Martin Bauer

Resistance to new technology and its effects on nuclear power, information technology and biotechnology

Book section (Published Version)

Original citation:
Originally published in Bauer, M. (ed.), *Resistance to new technology: nuclear power, information technology and biotechnology.* Cambridge, UK : Cambridge University Press, 1995, pp. 1-42. ISBN 9780521599481

Resistance to New Technology

Nuclear Power, Information Technology and Biotechnology

Edited by Martin Bauer

Book DOI: http://dx.doi.org/10.1017/CBO9780511563706

Online ISBN: 9780511563706

Hardback ISBN: 9780521455183

Paperback ISBN: 9780521599481

Chapter

1 - Resistance to new technology and its effects on nuclear power, information technology and biotechnology pp. 1-42

Chapter DOI: http://dx.doi.org/10.1017/CBO9780511563706.002

Cambridge University Press

-1-

Resistance to new technology and its effects on nuclear power, information technology and biotechnology

MARTIN BAUER

Basic questions

The word 'resistance' has become unsuitable for use in the context of new technology. The allegation is that it serves mainly to blame those who resist; talking about resistance implies a managerial and technocratic bias. However, in developing the idea for this conference, I was confident that 'resistance' would prove ambiguous in meaning and rich in connotations, particularly in the European context.[1]

Historians of technology recently rediscovered 'resistance' as a 'force' that shapes technology which requires an adequate analysis (Mokyr 1990, 1992). For the economist resistance is basically the vested interests of old capital in ideas, skills and machinery. In addition, in the light of the critique of the 'Whiggish' historiography of technology (Staudenmaier 1985), it seems reasonable to lift 'resistance' from the dustbin of history.

Artefacts such as machines, power stations, computers, telephones, broadcasts and genetically engineered tomatoes, and the practice of their production, handling, marketing and use – in other words, technological innovations – are not the only factors of historical change. Technological determinism seems an inadequate account of our history. Various social activities give form to processes and products, facilitate their diffusion and mitigate their consequences. However, technology is not neutral. It creates opportunities and simultaneously constrains human activity. We experience the latter as being paced by 'machines' rather than controlling them. The selection of options is not neutral; it is likely to be contested and in need of legitimation. The control of technology by those affected by it remains a desirable agenda. From here the disagreement begins: who should be accountable to whom, and which procedures ensure this accountability?

In this context it constitutes a challenge to reflect on the concepts of resistance, and to review historical events, in order to rehabilitate the notion. In my view this may be achieved by analysing resistance in terms of its various consequences. This means starting with a functional hypothesis, instead of assuming *a priori* dysfunctional consequences of resistance for the 'progress' of society. Here we are less interested in the causes of resistance than in its effects. Resistance as the 'enemy of progress' is only a part of the story, as we will see, both historically and for more recent events.

Methodologically resistance to new technology is as much an independent as it is a dependent variable: the public reaction to technology influences new technology in a circular process. The study of resistance is located halfway between traditional impact analysis and the recent focus on socio-technical networking of humans and artefacts (Latour 1988; in German, *Technikgenese*: e.g. Joerges 1989).

The term 'resistance' elicits contradictory connotations. It seems necessary to justify an academic contribution on 'resistance' because the term is loaded with a managerial and modernisation bias and is not suitable for an impartial analysis of social events.[2] A participant at the conference put it bluntly: resistance implies a 'whitewash of big industry' in technological controversies. The term 'resistance' elicits quite different connotations. Traditions of philosophical thinking give resistance a moral dignity; and events of the twentieth century impute 'resistance' (*Widerstand, resistence, resistenza*) with an aura of 'heroism' in the struggle against totalitarianism. In South America 500 years of colonialism give it the 'heroic' meaning of fighting a lost cause that may finally prevail. We may deal with a real cultural difference in semantics.

The managerial and technocratic discourse stipulates resistance as a structural or a personal deficit. Resistance is irrational, morally bad, or at best understandable but futile. In contrast, the German discussion of new technology since the 1970s has been conducted under the term 'acceptance crisis'; the debate carefully avoids the term 'resistance', which is reserved for the respectable part of the national identity for which post-war historians, not only in Germany, have fought (Schmädeke & Steinbach 1985).

Because of these semantic confusions authors have argued that the term be dropped. I disagree, and suggest that we keep the term and stress the intended meaning. The ambiguity of the term 'resistance' allows us to ask different questions about an old problem of social change. This volume provides a review of the notions of resistance in technological controversies. The nineteen contributions compare forms and effects of resistance across time, space and technology: from machine breaking and technology transfer in the nineteenth century, Fordism in the early twentieth century, to three base technologies after 1945: civil nuclear power, information technology, and new biotechnology.

The comparison is done, naturally, using different approaches. The scope of material is limited geographically. The technological processes in countries of the Far East, in China, Taiwan and Japan are excluded; equally excluded are countries of the Third World and of Eastern Europe, where the problem of resistance to new technology may have a different angle altogether. These chapters mark the ambitious beginnings of an attempt to map intellectual territory: to study the contributions of resistance to the 'progress' of technology.

In the following I elaborate the rationale that brought contributors together to address the following key questions:

What are the forms of resistance?
What is being resisted?
Who are the resistant actors?
What are the effects of resistance?
What are the (dis)analogies between technologies?
The concept of 'resistance': towards a functional analysis?

My own theoretical inclination is towards a functional analysis of resistance by its consequences in a wider context. We do better to study functions of a process first, and to study dysfunctions afterwards as a dynamic aberration of normal processes. To date we have assumed the dysfunctions and neglected the functions of resistance to new technology. My framework draws upon recent developments in the theory of autonomous systems and elaborates a functional analogy between resistance and acute pain with reference to processes of self-monitoring. Metaphorically speaking, resistance is the 'acute pain' of the innovation process. I cannot assume that contributors subscribe to this framework, so I put it at the end of the book in an attempt to summarize. I develop this framework which both stimulated the idea of the book, and, I dare to hope, embraces many of the issues in a coherent manner. The core thesis states:

> Resistance affects socio-technical activity like acute pain affects individual processes: it is a signal that something is going wrong; it reallocates attention and enhances self-awareness; it evaluates ongoing activity; and it alters this activity in various ways to secure a sustainable future.

Three base technologies after 1945

Someone interested in contemporary history might ask: why compare nuclear power, information technology, and biotechnology? The automobile and space technology are equally major technological innovations of the twentieth century.[3] There are several reasons for the focus on these three technologies. The choice depends on the frame of comparison or '*tertium comparationis*'.

Table 1.1 *Invention, innovations and Organisation for Economic Co-operation and Development (OECD) attention*

Technology	Invention	Innovation	OECD attention
Nuclear	1942 first nuclear chain reaction	1955–6 first nuclear power stations (USSR, UK)	**1956 first report**
Information technology	1943 ENIAC		**1960 micro**
	1947 transistor	1954 commercial	1965 office automat
	1959 integrated circuit	1961 commercial	1971 IT policy series
	1959 micro processor	1965 micro computer 1975 home computer 1981 IBM PC	1979 new IT series
Biotechnology	1944 DNA 1947 double helix		**1982 first report**
	1973 rDNA	1975 CETUS US 1977 BIOGEN (Europe) companies founded	

Sources: OECD publications catalogue; Wright, 1986; Rüdig, 1990.

Similarities

Five similarities of nuclear power, information technology, and biotechnology suggest a viable comparison. I am using these technologies generically as clusters of innovations that are distinct objects of R & D policy, planning and public perceptions.

First, economic historians suggest a periodization of time since about 1780 in cycles of roughly 50 years, commonly known as 'long waves' or 'Kondratieff cycles' of the world economy. Each upswing is based on the scientific and technical ideas developed during the previous downswing for which capital becomes available in the new upswing. Evidence indicates that the fourth wave turned into the downswing in the early 1970s, and a fifth long cycle may have taken off since.[4] The technologies commonly associated with this hypothetical fifth upswing are **civil nuclear power**, the new source of energy; **microelectronics**, with its ramifications into computer and communication technology, the new form of communication (Freeman 1985; DeGreene 1988; Ayers 1990); and **biotechnology and genetic engineering**, the new forms of food production, animal breeding and medical care. Resistance to new technology can take the form of social movements. Hobsbawm (1976) suggested that the size and intensity of social movements, in his case nineteenth century labour movements, relate to long waves of economic development. Screpanti (1984) showed that strike activity intensified during long economic upswings between 1860 and 1970 to reach peaks at the upper turning points of the long cycles; long periods of depressions showed the lowest level of strike activity. More recent observers see the decoupling of social protest movements from the economic system as characteristic of the post-war period (Pakulski 1993), suggesting that the link between economic cycles and popular unrest is historically contingent.

Secondly, nuclear power, information technology and biotechnology reach the attention of planners, forecasters and policy makers in a time series. Table 1.1 compares basic inventions, first-time commercial innovations, and the first related OECD policy reports for the three technologies.[5] This indicator shows that civil nuclear power gained policy focus as early as 1956; information technology after 1971, when the OECD starting a series of reports on information technology policies;[6] biotechnology came into the international policy focus not earlier than 1982. In terms of government policy nuclear power is older than information technology; and information technology is older than biotechnology.

Thirdly, each of these technologies gave rise to sociological imaginings of the 'coming new era', sometimes optimistic and enthusiastic in terms of revolutions, pessimistic in the light of doom, but often ambiguous. We find an abundance of books and articles with titles ranging from the 'atomic age', 'nuclear state' (Jungk 1979), the 'micro-electronic revolution', the 'computer age', the 'information society', the 'electronic society' (Dertouzos & Moses 1979; Lyon 1988), to the dawning of 'biosociety', the 'age of biology' or 'biotechnics' (see Bud 1993).[7]

Fourthly, all three technologies gained considerable media attention at different times, although in a controversial manner mainly after the 'Oil Crisis' of 1973. The cycle of press coverage for nuclear power, information technology and biotechnology confirms the time series in which these three technologies have entered the public arena. Figure 1.1 shows the shifting of media attention between these technologies, based on several European sources.[8] The peak of the coverage is indexed with the value 100 in each case. In Germany nuclear power reached a peak of press attention in 1979 (Kepplinger 1988, p. 665) coinciding with large scale anti-nuclear demonstrations.[9] The coverage of information technology peaks in 1984 (Sensales 1990, p. 66), the year ominously associated

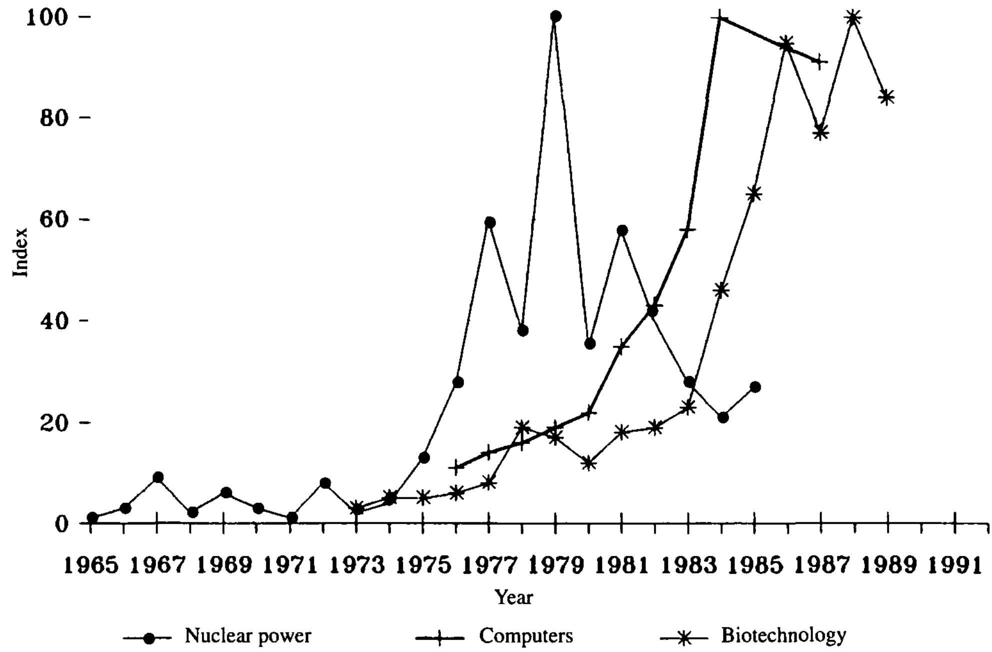

Figure 1.1. Press coverage of nuclear power, information technology and biotechnology in Europe 1965–90. The graph shows the development of press coverage on three technologies. The coverage is indexed with the peak = 100. Data on nuclear power and biotechnology from Germany; data on information technology from Italy.

with George Orwell's dystopian novel. This peak was probably reached earlier in Germany, during the public debate on the Population Census in 1983 (Mathes & Pfetsch 1991). The coverage of biotechnology, genome analysis and new genetics peaks in Germany in 1989 (Kepplinger, Ehmig & Ahlheim 1991; Brodde 1992; Ruhrmann 1992), coinciding with the publication of the parliamentary enquiry, the Catenhusen report, into the dangers and benefits of biotechnology (see Bud, Chapter 14, or Radkau, Chapter 16). In Britain, to date, press coverage on biotechnology peaked in 1992, and it is likely to rise in the coming years as the public debate intensifies (Durant, Hansen & Bauer 1996). The evidence shows that the Asilomar conference in February 1975 (Wright, 1986), where a group of US geneticists put a moratorium on their own research in order to explore the social consequences first, was an event with limited impact on the European public. Nuclear energy, information technology, and biotechnology form a series of policy and media attention. Media attention lags behind policy attention but the gap is decreasing (compare Table 1.1), an indication that public sensitivity to technological issues is increasing. The 'reaction time' from first innovations to public controversy in Europe is about 20 years for nuclear energy, 12–15 years for information technology, and about 8–10 years for biotechnology. Public opinion expressed in media coverage seems to function as feedback information for a process that is already under way.

Fifthly, all three technologies have been the subject of public controversy and social mobilization. Nuclear power has been contested by mass movements since the 1960s; local protests merged into anti-nuclear movements all over Europe and gained significant influence in energy policy (see Rucht, Chapter 13). The debate on information technology has been more of a concern for intellectuals; it rarely mobilized large resistance beyond local actions (Kling & Iacono 1988; Martin, Chapter 9, or Miles & Thomas, Chapter 12).[10] Issues of unemployment, social control, privacy, and security of information resulted in a cluster of opinion surveys in the mid-1980s (Jaufmann & Kistler 1986; Bauer 1993).[11] Biotechnology is the current issue: public opinion is forming on genome analysis, gene therapy, and genetically engineered plants and animals, to date without having mobilized mass actions. On the whole one could say that nuclear power has a long history of debate and has mobilized large-scale resistance which moved from local to trans-national activity. Information technology did not result in large collective resistance; resistance is local on the level of particular industries, work-place actions or consumer behaviour. Biotechnology is the great unknown. Local resistance has occurred against field testing of genetically altered plants, and public opinion has been gauged in recent years (Marlier 1992; European Commission 1993). Jeremy Rifkin and his associates campaign worldwide against new biotechnology and its ramifications.

In summary, nuclear energy, information technology and biotechnology have in turn been viewed as leading technologies with long-term impacts; each of them stimulated dreams of a 'new era', from the atomic age, to the information society, to the dawn of the biosociety. Policy concern and public debate about these technologies came in a sequence. One can assume that the resistance against nuclear power conditioned the resistance and its effects for later developments (see Radkau, Chapter 16). It is likely that we are dealing with an example of institutional learning, the building of new procedures and fora of debates at the interfaces of science, technology and society.

Together with similarities, we need to identify differences between these technologies. Such differences may be candidate variables for explaining the variance in resistance that accompanied these developments.

Dissimilarities

Analogies are useful, but may also be misleading (see Radkau, Chapter 16). In substance the three technologies contribute to different functions of human life. Nuclear power is a source of energy; information technology deals with ways of storing and processing information; biotechnology deals with enhanced production of food (fermentation, plant and animal biotechnology), and with new forms of medical care (pharmaceutical and genetic screening and therapy). These developments build on each other. Computers are to a large extent involved in the development of new biotechnology for process automation, modelling and information storage; and computers and biotechnology rely on available energy.

The three technologies differ in the choices they offer to the public. Buying a computer is different from buying a nuclear power plant. Choices offer points of resistance. Many different choices diffuse user resistance, and may prevent it from becoming a social movement. Nuclear energy is mainly a question of binary choice – yes or no – with some leeway on how large the percentage of the total energy production of a country should be in the form of atomic energy. In contrast, information technology and biotechnology offer wider choices. People have some choice over the extent of computerization they want for their lives: they may restrict the computer to assisting in a few tasks at home or at work, or conduct all their lives with 'computer assistance', from driving a car, to cooking a meal, to making coffee in the morning, to finding a partner. These choices are not free from constraints, as Dorothy Nelkin (Chapter 18) will argue on the issue of penetration of privacy. Biotechnology is similar to information technology in terms of choice among various food products; however, when dealing with the problem of production processes, the experimental release of genetically altered organisms, and the issue of patenting life forms, we may be confronted with binary choices of yes or no (see Jasanoff, Chapter 15, or Bud, Chapter 14).

Risk is both a unifying and a distinctive feature of these three technologies. The capital limits of insuring the potential damage of a large technological project marks a crisis point of modern societies and the transition into 'risk societies'. According to this view it is the success of institutions, not their failure, that undermines their basis and creates space for new political processes to emerge. The quest for technological control leads paradoxically to increased uncertainty, and undermines the capability for action. The distribution of unintended consequences of technological progress becomes a conflict area that cuts across traditional party political lines (Beck 1993).

Nuclear power is 'technically' a low risk area, with large dangers but small probability. Incidences such as Three Mile Island or disasters such as Chernobyl have low probabilities, but, as we all know, have happened – in 1979 and 1986, respectively. In contrast information technology poses small dangers with high probability. Computer addiction (Shotton 1989), exposure to VDU (visual display unit) radiation, and posture pains such as repetitive strain injury (RSI) are widespread, but are not regarded as alarming.[12] The empirical risk of suffering from RSI is probably larger than being contaminated by nuclear fallout. However, risk comparison is notoriously controversial (Covello 1991). Jasanoff (Chapter

15) will show that German, British and US expert proceedings attribute different kinds and sizes of risks to biotechnology. Comparisons are furthermore complicated by the fact that public risk perception is not cumulative; it does not add up many small risks to give one large risk. Risk perception feeds on the size and controllability of danger, and less on its probability. The magnitude of potential damage differs for nuclear power, information technology, and biotechnology. Nuclear power and biotechnology share the possibility, in the former case real, in the latter hypothetical, of large scale, unlimited in time and space, social and physical damage – a problem that is to a lesser extent associated with information technology. This difference may explain the presence or absence of large-scale organized resistance.

The type of risk makes a difference for public perception. The health risks of the three technologies vary. Radiation touches the problem of physical well-being of individuals and society. Leukaemia, cancer and malformations at birth are issues central to people's life concerns. By contrast the problems of information technology are more abstract: it seems to alter the way we think and make decisions; 'artificial intelligence' seems to bother mainly people with expertise in the field of 'thinking', such as intellectuals and academics. Information technology has not lent itself to mass mobilization of resistance that goes beyond local issues except in Germany in 1983 and 1987 where a computer readable identity card and the population census became a major issue (Mathes & Pfetsch 1991). Radiation fallout from accidents like Chernobyl poses **risks without limits**; the event had consequences in Northern Scandinavia within days. Power stations may pose geographically concentrated risks of leukaemia and cancer in the vicinity. The problematic impacts of information technology are more widely scattered and mostly transitory; and impacts such as enhanced social control and penetration of privacy are more symbolic and difficult to recognize (see Nelkin, Chapter 18). In new areas of biotechnology and genetic engineering health risks are an open question, and more of a diffuse but widespread concern than well defined.

The three technologies differ in capital intensity and geographical concentration. Nuclear power is the most expensive technology per investment unit. It may have once been part of the expert imagination that each household would have a nuclear power generator in the back garden, in the basement or in the automobile;[13] but nuclear energy production became concentrated in large plant sites – 423 sites in 24 countries by 1990. Information technology is radically different. Computing units have become increasingly smaller and cheaper and are widely distributed in business and in households as mainframes, micros, PCs (personal computers), laptops or notebooks, or as integrated parts of an increasing number of artefacts. Similarly, biotechnology does not require the large-scale investments of nuclear energy with all that it implies for the disposal or re-processing of nuclear waste. The human genome project is a small investment compared to the nuclear programmes over the last 40 years. The biotechnology industry started up in small businesses linked to university departments (Wright 1986), and turned into a venture of established chemical industries in recent years. Within one country nuclear power is centralized technology, while information technology and biotechnology tend to be distributed technologies.

Whether the enterprise is private or public makes a difference. Nuclear power and computers were initially a state enterprise from research and development to production, a matter of national security linked to the capacity to produce 'the Bomb' and to make large-scale calculations in missile technology. Private companies take over later: nuclear power remains a state enterprise in many countries until the present time while the diffusion of information technology and biotechnology is predominantly a matter of private business. Public control is limited to setting legal boundaries and incentives for investment. The involvement of the state makes nuclear power a direct political issue. Nuclear power is public technology; information technology and biotechnology are primarily private technologies. This leads to a different culture of industry. The nuclear power industry inherited a tradition of secrecy from its military roots. Research and development was conducted behind closed doors, dictated by national security during the Cold War years. The chemical, computer and communications industries are more open. Their processes and products are more visible in everyday use. Public enterprise does not mean an open culture, and private developments do not imply a culture of secrecy.

The public discourse of technology varies across and within technology over time. The geographical concentration of nuclear power makes it visible in the landscape as an icon of 'progress', 'doom', or 'a devil's bargain' (Gamson & Modigliani 1989). The Cold War favoured images of secrecy and national security in relation to nuclear power, while the 1980s favoured the imperative of international economic competition. Neither information technology nor biotechnology is a major issue of national security, but does impact on national competitiveness. Confronted with the threat of terrorism nuclear power implied intensified social control, perhaps even a police state within the 'nuclear state' (Jungk 1979): it has similarities with information technology in terms of political risk. Another variable of discourse is the 'newness' of technology. Jasanoff (Chapter 15) shows that for biotechnology the context dictates the rhetoric: for purposes of fund raising and innovation policy 'novelty' and 'revolution' are appealing arguments. However, to prevent legislation and judicial activity, 'novelty' is an undesirable argument as existing regulations are supposed to suffice; new biotechnologies 'become' forms of brewing and breeding, or 'old wine in new bottles'. The effects of 'newness' on the mobilization of resistance may be seen by comparison with 'old' technologies, e.g. the automobile or hydroelectric energy. According to all of these criteria – choices offered, risks involved, capital intensity, public or private, the culture of industry, and public image – nuclear power stands apart from information technology and biotechnology.

Larger contexts may account for similarities

Beyond these differences and the similarities of high expectations, innovation policy focus, media coverage and public controversies, all three technologies share the historical context of the post-war period. Four features of that period may explain the similarities: the end of Utopian visions, the Cold War period, the changing role of expertise, and the shift in cultural values.

The last waves of Utopianism motivated the 1968 student protests and have calmed down since; Utopias seem no longer suitable for conceiving the future. The criteria for criticizing our civilization towards the end of the twentieth century are diffuse. The malaise concerns the question: where are we going? The notion of 'Progress', writ large, is in crisis again (see Touraine, Chapter 2). The equation of progress and new technology is no longer taken for granted. Bold expectations of the future give way to concern for the present; optimism transforms into caution; democratic expectations become immediate and more widespread. In the search for sustainable development from a global perspective we need to co-opt dissent, rather than ignoring it, blinded by a vision for the future. We are interested in those who resisted without a vision of the future and trace the precursors of modern technology assessments: the actions of the latter-day guilds and Luddites to new technology. We are busy reinventing institutions that traditionally bridged the gap between the place of action and the place of consequences; institutions that got lost in the way of 'Progress' (Schot 1991).

With the fall of the Berlin Wall in 1989, the Cold War came to an end. The mobilization of science and technology to ensure a balance of military forces framed the public debates in all Western countries. Decontextualizing the three technologies from this common context may lead to false conclusions. The Cold War affected public discourse at all levels. National security was a whitewash for much mismanagement, many disasters and cover ups. Whole research programmes were conducted secretly. The discourse of new technology was framed by the East–West divide. Secrecy throws expertise into disrepute (Knorre 1992). The present situation may bring a different pattern of public response to new technology. The lack of democratic decision making on grounds of security is no longer justified; the end of the Cold War strengthens the aspirations of various groups of people to have a say.

We have witnessed over the last 30 years the disenchantment with expertise. Technocracy is not a socially acceptable form of government. The idea of technocracy is a modern idea, and equally the struggle against technocracy is part of modernity; resistance is part of this parallel process to secure freedom of choice. Anti-big business and anti-technocracy unites all three movements of resistance (see Touraine, Chapter 2). Bureaucracy is the target, rather than engineering or science itself. We find some similarity of motives with the Luddites (Randall, Chapter 3), who opposed a particular way of putting machines to work to avert the dissolution of their life world. Current technological resistance equally fights the process, not the product, of technological development. The issues are often public deceit and lies; manipulation and exclusion; pollution and exploitation; expert conspiracy; and the unequal distribution of risks.

The argument of a changing culture ties in with Inglehart's (1990, p. 143) diagnosis of a value shift in advanced industrial society from a material to a post-material orientation. Post-materialists believe in ideas and celebrate personal relationships, and want a say in their jobs, freedom of speech, and democracy. In contrast the materialists favour above all law and order, economic growth, and low inflation. The end of the Cold War, the loss of Utopia, the disenchantment with expertise and the culture shift point to a common context for nuclear power, information technology and biotechnology in the development of science, technology and industry. This opens up the possibility of analysing the functions of resistance for these three post-1945 developments: similar functions achieved with changing structures.

What are the forms of resistance?

The problem of definition

The first problem is to define resistance. In the following pages I take stock of ways that 'resistance' has been defined in various contexts. Mokyr (1990) lists resistance among the major variables that explain variance in technological development such as life expectancy, nutrition, willingness to bear risks, geography, path dependency, labour costs, science, religion, values, institutions and property rights, politics and the state, war, openness to new information, and demography.

According to the Oxford English Dictionary, 'resist' means 'to withstand, to prevent, to repel, to stand against, to stop' in four different contexts: to describe human actions, to describe the power or capacity of such actions, to describe the opposing relation of forces, and to describe specifically the non-conductivity of electricity, magnetism or heat. 'Resistance' as human action means the '**refusal to comply with some demand**'; and historically the **clandestine insurgence** against an occupying, illegitimate power during the Second World War of which the French '*Resistance*', the German '*Widerstand*' or the Italian '*Resistenza*' are well-known examples. I see three distinctions constitutive of what counts as resistance in the present context: rationality/irrationality, resistance/opposition, and the problem of self-reference.

Resistance as diversion from the 'one best way'

In the context of (social) engineering, resistance is traditionally the deviation from the Rational writ large, or F. W. Taylor's 'one best way'. Planners, engineers, managers and designers encounter the world as a set of ill-defined problems (see Staudenmaier, Chapter 7). To structure this uncertainty increases predictability and control over matter and people. Resistance is the uncertainty of the designer struggling with matter and people that needs to be reduced. Rationality is claimed by the designer, and actions that challenge his or her proposal are 'resistance'. However, a design is necessarily 'bounded' within constraints of space and time (Simon 1981) and the notion of a single best solution – Rationality writ large – is hardly justifiable. Under any constraint different assumptions suggest different solutions and legitimate the 'resistance' to a single best design.

Any design reduces some kind of uncertainty while creating others both for the designer and for the users. Risk analysis quantifies this as the product of damage and its probability. To take expert calculations and deviations from this baseline as 'bias' in risk perception is a common way of defining resistance (see Bauer critically on 'technophobia', Chapter 5). Bias is the outcome of either missing information or 'inadequate' information processing. 'Debiasing' popular perceptions with additional information and special training makes good business, but seems naïve as it assumes that additional information leads to the same conclusions for everyone. People are affected differently by the same information. Different assumptions suggest different conclusions on the same information.

Staudenmaier (Chapter 7) points out that historical narratives of great technological projects may pay legitimate tribute to 'great human achievements'; but they are 'Whiggish' in outlook and selective with facts. Complementary stories need to be told to understand the dynamics of technological developments: the stories of losers, sidetrackings, failures and obstacles on the way. Even the story of 'great men' is incomplete. Human achievements are ambiguous. Human actions encounter durability, material and cultural, which a universal notion of Rationality cannot displace without violence. Alain Touraine (Chapter 2) discusses this as the crisis of Progress leaving us in a conflict between the Scylla and Charybdis of narcissistic particularism and the universalism of large projects, both equally undesirable in the light of historical experience. Resistance reemerges as the dignity of bearing the tensions in between two illusory seductions in the late twentieth century without giving in to either of them (Touraine 1992).

Resistance and opposition

Both activities, resistance and opposition, challenge a given project, although in different relations to social institutions. Opposition is challenging activity within institutional boundaries. 'Institutional' activities are those that can be expected to happen. Resistance is best understood as **activity** which is **unexpected** in both content and form by the innovators. This does not preclude an observer predicting such activities; the surprise of the innovator and designer is crucial. This distinction allows us to describe the transition from resistance to opposition, whereby activities are institutionalized and become predictable; when institutions are dismantled, opposition activities can become resistance.

Furthermore, resistance is a form of **risky behaviour**. Someone who violates norms and rules runs the risk of exclusion, punishment or material sanctions. The legal discussion of the 'right to resistance' tackles the paradox of justifying actions outside the law without undermining the rule of law. This is done with a view to law as a process (*Rechtsfortbildung*); the legal system is always imperfect and in need of improvement along the lines of the constitution (Rhinow 1985). If resistance breaks a norm and institutions play a role in defining that norm, resistance as action is the **product of normative communication**. The more restrictive the norms, the larger the range of activities that count as resistance. Resistance is defined by a system that is in and of this conflict.[14]

Self-reference and resistance

Several questions point to the problem of self-reference. Does resistance always have clear motives and purpose, or can activities challenge a technological project without such motives and purpose? Do the resistant persons see themselves as being resistant or not; or, in other words, is 'resistance' an observer category or a category of self-description, or both? What activity counts as an act of resistance? We are dealing with the logical hierarchy of actions and behaviour: various behaviours can qualify as resistance actions depending on the context of motivation.

A clear **motive** and a **conscious purpose** to challenge a project in unexpected ways define an act of resistance. 'Purposeful' resistance means that the action is willed and planned, and that some consequences, positive or negative, likely or unlikely, are taken into account. It is risky action. Resistance may follow a moral imperative in justifying the motive. An ethical and moral discourse may provide the grounds for resisting a certain project.

Purpose and motive make the difference between resistance and mere

avoidance behaviour, such as not buying something, or not consuming or using it once a device has been bought. If avoidance meant resistance, this would imply that there is an obligation to consume in the first place. Some people would strongly argue the need to distinguish between deliberate boycott and the reluctance to consume or to change from typewriter to word processing out of ignorance or lack of opportunity. 'Not buying' becomes resistance only in purposeful consumer boycott. Conscious purpose and motive transform mere behaviour into dignified resistance. Defining resistance as the continuum from 'not consuming' to 'risking one's life' seems inadequate. Risking one's life for a moral reason has a dignity that does not seem comparable to mere non-consumption for non-specific reasons.

However, the problem of consciousness complicates the issue. To define resistance by its purpose may do justice to the moral claim, but it may be that a variety of events, often silent, unspectacular, everyday actions are equally functional in challenging a technological project, or setting limits to its power. It may be a way of life not to go along with a project, not out of high moral purpose, but out of tradition or parochial concerns (Scott 1985). Wynne (1993) shows how forms of so-called 'public ignorance' of science and technology are unorganized ways of negotiating an acceptable relationship with experts by limiting their cognitive control. Avoidance behaviour is an observer category; people buy goods or not, use them or not, are indifferent and frustrate one's expectations. Our actions involve variable degrees of awareness. We may be fully conscious, partially conscious, temporarily unconscious, or entirely unaware of what we are achieving with our actions. The attitude often follows the action, and we come to intend what we are already doing. In raising consciousness about what we are doing, we may adjust our attitudes to our behaviours. Behaviours without a conscious motive cannot be ruled out as forms of resistance by their consequences. In that sense the high moral purpose seems not to be a sufficient criterion for resistance actions.

Actions may differ in their ethical and moral dignity, but functionally they may well have similar effects.[15] For the present purpose we shall explore effects of resistance with or without motives; intentions serve to classify effects as anticipated or not. The discourse on the morality of resistance is a variable that is itself an indicator of the intensity of resistance. The more people reflect on the dignity of resistance the more pressing is the problem of resistance. Miles and Thomas (Chapter 12) see resistance as a narrow range of actions on one end of the continuum of acceptance of information technology. We should perhaps talk about resistance in the functional sense with a small 'r' and in the moral sense with a capital 'R'.

Towards a taxonomy

A taxonomy of resistance tries to distinguish different qualities and intensities of resistance. Kinds and strength of resistance are important for assessing differential effects on new technologies in various contexts. Identifying forms of resistance is also a precondition for the analysis of the internal dynamics of resistance, as it transforms with contexts and time.

Active/passive and individual/collective

Resistance is frequently described as active or passive. Active refers to purposeful actions that may involve violence against persons or objects: direct attacks against machines, the destruction of machines, the intrusion or occupation of building sites. This may include forms of violence that are often confined to a small circle of determined, specially trained and motivated activists. By contrast, passive resistance comprises forms of wilful inactivity, where bodily movements are restricted: non-compliance, blocking, sit-ins, not doing things one is expected to do by law. Passive resistance is more easily turned into mass action, as people do not need special training and it may be physically less demanding.

Another distinction draws a line between resistance as an action of one or many individuals: individual, cumulative or collective resistance. Isolated individuals may resist a project; large numbers of people can resist with cumulative effect without coordinating their actions.[16] An observer can identify the effects of these actions. People themselves may not see it. The cumulative effect of uncoordinated actions can be functionally equivalent to organized actions in a repressive context. Formal structures are both enabling and constraining, and some observers take them as a necessary criterion for resistance (see Nelkin, Chapter 18). The degree of coordination of resistance is a variable. Individuals may coalesce into movements, new movements may co-opt existing structures. Mazur (1975) has shown how the US anti-nuclear movement rode on the back of the older environmental movement. Jeremy Rifkin explicitly tries to co-opt animal rights groups, vegetarians, environmentalists, and Third World awareness groups into a 'rainbow' coalition for his apocalyptic struggle against biotechnology incorporated.

International activities must be distinguished by the mode of aggregation: multinational resistance operates from a hierarchical centre that coordinates and plans analogously to a multinational business (e.g. Greenpeace; Jeremy Rifkin); in contrast there is trans-national resistance which works as a forum for discussion more like the United Nations: heterarchical with various autonomous centres of activity (e.g. the international anti-nuclear movement).

Classes of actions and levels of analysis

In a stocktaking exercise a variety of behaviour patterns can be identified as 'resistance', of which civil disobedience is the most salient one. Sharp (1973) distinguishes symbolic actions, such as collecting signatures, distributing flyers and pamphlets and rallying, from non-cooperation and non-violent interventions. Among the latter are site occupations; setting up anti-nuclear camps; mass demonstrations or sit-ins that intervene with the normal course of the daily activities. Many of these forms are ritualistic, and so inhibit violence in similar ways to the rituals of the Luddites (see Randall, Chapter 3).

Economic behaviours include consumer boycotts, avoiding the consumption of certain products, or refusing to give services to certain institutions. We find campaigning by consumer organizations on behalf of users and consumers. Technological innovations may precipitate industrial action.

Cultural and symbolic activities are the public display of the ambiguity towards new technology (see Staudenmaier, Chapter 7). Cultural activities include film making, writing popular books, giving talks, ordering arguments and organizing conferences on controversial issues. Ambiguity is displayed in variations on the image of the 'mad or irresponsible scientists' or of 'Dr Frankenstein and his monster' as the motive force in science fiction writing and film. Resistance relies on alternative value patterns, an ethos of dissent, or religious values. Sociological evidence suggests that absolute religious values have become more salient in recent years and with them has come an uneasiness with compromise (see Nelkin, Chapter 18). The media's coverage of science and technology is an indicator of cultural resistance which Kepplinger (Chapter 17) analyses and critically addresses. Anxieties and fears ('technophobia', 'nuclearphobia', and 'cyberphobia') may result in a retreat from public life into the confines of privacy and into a controllable small world of non-engagement and alternative lifestyles.

Legal actions involve a call upon the state to regulate, in some countries by calling for a plebiscite. Thus, political lobbying and voting behaviour may indicate technological resistance (Buchmann, Chapter 10). In the USA activists force judicial rulings to change the law in litigations against individuals, corporations, or institutions. Court cases of this kind are called in the name of civil rights that are violated in the context of new technology.

We may distinguish levels of analysis. Our daily activity resists physical influences; we resist the weather, the sun, the heat and the cold in various ways; our immune system resists noxious agents. At the level of cognition we resist the 'external' influence on our experience that is mediated by film, radio or print media. At the organizational level the work-place is an arena of resistance against new technology, abject working conditions and exploitations. At the cultural level we may resist changes that are suggested or even imposed by exponents of other cultures on our way of life; where cultures meet there will be resistance. Symbolic meaning is both a resource and an object of resistance as shown by Staudenmaier (Chapter 7) in the case of popular images of Henry Ford in the USA.

Measuring the intensity of resistance

Measuring the intensity of resistance is essential to compare its effects across time, technology and national contexts. Measures of resistance allow us to associate resistance and effects in a systematic manner. Several measures of resistance will be put forward in this book.

I myself shall critically discuss how resistance to new technology has been measured psychometrically, and has been defined as a clinical problem. A test score defines 'cyberphobia', a supposedly 'irrational' form of anxiety towards information technology, that is claimed to be widespread. The measurement consists of two steps: first, to define 'cyberphobia' on a test distribution; secondly, to screen a population using this test as a criterion.

Daamen and van der Lans (Chapter 4) show how resistance to nuclear power, information technology and biotechnology is measured by negative attitudes on a multi-item scale of survey responses. The validity of survey measures is critically discussed in the light of the assimilation effect. Attitude measures are sensitive to the immediate context of data collection. Context effects throw light on artefacts occurring in survey measurements.

Rucht (Chapter 13) counts and analyses press coverage of protest events across countries. The type of event, the number of participants, and the degree of violence provide an indicator of resistance to nuclear power in different countries over an extended period of time.

Botelho (Chapter 11) demonstrates how diffusion studies measure resistance in a market system by the differentials in the diffusion rates of new products or processes. The later and the slower the process, the larger is the resistance of the system. Geographical concentration of an idea, process or product is another indicator for resistance in diffusion systems (Hagerstrand 1967). Some regions adopt new ideas and products, others not, so that over time clusters of diffusion appear in the landscape. Such processes are modelled by degrees of resistance in regions.

Miles and Thomas (Chapter 12) arrange forms of resistance to information technologies on an ordinal classification from non-acceptance at one extreme to resistance at the other. Degrees of non-acceptance of consumer electronics are: reluctant purchase; infrequent use, once purchased; partial use of functions; bewilderment over choice; and the moratorium 'no'. The criterion of acceptance is the purchase of consumer goods.

Comparing the intensity of resistance across the three technologies leads to the following conclusion: resistance is strongest against nuclear power, weakest in the case of information technology, and, to date, medium for biotechnology.[17] Information technology imposes small damage with high probability: no large-scale resistance has formed, yet. Nuclear power is characterized by high damage potential with relatively low probability. The risks of biotechnology are still largely unknown. The resistance against information technology is mostly local and a matter of 'intellectuals'; it is mainly informal, individual, and passive, such as refusal to work with computers. Organized resistance, as in the British printing industry (see Martin, Chapter 9), seems to be infrequent.

What is being resisted and why?

The title of this book suggests that the object of resistance is technology. This common-sense assumption is, as we shall see, problematic. What is being resisted is normally complex and requires empirical analysis. The study of resistance needs to face the possibility that resistance is more easily characterized by the process and its effects than by its antecedents; the causes may be more numerous than the effects.

Resistance may be directed against the machinery and the technical devices involved, as they become the symbolic focus of what infringes people's livelihood; this is traditionally the meaning of the term 'Luddism' or 'machine breaking' (see critically Randall, Chapter 3). It may be useful to distinguish resisting hardware from resisting its consequences. The latter case may target a parameter of the design, rather than the design as a whole. Effects have different ranges: personal, local, national, international. Local consequences differ from consequences in distant places by their significance.

Often it is neither design nor consequences that are resisted, but the process by which the technology is put to work that is found wanting. Manipulation, being patronizing and breaking informal contracts are the problems.[18] However, it makes only limited sense to separate the design idea from its implementation. The implementation is the design in time and specific contexts.

Big business and state power appear to be the principle object of resistance (Touraine, Chapter 2, or Evers & Nowotny 1987). New technologies are financed, developed and implemented by large corporate sectors or state bureaucracies under expert guidance, often in the context of defence and warfare. 'Technocracy' seeks to abolish politics and, by implication, to exclude the citizen and the public from the decision-making process; technocrats regard politics as an interference in the rational techno-logic. In such a context, neither science nor technology themselves are resisted, but their exclusive control by experts who are not held accountable in order to enhance control over non-experts. Intertwined as it became historically with a technocratic world project, not least in its Soviet version, 'scientific universalism' lost more and more of its appeal.

Another distinction is that between product innovation and process innovation. Process innovations increase the efficiency of production with new procedures and capital goods. Product innovations are new consumer goods. People resist new processes at the work-place and as investors and producers (see Bruland, Chapter 6); they resist new products as consumer (see Miles & Thomas, Chapter 12). Process innovations will be a focus for labour organizations, and product innovations for consumer organizations.

It is the new technology that is resisted, rather than the old one. 'Newness' makes a difference, not least because risks are difficult to assess, and the resulting uncertainty stifles action. 'Newness' is relative to place and time. Whether a technology is new is a matter of debate. Newness is claimed and highly desirable in the context of patenting, but it is not necessarily desirable in public debates on regulations. The features of public resistance are themselves the outcome of public debates, not least in the form of social scientific inputs into that debate.

Historically resistance is found in the context of technology transfer of fishing nets and techniques, the steam saw and automobiles in Scandinavia (Bruland, Chapter 6); and against the introduction of textile machinery in the early nineteenth century in Britain (Randall, Chapter 3). Its targets are specific implementations, a particular mix of techniques, or a technology at large. Furthermore, technology is resisted because it signifies the hegemony of a foreign power (Touraine, Chapter 2).

With regard to nuclear technology, various events are the object of resistance: nuclear power plants *per se*, government nuclear policy, the siting of particular plants, the disposal of nuclear waste in the sea or under ground, its transport over long distances, increased levels of radiation in the vicinity of installations, and nuclear power as foreign domination (see Rucht, Chapter 13, or MacLeod, Chapter 8).

With information technology, consequences are the object of resistance: the intrusion of privacy with sophisticated marketing control methods (Nelkin, Chapter 18); the threat posed to freedom and democracy by centralized social control over and misuse of information. VDU radiation and repetitive strains pose some health risks. Obfuscation of decision making with artificial intelligence is a major concern for people with intellectual commitments (e.g. Weizenbaum 1976). Loss in quality of working life, de-skilling, changing job structures, bad quality of user interfaces, and job redundancies are resisted. Electronic publishing revolutionized the printing process, making various intermediary tasks redundant. The conflict at Fleet Street, London, tells this story (see Martin, Chapter 9). Products such as minitel, audiotext and videotext diffuse at different rates in different countries (Miles & Thomas, Chapter 12). Current concerns about new media focus upon the spreading of pornographic material and of computer addiction, a protective concern on behalf of youth, with a legal angle when 'hackers' intrude and interfere with sensitive data bases.

Resistance to biotechnology targets the siting of research facilities, as, for example, in Switzerland (see Buchmann, Chapter 10), the field testing of genetically altered plants, the breeding of transgenic animals, the patenting of life forms, and experimentation with human embryos and new reproductive technologies for humans. The control of the genetic code is open to abuse. For Jeremy Rifkin this constitutes the latest in a series of secular 'enclosures' for purposes of exploitation: from land, to sea, to air, and now to genes. Processes, products, and their implications are resisted, where the sanctity of life and nature, biodiversity, and the sustainable development of the world are at stake.

The concept of resistance motivation summarizes those processes which start and end the resistance activity, and which maintain the momentum of activity in the face of obstacles, and maintain vigilance in the absence of a real concern (Haltiner 1986). It covers all processes of individual and collective mobilization. Motives describe particular processes of that kind. Owing to its ambiguous nature the technological process is accompanied by anticipations of known and unknown dangers and risks. Fear and anxiety are primarily evolutionary achievements that prepare the organism for adequate action in situations of danger. Emotions such as fears and anxieties redirect energies and prepare for necessary actions. Resistance often reveals competing '*Weltanschauungen*'. Images and visions of the future are motives both for technological design and for resistance to technology (see Staudenmaier, Chapter 7). Anticipations of doom may motivate actions to avert the catastrophe scenario. The diagnosed shift in cultural values (Inglehart 1990) influences people's preferences in private consumption and political behaviour. Finally there is motivation resulting from the recursive effects of resistance on itself; initial success mobilizes individual and collective energies for future action and rallies support and new resources; failure may lead to both increased determination or to loss of confidence; resources are depleted and resistance may come to an end.

Who is resisting?

Any study of resistance needs to identify the actors. Who are the people that resist a particular technology or new technology in general; how do they differ from other social groups; how large is this group, and where are they located within the structures of society? Generally there are two ways of defining social groups, statistically in terms of socio-demographic variables ('statistical groups'), or according to self-reported membership ('natural groups').

Natural groups

Natural groups provide a social identity and are often formally organized with a legal status as a club or society that carries a name. Specific groups that have been associated with resistance to new technologies are groups with a cultural mission. C. P. Snow's distinction of a world of arts and a world of science (Snow 1959; Hultberg 1991) has recently been called upon. Arts and the social sciences are associated with ignorance of and resistance to science and technology. Kepplinger (Chapter 17) recognizes in particular the post-1968 generation as political editors and agenda setters within the German press, the '**reflective elite**' that through its position influences public opinion about technology negatively.

New **radical social movements** such as feminists, environmentalists and animal rights movements are associated with resistance to new technology. Religious groups rally for moral concerns and stricter regulation of biotechnology. Activists such as Jeremy Rifkin in the USA rally rainbow coalitions around campaigns, which recently included chefs signing up to refuse to use genetically altered vegetables in their cooking. Much organized resistance is community and culture based, rather than based on economic categories such as labour or consumers. Local networks of people galvanize into large-scale activity under favourable conditions such as economic growth, persistent leadership and coalitions.

The **anti-nuclear movement** is made up of numerous groups with an international network and constitutes a well-defined topic of social research (Rüdig 1990). The resistance to computer technology is less organized. At times, but not generally, trade unions are the organizational resources for resisting changes in production technology (see Martin, Chapter 9). Kling & Iacono (1988) identify three core actors of the '**counter-computer movement**': libertarians concerned with civil rights and privacy issues; consumerists concerned with new forms of consumer credit; trade unionists concerned with impacts on the number and quality of jobs; and pacifists concerned with computerized warfare and the likelihood of wars. All these groups are formed around wider issues, and take up the resistance to certain developments in computing and information technology as part of their activity.

'**Green' parties** are trans-national and core activists like Greenpeace or Jeremy Rifkin are international actors of resistance to nuclear power and biotechnology, less so to information technology. Touraine (Chapter 2) points to the resistance of **governments**, for example in Islamic countries, who for reasons of nationalist politics may resist new technologies to block foreign hegemony. Botelho (Chapter

11) shows how a **civil service elite** with a particular vision of research is a factor of resistance, in this case unintended, in the development of semi-conductor technology in post-war France.

Statistical groups

Various classes of actors can be distinguished on purely conceptual criteria. Such criteria are not normally used by people to define their social identities. Sociological analysis suggests that the social basis of new social movements, some of which take among other preoccupations an anti-technological position, is diverse, but to a large extent **middle class** (Pakulski 1993). However, the correlation between an economic position and social mobilization weakens in the post-war period. According to Touraine (Chapter 2) cultural conflicts will increasingly supersede socio-economic ones. Value orientations increasingly explain political mobilization better than income or property based social stratifications (Buchmann, Chapter 10). Beck (1993) predicts a realignment of the political sphere over the distribution of large technological risks which is superimposed on the traditional conflicts over income distribution.

General public opinion is continuously gauged in social surveys and opinion polls. It caused a shock wave in 1984 when a German Allensbach poll found that 10% of the German population regarded technology as evil, and 54% partly so. The percentage of those who regarded technology as 'a good thing' dropped from 72% in 1966 to 32% eighteen years later (Jaufmann & Kistler 1986). Opinion polls and attitude research located negative attitudes towards information technology and computing in the mid-1980s among the less skilled, low earning, female, rural, older and left-orientated parts of the population (Bauer 1993). Studies on 'cyberphobia' (see Bauer, Chapter 5) report its prevalence among women, the less educated and the marginalized.

Vested interests in past investment is a frequently mentioned category of actors; Bruland (Chapter 6) shows how in Scandinavia holders of old capital obstructed the building of new capital in the form of new machines and new methods of production. Historically labour elites such as cotton spinners or wool combers, or groups such as small farmers, labourers, brick makers and paper makers, were resisting new technology during the industrial revolution (see Randall, Chapter 3).

Buchmann (Chapter 10) shows how in Switzerland the combination of **traditional values, social marginality and habitual nay-saying** forms a cluster of motives that explains negative votes in a national referendum on the regulation of biotechnology and reproductive medicine.

A rising number of people choose 'soft medical treatment', and practise **astrology and parasciences** which coexist with beliefs in, activities in and support for science proper. Observers often tend to construe such practices as expressions of anti-scientific attitudes; however, these practices serve different needs and are therefore not necessarily contradictory (Touraine, Chapter 2).

In organizational research it was a traditional claim that resistance is a matter of **corporate hierarchy**: the lower in the hierarchy the more likely is the resistance to innovations (Lawrence 1954; Johns 1973). The arrival of information technology and computers since the 1960s has altered this empirical finding. For some time resistance to the use of computers polarized on the top **and** on the bottom of the corporate hierarchy, with middle management being the innovators. In the context of new manufacturing methods (e.g. CIM, production islands), the middle strata are likely to resist the innovations (Klein 1984; Littek & Heisig 1986; Carloppio 1988). The position of the middle management is often at risk in the flattened hierarchical structures that computers may bring. In the corporate context resistance is no longer related to hierarchy; depending on the context, resistance is found at all levels of the corporate hierarchy.

Non-users, purchasers of electronic equipment who make only partial use of it, and family members who do not use the electronic devices that other members have bought (Miles & Thomas, Chapter 12) are **categories of consumers** that resist technology by underuse. Non-using may be deliberate resistance, or it may be an indicator of uselessness, functionally equivalent to pushing a product out of the market. Similarly the biotechnology industry anxiously anticipates consumers who will hesitate to buy genetically altered foodstuffs, such as the 'flavr savr' tomatoes specially engineered for a longer shelf life. The controversy on what information product labels should contain speaks clearly of the nervousness in the biotechnology industry.

What are the effects of resistance?

The literature on resistance is rich in descriptions of the various forms of resistance, the analysis of its actors, and of the causes, motives and conditions. Most studies focus on resistance as the dependent variable. The analysis of resistance by consequences, with resistance as an explanatory and independent variable of technological change, is rare; corresponding chapters in textbooks tend to be thin. Findings on consequences of resistance are best developed for the anti-nuclear protest movements (Rüdig 1990; see Rucht, Chapter 13).

Principally four dimensions of effects may be distinguished:

* foreseen and unforeseen effects,
* direct and indirect effects,

* impact and recursive effects,
* functional and dysfunctional effects.

These analytical dimensions define in combination a theoretical space of sixteen types of effects: from foreseen–direct–functional impact to unforeseen–indirect–recursive and dysfunctional effects.

Direct effects are the immediate effects on the innovation process, while indirect effects impinge on the technological process via mediating processes. Indirect effects are often instrumental in reaching the objectives of actors. The distinction of foreseen and unforeseen refers to the point of view of resistance actors. Unforeseen effects cannot be intended, while foreseen effects may be intended but need not. It may be helpful to distinguish the effects of resistance on the technological processes, and recursive effects on the resistance itself in terms of structural changes: growth, motivation, disintegration and decline. Functional or dysfunctional refers to the long-term effects of resistance on the technological process. Functional effects increase the viability of a project, dysfunctional effects decrease it, depending on the level of analysis; effects that are dysfunctional on one level may be functional on another level and vice versa. Events are not *a priori* functional or dysfunctional; it depends on the process dynamics. Processes assumed to be functional may turn dysfunctional under conditions that have to be clarified empirically; events may be both functional and dysfunctional simultaneously but for different processes. Commonly, functional and dysfunctional correspond with the positive or negative value. Actors try to reduce dysfunctional effects and to increase functional ones. However, from an observer's point of view we are able to appreciate the positive consequences of seemingly dysfunctional events.

Finally, resistance does not determine its own consequences; its effects are contingent. Similar forms and intensities of resistance result in different nuclear power programmes in different countries. Traditions of legal regulation channel the voicing of resistance and constrain its effects on technological developments (see Rucht, Chapter 13, Jasanoff, Chapter 15, or Martin, Chapter 9). In analysing effects we need to take into account the reactions of innovators and regulatory bodies. These contingencies make it difficult to attribute 'causality' between resistance and its effects. More realistic are circular influences where past effects condition the future relationship between resistance and its effects. This relationship is itself a variable.

Direct and foreseen effects

Direct effects are often reactions of actors such as governments, international agencies or corporate management challenged by resistance whose actions alter the trajectory of technology. On the one hand, actors may try to calm a conflict situation with the revision of a project or a policy reform: a response that may be in timing and content the effect of resistance activities. On the other hand, forms of repression and police actions need to be expected as resistance often transgresses the boundaries of legality. The state is called to enforce the rule of the law. Repression may be successful in temporarily suppressing resistance activity; however, in many cases this is only to strengthen its resilience, and to widen its mobilization basis, and media coverage, and to lead to silent conversion among the wider public (Raschke 1988, p. 355; Mugny & Perez 1991, p. 154).

Preventing an event from happening is the strongest direct effect. A project may be abandoned in response to resistance as in the case of the Austrian nuclear power plant 'Zwentendorf' near Vienna, mothballed before it started to produce energy. Other effects are: delaying the resisted events; postponing a final decision; abandoning a project for good, or for only a limited period of time. The Luddite struggle against machinery is an example of the latter. The introduction of textile machinery was postponed in a particular area of Northern England (Randall, Chapter 3).

Resistance lowers the level of expectations of innovators. The exuberant expectations of many a project face a 'reality test' on resistance, and get adjusted. A striking example is shown by the international projections for nuclear energy. The exuberant predictions of the 1950s and 1960s were massively reduced in the 1970s. Figure 1.2 shows the projections for 1977, 1980 and 1990 together with the actual development of world nuclear energy production. The actual production in 1990 is about half the projection of 1977. The projection for the year 2000 in 1990 is less than a quarter of that of 1977 (IAEA 1981; WNIH 1992).

A further effect of resistance is the relocation of innovations (Rucht, Chapter 13). Resistance to new technology may have spatial and cluster effects. Successful resistance in one location is no guarantee of success in other locations. This results in concentration of the technology in one region or in one country, while in neighbouring areas the technology is hardly present (Hagerstrand 1967). The effect will be the spatial distribution of new technology. Nuclear power is an example: some countries, such as France or Japan, have realized a large nuclear power programme while other countries have abandoned it. In the debate on new biotechnology dislocation is a much anticipated effect. If companies are prevented from building research facilities in some areas by local resistance or because of strict safety regulations, they may move into other countries, and finally to the Third World, where conditions seem to be 'favourable'.

Often the definition of the problem is at stake. Resistance may oppose the particular way a problem is 'framed' in terms of issues, themes and concerns. Such a frame may mean a lack of choices, or present an unacceptable choice. For

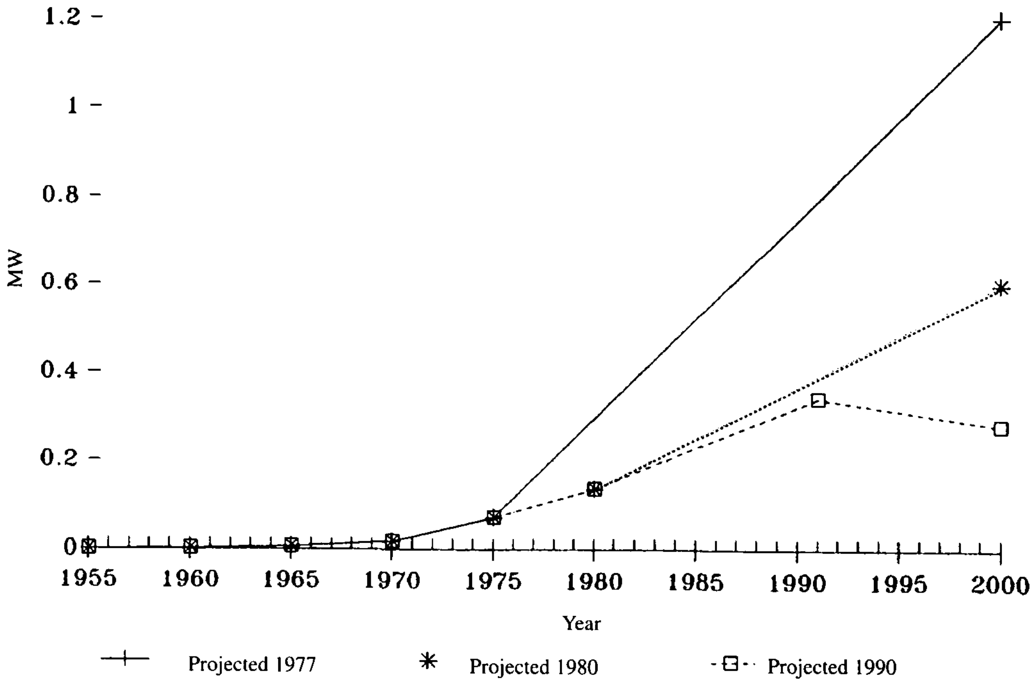

Figure 1.2. Changing expectations of the nuclear industry 1977 to 1990. The graph shows the production and projections of nuclear power production for the year 2000 by 1977, 1980 and 1990. Source: Nuclear Industry Handbook 1992.

political decisions issues are often reduced to a binary option corresponding to the polarities of an adversarial political system. This dichotomy is achieved in various ways. The role of resistance may be to indicate how inadequate the binary option is and to reopen the debate beyond the simplifying either/or. A variety of perspectives get voiced where formerly experts dominated the debate. As an outcome the parameters of a problem may multiply. The environmental movement introduced a set of new criteria (environmental impacts) on existing problems such as resource management and waste disposal. The environmental agenda has penetrated the rhetoric of most political parties to the extent that the movement has lost its distinct political profile; the environmental movement *becomes a victim of its own success. The success of a resistance movement may* be a condition of its dissolution.

Indirect and foreseen effects

Indirect effects are instrumental in achieving the objectives of resistance activities; as such they are intended. Of more tactical than strategic interest are media effects. Media coverage is important for setting the public agenda, mobilizing public opinion and forcing governments to act (see Kepplinger, Chapter 17).

Activities of resistance intend to be newsworthy and spectacular. Greenpeace and anti-abortionist activities, such as chaining protesters to a tree or to furniture or camping on the top of a chimney that pollutes the air, epitomize this quest for publicity. Depending on how the media are taking up the issue media coverage can be supportive or can backfire. Access to the media is important for defining an issue for public debate. Kepplinger shows how the anti-technological movements were able to mobilize major parts of the German press for their causes. Media coverage is also important for recruiting new members, stabilizing a public profile and legitimacy, gaining coalition partners, and challenging the reactions of opponents (Schmitt-Beck 1990).

In democratic societies a **referendum** can be an effect of resistance, particularly where such a procedure is not normally foreseen. The referendum on the Austrian nuclear power plant at Zwentendorf in 1978 is such a case. The Swiss referendum on biotechnology and reproductive technologies, part of the normal political procedure, is analysed by Buchmann (Chapter 10). Legal regulations set an important context for the development of new technology such as biotechnology.

Resistance often leads to new regulations to prevent misuse of knowledge and related practices. **Getting the legal system moving**, i.e. the production of new laws or new interpretations, can be attributed to resistance, while the kind of regulation that emerges from the process follows different constraints. Jasanoff (Chapter 15) will show how legal traditions condition the regulatory response to resistance to biotechnology in Germany, Britain and the USA: process versus product regulations, or a combination of both.

Unforeseen effects

Unforeseen effects are effects of resistance on the technological process that have not been intended nor anticipated by resistance actors. These effects share an element of surprise for actors, as they are unexpected. The analogy of evolution (mutation, selection and retention) on technological change (Mokyr 1992) stipulates resistance as an external factor that selects products and processes over time. Retrospectively these appear as lines of progression. At the time the selection process is surprising and subject to attempts to gain control. Any present range of technical devices and ideas is the outcome of past resistance which works as a filter; screening out some items, letting through others, pushing the path of 'progress' into a particular direction. Technological development is at times gradual, at times it jumps from one 'punctuated equilibrium' to the other, depending on large-scale environmental events. Within the temporary state of equilibrium small changes accumulate; fine tuning based on existing knowledge contributes massively to overall gains in productivity; revolutions from one equilibrium to another alter the basics of design with totally new ideas.

The resistance of consumers to new products or of investors to new processes make innovations disappear from the market. These products or processes are retrospectively the waste of evolutionary selection. Innovative activity produces variants of products and processes, from which consumer preferences and investment rationales select viable ones.

Another unforeseen outcome of resistance to new technology consists of institutional innovations and new political opportunities (Tarrow 1988). It seems paradoxical that social innovation is attributed to a movement that resists innovations. Resistance movements may bring new forms of political and social negotiation that did not exist before. Procedural outcomes are new forms of debate in new 'arenas' and with access to information that was previously not available. Evers and Nowotny (1987, pp. 279ff) have shown how formerly unknown technological risks are contained by new social institutions such as insurance, technology assessment in various forms, public consultations, hearings and other fora for public participation. However, more of a good thing is not always better. Participatory institutions create fora for discussions between the individual, groups, corporations and the state. Simultaneously they may produce an overload of democratic decision-making capacity. Too many democratic proceedings tire the citizens, slow the decision process, and if a new bureaucracy is established, institutional paralysis may be the consequence.

Once locked in a particular frame of definition, a problem may need to be opened again to find different solutions. Institutional proceedings that close a debate need the complement of those that open them, otherwise the social system becomes paralysed in divisions and inactivity. The 'reinvention of politics' is predicted for issues of new technologies (Beck 1993).

Private business contributes to institutional innovations; new forms of consultancies emerge, dealing with risk communication, public perceptions, public relations, and organizing fora for public debates on new technology. Consultancies provide a kind of 'therapy'; consultants are being well paid for telling highly unpleasant news to decision makers.

Another unforeseen effect is what social psychologists call 'silent conversions', 'delayed effect' or 'sleeper effect' (Mugny & Perez 1991, p. 63). A consistent and persistent minority will put its point across in an unexpected way. People are changing their attitudes silently; while publicly admitting to be in favour of some contested technology, some of these people are changing their attitude in private; the determinants of the old attitude weaken and a sudden change becomes possible, which will materialize during periods of public debate. For a consistent minority the potential support is often much larger than is publicly visible.

In the nuclear debate resistance managed to raise the safety standards to higher levels than were ever envisaged by the nuclear industry. The industry, by complying with safety standards to render nuclear power more acceptable, incurs increasing costs. Safety expectations in the public have increased the costs of building, running and waste disposal for nuclear power plants to an extent that makes its economic viability doubtful in competition with other energy sources (see Rucht, Chapter 13). In 1980 the unit costs of nuclear power generated electricity had risen to 571% of the 1968 level (Radkau 1983, p. 585). The recalculation of the economic rationale of nuclear power is at least in part due to the public scrutiny of anti-nuclear movements and its effects on public expectations and government regulations.

Social differentiation is an unforeseen effect of resistance. In taking part in a controversy on new technology public opinion is likely to polarize along the lines of that controversy if the issue is kept in the public eye for long enough. The segmentation of opinions and attitudes in social and geographical space may cut right across traditional lines of social differentiation, such as political party affiliation, religion, social class or income, as the environmental movement has shown. The alignment that anti-technology movements have introduced into Western societies in the last 25 years defies an explanation in terms of economic categories such as income or property ownership.

The paradox of resistance is that it may **increase the rate and the depth of change**. Crozier (1963) argued that bureaucratic institutions change in a cycle of cataclysms. Periods of small or no changes alternate with periods of fundamental upheaval. This may lead to the effect that the total rate of change and its range may be higher than otherwise. A similar characteristic of scientific progress was suggested by Kuhn (1962, p. 64) who observed that 'normal science' leads to a refinement of instruments and concepts and to institutional rigidity which will be shaken more fundamentally the more rigid it is. In the catastrophe model of organizational change by Bigelow (1982), resistance is the splitting factor that creates the cusp of **unpredictability** in the system. Depending on the degree of resistance in a system, the rate of change will be gradual or unpredictable. The linear correlation between forces for change and resulting changes becomes chaotic with high levels of resistance in the system. Resistance leads to abrupt, unpredictable and hence uncontrollable changes in a system. From the point of view of interest in fundamental change, resistance in the system is ultimately conducive to innovation.

Recursive effects of resistance actions

An outcome of any action is to inform future actions of a similar kind. All the effects previously discussed are contributions to the socio-technical process of which resistance is a subprocess; recursive effects strengthen or weaken the viability of future resistance. It makes sense to conceive the interaction of social actors, innovators and resistance as a learning process of structural change. Protest is its own school, and resistance feeds on past resistance for strategy, tactics, cognition, motivation, and its cultural basis (see Randall, Chapter 3). Conceptually one may argue that we are not dealing with **social analogies** – different social processes that solve similar problems – of resistance across technologies, but with **social homologies** – social processes that are similar due to common origin and tradition.

Resistance activity provides a social identity and fosters social cohesion. Scattered individuals or small groups merge in a larger network with an image and awareness of themselves in contrast to others, giving social significance to their members. The post-war history of European nations provides many examples: national identities are redefined based on the experience of resistance against fascism and Soviet–Russian hegemony. The experience and practice of resistance provides the bridge to span the gap between political parties and their ideological divisions, and locks them into an historic consensus (Wippermann 1983). As soon as the memory of that common resistance fades away, the structure that is built on it weakens, and the post-war political system is in crisis.

Official recognition is another recursive effect of resistance. An initially marginal core actor may gain official recognition to speak for the people in resistance. This **legitimation** has an internal and an external dynamic. Internally several actors and factions may compete for leadership; the external recognition of leadership may solve at least temporarily an internal conflict. The legitimation of leadership may provide a distinct profile, direction, coordination and personalized image of its causes. Personalization of ideas is important to obtain effective media coverage. A representative can join the formal political process in parliament or in commissions to negotiate face-to-face with other parties. On the other hand the basis of leadership is fragile as the increasing distance between figurehead, formal organization and grassroots may undermine its legitimacy (the iron law of oligarchy). The fate of the German Green movement, torn between basic democracy ('*Fundis*') and political effectiveness ('*Realos*') tells a story in that respect. A similar story is told about Greenpeace, where the increased attempt to legitimize claims by invoking scientific research and authority opens up the gap between the leadership of the movement and its basis, and undermines the basis of the movement (Yearley 1992).

Motivational effects need to be taken into account. Motivation describes the processes of beginning, ending, and sustaining resistance activity in the face of difficulties. Media coverage, favourable or unfavourable, provides a public profile and identity, which is likely to strengthen the social cohesion and determination of collective action. Success in some geographic location against a particular technological development may increase the determination and confidence of the actors involved, and by the spread of news stimulate actors in other areas. Repression deters people from action, but may increase the determination of a small group of actors to go underground and to fight with all means available, which may lead to extremism and to violence.

Measuring effects of resistance

Several measures of effect that are used in empirical research will be discussed in this volume. Rucht (Chapter 13) and Rudig (1991) estimate the **rate of completion** of national nuclear power programmes by comparing the status quo, current plans and initial plans of energy capacity. The difference between plan and reality after the occurrence of resistance is an index of its effect. Similarly projected figures of future (past futures) production of nuclear energy measure the **changing expectations** of the industry in reaction to resistance. The number of **orders of nuclear power plants cancelled** is another index of effect. However, the link between these effect measures and resistance requires detailed case analysis, because contingencies other than popular resistance influence the development of the nuclear industry.

Content analysis of media coverage measures the **attention** that resistance activities mobilize, favourable and unfavourable, for their causes. Media coverage is a crucial inroad to study social reality, because of the central role of media in reducing the complexity of modern reality for the citizens. What, to what extent, and how resistance is covered, are basic data for measuring the effects of resistance on public discussion. Intensity measures allow us to assess the strength and the structure of the 'resistance signal' and to relate it to the changes in the technological process. Time series data are essential for this purpose.

Another source of measures is diffusion research. Resistance in a system will lead to **clusters of innovations** in certain regions (Hagerstrand 1967). The degree of regional disparity, the number of clusters, and their size may be taken as indicators of the effect of resistance. Delays in the timing of the take-off of a diffusion process, and the rate of diffusion are indicators of resistance to innovation in a social system (Botelho, Chapter 11).

An overview of the book

The contributions to this book are grouped into five parts to compare resistance and its effects according to several criteria: comparisons by (a) time, between historical events before 1945 and after 1945, (b) across different technologies in the post-war period; and (c) cross-national. This three-dimensional grid of comparisons shows the complexity within which one attempts to generalize empirical findings; abstraction may prove to be more promising than induction.

The first part of the book introduces **conceptual issues of resistance**. Alain Touraine (Paris, France) opens up a wide horizon with reflections upon the origins of the present 'crisis of progress' and the modern dilemma of universal rationality and particular identities: we still believe in science but no longer in 'Progress' writ large. The progress of science brought the rise of 'big science', 'technocracy' and, dialectically, of anti-technocratic attitudes. He pleads for an extension of democracy to bridge the increasing gap between functionally differentiated social activities. Adrian Randall (Birmingham, UK) presents a detailed reassessment of three forms of Luddite resistance and their impacts on the early nineteenth century English textile industry: strike, violence and appeal to authority. His historiographical comments situate traditional views of 'Luddism' in Whiggish accounts of technological progress and labour history. Dancker Daamen and Ivo van der Lans (Leiden, Netherlands) discuss the measurement problem of 'context effects'. In measuring present-day resistance with surveys questioning public attitudes to technology, we incur measurement effects. The way we sequence survey questions in questionnaires and interviews affects significantly the results of the survey. The 'assimilation effect' is demonstrated and strategies to increase the validity of such survey data are discussed. Finally, Bauer (London, UK) will trace the periodic revival of the concept of 'technophobia' to assess people's reaction to new technology. Cyberphobia epitomizes the clinical view of resistance which attributes a pathological deficit to the computer non-user. We may more usefully conceive resistance as a signal of the mismatch of expectations between users and designers. With data from a study I show how this resistance signal affects a software development project over eight years in a Swiss Bank. I shall develop this idea of a 'signal' in the last chapter on the functionality of resistance.

Part II brings together **five national and regional studies** to show the **historical diversity** of resistance in form and effect. Kristine Bruland (Oslo, Norway) shows how, in the context of nineteenth century Scandinavia, resistance to new technology is not confined to labour. Governments, regional administrators, civil servants and industrialists have vested interests in old technologies. Long-term conflicts over new technologies in Scandinavia concern new fishing nets and the introduction of the steam saw in the timber industry. The private automobile in Norway and nuclear energy in Sweden are examples of public resistance forcing a selection on the technological process in the twentieth century. Staudenmaier (MIT, United States) shows how the name 'Ford' evokes images which are equally ambiguous as Henry Ford's personal reaction to his own achievements. Ford himself, in his later years indulging in an idyllic escapism while simultaneously bringing his technological visions to a climax, exemplifies the ambiguity with which humans confront technology. Roy MacLeod (Sydney, Australia) unfolds a narrative of the Australian debate on nuclear issues: of 'Nuclear Knights', of the official secrecy, of international relations, and of the resistance from various sources that to date has prevented nuclear power from producing a significant amount of energy on that continent. Roderick Martin (Glasgow, UK) recalls the first round of industrial conflict on the introduction of new computer based production technology in Fleet Street, London, where, between 1975 and 1980, highly unionized staff successfully resisted attempts to introduce computerized photocomposition. This was possible because neither proprietors nor unions were united in their strategies. New ownership and new industrial relations were capable of implementing the new technology ten years later. He discusses the functional role of resistance in 'voicing' issues that are neglected. Finally, Marlis Buchmann (Zürich, Switzerland) analyses voting behaviour in a Swiss referendum, where in May 1992 the electorate decided upon the legal framework for biotechnology and reproductive technology. A public debate gave strong signals to interested institutions and expressed the relevant concerns. Survey data show that supporters of the new regulations, young, urban and well educated, express a value pattern of 'limited progress' which is different from the 1950s' unconditional quest for modernization.

Part III compares **resistance to a new technology across different countries** and shows how both the occurrence of resistance and its effects are contingent upon contexts. Antonio Botelho (MIT, United States) analyses the diffusion of semiconductor technology until the mid-1960s in France and Japan. Resistance in the diffusion process is the product of a political arena where the state, industry and professional cultures meet. He unravels how France and Japan differentiate their involvement in the semi-conductor industry despite similar starting positions in 1945. Miles and Thomas (Manchester and London, UK) show how resistance manifests itself in the context of information technology such as videotex and audiotex with differential success rates in France, Germany and the United Kingdom. They order recent developments of interactive information technologies and distinguish forms of consumer resistance to explain the relative failure of videotex in Britain. They discuss the effectiveness of UK regulatory bodies in voicing concerns on behalf of the public. Moving to nuclear power, Dieter Rucht (Berlin, Germany) reviews the history of anti-nuclear resistance and presents an elaborate attempt to assess both resistance and its effects across sixteen countries. The strength and effectiveness of anti-nuclear resistance varies around the world. The emerging picture is complex. The effects of resistance on nuclear policy are contingent upon economic contexts, the way political decisions are made, and the attitudes of elites in different countries.

On new biotechnology, Robert Bud (London, UK) reviews the actions of various government agencies in Japan, Europe and the USA between 1970 and 1986. Trying to accommodate both public concerns and industrial interests, different concepts of biotechnology are promoted at different times. An undercurrent of public distrust survives all regulations and may resurface with new issues such as the human genome project. Jasanoff (Cornell, United States) compares the legal cultures of the USA, the UK and Germany and shows how they accommodate the risks of new biotechnology in different ways. She identifies three paradigms of control – product, process and programme – as contingent forms of public reassurance with regard to physical, social and political risks. Forms and effects of public resistance are both contingent upon these cultural contexts. The definition of what is 'new' is at the heart of the matter.

Part IV compares resistance **across different technologies in one country** and explores the problems of drawing analogies between technologies. Joachim Radkau (Bielefeld, Germany) compares the debate on nuclear power and biotechnology in Germany with a stage model and discusses the 'risks' of the analogy by risk. Nuclear power and biotechnology have mobilized the German Green Party; a parliamentary commission on new biotechnology preferred analogies with information technology to analogies between nuclear power and biotechnology. Both the risks and the chances associated with these developments require a more calm and more critical assessment. Hans-Mathias Kepplinger (Mainz, Germany) compares the press coverage of nuclear power and biotechnology in Germany and its institutional context. The long-term trend towards critical commentary on new technology seems to bear out a paradox: attention and negative attitudes increase while actual damage decreases. This is explained with a two-culture model where the scientific and technological elite confronts a 'reflective-elite' of literary and social scientific provenence. The mentality of the reflective elite changes the culture of journalism to a focus on 'negative' events. The agenda setting function of some newspapers for public opinion is assessed quantitatively. Dorothy Nelkin (New York, United States) finally compares information technology and biotechnology in the USA by their impact on people's privacy. She equally points to the contradiction between real impact and actual concern. Information technology, more intrusive into privacy than biotechnology, does not mobilize as much public concern. This contradiction reveals the hierarchy of values and exposes a gap between rhetoric and reality in American society. What makes people move are health risks, organized interests and religious agendas, while lip service is paid to the protection of privacy, freedom and democracy.

In Part V, Bauer will attempt to integrate the various contributions with the help of the 'pain analogy' of resistance by abstracting from various contexts: resistance is a signal that things go wrong. Resistance works as the 'acute pain' of the technological process. Social system theory provides the framework to elaborate the self-monitoring functions of resistance: it allocates attention, evaluates and alters the technological progress. Resistance is primarily a functional process that is constituted in communication about it; dysfunctions are likely, but are secondary. Several implications for research on resistance within socio-technical progress are suggested: the analysis of resistance shifts from causes to effects; and to the analysis of the symbolic encoding of events over long time periods and in the contexts of activity systems.

Notes

1 Many of the following ideas were developed during discussions at the conference workshop on 7 April 1993. I would like to express thanks to the many contributors, equally to Jane Gregory, George Gaskell, Sandra Jovchelovitch and Alan Morton for helpful comments on the chapter. However, I take full responsibility for the way ideas are presented here.

2 For a view of the managerial bias in the resistance literature in the Lewin tradition which I described as the 'forced feeding paradigm' see Bauer (1991, 1993); for a sharp critique of notions of resistance in modernization theory see Reverendi (1975).

3 Other comparisons were suggested: compulsory vaccination was withdrawn on public demand in Britain in 1907 after 37 years of resistance. Mazur (1975) has compared public resistance to fluoridation of water and to nuclear power in the USA. Mazlish (1965) explored analogies between railway building in the 19th century and the space programme in the 1960s with regard to social impact.

4 The debate on the empirical evidence for and the explanation of these cycles continues (Freeman 1984; Hall 1988). I use the idea of long waves descriptively to demarcate periods of historical events (van Roon 1981).

5 I assume that the OECD reports on particular developments indicate the timing of the giving of political attention by key member states to significant new developments; some states may have identified the issue earlier at a national level and drawn the attention of others through the OECD activity. For example, the German DECHEMA report on biotechnology dates back to 1974 and may have served as an international agenda setter (see Bud, Chapter 14).

6 I disregard here earlier reports on microprocessor developments in 1961, and on the automation debate in the 1950s and 1960s. These issues were temporary concerns which did not initiate a continuous focus of attention.

7 'New materials' are often being identified as a new base technology, but they do not give rise to public debate, nor to Utopian images of future societies such as the 'nuclear society', the 'information society', or the 'biosociety'.

8 Strictly speaking the demonstration of this serial media attention would require data from one single country; however, longitudinal data on all three issues are not available from any one country. One can expect that countries peak in different years, but the overall series in Figure 1.1 remains the same in the light of the available evidence. We are collecting comparative longitudinal data on press coverage of all three technologies in Britain between 1945 and the present, but the data are not ready yet (for preliminaries see Bauer 1994).

9 The coverage of nuclear power issues went beyond the 1979 peak to cover the Chernobyl disaster in 1985. For evidence of an international peak of nuclear power news in 1979, see Saxer *et al.* (1986, p. 169) for Switzerland; for the USA see Gamson and Modigliani (1989, p. 17); also Mazur (1984, p. 106), who indexed articles on 'nuclear power plants'; Weart (1988, p. 387) finds the news peak on civil nuclear power four years earlier in 1975 by following the

keywords 'atomic', 'nuclear' and 'radioactivity'. Weart equally shows an earlier peak in coverage on civil nuclear power in 1955 and 1956. Contrary to the late 1970s, the discussion in the 1950s was mainly in a positive tone.

10 Back in 1963 an American journalist working in London, Harvey Matusov, founded the '*International Society for the Fight Against Data Processing Machines*' (ISFADPM) with the aim 'to destruct man's overdependence on the computer' (1968, p. 7). Matusov (1968) published a record of computer atrocities. At the end of the book he lists a series of 'guerilla warfare' tips to confuse and challenge data processing machines; on request the ISFADPM would send more detailed instructions. How far this was a spoof or a serious endeavour is difficult to reconstruct without further evidence about the society's activity.

11 The topical distribution of public opinion surveys may be another indicator of public concern. To establish an inventory of such surveys across different countries is a topic for future research. See Jaufmann & Kistler (1986) for an international secondary analysis of public opinion on information technology. They managed to diffuse the idea of a particular syndrome of '*Technikfeindschaft*' (technophobia) in Germany by international comparison.

12 In fact the British judge, John Presser QC, has rejected a claim for compensation for RSI, declaring that the term RSI was 'meaningless' and 'had no place in the medical dictionary' (*The Independent*, 23 November 1993).

13 On such visions of nuclear power as a mobile source of energy for various small-scale purposes, see Radkau (1983, pp. 79f) in his discussion of the 'nuclear myths' of the 1950s.

14 This idea is taken from the discussion of what constitutes 'resistance' in the context of Fascism and National Socialism in Germany (Kershaw 1985, p. 781).

15 In the discussion on resistance against Nazism in Germany, a functional definition had the effect of shifting the focus of research from 'elite groups' and a few spectacular events to more widespread daily forms of non-conformism, which demonstrated the diverse ways in which limits were set to a horrendous political project. The symbolic significance and real effects of such actions remain controversial (Kershaw 1985, p. 780).

16 The resistance of 18th century French peasants as well as of present day Malaysian farmers to tax demands of central government is silent, and neither coordinated nor self-conscious as Scott (1985) has described in his *Weapons of the Weak*.

17 Newspapers have recently reported violent attacks on research institutions in the USA. Letter bombs seriously injured Carles Epstain, at Berkeley University, and exploded in the Computer Centre at Yale University. The FBI stresses that this is likely to be the act of an individual (e.g. *The Guardian*, 25 June 1993; *NZZ*, 26 June 1993). In Britain some scientists receive police protection due to threats from animal protection terrorists.

18 Psychotherapists call this 'interactional resistance' (Petzold 1981).

References

AYERS, R. U. (1990). Technological transformations and long waves, Part II. *Technological Forecasting and Social Change* 36, 111–37.

BAUER, M. (1991). Resistance to change – a monitor of new technology? *Systems Practice* 4 (3), 181–96.

BAUER, M. (1993). Resistance to change. A functional analysis of responses to technical change in a Swiss bank. PhD thesis, London School of Economics and Political Science.

BAUER, M. (1994). Science and technology in the British press, 1946–1986. In *When science becomes culture*, Vol. II, ed. B. Schiele, M. Amyot and C. Benoit. Boucherville: University of Ottawa Press.

BAUER, M., DURANT, J. & EVANS, G. (1994). European public perceptions of science, *International Journal of Public Opinion Research* 6 (2), 163–86.

BECK, U. (1993). *Die Erfindung des Politischen.* Frankfurt: Suhrkamp.

BIGELOW, J. H. (1982). A catastrophe model of organisational change. *Behavioural Science* 27, 26–42.

BRODDE, K.(1992). *Wer hat Angst for DNS? Die Karriere des Themas Gentechnik in der deutschen Tagespresse von 1973–1989.* Frankfurt: Peter Lang.

BUD, R. (1993). *History of Biotechnology.* Cambridge: Cambridge University Press.

CARLOPPIO, J. (1988). A history of social psychological reactions to new technology. *Journal of Occupational Psychology* 61, 67–77.

COVELLO, V. T. (1991). Risk comparison and risk communication: issues and problems in comparing health and environmental risks. In *Communicating risks to the public*, ed. R. E. Kasperson and P. J. M. Stallen, pp. 79–124. Dortrecht: Kluver Academic Publishers.

CROZIER, M. (1963). *Le phenoméne bureaucratique.* Paris: Seuil. (Reprint 1971.)

DEGREENE, K. B. (1988). Long wave cycles of sociotechnical change and innovation: a macropsychological perspective. *Journal of Occupational Psychology* 61, 7–23.

DERTOUZOS, M. L. & MOSES, J. (ed.) (1979). *The computer age: twenty-year view.* Cambridge, Mass: MIT Press.

DURANT, J., HANSEN, A. & BAUER, M. (1996). Public understanding of new human genetics. In *The troubled helix. Social and psychological implications of the new human genetics*, ed. T. Marteau and M. Richards, pp. 235–48. Cambridge: Cambridge University Press.

EUROPEAN COMMISSION (1993). *Biotechnology and genetic engineering*, Direction Generale 12. Brussels: INRA and European Commission.

EVERS, A. & NOWOTNY, H. (1987). *Ueber den Umgang mit Unsicherheit; die Entdeckung der Gestaltbarkeit der Gesellschaft.* Frankfurt: Suhrkamp.

FREEMAN, C. (ed.) (1984). *Long waves in the world economy.* London: Pinter.

FREEMAN, C. (1985). Long waves of economic development. In *The information technology revolution*, ed. T. Forester, pp. 602–16. Oxford: Blackwell.

GAMSON, W. A. & MODIGLIANI, A. (1989). Media discourse and public opinion on nuclear power: a constructivist approach. *American Journal of Sociology* 95, 1–37.

HAGERSTRAND, T. (1967). *Innovation diffusion as a spatial process.* Chicago: University of Chicago Press.

HALL, P. (1988). The intellectual history of long waves. In *The rhythms of society*, ed. M. Young and T. Schuller, pp. 37–52. London: Routledge.

HALTINER, K. W. (1986). Die Widerstandsmotivation in der Schweizer Bevölkerung. *Allgemeine Schweizerische Militärzeitschrift* 7/8, 403–9.

HOBSBAWM, E. J. (1976). Economic fluctuations and some social movements since 1800. *Labouring Men*, ed. E. J. Hobsbawm, pp. 126–57. London: Weidenfeld and Nicholson.

HULTBERG, J. (1991). *A tale of two cultures. The image of science of C. P. Snow.* Report No. 165, Department of Theory of Science, University of Gothenburg.

INGLEHART, R. (1990). *Culture shift in advanced industrial society.* Princeton, NJ: Princeton University Press.

INTERNATIONAL ATOMIC ENERGY AGENCY (1981). *Power reactors in member states.* Vienna: IAEA.

JAUFMANN, D. & KISTLER, E. (1986). Technikfreundlich? – Technikfeindlich? Empirische Ergebnisse im nationalen und international Vergleich. *Politik und Zeitgeschichte* **48**, 35–53.

JOERGES, B. (1989). Soziologie und Maschinerie. *Technik als sozialer Prozess*, ed. P. Weingart, pp. 44–89. Frankfurt: Suhrkamp.

JOHNS, E. A. (1973). *The sociology of organisational change*. Oxford: Pergamon Press.

JUNGK, R. (1979). *The nuclear state*. London: John Calder. (First published in German, 1978.)

KEPPLINGER, H. M. (1988). Die Kernenergie in der Presse, *Kölner Zeitschrift für Soziologie und Sozialpsychologie* **40**, 659–83.

KEPPLINGER, H. M., EHMIG, S. C. & AHLHEIM, C. (1991). *Gentechnik im Widerstreit*. Frankfurt: Campus.

KERSHAW, I. (1985). 'Widerstand ohne Volk'. Dissens und Widerstand im Dritten Reich. In *Der Widerstand gegen den Nationalsozialismus*, ed. J. Schmädeke and P. Steinbach, pp. 779–98. Munich: Piper.

KLEIN, J. A. (1984). Why supervisors resist employee involvement. *Harvard Business Review* **62**, 87–95.

KLING, R. & IACONO, S. (1988). The mobilization of support for computerization: the role of computerization movements. *Social Problems* **35** (3), 226–43.

KNORRE, H. (1992). 'The star called Wormwood': the cause and effect of the Chernobyl catastrophe. *Public Understanding of Science* **3** (1), 241–50.

KUHN, T. S. (1962). *The structure of scientific revolutions*. Chicago: University of Chicago Press.

LATOUR, B. (1988). The prince for machines as well as for machinations. In *Technology and social process*, ed. B. Elliot, pp. 20–43. Edinburgh: Edinburgh University Press.

LAWRENCE, P. R. (1954). How to overcome resistance to change. *Harvard Business Review* **32** (3), 49–57. (Classics reprint 1969.)

LITTEK, W. & HEISIG, U. (1986). Rationalisierung von Arbeit als Aushandlungsprozess. Beteiligung bei Rationalisierungprozessen im Angestelltenbereich. *Soziale Welt*, **37** (2/3), 237–62.

LYON, D. (1988). *The information society*. Cambridge: Polity Press.

MARLIER, E. (1992). Eurobarometer 35.1. In *Biotechnology in public. A review of recent research*, ed. J. Durant, pp. 52–108. London: Science Museum.

MATHES, R. & PFETSCH, R. (1991). The role of the alternative press in the agenda building: spill-over effect and media opinion leadership. *European Journal of Communication* **6**, 33–62.

MATUSOW, H. (1968). *The beast of business. A record of computer atrocities*. London: Wolfe.

MAZLISH, B. (1965). Historical analogy: the railroad and the space program and their impact on society. In *The railroad and the space program. An exploration in historical analogy*, ed. B. Mazlish, pp. 1–52. Cambridge, Mass: MIT Press.

MAZUR, A. (1975). Opposition to technological innovations. *Minerva* **13**, 58–81.

MAZUR, A. (1984). Media influences on public attitudes toward nuclear power. *Public reactions to nuclear power: are there critical masses?* ed. W. R. Freundenberg and E. A. Rosa, pp. 97–114. Boulder, Colo: Westview Press.

MOKYR, J. (1990). *The lever of riches. Technological creativity and economic progress.* Oxford: Oxford Univeristy Press.

MOKYR, J. (1992). Technological inertia in economic history. *Journal of Economic History* **52** (2), 325–38.

MUGNY, G. & PEREZ, J. A. (1991). *The social psychology of minority influence.* Cambridge: Cambridge University Press.

PAKULSKI, J. (1993). Mass social movements and social class. *International Sociology* **8** (2), 131–58.

PETZOLD, H. (ed.) (1981). *Widerstand: ein strittiges Konzept in der Psychotherapie.* Paderborn.

RADKAU, J. (1983). *Aufstieg und Krise der deutschen Atomwirtschaft 1945–1975. Verdrängte Alternativen in der Kerntechnik und der Ursprung der nuklearen Kontroverse.* Reinbeck: Rowolt.

RASCHKE, J. (1988). *Soziale Bewegungen. Ein historisch-systematischer Grundriss.* Frankfurt: Campus.

REVERENDI, J. C. (1975). Les resistances et les obstacles au developpement: l'envers d'une theorie. *Recherches Sociologiques* **6** (1), 62–97.

RHINOW, A. R. (1985). *Widerstandsrecht im Rechtsstaat?* Staat und Politik 30. Bern: Haupt.

ROON, G. VAN. (1981). Historians and long waves. *Futures*, October, 383–8.

RÜDIG, W. (1990). *Anti-nuclear movements: a world survey of opposition to nuclear energy.* London: Longmans.

RUHRMANN, G. (1992). *Das Bild der biotechnischen Sicherheit und der Genomanalyse in der deutschen Tagespresse 1988–1990*, TAB–Diskussionspapier No. 2, Bonn.

SAXER, U., GANTENBEIN, H., GOLLMER, M., HATTENSCHWILER, W. & SCHANNE, M. (1986). *Massenmedien und Kernenergie.* Bern: Huber.

SCHMÄDEKE, J. & STEINBACH, P. (ed.) (1985). *Der Widerstand gegen den Nationalsozialismus.* Munich: Piper.

SCHMITT-BECK, R. (1990). Ueber die Bedeutung der Massenmedien für soziale Bewegungen, *Kölner Zeitschrift für Soziologie und Sozialpsychologie* **42** (4), 642–62.

SCHOT, J. (1991). Constructief technology assessment as hedendaags Luddism. Dissertation, University of Twente.

SCOTT, J. C. (1985). *Weapons of the weak. Everyday forms of peasant resistance.* New Haven, Conn: Yale University Press.

SCREPANTI, E. (1984). Long cycles in strike activity: an empirical investigation. *British Journal of Industrial Relations* **22**, 99–124.

SENSALES, G. (1990). *L'informatica nella stampa italiana.* Milan: Franco Angeli.

SHARP, G. (1973). *The politics of nonviolent action*, 3 vols. Boston: Porter Sargent.

SHOTTON, M. (1989). *Computer addiction? A study of computer dependency.* London: Taylor and Francis.

SIMON, H. A. (1981). *The science of the artificial*, 2nd edn. Cambridge, Mass: MIT Press. (First edition 1969.)

SNOW, C. P. (1959). *The two cultures and the scientific revolution.* Cambridge: Cambridge University Press.

STAUDENMAIER, J. (1985). *Technology's storytellers: reweaving the human fabric.* Cambridge, Mass: MIT Press.

TARROW, S. (1988). National politics and collective action. *Annual Review of Sociology* **14**, 421–40.

TOURAINE, A. (1992) *Critique de la modernité.* Paris: Fayard.

WEART, S. R. (1988). *Nuclear fear. A history of images.* Cambridge, Mass: Harvard University Press.

WEIZENBAUM, J. (1976). *Computer power and human reason. From judgement to calculation.* San Francisco: W. H. Freeman and Co.

WIPPERMANN, W. (1983). *Der Europäische Faschismus.* Frankfurt: Suhrkamp.

World Nuclear Industry Handbook (1992). Sutton, UK: WNIH.

WRIGHT, S. (1986). Recombinant DNA technology and its social transformation 1972–1982. *Osiris* **2**, 303–60.

WYNNE, B. (1993). Public uptake of science: a case for institutional reflexivity. *Public Understanding of Science* **2** (4), 321–38.

YEARLEY, S. (1992). Green ambivalence about science: legal–rational authority and the scientific legitimation of a social movement. *British Journal of Sociology* **43** (3), 511–32.