Ten Paradoxes of Technology

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[draft: not for distribution]

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.

These facts form the context for the growing interest in the study of technology in the developing world. Awareness that standard strategies of development are not working for everyone 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 *re-modernization* 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 such "modern" technologies as the automobile since the automobile 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.

The "Prologue" to this book is based on articles published in several Chinese business journals. The interest in Chinese business circles in Western technology studies is significant, however marginal at present. China is the poster child for standard development strategies despite increasingly visible catastrophic side-effects. Critique may yet play a role in encouraging the necessary correctives.

The first chapter is an expanded version of a lecture delivered in 2009 in Brasilia to the international conference of the Social Technology Network. 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 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 environmental pollution, we should be engaged in a process of social experimentation leading to a new understanding of progress.

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 publications and lectures, Cao Kezhen, 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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Prologue
Thoughts on Development

Marx wrote *Das Capital* in England, inspired by the industrial revolution which first took off in that country. But he wrote the book in German. In the preface he explained the relevance of the English experience to still agrarian Germany with a Latin phrase: "De te fabula narratur," which translates "Of you the tale is told." By this Marx meant that the future of Germany was already visible across the water in England. And so it was. Germany industrialized too toward the end of the 19th Century.

Soon thereafter Russia and Japan entered the race to industrialize and later social theorists adopted Marx's prophetic confidence that late modernizers would recapitulate the experience of the early forerunners such as England. However, national particularities and the consequences of earlier developments made for significant differences in the "tale" of modernization in Russia and Japan. Today it is China of whom the old tale is supposed to be told. But in this case too the similarities begin to recede before the differences.

The models for China's rapid economic advance are the US, Europe, and Japan, and the obstacles are usually said to be inheritances from Chinese history and culture. But there is an enormous problem with this way of telling the story of progress: China's large and diverse population. Russia is also big, but it has its own vast resources. When Japan entered world resource markets its purchases represented a small increment in demand. Exploration and exploitation of new resources could easily match anything Japan required.

In the case of China imitation of the very wasteful consumption models of the existing industrial societies threatens huge disequilibriums in resource markets, especially in energy. The waste, furthermore, appears to be incompatible with effective strategies for dealing with the increasing inequalities that threaten social order.

The statistics explain why the tale cannot be told in the same way everywhere. With 4.5% of world population the United States consumes 25% of world resources. It also emits a corresponding percentage of world pollution. This is the result of several centuries of industrial development in the world's most dynamic economy.

China still trails far behind in total wealth. Its population is a bit more than four times that of the US but its share of world wealth is about one eigth the US share. Per capita income in the US is over 30 times that of China.

But China is catching up. It is growing four or five times as fast as the US. Extrapolating the trend, China too becomes a moderately wealthy country in the not too distant future, and this seems likely to happen if no great disaster arrests its progress.

This is the premise of the *China Modernization Report 2006* published by the Chinese Academy of Sciences. The report's optimistic scenario projects growth at current rates until 2050, at which time China will be 10 times as rich as it is at present. Poverty will have been abolished, five hundred million peasants will have moved to the cities, six hundred million urbanites will have moved to suburbs, and half the population will own cars. The author admits that this will be difficult to achieve but he believes it possible.

Of course the projection may be falsified by all sorts of contingencies. Forty five years is far too distant a future for anyone to foresee with confidence. But the significance of this document has less to do with the future than the present. The *China Modernization Report 2006* reveals contemporary aspirations. It is intended to inspire efforts rather than to guarantee results.

This is precisely what is most disturbing about the report. China today aspires to a future that bears a startling resemblance to the American present. The US is the country of car ownership and suburbanization. This is the model of wealth that has driven development in our economy since World War II. The report adopts this model uncritically for China and presumably this reflects the image of wealth in the minds of many Chinese citizens for whom modernization is Americanization. This is the image of modernity that has been most effectively transmitted by films and books that present the US as a utopia, an ideal of prosperity.

But there are two problems with this ideal: it is both unrealizable and undesirable.

Why can't China be rich in the same way as the US? The answer is simple. The American model consumes a quarter of the world's resources with a population a fourth the size of China's. The other 75% of the world's resources must be shared by 96% of the world's population. Multiply China's wealth 10 times over and where will it find the resources to sustain an American level of consumption? The problem of pollution is just as severe. America contributes about one quarter of all greenhouse gases. If China catches up it will flood the atmosphere with carbon dioxide, accelerating climatic trends fatal to its own agricultural productivity. This is clearly an economic and environmental dead end.

Can minor tinkering with the technology of American modernity solve the problem? That seems unlikely. The gas mileage of automobiles can certainly be doubled, but if the report's predictions are realized, China alone would double the number of automobiles in the world during an era of declining oil production and rapidly expanding demand for energy in other large underdeveloped countries such as India and Brazil. This makes no sense.

What about really radical technological transformation? Will fuel cells or some similar technology save the American post-war model and enable China to emulate it? This is possible but now we are in the realm of science fiction. In this realm anything and everything is possible. Gambling the global future on as yet uninvented technology also makes no sense.

Of course the world will not "run out" of oil all of a sudden because millions of Chinese buy Toyotas. But the price of energy can rise to the point where a social and economic model based on automobiles is impractical, leaving China stranded with enormous investments in an outmoded transportation system. Although cars and trucks will no doubt continue to be used where they are most appropriate, it seems unlikely that most people will drive to work or to the store to shop in a foreseeable future.

Apart from the question of whether, or rather how soon, the shift away from private automobiles may occur, there is a larger issue which has to do with the imitative basis of Chinese modernization. Imitation of technical knowledge, know-how and design can speed up development enormously. Transfers of technology and the knowledge on which it is based have been going on for thousands of years, including of course transfers from China to the West in earlier times. Without the possibility of drawing on the intellectual resources of the whole planet, development would slow to a crawl.

But imitation of technical knowledge is quite different from imitation of the model of consumption of the advanced countries. By a "model of consumption" I mean a specific basket of consumer goods and associated infrastructures that includes necessities and also the typical luxuries identified with prosperity in a given society. Technical knowledge is similar from one place to another, but what people prefer to consume varies widely and there is no absolute criterion by which a best model of consumption can be distinguished. This is not a matter of the accumulated knowledge of the human race but a local cultural phenomenon.

What it signifies to be rich and successful at any given point in history is relative to cultural factors that call into existence the corresponding technologies to the extent the prevailing level of technical knowledge and resources permit. Different times and places, different ideas of wealth. But China is importing a model of consumption along with the technologies designed to serve it. The deep question of what model of consumption might emerge from indigenous cultural roots and local resources is not addressed.

This does not mean that China will have to remain poor if by poor we mean a lack of access to basic necessities, a wide variety of consumer goods, education, and opportunities for many individuals to develop and apply their talents. The point is rather that what it means to be rich is subject to social definition and redefinition. Korea has a level of computerization and computer usage unrivalled in the world today but fewer cars per capita than the United States. Which society is more prosperous? French people eat far better food than Americans, but live in smaller lodgings. Who is better off? There are no final answers to such questions.

Furthermore, objective constraints and subjective desires do not always stand opposed. Rather, culture shifts in response to reality in interesting and complex ways. What people want and what they can realistically expect often change together. We can hope that constraints on Chinese development will be internalized as part of the culture and influence preferences, rather than simply experienced as obstacles to prosperity.

The *China Modernization Report 2006* offers a hint of how this might play out. The author imagines a wealthy China providing everyone with full medical insurance and access to 17 years of education; life expectancy would rise to 80 years, and the percentage of skilled knowledge workers would rise from the current 10% to 50%. These social goals are independent of the projected suburbanization and automobilization of Chinese society. In fact, they may well contradict it and offer an entirely different alternative future.

For all its wealth the United States has not achieved these goals. Approximately 45 million Americans are without adequate health insurance and educational levels are nowhere near as high as in other developed countries. Infant mortality rates are comparable with Lithuania, not France or Japan. Poverty is still widespread in the US, as hurricaine Katrina revealed, and America's rapidly growing prisons contain over two million people for a population of about 300 million, nearly one percent. The gap between rich and poor continues to grow and race is still destiny for millions of Americans. Social policy appears to have very little effect on these well known problems. It is hard to escape the conclusion that American society has misallocated its resources in an environmentally and socially disastrous way.

Such misallocations can be far more serious in a poor country than a rich one. On a recent trip to Brazil I was told that 50% of the population belonged to the “excluded.” “Excluded from what?” I asked. “From the modern economy,” was the reply. This remarkable statistic suddenly struck me with unusual force: exclusion in this sense characterizes the great majority of the world’s population, yet we rarely give that fact a thought. Why is “exclusion” itself excluded from our consideration?

I think the answer to this question is a historical analogy: the reassuring myth of modernization. The history of Europe, North America and Japan also records a time when the majority of the population still lived in a traditional, premodern economy while islands of modern economic activity rose in its midst. As industry expanded, it gradually absorbed the whole population into the modern world we take for granted.

Since World War II, we in the developed world have considered ourselves to be living on islands of modernity in the global economy, similar to the modern sectors of our own economies in earlier times. We assume that we are destined to pull the developing world into modernity just as the peasants of England and France were once similarly pulled into the modernity of their day.

And in fact there has been much progress. The modern sectors of large countries such as Brazil, India and China have expanded mightily in recent years. And yet, the “excluded” are still far more numerous than the “included.” It is time to ask whether the happy progress so far observed can continue to the point where the entire planet lives like us in the developed world. This hope is now very much in doubt as modernization comes up against the environmental crisis.

The modern economy is too resource and energy intensive to be viable with additional billions of participants. We are aware of this and have engaged an evolutionary process of regulation and technological innovation 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 in Latin America, and worldwide corruption, which causes waste and public health catastrophes, and which provokes considerable political violence in China. 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 progressive 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. For a time neo-liberal ideology consecrated the outcome. We lived in “the best of all (economically) possible worlds.” Recent events cast doubt on the wisdom of the clumsy historical process to which we owe the present configuration of our economy. We are committed now to regulatory measures aimed at correcting the worst results of this history.

But awareness that our society is a kind of accident suggests possibilities that go well beyond environmental protection and financial reform. To guide the construction of an alternative, we need to identify those aspects of our society we value and wish to conserve and spread. Three principal achievements come to mind: increased freedom of thought and action as compared with premodern societies, relatively greater protection against violence and disease, and the possibility for an increasing number of individuals to develop and apply their capacities and talents. Freedom, security, and capacities are the values we should be protecting in any reform of the divided world in which we live.

Instead official government policies support many foolish development strategies that may be politically popular but are ultimately self-defeating. The automobile is the most obvious example. Developed countries have become structurally dependent on the automobile, a wasteful means of transportation they can less and less afford. Developing countries now promote the automobile in imitation of this ill-advised choice. But the wastefulness of most private automobile transportation is a scandal in countries in which the great majority lack basic necessities. The urban designs that encourage automobile ownership should be changed to preserve the mobility of the population at lesser cost. The changes are not impossible. There are plenty of cities that work well with public transit. But typically both political will and cultural acceptance are lacking.

Even if progress is made changing culturally entrenched preferences, it seems unlikely that the billions of people on the other side of the line of exclusion will soon achieve anything like economic equality. So far efforts in the developed world to deal with problems such as climate change have been feeble, but there is even less concern with the problem of exclusion. Aid seems primarily aimed at dealing with crises of one sort or another where it does not support huge development projects of little use to the majority of the population in the near term.

If the developed world will not save the excluded perhaps they can save themselves with a little help. Can they draw on the rich cultural resources to which they still have access to innovate a new model of a decent life in which at least some modern values are realized, albeit at a lower economic level than we enjoy? Can we contribute to this process before their communities are destroyed by the negative side effects of development?

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 note, 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.

What all these examples have in common is a break with the economic and technological orthodoxies that have determined development strategies since World War II. But is such a nativist variation in development possible when a modernizing country such as China must depend on knowledge and technology imported from abroad? Western scholars do not all answer this question the way they used to 30 years ago.

A deterministic philosophy of technology was very influential after World War II. The most popular expositions of modernization theory, such as Walt Rostow's theory of the five stages of development, described the path of poor agricultural societies toward something very much like the American Way of Life. The theoretical certainty that America represented the future rested on the assumption that technology developed along a fixed track from lower to higher stages, determining social life in accordance with its requirements at each stage. If this is true then the most advanced country does indeed show the future to its less advanced neighbors, just as Marx claimed in the preface to *Das Capital.*

Since the 1980s this deterministic understanding of technology has come under increasingly effective attack by alternative theories such as social constructivism. These new theories argue that there is no one necessary line of technological development but many branches that correspond to different interests, cultures, and political forces. Of course there may be inventions so fundamental that all lines of development draw on them, such as electric power or the wheel, but many very different devices can make use of such basic discoveries. They do not determine a restricted panoply of devices with a single set of consequences at the social level. This is why it is possible for societies to adapt technology to their own needs rather than simply remaining backward where they lack certain resources or potentials exploited in more advanced countries.

Practically speaking, what is the significance of these new ideas? Recent scholarship in technology studies emphasizes the transformations technologies undergo as they are transferred and adapted from one institution to another and one nation to another. The extent of the change varies greatly. There is no rule or law of adaptation from which one could predict outcomes. In some cases, for example, early German industrialization, the changes may have been small enough to say that England truly represented the future. In other cases, for example, the Asian "Tigers" it is far from clear that the societies are becoming Americanized. In the case of China's future, even more radical departures from existing models will become necessary as the full weight of its huge population influences its developmental path.

Countries are held together by their dreams. So long as Russians believed communism was the path of prosperity the regime was stable. When doubt crept in collapse occurred. China has avoided collapse by harnessing the dream of prosperity with its successful economic reforms. Unfortunately, the image of prosperity that sustains the regime is ambiguous. Universal health care belongs on any list of important achievements of a rich society. Universal automobile ownership is specific to a temporary stage in the development of American society and has little prospect of realization elsewhere, certainly not in China.

There is something terribly unfair about this state of affairs. Whether one approves of the American model or not, why shouldn't China have a crack at it if it so desires? Consider the fact that the US and Europe have been polluting the atmosphere with their greenhouse gases for 150 years and those gases are still up there. In all fairness China should also get to pollute the atmosphere for at least a century. But the consequences of a fair distribution of opportunities to pollute would be catastrophic and China would suffer as much or more than other countries from such a policy.

Unfair it may be, but there is also an opportunity not to be missed in the obstacles to Americanization. The alternative is to innovate a different model of wealth, focusing on the social goals China can hope to achieve and devoting far more wealth to improving health, education, and the quality of work and urban life than to automobiles and suburban homes. Rather than America's sprawling suburbs where every move depends on the car, China can build inspiring and exciting cities in which it is enjoyable to live and easy to get around on public transportation. Chinese experts should be sent out to study small and vibrant European cities rather than Japanese and Korean auto plants.

This is a realizable ideal that will have unsuspected rewards for a world that knows more about American achievements than about American problems. The first priority of every developing country should be to avoid the tremendous inequalities of wealth, health care, and education that characterize the American model.

In sum a critical appropriation of Western ideas and technologies is indicated for China and other developing countries. with a realistic sense that Chinese will change those markets profoundly. They must anticipate the changes their interventions into world markets will cause and plan accordingly. They will not find their future told in the tale of the US, Japan, or any other country but must make up their own story from out of its own culture, resources, and dreams.

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-*

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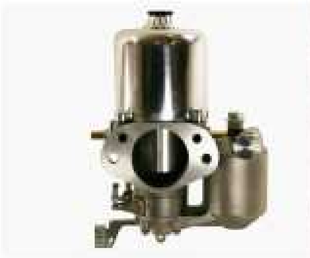
[1] Heidegger, Martin, *The Fundamental Concepts of Metaphysics*, trans. W. McNeill and N. Walker. Bloomington and Indianapolis: Indiana University Press, 1995, part II, chap. 4.

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.

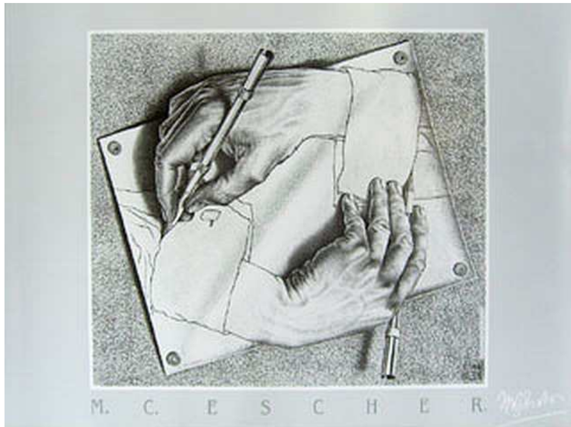
The structure of this process is a consequences of a technology cut off to a considerable extent from the experience of those who live with it and use it. But the experience of users and victims of technology eventually influences the technical codes that preside over design. Early examples emerge in 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.

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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-

[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

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[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-

[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 20^{th} 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

The Mediation is the Message: Rationality and Agency in the Critical Theory of Technology

Andrew Feenberg

Critical theory of technology brings technology studies to bear on the social theory of rationality. This paper discusses this connection through a reconsideration of the contribution of the Frankfurt School to our understanding of what I call the paradox of rationality, the fact that the promise of the Enlightenment has been disappointed as advances in scientific and technical knowledge have led to more and more catastrophic consequences. The challenge for critical theory is to understand this paradox without romantic and anti-modern afterthoughts as a contribution to a progressive worldview.

1. Rationality in the Critical Theory of Technology

In 1888 Edward Bellamy published *Looking Backward*, the most famous utopian novel of the 19th century. Bellamy's hero wakes up after sleeping for more than 100 years in a 20th century socialist society. All the institutions are explained to him as rational, that is, both just and efficient. Far from being regimented, Bellamy's socialist society is inhabited by highly developed and morally responsible individuals.

In 1932 Aldous Huxley published *Brave New World*, the most famous dystopian novel of the 20th century. Huxley's heroes are persecuted non-conformists in another perfectly rational society, but this is a society of total administration. Huxley's dystopia has sacrificed justice and individuality to achieve stability and control.

What happened to transform 19th century optimism into 20th century pessimism? Why did the 19th century foresee utopia and the 20th century dystopia? What transformed the meaning of rationality between these two centuries?

Bellamy's utopia is organized around an industrial army in which workers enjoy equal pay. They are relieved of the most difficult and dangerous work by machines. The hardest jobs are performed in 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 is 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 thus 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 achieve 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 human capacities 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 mere raw material for the production of better adapted models. The alternative the novel proposes, or rather the dilemma it constructs, distinguishes total technology from individualistic chaos, the one offering slavery and stability, the other freedom and catastrophe.

Both of these novels concern the radical consequences of social rationalization through technology. The comparison between them raises the question of the significance of rationality. Our common sense identifies the rational with science and efficiency. It is universal, necessary and morally neutral. But in Bellamy technical and moral progress are conjoined while in Huxley technology is bound up indissolubly with domination. In neither case is rationality the neutral medium in which independent desires and cultural impulses are transparently fulfilled and expressed. On the contrary rationality *is* desire and culture in living social form. As my title indicates with McLuhan-esque exaggeration, the rational mediation of social action biases the message or meaning of that action.

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, freedom in the one case, domination in the other. This leaves little room for human agency in the technical sphere. But a new politics is emerging that is neither utopian nor dystopian. This politics responds to breakdowns of rationality 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. My starting point in approaching these daunting issues is the critique of rationality in the Frankfurt School.

The Frankfurt School of Theodor Adorno, Max Horkheimer, and Herbert Marcuse elaborated an unorthodox version of Marxism that shared with Huxley a skeptical view of progress. Marx had relied on the spread of critical rationality to eventually render the working class immune to the ideologies that kept it in thrall. Like Bellamy, he believed in the emancipatory effect of a further process of technological rationalization under the control of workers. Later Marxists simplified the argument and concluded that capitalism distorted a pure technical rationality waiting to emerge under socialism. They expected social progress to unleash technology for the good of all. Although they were Marxists, the philosophers of the Frankfurt School believed that class consciousness had failed to emerge as Marx expected, that the opportunity for proletarian revolution had been missed, and that technology—rationality in its most concrete form—was the problem, not the solution.

The Frankfurt School argued that both capitalism and communism were based on the generalization of technical mediation in the oppressive form which capitalism first gave it. The factory was the opening scene of rationalization as domination. Today it is everywhere, reaching into medicine, entertainment, sports, education, and framing 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.

There are several possible responses to this situation. Traditional Marxists, liberals and neoliberals still hold that modernization must continue until it finally fulfils its promise. The negative consequences so far endured are dismissed as contingent accidents along the path of progress. Marxists had high hopes in the tumultuous period after World War I. But their hopes had dimmed by the time the Frankfurt School first flourished in the 1930s. These philosophers witnessed the rise of virulent racist and nationalist ideologies purveyed by the new mass media. They did not despair completely but in fact they saw no path forward.

The Frankfurt School criticized the progressive notion that domination is overcome through progress in rationality. On this view domination should recede as rationalization advances. This is what Habermas calls the “Enlightenment project,” but it seems to be failing. What we witness instead is a catastrophic reversal of the expectations of the Enlightenment which Marx still hoped to fulfill through socialist revolution. The Frankfurt School proposed a “rational critique of rationality” in response to this situation in the hope of salvaging a coherent basis for a critical theory of modernity out of the flawed inheritance of the Enlightenment and Marxism. This approach must be distinguished from the more familiar romantic critique that calls for a retreat from rationality and all its works. These two critiques imply different politics and it is therefore important to distinguish them clearly.

Romantic critique of reason as such begins in the late 18th century, accompanied by idealization of the past. I cannot review this trend here but must mention its essential thrust. That thrust is evident in much romantic literature which opposes passion to bourgeois calculation and social conformism. The theme is summed up by Balzac’s anti-hero Vautrin who declaims "J'appartiens à l'opposition qui s'appele la vie." The image of life versus mechanism captures the essence of the romantic critique. On these terms, rationality is not a reliable means for understanding life but is instead a specific form of life dedicated to questionable goals. In most formulations this critique implies a rejection of modernity as an instance of that form of life.

This critique appears to be verified by the 20th century catastrophes of reason. Wars, concentration camps, nuclear weapons, and now environmental disaster threaten the Enlightenment project. But it is difficult to believe that the full content and significance of rationality is exhausted by these disasters. Surely reason has underexploited potentials that can be mobilized in a self-critical approach. A distinction must be drawn between technical and critical rationality. This is the approach of the Frankfurt School’s non-romantic critique of rationality.

Romanticism despairs in enlightenment and gives 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 continuing promise of a different kind of rational society. The underlying problem, they believed, lay in the transformation of reason in modern times which left it vulnerable to exploitation by the dominant elites.

Horkheimer argued that reason is rooted in a value, 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 traditional “objective” and modern “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 socially. 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 subjective reason is concretely realized in modern technology. It 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 spreads the capacity for self-rule thus proving the obsolescence of class 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.

Marcuse's critique appears similar to the romantic critique of rationality, but in fact his argument is subtly different. The dire consequences of rationalization are not due to the nature of rationality as such, but rather to its restriction and narrowing under the influence of capitalism. Premodern technical practice cultivated the *potentialities* of its materials. Traces of such notions sometimes persist among practitioners of technical arts such as architecture. They may aim not at arbitrary goals but at realizing a value such as beauty latent in their objects, a natural site, for example.

Frank Lloyd Wright attempted to situate his buildings harmoniously in the landscape, but the same engineering techniques he employed, freed from aesthetic concern, are also available to create steel and glass monstrosities cut off from any relation to nature. The formal neutrality of modern reason, which derives from its mathematical construction of its objects, cancels its intrinsic connection to potentialities and places it at the disposal of the powerful, ready to serve their subjective values. With such considerations in mind, Marcuse argued for a social revolution in reason itself, incorporating values into its technological applications. He hoped this could be achieved through the fusion of aesthetic and technical rationality in a renewed objective reason.

These theories of rational domination elaborated by the Frankfurt School are suggestive but so abstract they fail to engage with later struggles over technology in domains such as the environment and the Internet. They are, furthermore, ambiguous. Horkheimer and Adorno argued that instrumental reason is essentially constituted by the repression of inner and outer nature. Yet Adorno also condemned capitalism for distorting technological development and lamented the suppression of beneficial technical alternatives. It is not easy to reconcile these two positions. The contradiction is even clearer in Marcuse. On the one hand he follows phenomenology in arguing that modern scientific-technical rationality is intrinsically linked to domination. On this basis he advocates a new science and technology that will treat nature as a subject, by which he means respect its potentialities. But on the other hand he rejects any regression to a premodern qualitative science of nature. What his reform of science and technology would entail remains obscure. This ambiguity has opened the Frankfurt School's critique of rationality to the charge that it is romantic and irrationalist.

Yet despite these problems, I believe the essential point of the Frankfurt School's critique is valid. That point is the social bias exhibited by apparently neutral technology and the attendant paradox of rationality, the fact that the progress of technology has gone hand-in-hand with the progress of domination.

There are no ready concepts for talking about this paradox. That the existing technology favors domination is clear, but we must clear up the ambiguity in the Frankfurt School's critique, show its relevance to the contemporary politics of technology, and clarify the distinction between critical theory and the essentialist condemnation 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. The Frankfurt School intended just such an analysis but failed to develop the categories and methods for performing it. The clue to an alternative approach lies in the notion that the very neutrality of technology links its fate to a project of domination.

I have formulated this approach as a theory of the bias of technology. This requires a departure from the usual concept of bias which is closely associated with prejudice and discrimination. But bias in a less familiar sense appears in other spheres as well. For example, because right handedness is prevalent, 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 exhibited by technology and other rational systems.

In accordance with this distinction, critical theory of technology identifies two types of bias which I call "substantive" and "formal" bias. Enlightenment critique addresses the more familiar substantive bias. Eighteenth century philosophers were confronted with institutions that claimed legitimacy on the basis of stories about the past and religion. Aristocratic privilege was justified by mythic origins such as participation in the crusades. Kings ruled in the name of God. Rational critique undermined these narrative myths behind religion, monarchy and feudalism. The Enlightenment judged institutions on the basis of 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 emotions, specific contents that motivate discrimination. For example, when women are thought to be less intelligent than men—a widely held view that appeals to feelings rather than evidence—even the smartest among them will have difficulty finding the jobs they deserve and less qualified men will perform less efficiently in those jobs. Substantive bias intrudes values and prejudices into domains that ought to be governed by rationality and justice. Critique of substantive bias therefore implies the purity of reason as such.

But 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 efficiently. No narrative myths or pseudo-facts obstruct its functioning, and it is certainly free of emotion. Nevertheless, when the division of labor is technologically structured in such a manner as to cause subordinates to perform mechanical and repetitive tasks with no role in managing the larger framework of their work, their subordination is technologically embedded. 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 although the technologies they govern may in fact achieve such goals through the side effects of their role in social life.

In this respect the formal bias of technology is similar to the bias of the market which was the starting point for Marx's critique of capitalism. The market appears rational but, strangely, equal exchange 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 “property is theft.” He argued that property income is not the result of an equal exchange. Various theories of this sort have 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, the market is treated as a fraud rather than as a coherent system.

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 worker’s wages, which is more or less equivalent to the value of his labor power, 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 problem is not primarily the unfairness of this system, but the larger consequences of capitalist management of the economy, such as the deskilling of work and economic crises. With this argument Marx showed that rational systems can be biased and he extended this type of critique to technology as well.

The methodological significance of Marx’s analysis lies not just in the condemnation of exploitation but in combining the apparently contrary notions of rationality and bias. This was precisely what the Frankfurt School was to do much later in its critique of technology. The point of that critique was not to blame technology for social ills nor to appeal to technological rationality as an antidote to the inefficiency of capitalism, but to show how technology had been adapted *in its very structure* to an oppressive system. This notion of structural bias can be elaborated further.

There are two familiar ways in which rational systems and artifacts are biased. In the first place they may 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, a simple 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 or the market in Marx's theory. As we will see in a later discussion of constructivism, design is shaped by many actors deploying rational solutions to the problems that interest them, not by pure reason alone. Artifacts and systems thus reflect particular interests through the role of powerful actors in shaping design. 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 "design code" to understand this apparent paradox.

Technologies are built according to a "design code" that translates social demands into technical specifications. The sidewalk ramp is a good example. Until it was introduced, disability was a private problem. The interests of the disabled were not represented in the design of sidewalks which obstructed their movements at every crossing. But once society accepted responsibility for the free movement of the disabled, the design of sidewalks translated the new right. This recognition takes the form of a standard for the width and slope of the ramp.

Progress is defined relative to design codes and not in absolute terms. Take commercial aircraft as an example. The criterion of progress in this domain has shifted from speed—the Concorde—to size—the 747—as a function of OPEC's power to raise the price of fuel. Neither size nor speed is the "right" criterion; there is no question of rightness because the choice of a criterion is contingent on shifting historical events. On these terms modern societies have experienced a specifically capitalist form of progress biased by class power.

Along the way, unsuccessful alternatives have been rejected and forgotten, covered over by a kind of 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 illusions of pure rationality and universal progress. These illusions obscure the imagination of future alternatives by granting existing technology and rationalized social arrangements an appearance of necessity they cannot legitimately claim. Critical theory demystifies this appearance to open up the future. It is neither utopian nor dystopian but situates rationality within the political where its consequences are a challenge to human responsibility.

2. System and Lifeworld in Instrumentalization Theory

In this section I present my own approach, which I call instrumentalization theory, in a critical confrontation with 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 rejected what he considered the anti-modernism of Adorno, Horkheimer and Marcuse. Their critique of social domination was based on a more fundamental critique of the domination of nature but, he argued, the category of domination applies only to human relations. The very concept of domination of nature is incoherent and implies a critique of technology as such not so very different from what one finds in Heidegger. Furthermore, these philosophers never explain the critical standard underlying their argument, nor do they propose a concrete program of reform of modern society. According to Habermas there is a gaping normative deficit in the philosophy of the early Frankfurt School.

In his 1968 essay on "Technology and Science as Ideology," Habermas takes up a strand of Marcuse's argument, the notion that the problem with technology is its universalization as a worldview or ideology influencing every aspect of life in modern society. Habermas quotes Marcuse who writes, "When technics becomes the universal form of material production, it circumscribes an entire culture; it projects a historical totality-- a 'world.'" This is Marcuse's critical 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 separating the critique of technology as such, which he rejects, from the critique of the legitimating function of technology in technocratic ideology.

Habermas develops his own version of this argument in the course of a critical confrontation with Marxism. Marx argued that the tensions between productive forces and relations of production motivate class struggle, but Habermas claims that class struggle has weakened in intensity to the point where this theory must be completely revised. The tensions Marx addressed through social categories must now be explained through an analysis of the generic action types involved in work and communication underlying those categories.

Habermas thus substitutes the concepts of "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, i.e. more or less effective and efficient. It differs from communicative interaction which aims at mutual understanding rather than technical success. The tension between the types of action involved in work and social relations now replaces the original Marxian problematic.

Habermas identifies two major features of all societies on the basis of these distinctions. 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 there are technical subsystems which contain the knowledge, practices, and artifacts that enable the society to produce the goods required for survival. The balance between the technical and communicative dimensions varies, 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 postwar period technology takes over where the market leaves off in organizing more and more of social life; market legitimation gives way to technological legitimation. The institutional framework is increasingly subordinated to the conditions of economic and technical development. Legitimation is now achieved by identifying the ruling interests with the efficient functioning of the system. Normative concerns are increasingly evacuated as a dystopian logic takes over. Depoliticization masks continuing domination and justifies a technocratic order.

Habermas's early essay is an attempt to establish a critical but positive relationship to modernity. 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 overemphasis on technical rationalization under capitalism at the expense of communication. Critique should aim at furthering communicative rationalization rather than denouncing technology.

In his later work Habermas develops an improved version of his theory. He realizes that individual action orientations do not a society make. The real problem is coordination among many acting subjects. Habermas distinguishes two different types of action coordination characterizing the domains of "lifeworld" and "system." These now replace the "institutional framework" and "technical subsystem" of his earlier work. In the new theory coordination is achieved differently in each domain, through mutual understanding in the lifeworld and through systems such as the market without much in the way of communicative interaction.

The concept of lifeworld is derived from phenomenology. Husserl used the term to refer to the domain of everyday meanings underling scientific conceptualization. In Heidegger it was 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. Both thinkers draw our attention to meaning as the irreducible medium of experience. Habermas reformulates the concept to emphasize the intersubjective 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 Talcott Parsons' generalization of certain features of markets to other social domains. These systems are self-regulating and require no collective agreement but only stripped-down and conventional responses such as the typical dialogue involved in making a purchase or obeying a command. Modern society depends on the effectiveness of systems at unburdening the lifeworld of excessively complicated tasks.

Technocracy is now redefined as "colonization of the lifeworld" by the system. The outcome depicted in *Brave New World* threatens, but unlike Huxley, Habermas does not despair. He advocates increased social control of the system in terms of a consensus reached freely in the public sphere through communicative acts. He thus revives the bipolar vision of *Looking Backward*.

Unfortunately, he abstracts completely from technology in this version of his theory. 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 questions concerning the environmental, the Internet, economic development in poor countries, and the democratization of technology?

Despite these limitations Habermas's dualism has interesting implications. As he argues, modern societies operate in two main worlds, a world of quasi-mechanical or causal institutional interactions and a world structured around meanings and communicative understanding. Each world requires its own method of analysis. But unfortunately there is an ambiguity in Habermas's application of this dualistic conception.

In methodological discussions the distinction is analytic. This means that system and lifeworld 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 find this overlap in the dependence of formal hierarchies 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.

But it is not easy to apply the colonization thesis on this interpretation since system and lifeworld are always already interpenetrating each other. How then can the one "colonize" the other? Habermas evades this question by tacitly identifying system and lifeworld with separate institutions such as the economy and the family. But this risks neutralizing the system as a sphere of pure rationality. Market rationality, for example, appears to be based on the essence of economic relations rather than on social choices. The market's boundaries can be set from the outside, but within its range it operates according to its own laws. Similarly, on this account technology can be employed for one or another socially determined purpose but its workings and developmental path are science based rather than socially based.

Habermas's formulation eliminates the problematic of rational domination so central to the thinking of the first generation of the Frankfurt school. He returns to a traditional liberal-Marxist notion of progress. Social critique is reduced to boundary policing. Apparently, systems are alright in themselves and the only problem is their extent. Such a view of systems has conservative consequences. The communicative sphere has only an instrumental relation to the separate systems and cannot redesign them from the ground up without violating their internal logic. This leads Habermas to reject radical proposals for changing the structure of the economic system such as self-management. The system is surrendered to capital and the experts.

If Habermas accepts the neutrality of systems, 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 romantic critique, he 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, not social spheres but overlapping perspectives. I therefore propose what I call a double aspect theory of technology and other rational institutions according to which their intrinsic logic is conditioned by the social forces presiding over their design and configuration.

The details of this double aspect theory require 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. The concept of formal bias serves this function in relation to rational systems, explaining the relation of the analytically distinguished system functions and lifeworld meanings.

Hegel wrote a short essay called ”Who Thinks Abstractly” that helps to clarify this. He argues for reversing 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 has ideas and purposes just like himself and who relates to him accordingly as a person.

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 Francophilia, it is considered proper even today to first recognize 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, but it is also part of the lifeworld of its owner with a significance in terms of beauty, status, social behavior, its role in 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, the functional logic that operates at the systemic level is abstracted from the meanings that circulate in the lifeworld.

I call this approach "instrumentalization theory." The term was perhaps poorly chosen. Phenomenologically considered, worlds are made as human beings engage *practically* with their environment. This is the sense in which I intend "instrumentalization," and not a specific reference to tools. I could have called my approach "world-making theory" and avoided this particular confusion while inviting others.

In the instrumentalization theory the causal aspect of the system level is called the "primary instrumentalization" and its social dimension, 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 lifeworldly significance.

The primary instrumentalization is an imaginative relationship to the technical affordances of natural objects. It "functionalizes" the object. Functionalization involves *decontextualizing* elements of nature in order to isolate their useful properties. The decontextualization is accompanied by a *reduction* of the object to just those aspects through which it can be incorporated into a device. Every technical insight involves these operations by which a natural object enters the social world through its practical 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 to some degree. Modern technology assembles huge numbers of such affordances in coherent patterns to accomplish goals that go beyond any individual's needs.

The logic of such assemblages is not exclusively technical. It is constrained by causal principles: only an assemblage that "works" is built. But usually many working combinations are available. The secondary instrumentalization determines which ones are realized. At this level the selected affordances are given meaning in their social context. They cannot remain simply in the form of a bright idea but must be brought within the scope of the *system of the meanings* that makes up the way of life of the society. The reduction of the object, which strips it bare of connections, is compensated too as its design is mediated by ethical and aesthetic values. This is the lifeworldly significance of the technical; it situates artifacts in the way of life to which they belong.

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. The pattern thereby established is not purely rational because powerful actors preside over the process of accommodation. Some possible designs are favored and others foreclosed with different consequences, beneficial or detrimental, for different social groups. Here is where the formal bias of technology reveals its political significance.

The instrumentalization theory offers a framework within which to analyze the imbrication of the technological system and 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 are only analytically distinguished, each level reflecting the other on its own terms. The fact that modern societies are able to abstract the functional level of artifacts and to construct technical disciplines on that basis masks this 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 on purely technical terms in a specification, but that specification is not purely technical; it represents the rights of the disabled technically. That is its significance in the lifeworld.

Social criticism must address the design and configuration of technical systems. The instrumentalization theory offers a critical approach to technology without technophobia. It identifies systemic domination with a secondary instrumentalization that narrows the values technologies serve to exclude important contexts and consequences. This is what happened in the development of industrial technology under capitalism. But it also identifies the breaking-points at which technologies can be reconfigured to serve democratic purposes. The secondary instrumentalization may 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. Distinguishing these two levels saves the theory from the dilemma of essentialist technophobia vs. the neutrality thesis 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.

3. Constructivism, Critical Theory, and Communication

The Frankfurt School's responses to the failure of the modern faith in reason was a "dialectic of enlightenment" that recognized the catastrophe of modernity but also the promise of a rational society based on freedom from myth and domination. The most significant application of this dialectic was to the development of mass society. The Frankfurt School's argument presupposed Kant's ideal of enlightenment formulated in the phrase *sapere audi*, "dare to know." This is the ideal of autonomous individuality Marx projected onto the working class as class consciousness. But instead of a self-conscious class atomized and homogenized masses betrayed Marx's hope. This is due to the surprising effectiveness of propaganda and advertising which he could not have foreseen.

The mobilization of whole populations through nationalism, racism and consumerism is the new basis of class rule in the 20th century, made possible by the technical mediation of the public sphere. The Frankfurt School argued that at the basis of the new system lay the "culture industry," which extended the commodity form to culture. Today's commodified cultural products are fundamentally different from earlier cultural artifacts, even those sold on markets. Art used to have 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 contemporary commodified cultural products. These products communicate a conformist ideology through stereotyped characters, plots and images. A new authoritarianism emerges in which accepting the facts established by power and reflected by the media appears as the only rational response to "reality." This is the rationalization of consciousness itself. But the counter ideal remains: democratic discussion between free individuals is still an imperative of critical reason.

This ideal was concretized sociologically by Habermas. In an early book he argued that the interventions of private persons into public discussion in bourgeois society constituted a new social form, which he called the public sphere. The contexts of these discussions, such as coffee houses, and their literary background in texts valorizing individual feeling and private life, demarcated this form of publicity from the institutions of the pre-bourgeois state. The ideal of citizenship as the right to engage in rational discourse concerning the common good emerges from this innovative communicative structure. Habermas's book concludes on an analysis of the destruction of the bourgeois public sphere by the mass media. Just as participation in the public sphere broadens to include the whole underlying population, it is transformed and instrumentalized by governments and corporations. Rational discussion is replaced by propaganda and citizenship in the full sense of the term gives way to passively manipulated masses.

Oscar Negt and Alexander Kluge replied to Habermas, defending the notion of a proletarian or oppositional public sphere as an alternative instance of democratic self-expression and debate. But their conception was tied to forms of action and organization characteristic of the high points of political struggle, such as workers' councils and student revolt, and these have played a relatively small and intermittent role in the life of advanced societies. Habermas's pessimistic conclusion was relayed by Marcuse's critique of "one-dimensional man" which itself reached a mass audience in the 1960s and '70s. So strong is the commitment of most critical theorists to this decline-and-fall schema that they have barely noticed the contrary effect of the Internet. Habermas himself dismissed it—incredibly—in a footnote to a presentation to the International Communication Association in 2006.

This blind spot is rooted in the history of the Frankfurt School. Its thought was elaborated during a long period of defeats for the left. Broadcasting and technical macro-systems offered a dystopian paradigm of technology in this period. There is a large dose of truth in these philosophers' pessimistic conclusions despite the evident exaggeration. But their critique of technology is limited by this historical context. Today it appears abstract and technophobic and as a result it is frequently dismissed by a younger generation of scholars for whom the Internet is a natural milieu and who are attuned to new forms of struggle and contestation.

In particular, struggles around technology cast a different light on the theory of the public sphere. Environmental struggles, user agency on the Internet and in medicine, and economic and technical struggles in developing 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. As a result it remains caught in the dystopianism appropriate to the age of broadcasting even as the Internet creates a new social and technical context. If the Frankfurt School's radical political conception is to survive it must take into account this changed context.

The Frankfurt School requires some new intellectual resources to make the turn toward technical issues. These can be found in social constructivist technology studies. Social constructivism offers methods for studying technology and emphasizes the role of agency in technical development. Although social constructivism is not a political theory, it undermines technocratic ideology and modernization theory. Placing it in the context of critical theory brings out these political implications.

The term social constructivism refers to several related approaches in science and technology studies that have in common a rejection of positivist and determinist theories according to which science and technology are products of pure rational understanding of nature. If only logic and evidence count in scientific and technical controversies, social explanation of the most dynamic forces in modern societies is excluded apriori. In opposition to this view constructivists emphasize the social shaping of science and technology, not to the exclusion of rationality but as its context and medium. In their research constructivists strive to conform to the "principle of symmetry" which recognizes both cognitive and social aspects in all scientific and technical activity.

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 analog to positivist truth. Just as positivism exempts scientific truth from social explanation, so traditional sociology dismissed social explanation of technology. Progress in efficiency was viewed as an exogenous source of social change. For social constructivist technology studies, on the contrary, technical choices, like scientific choices, are underdetermined by purely internal criteria such as efficiency.

No doubt constructivists were not alone, nor were they the first, in rejecting determinism for more empirically grounded studies of specific technologies. However, their work brought two fundamental methodological principles to the fore: the role of *interpretation* in design, and the *co-construction* of artifacts and social groups. The application of these principles to the study of technologies opens up a lifeworld perspective on the material underpinnings of modernity. Let me begin the demonstration of this approach by briefly defining these principles which are applied in the analysis of the Internet that follows.

Social constructivist technology studies attempts to identify the "relevant actors" engaged with the design process. These actors define a given state of affairs as a technical problem for which they seek a technical solution. But problem definitions are not absolute; they are relative to actors' interests and concerns. A slightly different perspective on the "same" problem may yield a very different technical solution. This is called the "interpretative flexibility" of artifacts. As Pinch and Bijker explain, the interpretation of an artifact influences not just its use but also its very design. In this sense technology is socially relative. Interpretative flexibility is especially important in the early stages of development.

Technology is not simply a matter of artifacts but, as Latour has argued, it involves networks of individuals and things co-constructed through various types of associations. The presence of the network is often obvious, for example, a factory or a hospital, organized around the technologies that mediate the individuals' activities. In other cases a latent group may be constituted in response to a network's unintended side-effects or unexplored potentials. This describes, for example, the experience of victims of pollution or unsafe foodstuffs, mobilized once they discover the source of the problems they share. But it also describes the experience of users of a technology who introduce innovative features as they discover new ways of exploiting it.

Although it would seem possible in principle to include them, missing in most constructivist accounts are these latent groups, the "irrelevant actors" who lack the power to influence design decisions. This describes the entire underlying population in Marxist accounts of the development of the industrial system and the Frankfurt School's account of the mass media. The absence of these non-actors from constructivist accounts is problematic. Constructivists have also shied away from invoking diffuse influences such as ideology and culture that play an essential role in politics.

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 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. Without idealizing the scientific community, we can confidently assert that a vision of society modeled on it is quite unreal. Thus constructivist insights must be supplemented by other methods to gain a full picture of the significance of technology.

Despite its limitations, constructivism is useful for overcoming the complementary limitations of the Frankfurt School. The theory of the culture industry was formulated at a specific stage in the development of the media, essentially, the early days of radio and film. The theories of the decline of the public sphere and one-dimensional society reflected the era of television in which broadcasting gained new powers. But the media system has changed radically with the emergence of the Internet and it is therefore necessary to modify the earlier analysis. Constructivist methods make this possible through a much more detailed account of the relations of technical design to social design than the Frankfurt School achieved.

If these apparently unrelated approaches can be combined, this is because there is a significant methodological similarity between them. 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 critical theorists and constructivists insist on the underdetermination of cultural and technical products and the role of social actors in shaping their inner workings.

This is the case with the Internet, a technology that is still at an early stage of development. The Internet illustrates the basic constructivist notion that technologies are not things but processes, contingent on shifting interpretations as well as knowledge of nature. Since the Internet is not a finished product, but is still incomplete and evolving it is impossible to fix its nature once and for all and to praise or damn it for qualities it may very well modify or lose in the near future. Hence the pointlessness of much of the hype and demystification circulating among scholars and journalists who write about the Internet.

The history of the Internet reveals the complexity of the relations between technology and politics. Originally called "Arpanet," it was developed by the Pentagon for timesharing on mainframe computers. It was intended 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 handling data.

Computer networks communicate on telephone lines by sending small "packets" of data which are assembled at their destination. Telephone companies manage regular telephone calls on central computers and they extended this system to data. In principle the central computer was no longer required in computer networks based on "packet switching" yet it survived because of the limitations of early personal computers and the institutional momentum of the telecoms. This was reflected in the main early packet switching protocol, known as X.25. The distributed packet switched Internet was based on a competing protocol, TCP/IP, which required local computers to run a small program to construct and send the packets. X.25 networks were accessible from dumb terminals with practically no computing power, but the Internet protocol required every computer attached to the system to manage its own data. Hence the long delay in the expansion of the Internet which had to await cheap computing power.

These arcane technical differences have huge social implications. No centralized control over the Internet was necessary or possible and this had two unanticipated consequences: internationalization and frequent user innovation. These consequences should not be conceived on deterministic causal terms but rather as openings seized and given meaning by social actors who then intervened to exploit and modify the system in accordance with agendas unimagined by the original inventors. As personal computers spread and the Internet grew, these agendas gradually modified the very definition of the technology. The Internet went public in the 1980s and the Web made it popular in the 1990s. Millions of new users layered it with new functions and social meanings, 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 an X.25 network controlled by the other. The French Teletel system, 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. Internationalization of the Internet had immense repercussions for localized political struggles that were able for the first time to appeal to a worldwide audience inexpensively and through means under their own control. This is the technical base of world public opinion on resistance to tyranny around the globe.

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, but their system was quickly colonized by communicative usages. In fact one of the engineers who developed the system introduced an e-mail application simply for fun. A circuitous path leads from that first initiative through many intermediary steps down to the "blogosphere," Facebook and the huge online lobbying organizations of today. The reliance on TCP/IP meant that no gate keepers could block these secondary instrumentalizations which have changed the over-riding meaning of the network from an information exchange to a space for community.

This multiplicity of actors and their interpretations yields alternative models of the Internet none of which has yet achieved closure. The scientific model of free information exchange came into conflict with corporate interests, while all sorts of communicative applications developed rapidly once the Internet went public. The various interpretations of the Internet reflect ideologies, conceptions of society. The struggle between them implies different social visions, ultimately, different ways of life embodied in design, not simply different uses of the same technology.

Three coexisting models of the Internet compete and complement each other today. 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 effectiveness of broadcasting in promoting a consensus favorable to the ruling interests. The Internet weakens consensus by introducing unconventional viewpoints and making them visible to a large audience at no cost.

It is true that the quality of discussion on the Internet varies widely. Everyone has access to the unmoderated comments that follow news stories and many of these discussions are spoiled by intemperate contributors. But it is unfair to judge the Internet by this example. No doubt political discussions on street corners would similarly degenerate. This is not so much a technological issue as a problem of civic culture. More significant phenomena have developed around moderated online communities, independent media sites, blogs, and social networks. These spaces of interaction break broadcasting's one-way monopoly on opinion formation. The network revives a public sphere of discussion and debate.

Technology is not only instrumental to this development, but it plays a central role as an object of discussion in this new public sphere. The Internet connects scattered users and victims of the vast technical systems that underlie modern societies. Environmental campaigns employ the Internet to build constituencies affected by pollution and other problems. 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 to enable latent communities to recognize and articulate their needs.

Perhaps the most important manifestation of that potential to date is the defense of the Internet by its own users. The emergence of large online communities has empowered their members 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. Threats to network neutrality have been met by effective mobilization of huge numbers of Internet users. These are democratic interventions for the sake of democratic communication.

The democratic applications of the Internet have implications for the theme of rationality and domination. The Frankfurt school demanded that we situate rationality in its social context. It so situated the dominant rationality as exemplified in the bureaucratic and technical systems of advanced capitalism. The politics of the Internet and the agency of users and victims in domains such as environmentalism and medicine signify the existence of another situated rationality, a rationality from below. Foucault's concept of "subjugated knowledge" reflects the experience of those who are poorly represented by the dominant rationality. The perspective from below reveals the blind spots of those in charge and inspires resistance where participant interests are slighted by the dominant design. Rationality and values come together in the incorporation of those interests in revised technical codes. Insofar as technical codes are more or less representative in this sense, they are political and interventions by actors into their formulation are political interventions.

Just as the Frankfurt School related the dominant rationality to a social subject and its project, so must this rationality from below be related to a subject and project. That subject is multiple; it consists in the technical networks that become self-aware and emerge as a resistant communities. Where their struggles yield new meanings that feed back into technological development, they affect designs and technical disciplines. In such cases of public action around technological issues, rationality and values come together. This is not quite Marcuse's synthesis of aesthetics and technology in a new objective reason but it is as close as we are likely to get for the foreseeable future.

The Internet is an example of the co-construction of technology and society in action. Since it widens the range of communicative features represented by the technical codes I call it "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 strict regulation from above. This is what led him to pessimistic conclusions. By excluding democratic or cooperative control apriori he condemned developed societies to an iron cage. But democratic rationalizations bend the bars of the cage.

We must generalize beyond Weber's concept to a view of rationalization that does not prejudge the future. This generalized notion of rationalization would still refer to optimizing means through calculation and innovation but it would not imply a tyrannical system of control. A different type of "rational" society is possible based on mutual discipline and democratic leadership. It would require different technology. 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 more democratic procedures than those of corporations and many government agencies.

The new politics of technology is gradually introducing technology into the public sphere where it is subject to normative considerations. We need a theory of democracy adapted to this evolving situation. The available conceptual framework 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.

That goal does not imply the replacement of experts by lay actors. Rather, where their relationship is healthy and constructive, they learn from each other, reflecting the complementarity of everyday experience and technical rationality. Populist anti-intellectualism is of course a danger, but expert arrogance is its still more worrisome counterpart. It motivates the commonplace dismissal of public protest as irrelevant, regressive, and ideological. Yet such interventions often lie in the background of technical codes first formulated long ago and now taken for granted by experts. There is thus no reason of principle to exclude it from current technical debates. But expertise tends to obliterate its own history, forgetting the often complicated origins of its current standards. Now in a period of rapid change in technology, the background is coming to the fore. It is clear that public influence on technology is not an extraordinary external intrusion into a fully 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 technical phenomena from the standpoints of system and lifeworld.

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. Slavery was abolished and marriage and education were removed from religious control and transferred to the secular authorities. Somewhat later governments begin to intervene in the economy, removing it from the sphere of "natural law" and repositioning as a political issue. This process of dereification continues as technology, another pseudo-natural domain, is incorporated into the public sphere.

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. The early Frankfurt School's approach to technology corresponded to the Marxist critique of political economy in demystifying the biases of the prevailing technological rationality. Today we can extend and concretize that approach in a critical theory of technology. Like the Marxist critique it explains struggles over design as rational in a democratic social context.

I began by comparing utopian and dystopian images of technology, but in reality we neither seek the one nor flee the other. The threat of technology has diminished with the rise of new social movements that establish the possibility of human agency in the technical sphere. Environmentalism and the Internet have renewed the aspiration to control technology. What we seek is not a conflict free utopia but a technologically advanced society that preserves democratic values. Although my emphasis here has been on struggles in the technical public sphere, they alone cannot decide the issue. The dominant ideology is still dominant but at least its hegemony is no longer technologically secured without fear of contestation. The contest engaged around freedom of communication promises further democratic advances. Insofar as success in this struggle is a theoretical task, critical theory still has a contribution to make.

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.[19] 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.

[19] 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."[20]

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.

[20] 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.[21] 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

[21] 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."[22]

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.[23] This lay intervention added a new

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

[23] 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.[24]

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.[25] 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.[26]

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

[25] 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.

[26] 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.[27] 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

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[27] 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.