporated completely into the system. These struggles are not always political in a traditional sense but they refute the dystopian tendency of critical theory. Unfortunately, critical theory in both its early formulations and in the recent work of Habermas and his followers ignores agency in the technical sphere. For this reason I've turned to social constructivist approaches to technology which are more open to empirical reality in all its variety.

Social constructivism, the currently dominant trend in science and technology studies, refers loosely to several approaches that have in common a rejection of positivism and determinism, and an emphasis on the social character of science and technology. Although social constructivism is not a political theory, it has political implications. Its critique of positivism and determinism undermine the basis of technocracy and modernization theory. But this implication is rarely made explicit. Social constructivism presents itself as a strictly academic approach to the study of science and technology. Where it addresses politically sensitive issues the radical implications and the larger philosophical significance of the argument tend to be muted. Placing constructivism in the context of critical theory brings out these connections.

Social constructivism originated in a critique of traditional sociology of science. Until recently, most sociologists distinguished between the causes of belief and the reasons for belief. Causes may be irrational but reasons are by definition based on argument and evidence. Superstitions are explained sociologically by their causes, but belief in scientific theories is explained by the reasons that prove them true. With this conclusion sociology handed science over to positivism which studies rational methods of investigation.

David Bloor and his colleagues challenged traditional sociology with what they called the "strong program in sociology of science." They observed that what we use for truth arises from controversy. Closely examined, controversies show a mix of causes and reasons on all sides. It is simply not the case that the losers are moved exclusively by causes and the winners by reasons. Scientific truths are rarely proven by evidence so clear and decisive as to preclude all reasonable objection. Given this "underdetermination" of theory by reason, it is necessary to study both sides of scientific controversies with the same methods. Bloor calls this the "principle of symmetry." It leads to a kind of relativism in terms of which science is seen as a craft that manufactures facts rather than artifacts. Like any craft it requires great skill but possesses no absolute evidential ground.

In the 1980s social constructivism inspired new approaches to technology studies. Some of the major figures in this trend are Trevor Pinch, Wiebe Bijker, and Bruno Latour. In their writings efficiency appears as an analogue to positivist truth. Just as positivism exempts science from social explanation, so traditional sociology explained technological development by progress in efficiency. For social constructivism, on the contrary, technical choices, like scientific choices, are underdetermined. Technology is thus socially shaped, not rationally determined by pure efficiency as in deterministic accounts.

Social constructivist technology studies attempts to identify the "relevant actors" engaged with the design process. These actors seek a technical solution to a problem of some sort which they have defined in accordance with their concerns. Artifacts become the focus of a variety of actors with related but slightly different concerns. Problem definitions thus vary accordingly. This is called the "interpretative flexibility" of artifacts. It leads to different designs of what is generally understood as the same type of artifact. Interpretative flexibility is especially important in the early stages of development. Pinch and Bijker present the bicycle as an example in their classic article.

In the late 19^{th} century, bicycles were designed in several different ways. Two of the most famous designs were the Ordinary, with a large front wheel for racing, and the Safety with two wheels the same size designed for utilitarian transport. The two designs corresponded to different interpretations of the problem the bicycle was intended to solve: either speed or transportation. The bicycle developed out of a struggle or negotiation among the different actors involved, young men out for a thrill and everyday riders. The different problem definitions concerned not just ideas in the minds of the actors but the content of the technology itself, its design and functioning, which was modified in accordance with these ideas.

Eventually the search for a softer ride, which led to the invention of inflatable tires, had the unexpected side effect of enabling the Safety bike to go fast, fast enough to make the large front wheel unnecessary for racing. The outcome, the triumph of the Safety, became the basis for all later progress in bicycle design. This, and not some inherent superiority of the Safety, is why the Ordinary appears frozen in time, a technological fossil from another era. Social constructivists call this "closure" or "black boxing." It is roughly equivalent to the establishment of a technical code.

Constructivist technology studies offer a fine grained approach to understanding technological development. But so far most of the work has been based on empiricist methodological foundations. The focus on technical function tends to occlude the larger forces and visions that move the actors. The systematic exclusion of macro social concepts such as class, ideology, and culture diminishes the explanatory power of the approach. Case studies abound but there are few ambitious attempts to integrate what is learned about particular technologies into the wider framework of social and political history, much less contemporary public debates.

Take the bicycle case as an example. Women's clothing at the end of the 19th century was incompatible with bicycle riding. Thus gender issues became entangled with the spread of the bicycle. This was a time of considerable controversy around women's rights. Some women saw access to the bicycle as a significant issue. They launched the "rational clothing" movement to free themselves from the huge, unwieldy dresses and bustles they were expected to wear, and substituted more convenient and practical clothes.

Gender theory is relevant to this surprising consequence of the introduction of the bicycle, but for the most part social constructivism is unable to deal with such large issues. Feminist technology studies have had to retreat from some of the more extreme methodological strictures of their constructivist colleagues to get around this limitation. In particular, feminists have complained that there is no place in the theory for the absent or powerless, the "irrelevant" actors who suffer the consequences of technology without being engaged in the design process because they are systematically excluded. The bicycle case reveals such an "irrelevant actor" striving to make itself "relevant" as part of a cultural and political upheaval in which the bicycle played a symbolic role. In this respect women were more successful than the deskilled workers we discussed previously who were never able to make themselves "relevant" to the design of production technology.

The methodological limitations of social constructivist technology studies appear to stem from the heritage of science studies. Scientific controversies involve actors who are roughly equal in power, committed to their profession, and more or less sincere in their pursuit of truth. The principle of symmetry makes sense in this context. The world of technology is quite different. Much technology is developed by organizations rather than individuals and the disproportion in their power is often enormous. Furthermore, organizations are far less trustworthy than individual scientists and engage in blatant manipulation far more frequently than scientists commit fraud. Symmetry may tend to mask rather than reveal the truth of what is going on in technological controversies. Thus constructivist insights must be supplemented by other methods to gain a full picture of the social significance of technology.

Despite these limitations of its own, constructivism is useful for overcoming the limitations of the Frankfurt School. The theory of the culture industry reflected a specific stage in the development of the media, essentially, the early history of radio and television broadcasting. With the emergence of the Internet the media system has changed radically and it is necessary to modify the earlier analysis. Constructivist methods enable a much more detailed approach to the relations of technical design to social design than the Frankfurt School achieved with its theory of commodification.

Yet, there is also a significant methodological similarity between these approaches. Just as the commodity form enters the content and inner details of the products of the culture industry, so constructivism argues that social demands enter the content and inner details of technical designs. This parallel reflects a similar attempt to get beyond the notion of autonomous fields, neutral in themselves, and merely "used" for extrinsic purposes by social actors. Instead, both the critical theorists and the constructivists insist on the underdetermination of cultural and technical products and the role of society in shaping their inner workings.

This is certainly the case with the Internet and a combination of constructivism and the instrumentalization theory shows how. The Internet illustrates the basic constructivist point that technologies are not things but processes, contingent on shifting interpretations as well as knowledge of nature. The history of the Internet reveals its extraordinary interpretive flexibility.

Originally called "Arpanet," it was developed at the direction of the Pentagon for timesharing on mainframe computers. The goal was to ameliorate scientific communication for defense with an information exchange and calculating service. The key to its later evolution was the selection of an unusual method for processing data. Telephone companies managed data flows on central computers, but the Internet protocol enabled every host attached to the system to manage its own data. No centralized control over the system was necessary or possible. Frequent user innovation has been an unanticipated consequence of this approach

The Internet's unique technical structure reflected a social agenda, a secondary instrumentalization, for which control was less important than redundancy and survivability in the event of war. The corresponding primary instrumentalization is the notion of a distributed network in which data can take a multiplicity of paths to reach its destination. This elegant technical idea drew out the full potential of a technology called packet switching. Packet switching enables communications to be broken into small bundles of data sent out separately whenever there is available bandwidth on the network. The packets are then reassembled at their destination. This system achieves notable economies as contrasted with the telephone network's open lines which consume the same bandwidth whether or not anyone is actually talking. Long before the Internet achieved its present prominence, packet switching was deployed by telephone companies but in these early implementations it still shared aspects of their centralized structure.

The telephone network connects subscribers through a central switch. The central switch is no longer required in a packet switched network, yet it survived because of the limitations of early computers and the institutional momentum of the telecoms. Thus delivery and data flows were centrally controlled under the main early packet switching protocol, known as X.25. The distributed packet switched Internet was based on a competing protocol, TCP/IP, which included an address and packet order information in each packet and enabled each host to control its own data flows. But TCP/IP required hosts able to run a small program to construct the packets whereas X.25 networks were accessible from dumb terminals. The rise of TCP/IP thus corresponded with the fall in the price of computing power.

As personal computers spread, new actors introduced other agendas unimagined by the initiators of the Internet. These initiatives invested its original technical structure with new functions and social meanings. These agendas constituted additional secondary instrumentalizations to which corresponded various technical reconfigurations, primarily in the software running on the network. For example, the ability to hook up any computer running TC/IP turned out to favor the internationalization of the system in competition with national telecoms, each of which resisted joining a system controlled by the other. The French Teletel, which was many orders of magnitude more successful than any other national network, was unable to recruit other nations to its protocols and was slowly overtaken by the Internet.

The same design that enabled the Internet to expand geographically, also enabled it to expand socially. To its distributed technical structure there corresponded a distributed social structure. Of course this was not the original intention of the Pentagon planners, but their system was quickly colonized by communicative usages. The decentralization of the system made it relatively easy for users to reinvent it from one year to the next. In fact the first e-mail application was introduced by an engineer simply for fun and was not in the original plans of Arpanet at all. A circuitous path leads through many intermediary steps from that first initiative down to Facebook and the huge online lobbying organizations of today. No gate keepers can block these secondary instrumentalizations which have changed the over-riding meaning of the network from an information exchange to a space for community.

The Internet went public in the 1980s and the Web made it popular in the 1990s. At this point the scientific model of information exchange came into conflict with corporate interests. Meanwhile, all sorts of communicative applications developed rapidly on the now public Internet. This multiplicity of actors and interpretations yields alternative models of the Internet none of which has yet achieved closure.

As with bicycles, rational clothing, and feminism, so in this case the technology is an aspect of a larger complex of meanings. To understand that complex macro social concepts must be employed. The various models reflect ideologies, conceptions of society. The struggle between them implies different social visions, ultimately, different ways of life, not simply different technological designs and uses. The visions influence design and redesign and so are significant for the evolution of the system.

Three coexisting models compete today on the Internet. An information model stems from the original actors in the scientific community. A consumption model responds to the needs of business. A community model introduced by lay users has transformed the Internet into an innovative social phenomenon. If closure around one of these three models is so difficult to achieve, this is largely due to the policy of network neutrality. Under this policy no one type of data can be privileged and given extra bandwidth at the expense of other types. This has prevented powerful actors in business from turning the Internet into another broadcast medium at the expense of its communicative functions.

The significance of the community model appears clearly in the light of the Frankfurt school's critique of the mass media. The essential point of that critique was the surprising effectiveness of broadcasting in dominating the public sphere. This outcome needs to be understood in terms of the considerable interpretive flexibility of communication technologies rather than in a deterministic context.

The centralized structure of broadcasting, like that of the telephone networks is only one possible application of the technologies involved. But in both cases centralization responded to certain real limitations. For example, radio could have developed as a distributed system based on walkie-talkies, but only over very short distances given the cost and size of extending the range of communication. Only governments and corporations could broadcast widely to mass audiences silenced by the limits of their own technology. The dystopian fate of electronic mediation in the 20^{th} century was thus bound up with the positioning of its subjects as either local or regional actors. In the first case, they had a wide range of initiative but a short range of transmission. In the second case, the transmission range increased dramatically as user initiative was reduced to channel selection.

Broadcasting has the form of a star with all communication flowing out from the center and no reciprocal feedback. Communication on the Internet is quite different. It takes an interactive form without geographical boundaries. Computer networks offered the first technical mediation of reciprocal group communication, useful for work, learning, public discussion, and any other purpose that can be pursued by small groups using language. Huge reductions in the size and price of technical access made this possible.

The Internet weakens consensus by introducing unconventional viewpoints and making them visible to a large audience at no cost. The famous case of the Zapatista movement using the Internet to spread word of its cause initiated widespread awareness of these democratic implications of networking. Lately the election of President Obama owes a great deal to his campaign's mastery of the Internet. Something like a public sphere of discussion and debate revives on the network.

To contain the Internet within the limits of the broadcasting model would require extensive government intervention. Already one sees how hard it is for countries like China to control it. Where a single Rupert Murdoch can change what millions see and read, tens of thousands slave daily to censor the Chinese Internet. Perhaps flooding the network with entertainment would be more effective than repression, but even that may fail given the desire the Internet has awakened in millions of users to participate in online activities through free communication. The future of the networked society is very much in question.

Politics on the Internet reflects a wider phenomenon, the emergence of new forms of individuality and sociability. This phenomenon takes what might be called inauthentic and authentic forms. To be sure, there is a great deal of narcissism and posturing, but on the other hand opportunities for creative expression are multiplied to good effect. The manifestations of creativity on the Internet have led to new ideas about intellectual property most effectively implemented by the free and open source software movement. The emergence of large online communities has empowered their members on occasion to protest and enact their own vision of their rights. For example, when Facebook attempted to assert its perpetual ownership of all materials placed on its pages, users organized to block the change and forced a retreat.

The Internet has a particular relevance to technological issues. It connects scattered users and victims of the vast technical systems that underlie modern societies. Environmental campaigns employ the Internet to build constituencies from scattered indivdiuals affected by pollution and other problems. In the medical domain communities of patients have organized to demand increased research funding and access to experimental treatments. The Internet thus has a unique and still largely untapped democratic potential. Perhaps the most important manifestation of that potential to date is the defense of the Internet by its own users. This is democratic intervention for the sake of democratic communication.

The democratic applications of the Internet have implications for the theme of rationality and domination explored by the Frankfurt school. The first-generation Frankfurt school theorists had no solution to the problems they posed. Adorno and Horkheimer suggested that a self-reflective subject could restrain the impulse to domination, but this does not take us very far. Horkheimer's discussion of objective and subjective reason concludes disappointingly with the observation that he knows no way to recombine them for the new era in which we live. Objective reason thus remains as a vestige of traditional society rather than holding a future promise of redemption. Marcuse goes further to propose a return to objective reason through aestheticizing technological rationality but this solution remains too abstract to carry conviction.

The politics of the Internet and the agency of technical users and victims signifies the existence of an alternative: rationality from below. Technology is not simply a matter of artifacts but, as Latour has argued, it involves networks of individuals and things held together by various types of associations. In some cases the presence of the network is obvious, for example, a factory or a hospital, organized around the technologies that mediate the individuals' activities. In other cases a latent group constituted by the network may become aware of itself. As members of networks, individuals acquire participant interests that are more or less well represented by the technical codes presiding over the network's design. Foucault's notion of "subjugated knowledges" is useful for articulating the perspective from below, which reveals the blind spots of those in charge. This perspective can inform resistances based on interests slighted by the dominant design. Rationality and values come together in the incorporation of those interests in revised technical codes.

This is what I call "democratic rationalization." The term is an apparent oxymoron. In Weber rationalization means calculation and control and is implicitly linked to top-down management and administration. Weber assumed uncritically that organization in a modern society requires operational autonomy and this is what led him to pessimistic conclusions.

We must generalize beyond Weber's formulation to a view of rationalization that does not prejudice the future. This generalized notion of rationalization would still refer to optimizing means through calculation and innovation but it would not imply a hierarchical system of control. A different type of rational society is possible in which mutual discipline and democratic control offers an alternative method of management. By excluding this alternative apriori he condemned developed societies to an iron cage. But democratic rationalizations bend the bars of the cage. This possibility sheds light on the increasingly common interventions from below.

These interventions do not usually take the form of electoral politics. Rather, they emerge from controversies, hearings, lawsuits, participation in design, and creative appropriations. They often yield better working systems, for example, in the case of much environmental regulation, or the introduction of communication on computer networks. It is legitimate to call these "rationalizations" since they do improve efficiency albeit relative to goals established through democratic procedures. The effect of these interventions is to limit the operational autonomy of experts and to translate new values into regulations and codes.

In these cases the human beings enrolled in the technical network become self-aware and emerge as a community. They recognize that they inhabit a new world created by the technologies that enlist them. The community defends its participant interests on the basis of its subjugated knowledge and whatever scientific and legal advice it can get. Where struggles yield new meanings that feed back into technological development, they affect designs and technical disciplines. Public influence on technology is not an extraordinary external intrusion into an autonomous technical sphere but an intrinsic aspect of the dynamics of technical development. The technical sphere must be redefined to include the experience of users and victims as well as the knowledge of experts. Exchanges between them offer two different articulations of the same basic phenomena.

In one sense this could be seen as a generalization from Marx's approach to class struggle. Marx too anticipated technological change under a socialist system in which the workers who use technology would also determine its future. But now the emphasis has shifted from economics to design. The role of social and historical study of technology today corresponds to Marxist economics in demystifying a rational system and explaining struggles over design as rational too in a different sense.

Technical politics does not replace traditional politics but today no regime can ignore it. The neoliberal technocracy is vulnerable; it is time to replace it with a more democratic approach. We need to find ways of systematizing controversy and dialogue as methods of technological development. This is just as true of communist regimes as of capitalist ones, witness the huge conflicts in China over pollution and food safety. Technical politics promises to play an even more significant role in a truly democratic socialist society than under capitalism. It is time to reconstruct radical politics around these themes.

The health of any democracy is measured by the relevance, vigour and intelligence of debate in the public sphere. Despite many discouraging political developments in recent years, technological issues have been swept up in controversy, restoring some of the liveliness of public debate lost to broadcasting. This ambiguous situation calls for serious analysis. If a revised critical theory can bring philosophy to bear on the controversies surrounding technology today, that will be a significant contribution to the evaluation of the problems and prospects of contemporary democracy.

Chapter Four

Science, Technology and Democracy: Distinctions and Connections

Prologue: The Cold Fusion Fiasco

On March 23, 1989 Martin Fleischman and Stanley Pons appeared at a press conference at the University of Utah where they announced the discovery of cold fusion. The President of the university and several other officials were also present and spoke to the press. The unaccustomed involvement of the press and these officials signalled that cold fusion was more than a scientific advance. Soon the University announced the formation of a research institute with funding from the state. Its goal was not only to produce knowledge of the phenomenon but also to prepare large scale commercial applications. It seemed possible at first that cold fusion would revolutionize electricity production and transform the world economy.

We know the end of the story. Within a short time cold fusion was discredited and most researchers lost interest in it. The institute at the University of Utah closed in 1991 and support for further work in this field quickly evaporated.[21] These events provide a particularly clear illustration of the complexity of the relation between science and technology today.

The classic but generally discredited account of these relationships holds that science is a body of truths about nature and technology an application of these truths in the production of useful devices. Truth and utility belong to different worlds linked only by the subordination of the latter to the former. But historians have shown that few technologies arose as applications of science until quite recently. Most were developed independent of science and, indeed, in cases such as optics had more impact on science than vice versa. Science is even more dependent on technology today than in the past. It is true that the 20th century saw a dramatic increase in practical applications of scientific knowledge, but this new situation does not reveal the essence of the science-technology relationship. Rather, it confounds the common sense distinction by establishing the productive character of science itself.

[21] Simon, Bart (2002). *Undead Science: Science Studies and the Afterlife of Cold Fusion.* New Brunswick: Rutgers University Press.

In any case, the classic model does not describe cold fusion. Fleischman and Pons did not apply any existing science in their work but made an empirical discovery of the sort that we associate with invention. They were not seeking to confirm or invalidate a theory with experiment as philosophical accounts of scientific method would have it, but rather aimed to produce an unexplained (and ultimately unexplainable) effect. Their discovery employed a technical device that was both an experimental apparatus and a commercial prototype. Accordingly, the two pronged launch of their discovery at a new conference aimed at both the scientific and the business communities.

Cases such as this one proliferate in the biological sciences, where scientific techniques are deployed in the search for results of interest not only to researchers but also to pharmaceutical houses. Products and knowledge emerge from the laboratory together. The pursuit of knowledge and the making of money are joined in a single labor. The distinction between science and technology appears to break down. Hence the widespread use of the term “technoscience.”

Distinguishing Science and Technology

Postmodern scholars and many researchers in Science and Technology Studies no longer believe there is any distinction of principle between science and technology. This scepticism about the traditional distinction confirms the worst prejudices of some leftists who blame science and technology for the mess the world is in today. Certainly the boundaries between science and technology are much fuzzier than in the past and science is thus implicated in the failures of technology to an unprecedented extent. But if we conclude that they are no longer distinguishable at all, what becomes of the associated distinctions between theory and practice, research and application, scholarship and business, truth and utility? Must they be given up too?

The old distinction between science and technology and all these associated distinctions implied a value hierarchy. Science, theory, research, scholarship and truth were considered nobler than technology, practice, application, business and utility, in accordance with the ancient preference for disinterested contemplation over worldly activity. This hierarchy grounded the demand for the complete autonomy of science. In 1948 P.W. Bridgman expressed this “ivory tower” indifference when he said “The assumption of the right of society to impose a responsibility on the scientist which he does not desire obviously involves the acceptance of the right of the stupid to exploit the bright."[22]

As the distinction between science and technology blurs, the value hierarchy that justified such outrageous snobbery loses its persuasive force. A basic change has occurred in the relationship between science and society. There is growing openness on the part of science to various forms of political and economic control and in some cases what I will call "democratic intervention" by lay members of the public. But what exactly do we mean by this?

Certainly not eliminating the laboratory, obliging scientists to work with the public looking over their shoulders, and relying on government for epistemic decisions. Democratization and political and economic intervention into science are more modest in their objectives for many reasons. But public action regarding technology is considerably more ambitious. It occurs more and more frequently and it often leads to direct intervention by citizens and governments into technological decisions and even into the decision-making criteria employed to select technologies.

The old value hierarchy has been scrambled in recent years as more and more scientific work aims directly at producing marketable goods. We live in a two dimensional flatland, not a three dimensional universe with vertical coordinates. But despite the changes, we cannot do without the old distinctions. They correspond to vital strategic divisions within the world of politics. The question is, how can we reconstruct the distinction between science and technology without falling back into an outmoded valuative framework? That is what I will attempt here.

In the remainder of this presentation I want to offer a new framework for discussing the relationship between science, technology and democracy. I will discuss four issues. First, I want to introduce some basic criteria for making the distinction that concerns us here. Second, I will propose a sketch of the evolving cognitive relation of science and society in recent years. Third, I will argue that democratization has a specific significance for technology it does not have for science. In conclusion I will place the issues raised in this lecture in a wide historical context.

[22] Bridgman, P.W. (1948). "Scientists and Social Responsibility," in *Bulletin of the Atomic Scientists,* vol. 4, no. 3, p. 70.

Two Criteria

Even if it is sometimes difficult to distinguish the pursuit of truth from the pursuit of utility, other criteria enable us to the make a usable distinction between science, technology and technoscience. I am not concerned here with the obvious cases such as the difference between theoretical physics and road work. The difficult cases are more interesting. They arise in the expanding zone of activities that appear to cross the line between science and technology. Engineering has always occupied that zone at the cognitive level, but in practical terms it usually contributed to technical projects. Today the projects themselves have lost clear definition. Criteria for distinguishing science and technology can still be developed from study of scientific and technological practice, for example, the subtle differences in the roles of knowledge and technique in experimental research and science based technology.[23] Here I will focus on criteria reflecting significant differences in governance and procedures because they are directly relevant to the politics of science and technology.

Since the 17th century, the study of nature has been organized by scientific societies and communities, at first informally, and later formally and officially through academic credentialing and employment. This relative cohesion and autonomy of the scientific community persists even today despite all the intrusions of business, government, and the public. Scientific controversies are decided by the scientific community, or rather, by what sociologists of science designate as a "core set" of researchers engaged in debating the relevant scientific issues. Social, cultural and economic constraints play only indirect roles in these debates, for example, empowering some participants to carry out expensive experiments or influencing the initial response to the announcement of results. But in the final analysis epistemic tests carried out by individuals or small groups in conferences, articles, and laboratories are the principal measure of competing ideas.

I do not mean to imply that scientists' ideas are free of social influences, but they do often achieve credible knowledge of nature and this is their primary aim, the make-or-break factor in their work, even if that work also involves them in commercial activity. Technology too involves knowledge of nature but many of the most important decisions in this case are not about knowledge. A quite different history has shaped the domain of useful invention and production. Technology has

[23] Radder, Hans (2009). *Handbook Philosophy of Technology and Engineering Sciences,* ed. A.Meijers,. Amsterdam: Elsevier, pp. 71-87.

always been far more closely integrated to society than science, either through institutions such as guilds or through direct employment in industry.

Social and economic criteria are relevant to technological choices and intervene through the mediation of organizations such as corporations or government agencies that employ technical workers. These workers, who may be scientists, are usually situated in a chain of administrative command leading up to individuals in non-technical roles with wide responsibilities that have nothing to do with knowledge of nature. Where those individuals determine outcomes, we can be fairly certain we are dealing with a primarily technical activity, even if scientific knowledge is ultimately generated as a by-product.

Of course the boundaries are fuzzy, as scholars in science and technology studies insist. It is easy to cite examples that are difficult to classify. Technical workers, until recently of lower class background and poorly educated, have always possessed considerable knowledge of nature. Galileo's dialogue on Two New Sciences begins with a reference to "conferring" with the wise craftsmen of the Arsenal, as though with intellectual equals.

The science/technology distinction is often associated with the distinction between academic and corporate-military research. But there are obvious counter-instances such as Bell Labs where high quality scientific world has been done under corporate auspices. Nevertheless, there is a difference between the kind of research done in universities and Bell Labs and most product development, including development that employs laboratory methods but which is conducted in secret or used to promote specific products.

The institutional separation of mainstream science and technology, consecrated in the 19th century in the academic status of the most important researchers while engineering became a staff position, has developed continuously from one generation to the next for centuries. This suggests a first criterion for distinguishing science and technology: the difference in decision procedures in the two cases.

Current technoscience does not represent the erasure of the difference, but only its latest stage. The cold fusion affair illustrates this stage, in which science and technology are practiced simultaneously. The pursuit of commercial cold fusion depended on the willingness of the state of Utah to invest in a likely money-maker. The research was to be oriented toward this goal. Within the institute the existence of cold fusion was not in question and the experiments were conducted in secret. But the very same effect which the organization was created to exploit was also exposed to scientific evaluation and this proved to be decisive. There the potential profits to be made on commercial electricity production were attention-getting but less significant. Scientific criteria were brought to bear on the effect, so far as knowledge of its production was available, and it was rapidly discredited, primarily by two epistemically significant factors: failures to reproduce the effect in the laboratory, and lack of a plausible connection between the effect and existing theory. Clearly, truth and utility still belong to distinguishable worlds, even if they refer to aspects of one and the same phenomenon and often cross boundaries in pursuit of their separate goals. The point of intersection, where scientific and technological criteria must both be aligned, corresponds to successful technoscience.

A second related criterion useful for distinguishing science and technology is the different role of underdetermination in the two cases. The concept of underdetermination was introduced by the French historian Pierre Duhem to explain the fact that scientific theories are not uniquely determined by observation and experiment. The interpretation of these tests of theory always depends on other theories and so the whole edifice of knowledge is implicated in the evaluation of any particular branch of it. In practice, this means that no logically decisive experiment can relieve the researcher of the need to make a personal decision about the truth or falsity of the tested theory. Such decisions, Duhem claimed, are based on "good sense." They are rational, but not possessed of the certainty often claimed for science.

Cold fusion illustrates this conclusion, if not Duhem's precise point, since failures to reproduce the effect were interpreted by Pons and Fleischman as technical breakdowns and by their opponents as proving the non-existence of the effect. The decision between these two interpretations could not be made on the basis of experiment alone since the competence of the experimenters was in question.

Variations on this theme have been discussed in philosophy of science for a century. No doubt there is something to it. But Pons and Fleischman discovered that ad hoc explanations are weak defences for anomalous and conflicting experimental results such as characterized the cold fusion case. The only effective move in such cases is the production of new theory that encompasses old and new observations alike. But the production of plausible scientific alternatives is extraordinarily difficult. Advocates of cold fusion were unable to supply one. Their failure is not unusual. Although Einstein objected to the uncertainty principle, he found it impossible to come up with something better. Creating new scientific theory requires rare originality and a special kind of critical insight into existing theory.

The case with technology is quite different once again, not least because alternatives are usually easy to invent. The concept of underdetermination can be adapted to signify this difference. It is obvious to engineers and other technical workers that no "technological determinism" or "technological rationality" dictates a single design of each device. The technical equivalent of Duhem's "underdetermination" of scientific observation and experiment is the proliferation of alternative designs of roughly similar devices. Just as observation and experiment can have different meanings in different theoretical contexts, so devices can be designed differently and have different meanings in the larger framework of the society.

There are of course hard technical problems such as the AIDS vaccine. We will be lucky to find a single successful design, much less a multiplicity among which to choose. But most technical problems are not so hard and alternatives are available. The question then is how choices are made among them. Technical underdetermination leaves a wide opening for social, cultural and economic criteria to weigh on the final decision between alternatives. The equivalent of scientists' "good sense" in this case is supplied by management sending orders down the chain of command to technical workers whose advice they may or may not have taken into consideration. This high degree of flexibility is what makes the management of technology development possible with a degree of top down control that is very unusual for science.

Again, technoscience is a special case in which characteristics of both science and technology are mixed. Aspects of technoscientific work share the very limited scope for alternatives typical of science, while other aspects compensate with a wide range of technical possibilities. The development of pharmaceuticals is a good example. A great deal of scientific knowledge is involved, and this is organized in an at least provisionally authoritative corpus. Management does not pick and choose among the items in this corpus but relies on scientists to identify the useful bits. At the same time, experimental substances abound and research laboratories have developed procedures for rapidly mining the possibilities for worthy candidates for study. The study of these candidates is arduous and expensive and often leads to ambiguous results. Managers and government agencies are deeply involved with the selection of research projects and the approval of new drugs.

The blurring of the boundaries between science and technology has brought huge sums of private money into research with many useful outcomes. But it has also had an unfortunate influence on the evolution of research funding. In recent years neo-liberal ideologists have convinced governments that the responsiveness of science to society is measured by the commercial success of its applications. Such a tight bond between business interests and research funding is not always desirable. Publication and public support for basic research in a wide variety of fields, including many with no immediate prospect of commercial payoffs, are the basis of long term scientific advance. Practices of secrecy, deception and tight control over employee speech that are commonplace in the business world distort research and damage careers. It is also essential that science have the means to serve the public interest even where business prospects are poor, as in the case of medicines for "orphan" diseases. This new system reduces science to a handmaiden of technology, with unfortunate consequences because not all of science is "techno-" and not all "techno-" is profitable.

Democratizing Science

With these distinctions in mind, I want to introduce some historical considerations on the concept of the democratization of science. Science was always marginal to national politics until the Second World War. The Manhattan Project and radar research actually changed the course of the War and thereafter the union of science, government, and eventually business became one of the driving forces of social and economic development. Science was exposed to new forms of public intervention as a result. I will sketch this history very briefly in the American context.

The Manhattan Project played a special role in this transformation of the relationship between science and society. The scientists involved were sworn to secrecy throughout the War. They acted as agents of the federal government under military command. But they realized toward the end, when it came time to decide whether or not to use the bomb, that they were not simply government employees. Because of the secrecy of the project, they were also the only citizens able to understand the issues and express an opinion.

Under the leadership of Leo Szilard and James Frank they attempted to enact their role as citizens by petitions and reports advocating non-use. They were unsuccessful but after the War, when they were no longer bound by military secrecy to the same degree, a number of them committed themselves to informing public opinion. The famous

Bulletin of the Atomic Scientists was the semi-official organ of this "scientists' movement." It had wide influence but it took many years for its advocacy of test bans and disarmament treaties to have an effect on public policy.

There was a strong element of technocratic paternalism in this movement. In the immediate post-War period, up until the middle 1960s, technocratic notions were widely believed to chart the course for the future of modern societies. Politics was increasingly guided by technical experts of one sort or another. But the problem of what to do about public opinion remained once its input was devalued relative to expert advice. One solution consisted in refining the techniques of persuasion. Scientists chose a more respectful alternative and attempted to educate the public. Their efforts were motivated by the sense that an uninformed public might obstruct essential government decisions based on scientific knowledge.

This experience influenced the attitude of scientists in the 1960s and '70s as the environmental movement began to take shape. Biologists saw themselves in the role of the atomic scientists of the post-War period, possessed of knowledge of critical importance to the public. They too attempted to inform the public, advocating science-based solutions to problems most people could barely understand.

But technocratic paternalism soon gave way to a new pattern. Disagreements arose among environmentalists in the early 1970s and weakened the authority of science. True, some physicists disagreed over issues such as civil defense but the vast majority of the articulate scientific community favored the policies embodied in the treaties that still falteringly regulate nuclear affairs. No such consensus emerged in the environmental movement. In fact there were open conflicts over the causes of pollution, some blaming over-population and others blaming faulty technology, some calling for more vigorous regulation of industry, others for a return to nature or at least to "voluntary simplicity."[24]

The appearance of politically significant splits in the environmental movement meant scientists could no longer occupy the role of teacher to an ignorant public, but that they were obliged instead to play politics in the search for public support. For a population that made little distinction between science and technology, the loss of authority that resulted from these controversies was amplified by a series of technological disasters. The Vietnam debacle testified to the limits of the kinds of knowledge and power the technocratic state had at its disposal. The Three Mile Island nuclear accident in 1979 refuted the standard measures of risk put forward with such misplaced confidence by the scientific and engineering community. The Challenger accident in 1986 was a rebuke to the hubris of a nation that was proud of having put a man on the Moon. Many other incidents contributed to a gradual shift in sentiment and by the end of the millennium few young people were choosing scientific careers and strong fundamentalist movements were increasingly effective in opposing the teaching of science in schools.

Against this background a new configuration gradually emerged. By the 1970s we were beginning to see more public awareness of medical and environmental issues that affected individuals directly in their everyday experience. These issues were not confined to the realm of public discourse as had been nuclear issues in an earlier period. Now individuals found themselves involved in scientific-technical controversies as victims or potential victims of risky technical activities. In cases such as these ordinary people sometimes possess part of the truth before scientists interest themselves in their problems. That is a reason for scientists to listen as well as speak, to accept the role of learners as well as the role of teachers. In this context small groups of scientists, technologists and citizens began to explore an entirely new relationship between science and society. This relationship took the form not of paternalistic education but of a true collaboration with community activists.

A signal instance was the Love Canal struggle in the late 1970s. Residents of this community organized to demand government help dealing with the nearby toxic waste site that was sickening them and their children. They worked closely with volunteer scientists to document the extent of the problem and eventually won reparations. In this case lay informants brought a problematic situation to the awareness of scientists and collected useful epidemiological data for them to analyze.

Another similar movement among AIDS activists in the 1980s started out with considerable conflict and distrust between patients and the scientific-medical community. Patients objected to restrictions on the distribution of experimental medicines and the design of clinical trials. But the struggle eventually died down as the leaders of patient organizations were invited to advise scientists and physicians on a more humane organization of research.[25] This lay intervention added a new

[24] Feenberg, Andrew (1999). *Questioning Technology,* chap. 3. New York: Routledge.

[25] Epstein, Steven (1996). *Impure Science*. Berkeley, University of California Press.

ethical dimension to scientific practices that were not well conceived from the standpoint of current values. The changes were also cognitively significant since they made it easier to recruit human subjects and to insure that they cooperated in supplying researchers with the desired information.

These are American examples but other cases and other institutional procedures in other countries confirm the general pattern: from indifference to paternalism to signs of democratic engagement between science and society. If this trend develops widely, it promises to make a lasting contribution to democracy in technologically advanced societies.[26]

Technology and Society

I have left an ambiguity in the above history. I cited a weapon, a toxic waste site, and a disease. Both science and technology were involved in these technoscientific examples but too often they are treated as illustrating the disastrous consequences of science alone. In my view it is a mistake to focus exclusively on the relationship between science and society in discussing cases such as these. That approach emphasizes the cognitive aspect of the relationship and obscures the problem of authority. But when science leaves the laboratory and enters society as technology, it must serve many other interests besides the interest in knowledge. As we have seen, technology is a field of activity in its own right. It is not a mere application of science. Industrial organizations intervene between the work of scientists and their technoscientific products. These organizations are independent mediations with their own logic and procedures. Technical creation is far less protected from lay intervention than is science in its cognitive role.

In those fields properly described as technosciences the situation is complicated by the ambiguity of the various activities involved in research and commercialization. When the actors seek more autonomy, they claim to be doing science; when they seek financial support they claim to be engaged in technology. Jessika Kammen describes an interesting case where researchers working on a contraceptive vaccine attempted to offload all the difficulties onto complementary "technologies" while reserving the title of "science" for their work. The distinction enabled them to continue pursuing the vaccine without worrying about the practical obstacles to its actual deployment.[27] Here the distinctions we are working with become political resources, but this should not blind us to what is really at stake in this case, namely, the welfare of millions of women and their families.

The reason for the difference between the role of the public in science and technology is simple. While scientific theories are abstractions and experiments are confined to the lab, technologies supply environments within which ordinary people live. Experience with these environments is a potential source of knowledge as we have seen, and everyday attitudes toward risk and benefit prevail there. All this distinguishes lay publics from scientists and technologists whose knowledge is formalized and who evaluate risks and benefits with mathematical tools.[28]

Bridgman simply dismissed the public as "stupid," but this is no longer possible. All too often lay observers have turned out to be the canaries in the mine, alerting scientists to overlooked dangers. And scientific and technical disciplines contain many traditional elements introduced during an earlier state of the society and its culture. In the case of technology the persistence of these elements past their time sometimes causes harm and motivates challenges from below that bring the tradition up to date.

Consider the huge variations in obstetrics from one time and place to another. Not so long ago husbands paced back and forth in waiting rooms while their wives gave birth under anaesthesia. Today husbands are invited into labor and delivery rooms and women encouraged to rely less on anaesthetics. The result of scientific discoveries? Hardly. But in both cases the system is medically prescribed and the role of the feminist and natural childbirth movements of the 1970s that brought about the change forgotten. A technological unconscious covers over the interaction between reason and experience.

There is a further distinction between the relation of science and technology to society. Even when they employ scientists and scientific knowledge, corporations and government agencies should not en-

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26 Callon, Michel, Pierre Lascoumbes, Yannick Barthe (2001). *Agir dans un Monde Incertain.* Paris: Seuil.

27 Kammen, Jessika (2003). "Who Represents the Users? Critical Encounters between Women's Health Advocates and Scientists in Contraceptive R&D," in N. Oudshoorn and R. Pinch, eds., *How Users Matter: The Co-Construction of Users and Technology,* Cambridge, Mass.:MIT Press, pp. 151-171.

28 Collins, H. M. and Robert Evans, "The Third Wave of Science Studies: Studies of Expertise and Experience," *Social Studies of Science* 32/2(April 2002) 235–296.

joy the relative autonomy of science. Their products give rise to controversy not about ideas but about potential harm. Those in the best position to know are usually associated with the very organizations responsible for the problems. But these organizations cannot be trusted to tell the truth or to act on it. Of course many corporations and agencies are honest, have the public welfare at heart and act accordingly, but it would be imprudent to generalize from such instances to the conclusion that vigilance and regulation is unnecessary.

The dominant feature of this relationship is the potential for conflict of interest. Familiar examples are the manipulation of information and the manufacture of artificial controversy by the tobacco industry with respect to lung cancer and energy companies with respect to climate change.[29] Conflicts of interest in such cases give rise to political struggles over regulation and, unlike scientific controversies, we do hope democratic procedures will decide the outcome rather than a "core set" of actors, namely, the corporations and agencies involved.

There is thus an enormous strategic difference between the science-society and the technology-society relationships. No matter how extensive the many interdependencies of scientific research and technology, no matter how blurred the boundary between them may sometimes be, there remains a fundamental difference with real consequences. In the case of scientific research we may value public input on occasion but leave scientists to draw their own conclusions. We may suspect particular scientists of incompetence or chicanery and ask for second opinions, but in the end we must rely on the scientific community. We do not have a similar confidence in corporations and governments. When they order up "truths" on command the results are disastrous. Nothing has changed in this respect from Lysenko to HIV denial in South Africa.

As public institutions corporations and government agencies, including those that employ scientists, must submit to democratic control of their activities. That control is often extensive and detailed and needs to be where their products circulate widely with significant public impacts. Thus we do not want an oil company or a government agency rather than scientists to decide if climate change is real, but we are not worried when the government orders a medicine off the market or bans a pesticide. Such decisions are a normal exercise of governmental authority and easily implemented by technical workers because, as noted above, so many viable alternatives are generally available.

The danger in confusing the cases is that when we demand democratic intervention into "technoscience," we will be understood to blur the line between cognitive and regulatory issues. Unless we keep these issues clearly separate we will appear to be irrationalists rejecting science when in fact we need it precisely in order to control the activities of technological actors such as corporations.

Differentiation and Translation

These reflections on the changing relation of science and technology are aspects of a much larger transformation of modern societies. Modernity has been characterized by sociologists since the end of the 19th century as a society in which social functions are highly differentiated. The obvious example is the differentiation of offices and persons. In a feudal society offices are family property and are inherited, whereas in a modern society individuals must qualify personally to hold offices which they cannot leave to their children. When dictators promote the succession of their sons or voters favor the children of prominent leaders, we immediately sense incipient de-differentiation, a suspicious cultural throwback.

Differentiation makes modern science and technology possible. The emergence of scientific specialization and the separation of technical work from everyday life mark major milestones in the process of modernization. The case of technical work is particularly significant for understanding the problems of modern societies. In premodern Europe crafts were organized by guilds that had social and religious functions as well as regulating training, quality control, and standards. The crafts of this period were thoroughly integrated with society and craftsmen communicated easily with the authorities and customers using everyday language and traditional concepts shared by all. Indeed, many craft products required finishing by users who thus participated in a small way in the production process. Remember "breaking in" smokers' pipes, shoes and car engines, bygone practices for which few are nostalgic.

Differentiated technical work draws on specialized scientific knowledge and speaks a language inaccessible to the mass of users of its products. At the same time, the stripping away of social concerns, such as preoccupied the guilds, breaks the last links between technology and tradition. Instead, most technical work is now situated in the

[29] Michaels, David (2008). *Doubt Is Their Product: How Industry's Assault on Science Threatens Your Health*. Oxford: Oxford University Press; Oreskes, Naomi and Erik M Conway, *Merchants of Doubt: how a handful of scientists obscured the truth on issues from tobacco smoke to global warming*, Bloomsbury Press, New York, 2010.

context of capitalist enterprise. This has dramatic consequences we are only beginning to fully understand.

Capitalist ownership is also affected by the process of differentiation. Owners of property, especially land, in precapitalist societies had broad responsibilities to tenants that included political, judicial and religious functions. These are all stripped away as capitalism defines a new concept of ownership based on personal labor. This new concept of ownership focuses the organizations capitalism creates, the corporations, factories and stores, on a single simple goal: profit. Responsibilities to workers and the surrounding communities are abandoned.

The industrial revolution occurred under this dispensation. A heritage of indifference to nature and human beings lies in the background of the development process from which modern technology first emerged. Throughout the process capitalism drew on specialized scientific and technical knowledge for innovative ways of making a profit. The narrowness of these specialized bodies of knowledge complemented the narrowness of the structure of ownership. A sharp focus on a vastly simplified view of the problems to be solved with technology accelerated progress while also multiplying unexpected side effects.

So long as those harmed by this process were too weak or ignorant to protest, the juggernaut of capitalist technology could go forward unimpeded. But in the post World War II period, two new trends emerged. On the one hand, the technologies became far more powerful and dangerous, causing more frequent and visible harm. This trend culminates in the technosciences which transform science and technology into a powerful productive force. Their unity can be understood as an original type of de-differentiation. It does not involve regression to an earlier undifferentiated state but advance to a new configuration in which the interpenetrating institutions greatly enhance each others' powers.

On the other hand, as technical transformations affect more and more of social life under this new dispensation, unions and social movements became more influential and regulation of industry more widely accepted as a normal part of political life. As a result, a slow compensatory process begins which continues down to the present. This process also is also de-differentiating and compels industry to respond to a wider range of values and functions than profit, or rather, compels it to seek profit under an ever widening range of constraints. At the same time, this process also encourages various interdisciplinary scientific initiatives which attempt to encompass the full range of effects of our action on the environment and the human body.

It is in this context that we discover the many conflicts between technology, the environment and human health. These conflicts do not arise from the essential nature of technology but from the confluence of specialized knowledge and the narrowing of social responsibility characteristic of capitalist ownership. As we attempt to move forward toward a reformed technology, the role of everyday experience in technoscience and technology is re-evaluated. Where formerly cognitive success required breaking all dependence of technical knowledge on everyday experience, experience now appears as a final court of appeal in which technical knowledge must be tested. The limitations and blind spots of specialized knowledge are no longer routinely smoothed over and ignored. They have become targets of questioning and protest as users and victims of technology react to the suffering they cause.

This and not hostility to science and technology explains the new climate of opinion in which the autonomy of scientific and technical institutions is increasingly challenged. The goal of these challenges is a science and technology that responds to the claims of the environment and human health and not just to profit and the technical traditions built up under the influence of capitalism. This aspiration can only be fulfilled through a long corrective process in which the return to experience for validation of technology focuses attention on those of its effects which were ignored as it was differentiated from everyday contexts to create specialized disciplines and to better serve capitalism. The return to those lost contexts is no relapse into romantic immediacy, but requires ever more complex social and technical mediations.

This process cannot succeed through destroying the institutions within which science and technology have developed. Rather, it must develop its own institutions for translating social knowledge about technology's harmful effects or overlooked potentialities into new technical specifications for better designs. These institutionalized modes of intervention are gradually emerging. They include protest movements and lawsuits, but also various forms of apriori participation in debate and design which attempt to inform technical work before products are released on the public. The routinization of the translation process is a foreseeable outcome of these activities. Translation in this sense completes the circle in which technology modifies society while itself being modified by society. This is an important democratic advance.