SCIENCE, SOCIETY, TECHNOLOGY AND HOLISTIC MODES OF THOUGHT

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DECLARATION

I, the undersigned, hereby declare that the work contained in this assignment is my own original work and that I have not previously in its entirety or in part submitted it at any university for any degree.

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Abstrak

Hierdie werk behels die studie van verskillende konsepsies/begrippe van kennis soos gevind in `n meganisties - naturalistiese kyk op wetenskap, in die besonder vanuit `n Westerse intellektuele kultuur, en hoe sodanige konsepsies die wyse beïnvloed waarin wetenskap en gemeenskap in verhouding betrag word. Dit poog om implikasies aan te dui vir die grense van daardie konsepsies wanneer vanaf `n holistiese hoek betrag, en bied denkwyses wat meer voldoende is om menslike realiteit aan te spreek en te verstaan.

In die besonder bly tegnologie en tegnologie-onderrig veel verskuldig aan Westerse en meganisties - naturalistiese aannames rakende die mens en samelewing. Voorstelle hoe holistiese denkwyses gebruik kan word om sin te maak van die tegnologie as menslike bedryf, en hoe die Suid-Afrikaanse tegnologie-onderrig-beleid omskryf kan word om beter by menslike waardes aan te pas, word aan die hand gedoen.

In hoofstuk 1 word sommige van die historiese bronne van die meganisties-naturalistiese begrip van wetenskap, in die besonder as `n objektiewe, universele en rasionele proses, in oënskou geneem. Die skrywer poog om sommige v. d. basiese aannames van so `n blik (beide wetenskaplik en filosofies) duidelik te maak, die algemene invloed op Westerse intellektuele kultuur uit te lig, en om die breë teenstelling in denke aan te dui wat dit impliseer nl. dat die wetenskaplike uitkyk `n heelal van doellose materie veronderstel terwyl daar aan die menslike verstand doel en voornemens toegeskryf word.

Sommige v. d. maatskaplike implikasies vir die meganisties-naturalistiese standpunt word in hoofstuk 2 gegee, insonderheid hoe wetenskap en samelewing met mekaar in verband sou staan. Sommige kontemporêre opinies ten gunste van die siening dat wetenskap grotendeels buitekultureel is in sy prosesse,word behandel. Verskeie sosiale norme wat die projek van wetenskap uitmaak, word ontleed. Die siening van wetenskap as eerstens `n voortbringing van kennis wat veel verskuldig is aan verskeie maatskaplike wisselwerkings nodig vir sy voortgesette bestaan, word aangespreek en tweedens as `n saak van professionele kundigheid vir die oplos van maatskaplike probleme.

In hoofstuk drie word holisties-gelyke denkwyses aangebied wat kan dien tot die verryking van ‘n oor-entoesiastiese aanvaarding van `n meganistiese wêreldsiening en aannames rakende die samestelling van die rede (verstand). Sommige huidige ontwikkelinge binne die wetenskap wat vroeëre begrippe van die meganistiese verduideliking in twyfel trek, word uitgelig. Twee benaderings tot verstaan, nl dié gegrond op self-organiserende stelsels en die siening v. d. mens as `n self-verklarende skepsel word aangebied om `n ryker begrip v. d. menslike realitiet anderkant die grense van `n eng meganisties-naturalistiese weergawe te bied.

Tegnologie as `n voorbeeld van intelligensie,gesien as `n wêreldsiening v. d. masjien word in hoofstuk 4 ontleed. `n Alternatiewe uitbeelding van tegnologie, gesien as self-organisasie en interpretasie word verskaf. Beide sienings verskaf `n greep op die betekenisvolle menslike tegnologiebedryf. Tegnologieonderrig-beleid betrek `n ontleding van uitkomste v. d. tegnologie leerarea en dui op die maniere waarop hulle veel verskuldig bly aan die meganisties-naturalistiese begrippe. Idees gegrond op self-organiserende stelsels en betekenisvolle vertolkings bied `n ander benadering tot tegnologieonderrig wat meer afgestem is op menslike waardes.

Die slot bied `n stel holistiesgelyke idees en beginsels wat dwarsdeur die werk gebruik is en `n deel vorm van `n algemene begrip van holistiese denkwyses.

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Abstract

This work involves a study of different conceptions of knowledge as are found in a mechanistic-naturalistic view of science, particularly from within Western intellectual culture, and how such conceptions affect the ways we regard science and society in relation. It attempts to draw out some implications for the limits of those conceptions when seen from a holistic stance, and presents modes of thought more adequate to address and better understand human reality.

In particular, technology and technology education remain indebted to Western and mechanistic-naturalistic assumptions about man and society. Suggestions are made as to how holistic modes of thought might be used to make sense of technology as human practice, and how South African technology education policy might be framed so as to be more in tune with human values.

Chapter one reviews some of the historical sources of the mechanistic-naturalistic conception of science, particularly as an objective, universal, and rational process. It attempts to make explicit some of the basic assumptions of such a view (both scientific and philosophical), to highlight its general influence in Western intellectual culture, and to point out the broad contradiction in thought it implies: namely, that the scientific view supposes a universe of purposeless matter, while to the human mind is attributed aim and intents.

Chapter two maps out some of the social implications for the mechanistic-naturalistic stance, notably in how science and society are conceived to relate. It treats some contemporary opinions in support of the view that science is largely extra-cultural in its processes, and analyzes the various social norms that make up the project of science. It addresses as well the view of science first as knowledge production, indebted to various social exchanges for its continued existence, and then as a matter of professional expertise for the solution of social problems.

Chapter three attempts to offer holistic-like modes of thought that may serve to enrich an overly enthusiastic adoption of a mechanistic world view and its assumptions about what constitutes reason. It highlights some current developments within science that call into question prior notions of mechanistic explanation. It presents as well two approaches to understanding, based on self-organizing systems and the view of man as a self-interpreting creature, that provide for a richer grasp of the human reality beyond the limits of an only mechanistic-naturalistic rendering.

Chapter four analyzes technology as an instance of intelligence, seen from the world view of the machine. It provides an alternative depiction of technology viewed from the standpoint of self-organization and interpretation. Both provide a handle on the meaningful human practice of technology. Technology education policy involves an analysis of outcomes from the technology learning area, pointing out the ways in which they remain indebted to mechanistic-naturalistic conceptions. Ideas based on self-organizing systems and meaningful interpretation serve to frame differently an approach to technology education that is more attentive to human values.

The conclusion offers a set of holistic-like ideas and principles, used throughout the whole of the work, and which make up part of a general conception of holistic modes of thought.

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... dedicated to the memory of Jackob Bronowski, whose works shaped my earliest thoughts about science and human values, and to James Chadwick, the discoverer of the neutron - were it not for the particle he discovered, we would all be insubstantial as hydrogen.

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Introduction

Problem statement and approach

Modern science, the constructs by which it is made sense of in society, and contemporary conceptions of technology are based in part on assumptions about the nature of the world and how it can be known. Much thinking here comes out of a mechanistic view point and a belief in positive, objective knowledge - positions that still govern Western notions of natural science and technology. These assumptions, however, are also often adopted in the various human sciences, are employed in reasoning and reflection in many conceptual systems, and greatly influence thinking in general about the nature of science and its relation to society. In addition, the methods of deriving knowledge from within the mechanical world view are widely accepted as an incomparably effective avenue for understanding man and the universe. The modern empirical view - or the naturalistic stance - often goes unquestioned. Yet its assumptions are far from unproblematic. Typically regarded as universally applicable or uniquely valid, the position it implies has its own limits. A near blanket application can lead to wide-spread fragmentation in thinking about society, to the posing of artificial questions about our selves, and to attempts to reduce a rich matrix of experience to a code of operations, functions, or calculations. While the success of the naturalistic stance cannot and need not be denied, neither can be ignored the complex of problems to which the mechanistic world view gives rise, nor the range of human experience not decipherable on its terms. Its heritage in Western intellectual culture is a long one, but it is not without equal; its own limits warrant the study of alternative themes and related ideas that provide a richer basis for making sense our world and human significance.

This thesis explores some of these limits, and alternative themes and ideas. It is based on the notion that science, how we understand society, and the technology we use cannot be rightly considered apart from meaning giving ideas; that the mechanistic view point and the modern empirical stance need not be considered as the only valid means to understanding our world and our selves, nor are they wholly adequate to its tasks. Indeed, the problems to which the naturalistic stance give rise point to an incompleteness. Instead, the attempt can be made to understand such notions from a broader, holistic context to thinking about the practice of science, the working of society, and the use of technology. In this context, part of understanding science or technology involves interpreting their ideas and aspects beyond strict material, methodological, or institutional traits - aspects that place them in a broader social nexus, and within a richer ontology, extending beyond the set of standard abstractions that comprise the mechanistic and positivistic stance. (Here, forms of science or technology can be seen as fabricated artifacts to the processes that create them, and treated as a range of symbolic forms that convey meaning.) In this thesis an attempt will be made to study them from within an interconnected, holistic set of meaning giving ideas that might maintain the significance of human persons while making scientific sense of the world. In one sense, the working premise here is that the modes of thinking and reasoning common to the naturalistic stance, together with the mechanistic world view, are insufficient for an understanding of our human significance as self-interpreting creatures; that to regard them as sufficient can lead to confusion about what constitutes science and about how meaning is constitutive of our self understanding. If so then one option is to look for linkages and

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connections in the realms of human knowledge and experience that might serve to expand our constructs towards a more adequate (or perhaps less inadequate) understanding of the implications of scientific abstractions for our notions of human meaning and significance.
In very general terms, this thesis will attempt to describe some characteristics of, and to depict some limits to, both the mechanistic world view and the belief that objective knowledge is to be restricted to empirically based knowledge. To this will be added a brief study of the manner in which science works in society, particularly in the distinction between scientific knowledge as means, and the social ends of that knowledge. Here, science is often seen as a value free endeavour largely independent of society or schemes of social thought; as a project substantially indebted to institutional norms, though largely dedicated to the empirical truth; or as a large scale research institution funded by society and requiring in turn the production of useful results. However, all of these approaches are substantially indebted to the naturalistic stance and its established practice of thought. These views will be offset by looking at a few aspects to what could be called holistic modes of thinking about science and society that might work to overcome the limits in the mechanistic form of reasoning and the way scientific knowledge is often conceived to operate in society. In particular, such modes of thinking will treat self-organizing systems and aspects of an interpretive framework that regards humans as self-interpreting creatures. Furthermore, technology is often taken to be a product of scientific knowledge, and is typically seen as neutral or instrumental in its design and use. The thesis will also look at some common assumptions about technology and its limits - particularly when conceived as a fabricated and neutral tool for the accomplishment of chosen ends - and how holistic modes of thought might serve to rethink these limits. The thesis will round out with a study of issues surrounding technology education policy in the South African education system - how it remains largely an expression of the naturalistic stance, and how it might be approached from a more holistic view.

Preliminary remarks

Choices for power

Ours is often called a technological age. It is, for example, a generation fast becoming versed in the use of computers. Meanwhile, air planes, automobiles, televisions, and telephones are taken as technology of the everyday, with radio and newspaper seen as seasoned techniques. Whether novel or established, these are all technologies of modern transportation or communication, and have contributed to our world a quality and character to living unlike any past age. Of course, people have always been moving or communicating, and here modern techniques merely reduce the time and trouble to travel or to speak. But they have also - at least in principle and sometimes in practice - given women and men of the everyday the chance to see and to know the entire earth as one home, and to realize that others different from us are not unlike us. This is a historic scale of awareness.

However, the same scientific-technological world that provides for such a sense of opportunity presents as well the chance for alarming ruin. Of all the scientific-technological developments of a

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modern age, nuclear weaponry is among the most to be held in anxiety and dread. Although weapons of mass destruction extend beyond the boundary of nuclear devices - they as well treat biological and chemical attack - thermonuclear devices are probably the most vivid in their evident destructive power, and symbolic form. However, it is not only the blast from a weapon of mass destruction that need concern, but so too its delivery system - for a nuclear device cannot be used, no matter how well engineered it might be, without getting it to a chosen target. To do this a means must be created for taking it there without miss, risk, or fail - and that is what a delivery system does. The rocket propulsion, the guidance control, the multiple reentries, the detonation time each insure that the efforts are worth while in creating a weapon in the first place. In this sense then are delivery systems for weapons of mass destruction the height of high-tech transportation and communication, and the bitter fruit of an age[1]. But this then is also their folly, for those who work the delivery system - those who, for example, support its construction or secure its funding, who engineer its design, who select the missile's destination, or who programme its flight - are helping to choose and calculate the death of millions. There are not enough missiles to destroy all possible military and industrial sites. A choice is made. People weigh and balance the military advantage or the destructive gain in the hope of survival, and in this there is only folly[2].

Of course, South Africa has discarded its nuclear weapons development programme. That this need no longer directly concern the people of South Africa, while perhaps locally comforting, does not allow escape from the anxieties of an age, its opportunities, and its devices. The problem is for a 'us', not a 'them'. However, the issue is not isolated to nuclear weaponry, but is characteristic of our age. Science and technology remain both wonderful and dreadful. They enable us; they tie us down. They amplify our powers and render us weak. With their advance comes too a closure of options, actions, or thoughts - not for every one every where, but always for some and in some way. There seems a characteristic joining of freedom with a confusion or loss of meaning in the working out of science and technology. This quality is not just material or economic, but is also an opening and restricting of ideas, perspectives, and practice both in how we understand ourselves and in the constructs by which we make sense of our society. In the end issues unavoidably turn to matters of ethics and a choice of commitments because science involves power gained from knowledge and the appearance of that knowledge in devices that amplify our powers. Of course, issues of knowledge with choices for power have always concerned people and societies - our modern dilemmas are also ancient - but what is new is the proficient and monumental use of what we know.

The interpretation of science

Part of this involves the importance of the ethical in scientific knowledge and know-how, and in what it might offer to people in a society. For example, it may happen that we may too often base notions of 'the have nots' and 'the haves' (for instance, in the distinctions that might be made between village and urban environments) on certain unreflected assumptions about what science or technology is, what it does or might do in or for society, and the effects it may have on life or on living - in other words, how it changes human practice. It is common for people to see these

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effects in the owning of goods and devices made possible by science, or through some material advantage that comes from technology. Most would likely grant that the impact of modes of scientific reason and technological design on material well being is a key aspect to what is called innovation. But the argument here is that this is not their only main result. A central aspect of these practiced modes of thought, and the formidable institutions that house them, is often inexplicit; it is hidden in spheres of knowledge, action, interpretation, and values - in the realm of meaning giving ideas and practice.

Our abstract concepts and practice serve to specify a science and to make it work, but they need also provide for an interpretation of that science - what it is or should be for, what effects it might have, what it says about our selves, and whether scientific or technological consequences need be accepted or rejected in social practice. Scientific methods or technological tools can be seen as artifacts (or symbolic forms) of a given view of the world, and of the values behind their employ. Though artifacts and symbols, they enter our world with an energy hard to ignore, often veiling our choice of giving consent or repeal. Each of us daily receives and uses the ideas of science or the workings of technology of one type or another. But these must everywhere be interpreted by us - judged not only for their use but also understood in their various senses of significance to our own lives and to the working of society. In other words, we must ask questions of the social validity and personal meaning of science and technology. Neither in our society nor in ourselves are we mere passive receptors in respect to them - at least we need not be passive, and certainly we should not be so except at our own peril[3].

The point here is that our concepts of science or technology need also concern the commitments by which people come to understand themselves, not only devices and how to use them; that their implications need involve the interpretation of meaning giving ideas and practice working behind their composition, construction, communication, or trade; and that their consequences cannot be judged aright outside their significance to our lives as creatures for whom science is a part, but only a part, of how we understand our world and ourselves. It is this realm of significance - of meaning giving ideas and practice obtained in and working through the spheres of knowledge, action, interpretation, and values - that in this thesis most concern issues both in scientific rationality and objective knowledge, and in social values and the use and purchase of technology into our lives. Behind all of these issues are questions of intent and origin, ethical action, and human significance. If science is conceived as a secure and reliable instrument of knowledge, if technology be construed as means to achieve some economic, material, or social advance, then it is incomplete to adopt the explanations of science or to incorporate a technology that amplifies our powers by considering only the what or how or that of such knowledge or innovation. Questions of who and why and what for need be asked, repeatedly explored, and so remain open to renovation or rejection. This is true for science and scientific gain, and is equally so for technology and technological change. There are no assurances that the knowledge to which we attain or the devices we employ are wholly beneficial, nor that they need necessarily serve to strengthen an understanding of man and the character of his social practice. It is appropriate then to question and clarify the abstractions behind the assumption that scientific knowledge is an unqualified good - that we may be mistaken only in the use of what we know.

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Knowledge and power

In one sense technology can be made in part out of a body of scientific knowledge or practice whose ideas or skills are used to design and make a working device. Without that knowledge and a tradition of technique many such inventions could neither be conceived nor constructed. The ordering is not one way. Empirical scientific knowledge depends on the existence of precise tools that make possible such observations or measurements of phenomena that are the objects of the scientist's attention. Yet existing knowledge and the technology together are insufficient for the further creation of either alone. Clearly there is much more to either process than empirical knowledge and material technique. There is a history to the work - a history not only of events, discoveries, and community scientific skill or obligations, but also a history of ideas and assumptions that place science and technology in the broader context of how we live, interpret, and make sense of our world, ourselves, and our society. These relations are complex and hard to get at, and often it seems scientists have opted for simpler formulations of the solvable. Nevertheless, within the workings of science can be found effects of empirical knowledge and rational technique that connect them to the impact they will have on human life and living, but whose impact affects at the same time how that very science is understood and practiced. For clarity, a specific example is worth noting.

Constituents of matter are essentially dynamic patterns of relations. The scientific theories developed in this century to make sense of them (based on work of centuries past), together with their techniques of formulation, observation and experimentation, are revolutionary in their conception. Revolutionary too are their implications and consequences. Our new science of the micro-domain grants certain skills over matter we did not formerly own (computers are not possible without them.) The same skills can decidedly affect how we understand ourselves and the way we relate to each other - the nuclear arms race is a broad case in point, as is the current work in molecular genetics and nanotechnology (and so too the delivery of telephone or electricity to rural communities). Knowledge of elementary and atomic matter is extensive. For example, volumes alone can be written about the neutron - and the neutron is worth noting here as it is unique in being integral to the workings of nuclear structure while being essential for the transformation of that structure and the release of nuclear energy[4].

We believe we possess some certainty in this knowledge, and carry a conviction in the practice and power of our skill, since we can build nuclear devices to direct that transformation[5]. Of course, the actual construction of such apparatus that manoeuvre nuclear processes had to be a complex and difficult affair. It certainly was and is not only a matter of putting together the physical pieces that will make a working device. It includes the creation of new and now vast institutions of society without which nuclear power could not exist or be used. Still, the process of controlling and manipulating the random fission of nuclei in radioactive matter requires the most sophisticated maps of scientific knowledge to imagine, conceive, and execute[6]. With this knowledge, and the institutions to direct it, we have fabricated the most powerful of scientific artifacts, and a commanding symbolic form.

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The neutron that makes possible the control of atomic processes for nuclear power was only first found in 1932[7]. Slightly older, but vastly more profound, is the idea in science that the atom has a real existence that can be studied - that it possesses a structure and components that can be found out and used. One perhaps forgets how revolutionary is this concept, at least in the tradition of Western empirical science and natural philosophy (the question of the real existence of atoms was under serious debate in 1900). Yet it was this belief, equal to any technique or device, that made possible nuclear knowledge and power. The atom gives up its secrets with only the keenest of human efforts, and these efforts - achieved by institutions and resources of science and society - could never have been believed fruitful did we not also believe both that the atom had an existing structure and that its parts could be known. It is by virtue of this dual belief (and by its realisation) that nuclear physics can be called a deep and powerful discovery of science[8].

It is also true, however, that this knowledge gives rise to ethical issues surrounding the power of and from what we know. Debate often centres on the correctness of a kind of knowledge whose consequences in practice can appear in wars of mass destruction - a knowledge made real in technological works that portray it and in institutions through which it is used, housed, and controlled. Scientific knowledge, and technological artifacts 'grown out' of that knowledge, are a type of power whose effects require us to return to questions of ethics, to the nature of the institutions we create and maintain, and, given what we know, to a substantive inquiry focussed on meaning-giving ideas and practice.

Science and human significance

There exists a relation between the profoundness of scientific knowledge, the methods by which it is attained, the way in which technology amplifies our own powers, the institutions and constitutive meanings that give them a social reality, and the ethical and moral questions to which the consequences of that knowledge, technique, meaning, and amplification give rise. This is evident (though not simple) in the case of nuclear physics and the creation of weapons of mass destruction[9]. Yet the queries need not only appear upon attaining a particularly deep level of scientific knowledge or with the construction of artifacts that disproportionately amplify our powers; they also ensue out of mass production technologies - the proficient use of knowledge such that relatively direct applications of seemingly innocuous know-how lead through their monumental use to intractable issues of power and scale[10].

Here the wonder of knowledge and technique (be it in their consequent depth of understanding, in their scale of use, in the manner of their institutional forms, or in their amplification of our powers), and the excellence of the intellectual tradition out of which they come, gives way to the anxiety or dread mentioned earlier. Nagasaki and Hiroshima is the twentieth century archetypal case. Yet there are no guarantees that their example will be unique. The artifacts of our scientific ideas, such as those fabricated devices of nuclear weaponry and their delivery systems as we now know them, alert us to pause and consider the humanness of the knowledge our fabrications manifest. "We looked up and saw the power of which we had been proud loom over us like the ruins of Nagasaki"[11].

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Because of the looming power of nuclear weapons it is hard to ignore the vital issues of ethics and human significance in the power of nuclear knowledge. Yet the issue here is certainly not about nuclear knowledge alone, nor only about deep levels of scientific understanding. Wherever issues of power born of knowledge are not so evident - often because the consequences of some practice thereby achieved are not so unique, distinct, or worrisome - then there seems to be a robust tendency to forget or to overlook the central importance of the thought behind the practice of that knowledge, the fabricated artifacts, or its institutional reality. They too easily become mere givens of rational life; neutral, unattached tools for those who would will to use them. Yet what the argument here has been trying to phrase is that the ideas from which derive our scientific knowledge (or fabricated artifacts), need to be understood through the meanings and social practice out of which they are constituted - that these ideas proceed from and contribute to a substantive focus upon an understanding of human significance. Without such an attempt to interpret science via those ideas and practices constitutive of human significance, we will necessarily be less able to make sense of who and what we are, and so too therefore what our science actually says. This is so with every systematic study that makes a claim to knowledge of either a deep or a proficient sort - whether it treats our material universe, our social worlds, or our inner selves. Whatever the knowledge or artifact, they possess a substantive focus that concerns a constitutive understanding of who we are. And to misplace this sort of understanding is to fall into confusion not only about the nature of knowledge gained from science, demonstrated in technology, but equally so for knowledge about our own selves.

Science as rationality, technology as control

Of course the need to connect the ideas that characterise scientific knowledge and its fabricated artifacts in technology with a substantive focus on human significance often go unmet. One difficulty is that this connection can too often be well hidden by the assumption that empirical scientific method and the naturalistic view point are the *sine qua non* of rationality such that there is no better recourse to knowledge, and perhaps even no other kind of knowledge. Another is in the way we dance the technological dance - that our fabricated devices are there to be taken and used as impartial tools for the control of the natural world, or for the advancement of material well being. However, and in the end, when our powers are amplified by technology indebted to scientific knowledge, then the intellectual tradition of science - to which the West is remarkably obliged - is brought into a realm of social practice populated by the power seeking and the power keeping. Here any advantages in a 'democracy of the intellect' may be thwarted by an ambitious drive for the 'aristocracy of the intellect' - knowledge and reason taken out of the hands of women and men to be placed in houses of power[12]. The problems of choices for power have long concerned Western intellectual culture; it is a trial of both modern and ancient practice. The contemporary choice then is not about abandoning the dance, but one of choosing a pace and step. To do this there is a need to reevaluate the intellectual tradition out of which comes knowledge from science, its fabricated artifact in technology, and the way our powers are thereby first amplified and then controlled and redirected by the institutions we create and maintain - by the character of our commitments and their human practice.

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Return to ambivalence

Paradoxically, knowledge and artifact (or concept and practice) can both free and restrict a sense of self. The deeper or more proficient our scientific knowledge, the more extensive the scientific enterprise, and the more we come to adopt scientific reason as reason (and its goal as the best of goals), then both more wonderful and more anxious are the prospects of our beliefs and choices. We quickly reach here the limits of the naturalistic stance, its modes of thought, and the world view of the machine. The fabrication of artifacts that exemplify our knowledge and amplify our powers, together with influential symbolic forms whose meanings serve to substantiate that knowledge, can bring some small or great change in the awareness of what we can do in nature and what practices might make up society - and so, in part, of who we are. At times we even witness unique advances in our categories of action. But the change is not always additive, often it is unexpected, and sometimes it is tragic. The adoption of new social institutions or cultural forms can displace others once commonly shared, even well loved. This alters the kind and quality of our experience - be it of the every day or of the profound; be it as individuals or as a society. It can force us to select, or forces selection upon us, in so far as how we might live our lives, what lives it is possible to live, and which values find recognition and support as we live. This is of specific importance in an age where communication and movement across cultures have brought into close relief a diversity of modes of thought and practice, but where the Western scientific tradition (not rarely claimed the superior) and its categories of rational practice (especially the economic and the educational) find a nearly global influence.

In this sense then the adoption of new artifices for living and acting in a society often coincide with a shift in values and commitments. The shift can occur in clear and evident terms, or through meandering avenues hidden from thought and realization. Proficient scientific know-how can bring about wholesale changes in people's lives, and in conceptions of how to live. Experience with deep forms of knowledge, with the techniques created, and the institutions built or adopted, can help envision new prospects for humanity or incur the sight of a looming power that threatens a ruinous toll.

Making sense of science

Despite the paradox, or perhaps because of it, the practice of empirical science and technological fabrication need be constantly debated - take for example our knowledge of genetics and the growing practice of biological engineering. They are both wonderful and frightening. Despite the tendency of people to see in scientific efforts a search for truth free of prior commitments or social values, neither the work of science nor debates about choices for power appear from nowhere. They cannot be understood or used in a vacuum. There is a history to science (a Western history), to the institutional workings of a society, to the symbolic forms employed, to an adoption of technology, and to a shift in values this all may involve. While it may be true that these things are man made, they are not thereby made arbitrary. History and habit lead to questions about method and results, about human action and rational ends, about how we conceive and use our tools, and about social practice and self-understanding. These are just words, but the history (and

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the habit) is real enough. It makes up part of the tradition of modern Western thought out of which science and technology have come, and where the task in turn is to try to make human sense of them (particularly in a world grown small via the appearance of new techniques of transportation and communication).

Perhaps because of the notable depths of scientific empirical knowledge we have achieved, and because of the prospects for unique progress or repeated ruin the practice of such knowledge seems to offer, the byways of this tradition need to be repeatedly explored and reevaluated. Not all is well with it or the civilisation said to flow out of it; this has long been spoken. Two world wars, both largely of European origin, are a notable testimony. The Western tradition of empirical science and instrumental reason is an impressive and worthy enterprise. But practice stemming from it can also prove dreadful in its consequences. It is of course simpleminded to lay blame on science for the ills of an age. However, the impact of science is distinct and real. There is no good reason to simply dismiss the prospect that we have misconstrued the artifact for substance by accepting too deeply the naturalistic mode of modern scientific knowledge and reasoning, and in so doing divorced ourselves from a crucial focus on human significance and the institutions and social practices we create and adopt.

Summation

The object of this thesis is to expand on the notion that science, its connections to ways of change in society, and the use of technology cannot be rightly regarded apart from meaning giving ideas and practice; that these ideas and practice provide for a larger context to both how we conceive what science and technology are, the social uses we make of them, and their place in making sense of human significance. In other words, not only do our understanding of science and technology involve the interpretation of ideas behind what we know and the fabricated artifacts that both amplify our powers and express what we know, but that in some sense we cannot make sense of science and technology without attending to the ways in which meaning and values constitute human practice, of which science is a part. My intent in this thesis is to explore some of the main conceptual schemes that have dominated Western thinking about what science is and what some aspects of its method entail, together with what effects it has had on the institution of science and in the way we often conceive of science and society in relation. In the end I hope to have outlined some aspects of thinking that may be faulty or inadequate, and to suggest instead a different set of broadly holistic approaches that might help put things in perspective.

In particular, I will try to unmask some of the ontological and epistemological assumptions in thinking about science and how it works, particularly the Western habit of thought that works out the puzzle of what something is in terms of the way it is known[13]. This will include as well a look at the ways the institution of science may often be construed to act in society as a value free enterprise. I will also treat the view of science as being bound to institutional norms, or as system of research for the fabrication of socially useful results. As a counter to the mechanistic world view I will try to offer a set of ideas that may help convey relations between science and society conceived as dynamic patterns within an active whole. In other words, how they can be related in

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holistic modes of thought - modes that in some sense involve making connections and linkages among seemingly diverse fields of knowledge and experience, but which, given the short-comings of existing scientific constructs, may be indispensable for a revised and modified, though always incomplete, understanding of human scientific-social-technological practice. Such an approach will include, in particular, the character of systems as self-organizing wholes, and the view of man as a self-interpreting creature. I also aim to survey recent developments in science itself that point to alternative theoretical schemes of a more interconnected sort, and which might give credence to the notion of holistic modes of thought. In addition, I intend to highlight ways in which the traditional ontology of science offers an inadequate account of our best attempts to understand ourselves (for instance, as self-interpreting creatures), and that this therefore affects judgments about, and the ways of attaining to, knowledge of a holistic sort. The overall point however is not to reject science or scientific rationality, only to question the proposition that the mechanistic stance and its naturalistic mode of thought is adequate to give a self-sufficient explanatory account of our world and ourselves to ourselves.

To a lesser extent, and to close the thesis, I will include comments about the character of and limits to the view that technology is a neutral tool for use in society. This will involve some remarks about technology as a fabricated artifact of our knowledge, an amplifier of our powers, and a type of influential symbolic form - all taken from the point of view of technology as the social practice of science. Following this, and finally, there is perhaps no more faithful reflection of the modes of thinking that obtain in science and scientific reason than those apparent in modern systems of education, their content of instruction, and the academic disciplines into which they are divided. Among these is technology education. I will round out the thesis by exploring some South African issues in technology education policy that continue to reflect a naturalistic stance. In so doing I hope to bring together into a specific case the overall difficulties and prospects discussed in this work, and thereby suggest, at least as regards education policy, changes to the 'pace and step' of our twentieth century scientific-social-technological dance.

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Chapter One

Science and Self Description

Introduction

How might we conceive our reality? Of what significance is our world? How are we to portray our humanity? This thesis concerns a study of science, society, and technology, yet within each of its pages stand such questions. They have no invariable answer, no unique solution. Various conceptions hold tenure in historic time, and within a time there obtains diverse portraits and emphases. We are always trying to glean (or to speak) the incomplete. Howsoever man is viewed - as a rational animal, an image of the Creator, an ethical being, an embodied spirit, a biological mechanism, a social creature, a survival machine, a learner of learning, a holder of language, a maker of history, a user of tools, a consumer of goods, an evolutionary gambit, a self-interpreting organism - no one characterisation does justice to the human reality. While the task of human self-description is always unfinished, the talents of an age, its problems, and its potentials can direct the thinking of women and men along one or another climate of reasoning about who we are and what we might achieve or aspire to be[1].

In the case of the twentieth century Western tradition the who and what of our existence cannot be separated from the what and how of science. Whatever view be taken about human nature and the world in which we live, some conception of science must certainly be entertained. This is so because in the West the intellectual leadership of the twentieth century rests with scientists, and this cannot be divorced from the enterprise and project of science (nor the working of technology)[2]. Its planet-wide use accentuates as well a relevance and influence, not necessarily for the better, beyond the bounds of an only Western scientific tradition, civilization, and social practice.

One way to explore the significance of science, society, and technology - not only for the tradition itself but to help discern the ways they bear upon a planetary inheritance - is to begin by looking first at the ideas behind the scientific world view and the suppositions supporting the nature of scientific knowledge and instrumental reason, and then to view how they affect, respond to, and cohere with beliefs about the significance of the human reality, with assumptions as to the nature of the world in which we live, and hence the forms and character of knowledge which might be thereby attained. Such is the broad approach taken in this thesis. The work on the whole is partly descriptive, partly interpretive, and partly critical. It involves an attempt to unmask some of the confines of the classical scientific world view and to offer, if only tentatively, an extended set of ideas from within what may be considered richer, more holistic modes of thought that might help rework some of the established constructs typically used to make sense of the scientific-social-technological world.

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Within this work two main questions are repeatedly met (though often indirectly) in the attempt to map out some of these limits and their extension towards a more holistic view. First, in the relation between science, society, and technology, what sort of judgments can be made about scientific knowledge taken as the means to power, and the uses to which that knowledge may be put? In other words, how might be overcome the belief that the ends justify the means - that they are separate and separable, are to be approached on different terms of action and thought, and that science as the drive for objective knowledge is largely independent of the social, ethical, and human judgments passed on its use? Second, and similarly, in what ways might such classical and contemporary scientific constructs as characterize the nature of reality serve to limit or to advance the knowledge and understanding we have of ourselves and our social world? Put differently, to what extent are scientific abstractions and the methods of empirical science sufficient to make sense of the human reality - to account for the significance of man's self-understanding - and in so doing advance or retreat our conception of secure and reliable knowledge (as well as the itch for absolute certainty) together with the use of such (technological) power as that knowledge offers?

Chapter preview

The work here does not pretend to provide answers to these questions; it only attempts partial, halting moves towards a holistic response. Nevertheless, and as just stated, a first step towards this involves unmasking some of the suppositions and ideas within the mechanistic view of modern science and the naturalistic stance of a Western intellectual culture. The target of this first chapter is to approach such an analysis of the limits of ideas. This is necessarily an extensive task of many complex contributions extending far beyond the scope of the thesis. Here it can only be briefly and incompletely surveyed.

In brief, the chapter will begin with a historical note about early steps leading to the modern scientific stance. In particular, there is a long scientific tradition in the West, beginning with the work of Greek scientists and thinkers. But even here scientific thought relied on views of the world born of the philosophic concepts of the day, and on the resources available to the man of rational inquiry. Such a historical introduction will lead into a gradually more substantive account of the rise of modern science through the construction of a specific view of the natural world and man's reasoned place within it - the mechanistic world view and the naturalistic stance. This will involve the interplay of some general historical developments, in no wise comprehensive, and the analysis of a few key ideas related to the abstract constructions of scientific thought and method. The chapter will also attempt to connect these constructs to some broader aspects of Western intellectual culture, particularly in how the mechanistic world view and the naturalistic stance - the rise of scientific rationality, of mechanically causal explanations, and the drive for objective knowledge - have come to occupy a position of prominence, even of unquestioned adherence, in the West's intellectual climate.

The latter part of the chapter will attempt to treat aspects of science as rational method - that it has come to provide the West's primary characterisation of rationality. The chapter will look at how this relates to the notion of objective reason and the need for a disinterested, context free

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analysis, placed in a habit of thought that requires of rationality an analysis leading down to clear and explicit foundations from which claims of validity can be argued and must be settled. It will as well highlight the view that the commitment to the search for empirical truth is arguably the first prerequisite for science, such that without this commitment science would loose its major harmonising chord. The chapter will close with summary comments about the handicaps of the mechanistic world view, about the habitual characterisation of scientific knowledge as means only - with ends chosen on non-rational or less rational grounds - and about the importance of this distinction for the way in which is conceived the relation between science and society - the topic of the second chapter.

The mechanistic world view

Early steps

The earth was created once only, but the world has been made many times over. In the tradition of the West, one might propose noon on June 21st some 2300 years ago as a time for a remaking of the world. Eratosthenes of Alexandria lived in the 3rd century BC. He was a man of some note for his time, and his scientific work has survived in Western history. According to the story, he had read reports that on June 21st in the city of Syene a vertical stick casts no noon shadow. Yet, when he investigated, he observed that at the same time in Alexandra similar sticks cast evident shadows. Eratosthenes asked himself how is it possible that in his home city a stick's shadow is pronounced while at the same time far to the south in the city of Syene a similar stick casts none? It is a commonplace observation - the shadows of sticks (some say it was temple columns, or obelisks, or of the sun shining down deep wells) - and a deceptively childish question, but Eratosthenes claimed that it would give a surprising result: the circumference of the globe[3].

It is hard to say exactly the steps he took towards his conclusion, or how long he mused over the observation before he thought something out of the ordinary was there to be found. Yet certainly he had at some time to propose an explanation and to work it through. Since he accurately calculated the Earth's circumference, it is equally certain that he had to set up the problem such that given certain assumptions and known values, he could derive others.

However, there are four things Eratosthenes possessed without which he arguably would have been powerless to achieve his result. First, he inherited Greek geometry and its discipline of both visual and abstract thought. Second, he possessed what today would be called a theory of the natural world that enabled him to ask what must the world be like on its own terms that might explain what he saw. In addition, and third, he lived in the Egyptian city of Alexandria - perhaps the greatest metropolis of its age, and an equally great seaport - receiving thereby a world of thought from its long, complex history and active present. Finally, he was the director of the Alexandrian library, the centre of the science and scholarship of the times, and thus 'owner' of a vast store of knowledge to which he could refer. Although none can be sure today, yet without such an inheritance and opportunities it is unlikely he would have measured the earth, nor would have history recorded his name[4].

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Today, the result he calculated is a matter for the schoolbooks, but its conception then was not so simple. It is plain for the modern mind to understand - the West has inherited much of the Greek tradition, placing it thereby on a line of thought that connects it to a past making up an identity in tradition. All that is wanting to perform the calculation, both now and then, is the angle of the stick's shadow in Alexandria, and the distance from Syene. It is a relatively easy task to measure the first, and, perhaps revealing of the man, to get the second Eratosthenes hired someone to pace out the distance from Syene (in modern terms it turns out to be about 800 kilometres). If the picture is right - if the Earth is taken as a sphere with the light from a distant sun travelling in parallel lines - then an angle measure and a distance combine to give a circumference. The result is important, yet the assumptions are crucial. For they are not only assumptions but explanations, and latterly descriptors of the world. What Eratosthenes proposed is that given the differences in shadows between the two cities, then the only way to explain it - to account for what is observed - is to conclude the world must have a certain shape, assuming certain properties of light from the sun. And it can be shown that other shapes besides a sphere (or something sphere-like) simply cannot work, while the measured unknowns give a demonstrable size whose accuracy depends only on the accuracy of the measured values.

The insight, formulation, and experimentation of Eratosthenes are modern in spirit. The mathematics, the problem setting, the interpretation, the patience of measurement are as they are done today. This is so not because such ways of thought are among the modern mind's most favoured and familiar, but because his were among the early steps in what has become a Western intellectual tradition: to explain the world through a subtle balance of empirical observation, inductive argumentation, and the formulation of abstract laws. Eratosthenes made the world in the sense that he set out conditions for discovery which now comprise part of the modern Western view of science, its intellectual culture, and its rational modes of thought[5]. The rise of such a world of concepts is extended and intricate. In the following sections, the ascent of this mode of thinking will be discussed but in part, and will touch only of some of its main characteristics.

Ordered beginnings

The ideas and methods of modern science were forged in the sixteenth and seventeenth European centuries. In the thousand years before nothing quite like it existed. In 1500 Europe had but scant notions of what might constitute an empirical science; by 1700 Isaac Newton had completed his major scientific work, and the modern era had indeed well begun[6]. Between this relative ignorance and Newton's achievements stand a host of ideas, both philosophic and empirical, that make up the early orchestration of modern scientific thought. Copernicus, Kepler, Francis Bacon, Descartes, Galileo, and Newton are among its first composers - many others justify inclusion[7]. Yet the origins of modern scientific thinking can be traced back into Europe's middle ages, and beyond them to the orbit of Greek science and philosophy (as in the work of Eratosthenes). Neither can be ignored the place of Islamic scholarship, science, and thirst for knowledge through which the brilliance of Greek thought and civilisation was preserved, advanced, and later reintroduced into parts of European society.

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The architecture of thought in the middle ages is the immediate antecedent to the house of modern science. It is a period to which the philosophic origins of science are indebted, but whose form of scholastic rationality science rejects. Of course, the mediaeval period is both long and complex. It cannot be rightly subsumed under a single term. Neither is there enough space here to go into the subtleties of that age as regards the later rise of science. Yet on the whole it was a period of study dedicated to the proposition that the world is ordered - wholly ordered, both morally and naturally, according to rational principles that can be known by the human intellect. Scholastic logic was coherent and highly rationalistic (the syllogism was a favoured mode of reasoning)[8]. The detailed workings of mediaeval legal systems, generally inherited from the codification of Roman law, reinforced the theme of order and of a rational system of organisation. Scholastic divinity focussed on the ordered rule of God, and His intimate ordering of all affairs - either by His powers of creation or through the willing consent of His human creatures. The mediaeval commitment to a detailed order of nature gave to modern science its unquestioned belief in both the existence of that order, and that men can find it out through empirical study, inductive reasoning, and abstract conceptualisations[9].

Modern science also began as a reaction to that unbridled rationalism of the latter middle ages and its scholastic natural philosophy[10]. The metaphysical analysis of the nature of things through their place in a purposeful moral order, by which questions of action and function were to be settled, is a hallmark of the age. The belief in a detailed order in nature (scarcely divorced from God's, and thus man's, moral designs) depended on the purposeful end to which all things were created and in terms of which they acted. For those who sought knowledge both of revelation and of creation, the place of things in the order of the universe became the object of inquiry through the rational study of purpose. Such a teleological treatment of the world was rejected by the modern scientific enterprise[11]. Instead, the revolt in history and against tradition based its search for knowledge on the discovery of order in empirical facts. Their's became the appeal to experimental results, and thereby to the relating of prior events to consequent outcomes through some statable, lawful behaviour among observed phenomena. Men would thus come to know how things act as they act among themselves, not by virtue of their ends.

Experiment and explanation

Galileo's case demonstrates this nicely. He arguably made two vital steps in the creation of modern science. First, and as regards motion, he turned the tables on what needed to be explained. His contemporaries were dedicated to extending and refining their notion of natural motion - that things have a natural place or condition to which they tend. For them rest was a natural state, and, hence, what need explanation was that which kept objects in motion. There is no doubt that it was serious science subtly developed. But Galileo instead proposed that rest is the consequence of some obstacle to movement, without which bodies would otherwise keep in continual and constant motion. In other words, steady motion is the norm. What needs explaining is not why things come to rest but how their states of motion change. It is not through the appeal to purposeful ends that nature can be understood, but by studying the (efficient) causes of changes in states of motion[12]. Nature acts as it acts - though always with a natural order. This

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does not require explanation, but is a given. 'How then does it in fact act?' is the question which Galileo and all his scientific decedents addressed[13].

Galileo's other accomplishment, one done with ever greater refinement after him, is to set up experiments expressly designed to measure numerically the phenomena of study - in this case, changes in motion of objects. In modern science, any fruitful knowledge of nature must come out of first, the quantifiable relations gleaned from empirical experiments - experiments set up to exhibit some relation between certain well chosen abstract aspects to phenomena - and second, the formulation and communication of those relations in unambiguous terms. Classification occupies a very much less important place; repeated measurement and its precise communication becomes the key to disclosing the ordered natural world. As goes classification, so too goes a reliance on building deductive syllogisms as the method of discovery. Into the search for knowledge via repeated measurement is thereby imported the vitalness (and vitality) of inductive reasoning, for there seems no other way to argue about a mass of experimental data supposedly pointing to the existence of ordered relations joining events of the past to those in the future[14]. Thus does science begin (but only begin) to build up an empirically definite, detailed portrayal of nature in which general explanatory and predictive principles find expression[15].

The place of mathematics

Galileo used the mathematics of geometry to express both the detailed relations he observed and the inferred general behaviour thereby exhibited. Ever since, mathematics has been the common tool and helpmate of the sciences, even to the point of characterising the success of its approach[16]. It is typical today to think of mathematics as a system of rigorous thought based on the stipulation of certain general conditions that characterise the relationships among the conceptual objects of a study[17]. These characteristics and concepts hold in the abstract - they do not specify anything in particular. If cases can be found that satisfy the general conditions (or equations), then the logical and abstract consequences derived from those conditions may be said to apply to the particulars of the specific case. Such a view is a central principle of mathematical modelling - a main technique of study in contemporary science.

As regards pure mathematics, each step in the work of discovery is established by the application of a set of clear deductive or manipulative rules, combined with the intuition, inspiration, and genius of a mathematician. The mathematical researcher establishes facts through the means of proof, and so proof becomes central to mathematical knowledge. How someone comes to that knowledge is a matter of ability, insight, and approach. Once an idea is formulated, it counts not as knowledge until deductive proofs are given[18]. Yet none of this works unless the relations among concepts are precisely defined such that there is no ambiguity as to meaning or operation; hence, the use of a system of symbols unique to mathematics that provide it with modes of calculation and communication adequate to the precision of its ideas. Those ideas not amenable to precise definition or whose exact relations cannot be captured in a rigorous system of symbols cannot be called mathematical ideas proper. They cannot be accorded the status of knowledge.

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Here the scientific genius of the seventeenth century found a favoured tool, and the inspiration for a way of thinking that has come to dominate modern scientific domains. The happy combination of first, a well chosen set of abstract ideas that pick out clearly definable and measurable relations and their properties in nature (as in distance, speed, inertial mass, and time but opposed to smell, taste, or colour which are considered only impressions in the mind), and second, the precise use of unambiguous mathematical operations and symbols to represent and relate those abstract ideas and their measured values together gave to natural philosophy its triple force. The methods of natural science were born out of the balance of experimental observation, their abstraction to general cases via induction, and their reasoned formulation in precise mathematical terms open to further deductions whose claims can be tested by experiments in nature.

Detailed natural order

None of this would have been believed possible without the instinctive belief in a detailed order of nature. The amazing results of Galileo and the later perfection of expression captured by Newton convinced many that the order of nature factually exists as a mathematical order, and that through the methods of empirical, experimental science its lawful and general relations can be found out, and found out to apply in exquisite detail[19]. Nature is not simple. Scientific understanding is always incomplete. Yet the measurements reveal an underlying order to which the mind of man can give a representative expression. The historical reaction of modern scientific thought to the categories of the latter middle ages was against an overly deductive rationalism, and the inheritance of traditional but unquestioned knowledge. The eventual success of the methods of the scientific enterprise propelled European thinking into a new mentality - one now widespread and equally widely adopted.

In 1637 Descartes' *Method* was published. In it he describes what is today called analytic geometry[20]. It represents the birth of modern mathematics (some call Descartes the father of modern mathematics). Before Descartes, there was no way to express fluently in symbolic equation form the relations for continuous and changing motion. Analytic geometry divides space (both two and three dimensional) into a system of scaled coordinates capable of stating exactly the position of any point (or object) in that space, and thereby, through establishing general algebraic equations, to the relations among a set of variable positions[21]. By giving interpretation to the scales of position, a host of dynamic relations can be portrayed with a mathematical precision capable of subtle and fine analysis. All manner of measured values can be represented thereby, and confirmed in calculation. Analytic geometry became a perfect board for the festival of experiment, and helped advanced the scientific setting out of new abstractions about nature.

New abstractions

Cartesian geometry thus provides a means for calculating in abstract space with abstract relations using abstract position. But by itself it is a static system. Prior to this, Galileo managed to conceive abstract time, separable from the event being studied. The conception of time as another

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factor in the calculation of motion made all the difference to the formulation of the laws of motion. Scientific time became distinct, precise, and measurable (at least in principle). Just as important, it is taken to be constant in its rate regardless of the object of study, and, as regards the lawful formulation of the dynamics of motion, is independent of past or future states. In other words, scientific formulations of predictive motion treat past and future equally - they can be used to calculate both past and future states without distinction. In this sense then is time taken as an abstraction, and its actual passing (as opposed to its measurement) as inconsequential for scientific constructs adequate to the study of nature. No more the healer of ills or the exercise of patience, time is another quantity measure by which the mathematical order of nature can be breached and held[22].

[Indeed, today scientific time in the West has come to stand for time of the everyday. It is a prime example of that form of scientific thinking and reasoning (now common in general Western forms of thought) that adopts an absolute stance for the provision of knowledge. Science does not speak of human lived-time, but time from a position of universally true descriptions of the state of the universe as a whole and as it is - be it, at least in principle, states in the past or of those in the future. By making time abstract and universal, and given the great predictive success science has thereby achieved, Western intellectual culture has tended to treat human lived-time as belonging to some other category of experience not having the same sense of validity or truthfulness as is found in its scientific counterpart as actually descriptive of reality. The human experience of time is more individual, personal, subjective, and changing. Indeed, that is why science must make of it some abstract notion, for otherwise it could not become part of, or count towards, the scientific scheme of accurate measurement and valid knowledge.]

On the whole then Descartes' mathematical system of positional and spatial analysis, and the conception of natural properties (as in change of motion of objects) occurring over abstract, non-directional, independent time in that positional space provided the key which, when joined with experimental precision, helped men of science specify nature's lawful relations of motion and behaviour - not merely as men might understand it to be, but from a position of certainty as it acts within itself from a universal viewpoint. Descartes' constructs not only provided a starting point for the mathematically precise, experimental analysis of nature, but his conceptualisations also set out the basics of that natural philosophy in terms of which scientists came to make sense of their work (and by which a new world was conceived). It is of course incorrect to suppose that he can take credit for the enterprise in its historical development. Much of his scientific speculations about the nature of the physical world were soon discarded. But his age is largely the century wherein the ideas were born and then honed to perfection (notably by Newton). In his distinction between *res cogitans* and *res extensa* he sets the cornerstone of what was to become the atomistic and highly abstract conception of matter: inert and blindly moving according to the forces acting upon it[23]. Matter is independent of time, but occupies distinct positions in abstract space. Isaac Newton made concrete use of such conceptions in his system of the world. 'I take space to be absolute' was his position, and no doubt he believed the same to be true of time[24].

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In the Cartesian dualism of mind and body, matter is that which is extended in space existing independently of passing time. Mind is that which thinks; it is the locus of consciousness and duration. Descartes (not Galileo) states the abstract law of inertia, and the universe of matter in motion becomes analysable in the mind in clear geometric terms[25]. And to what do these terms refer?: the mechanism of matter, whose movements can be explained by their own conditions and their own relations as extended bodies void of purpose but definite as to motion. The world is thus portrayed by Descartes as a mechanism of the material. To the question what keeps the planets in their orbits Descartes replies: the machine-like workings of constantly moving matter[26]. As a basis for the work of empirical science, the materialistic, mechanistic and dynamic view of nature (operating within abstract space and through independent, reversible, abstract time) became the picture of choice in physics. Descartes' own speculations about physics were abandoned as unworkable and wrong. Yet one by one there were founded the empirical sciences - astronomy, then dynamics, followed by chemistry and then biology - and these only confirmed the vision of a world composed of material causes and mechanical principles.

The mechanical universe

Early on in the scientific enterprise Isaac Newton perfected the Cartesian picture of the mechanical universe. The new scientific method was still incomplete, or perhaps piecemeal. The abstractions were generally available. The view of matter and nature were newly placed. Kepler had established the rule of planetary orbits. Much of the mathematics was in waiting. Newton combined them to create a system of the world that held together as a perfectly orchestrated scientific score, and established thereby in modern science the balance between empirical investigations and rational, causal, abstract explanation free of unnecessary hypotheses. Although he invented the calculus he needed to establish his results (for instance, those concerning the point action of gravity at a body's centre of mass), when he finally published his *Principia Mathematica* he wrote it out in familiar geometric terms. Still, his work in gravity, in motion, in optics set out the principles by which all future science was to be done - empirically sound, mathematically precise, and thus mechanically dynamic, exact, and materially causal.

Not only was science thereby put on a path leading to the detailed prediction and explanation of phenomena, but it took too from Newton its tendency towards universal application. His first efforts in the study of gravity not only provided a clear, predictive train of thought and a powerful mechanical explanation of how things happen, but his conception applied universally - a host of distinct and seemingly diverse events could be accounted for by a single set of relations succinctly stated. The discovery of principles that, through their predictive and explanatory focus, give unity to a range of otherwise unrelated phenomena has provided science with much of its confidence in extending to unexpected realms (such as in the sciences of man) the same methods that work so expertly elsewhere in the study of nature.

The confidence was there in the thought of the age - that not just planetary orbits but all things that admit of extension, including living beings, admit too of mechanical explanation. Newton actually achieved the basic result in his theory of gravity and in his equations of motion. Even

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light came to be explained on the same essentially mechanical grounds. When white light passes through the triangular prism, distinct colours are made evident. And Newton's explanation? Light is not thereby modified, it is simply physically separated. Newton wrote with pride:

> A naturalist would scarce expect to see ye science of those colours become mathematical, and yet I dare affirm that there is as much certainty in it as in any other part of Optics[27].

'Optics' is his work on light, and one could just as well imagine Newton saying that there is as much certainty in it as in any other part of Science. The European mind was astounded by Newton's accomplishments. Today many consider them the greatest single intellectual accomplishment of modern European times. Indeed, it may be said to have made the modern age to the extent that modern science has any importance in Western intellectual culture.

Descartes thought that nature was simple in what it was[28]. This is not an idea that physicists today adopt. Nature is complex, subtle, and hard to get at. The modern scientific enterprise is arduous. As a tradition of thought it requires an unequalled focus of attention and dedication to the task. Einstein's famous answer applies here. When asked why he thought the older civilisations of China or India did not invent science, he said the problem is rather to explain why Europe did - why anyone did? At least part of the answer is the intellectual belief in Europe that there exists a detailed order to nature that can be taken apart and studied. Perhaps it was the faith in such a belief that gave energy to the sustained effort of discovery otherwise too taxing to pursue. Newton's words are suggestive:

> To explain all nature is too difficult a task for any one man or even for any one age. 'Tis much better to do a little with certainty, and leave the rest for others to come after you, than to explain all things.

Of course, Newton was a man of his age and when he used the word 'man' he meant exactly that. However, the obvious thing about the passage is that, while he or his age alone might not be able to explain all of nature, the task itself is not in question but only time. Certainty is there to be had, if only step by step, piece by piece, age by age.

The basis for the image of the mechanical universe is that it can be broken into component parts for the sake of study, to then be recombined in understanding. But before it can be divided, it must already be made of divisible parts from which it is assembled. Whether it is dynamic or static, in equilibrium or unstable, or an instance of forces and energy does not matter. Hence, modes of thinking are devised by the scientific intellect to proceed by step to analyse, divide, dissect the phenomena into those explanatory parts out of which it is made and that make it work. To master an explanation of the parts is to master an explanation of the whole. The act of experiment and measuring, the methods of reasoning, the basics of the world view (abstract divisible time, position, and divisible space), and the abstract concepts of dynamic but inert matter, together with other primary aspects to nature and extension all work as one to support the main image of the universe and its parts as a machine[29]. In terms of scientific laws, the mechanistic view point takes as basic the assumption that the way phenomena behave in local

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space is the same in all of space - universally so - and that the way abstract time is conceived to operate on earth is the same for all phenomena. Thus, scientific laws worked out and validated on earth work equally so throughout the entire universe - a knowledge of those aspects of space and time which can be measured here on earth specify as well the workings of the entire universe.

In this way laws formulated 'locally' are taken first, to have a universal application, and second, are sufficient to account in principle for the complexity seen in nature. Since space has the same properties everywhere, then the laws of science as formulated on earth by the human intellect apply to the whole of nature. In other words, the mechanistic world view posits first, the existence of a god-like view of the workings of nature (or the extended universe), and second, that the laws of science give detailed expression to these workings.

Giving support to this view is the fact that in the dynamical laws of motion time is taken to be an independent variable. In other words, Newtonian science accounts for motion without regard to any actual distinction between past and future states - the motion of matter is the same in all past and future time because the one mathematical law is used to determine them both. As go the laws of motion, so too follows the character of the physical world, therein conceived as being independent of time. Science is able thereby to adopt a universal and absolute stance in its knowledge claims about the extended natural world. This of course is not to claim that the laws of science are a complete description of nature, only that the laws thus far established have this objective status (universal and absolute descriptive content), and that, given the mechanistic view, further discoveries will as well exhibit this property of scientific knowledge. While recent developments in physics point to changes in this mechanical and objective stance, the naturalistic view point, so finely represented by the science of Newton, remains an established and influential inheritance within the tradition of the West. Its configurations form a basis to the modern climate of thought, particularly Western notions of rationality.

Materialism

In notable ways the growth of science coincided with the advance of the atomistic, materialist view of mechanism. However, the founders of modern science were not materialists in the sense we often mean today when people typically, perhaps stereo-typically, speak of science. God the creator, the maker, the revealer was intimate to the whole of creation. Descartes' conception of certain knowledge posited God second only after the existence of his own thinking. Newton was a biblical scholar who wrote commentaries on the Book of Revelation. But with the success of Cartesian analysis, and the positing of matter in extension, only as extension, the material world became void of that purpose whose traces it had previously revealed. As regards the physical universe, God was a mathematician, the Craftsman of the laws and forces that now obtain and hold all things to motion. How appropriate and liberating then that the highest creature, man, should sound out the new geometric symbols of creation in the enterprise of empirical science. Only later did the corpus of scientific work regard God as either too distant or simply irrelevant to the discoveries being made. Exact causal predictions and explanations need only the abstract conditions of atomistic matter and distinct, measurable natural forces to make sense of the world.

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No mysterious connections to the unseen, or to the 'unseeable', need be assumed. Early natural science was inspired in part by the attempt to account for the world as it actually behaves. Galileo, Descartes, Newton hoped to speak the truth about the order in nature, though it was still part of God's domain. They had the confidence in themselves and in their ideas that it could be found out. While to them can be traced a splitting, in modern times, between God and the natural world, it was only later (but not too much later) that religion and matters of values in general became suspect - an obstacle to clear thinking or a hindrance to the empirical truth. Indeed, Lagrange's materialist position of a completely determinist, mechanistic world set down the principle: if the working of the universe can be explained by internally self consistent laws of motion, then science can dispense with any talk of a prime Mover[30]. That belief too still holds ample sway today in the naturalistic temperament of modern thought.

The previous pages have tried to survey some of the historical developments leading to the scientific view of the world. They have also attempted to present a few of the basic conceptions - mathematical, material, mechanical - that greeted the origins of the naturalistic stance. In many ways these have come to characterise not only much of modern science but many Western notions about knowledge and rationality, thought and action. The following pages will attempt to accent some notions in reason, knowledge, and language which have come to be adopted unreflectingly in Western modes of though, which have bearing on contemporary issues in the relation between science and society, but which are intended here also to show up some of the limits of the scientific stance. Since they cover a fairly broad range of topics, none can be treated in detail - though they are vital aspects to the mechanistic world view now a part of intellectual culture.

Parting from your shadow

Introduction

In very broad terms, the way of natural science is the way of focussed attention on a particular set of abstractions about nature - neglecting thereby all others - and through them extracting via experiment all that can be known about the properties of phenomena being studied, taken to apply universally. The enterprise of science thereby restricts itself to a particular set of ideas and approaches adequate to its task[31]. However, the modern scientific enterprise began in an age where thought was largely dedicated to finding methods of reasoning for founding secure knowledge not dependent on tradition - achieved by formulating its content via the clarity of mathematical-like expression. In this way a new view not only of science but of all of (Western) human knowledge was being revisited and reborn[32]. It was the birth of a set of ideas with which the modern mind is still preoccupied. In a strong sense then, the originators of this enterprise - individuals such as Bacon, Descartes, Galileo, Harvey, Newton, and Boyle - lived in a mathematical age. They produced scientific abstractions suitable to it. However, given the success of the project of science, these concepts have become part of the broader tradition of Western thought, not limited only to matters of mathematics and of scientific method. They have come to enjoy a degree of influence well beyond the realm of science proper.

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Yet not all is well with these abstractions adopted fully into a modern intellectual culture[33]. The scale of influence of scientific concepts turns out to be quite vast, as does the impact of scientific method on notions of, and beliefs about, rational thought and action. Yet the vastness of the influence is now part of the problem. Concepts meant for specific realms of empirical analysis have been adopted wholesale in areas where they do not (or need not) properly apply. The concept of a mechanical universe, the cosmology of mechanism, became so widespread that it could not but begin to break down. And yet the success of science was and is most convincing such that it needed not to revise its set of basic abstractions or its central methodological canons. Indeed, they became so successful that all manner of rational inquiry had to pay homage to them, and, if wanting to remain intellectually respectable, to adopt them wholeheartedly[34]. The result is that concepts of the material, the mechanical, and the rational that work well in specific cases have been applied generally, and have come to influence a very much broader range of constructs affecting nearly the whole of Western concepts about nature, the sciences of man, the world of human self-understanding, and the portrayal of reason and explanation.

In very general tones, these influences can be characterised by two pairs of related ideas. The first concerns a somewhat direct impact of science on Western modes of thinking in general, namely:

> i) The belief in the universal validity of scientific thought. In other words, scientific rationality is rationality - that to reason means to reason as one might in science: empirically, instrumentally, from foundations, and on the basis of external criteria of judgment.
>
> ii) The acceptance that material and mechanical explanation is what is meant by explanation - that causal, lawful, material accounts of phenomena are the only valid accounts, whatever the phenomena.

The second is more broad, dealing with the philosophical current of ideas that have influence throughout Western culture, namely:

> i) The adoption in Western thought of the idea that bodies and minds exist, and exist each in their own right as independent, individual entities (or worlds), the one free from any necessary reference to the other[35].
>
> ii) The drive for objective knowledge of the natural (material and extended) world by observing (conscious and thinking) minds, leading thereby to the general belief that objective knowledge as conceived in science is the only knowledge worth having (or in the extreme, that such objective knowledge is the only secure and reliable knowledge)[36].

Some provisos must be added. From the first case, the intent here is not to suggest that these general statements hold in every instance, or that all give assent to them. There are other types of explanation available, and there exist other forms of reasoning. However, it is true that these modes of thought are part of a climate of ideas which the West inherits and in terms of which it is characteristic of thinking to proceed. Their influence is broad and diverse, sometimes focussed, often nebulous, but present nonetheless.

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From the first part of the second case, there is little doubt that the Cartesian distinction of mind and body (or extension from thought) has had a profound influence on Western conceptions of the world and of man - an influence amplified by the great success of the natural sciences. Whether one adopts the basics of the distinction, or attempts to mitigate its results, or seeks for a wholly different alternative, the Cartesian division of mind and body remains a centrepiece of the modern Western intellectual tradition, and it and the naturalistic temperament work together in mutual support. The second part of the second case reflects somewhat back to both parts of the first. Scientific explanation and rationality are directed towards the creation of objective knowledge. However, this second broadly philosophical influence has a much wider range than that attributable to science only, particularly in 'subjective' and 'objective' accounts of experience and in how they relate to a real world known in conscious experience. Undoubtedly, contemporary issues surrounding objective knowledge flow out of developments following its seventeenth century philosophical treatment by Descartes and his contemporaries.

The science of man as contradiction

These two pairs of aspects of the mechanistic world view involve a contradiction in modern thought. On the one hand, we have the mechanism of the material. With the grand success of science, and the decline of religion in its wake, belief is strengthened in the truth of both its mechanistic and material premises. Of the dualism that is Descartes' legacy, science opts for the objective reality of matter in motion. With the increasing stature of the scientific enterprise so too increases the assent given to its basic world view: in principle, all things can be explained as movements of a material world which the intellect of man grasps through instrumental reason. The operation of natural laws (mechanical and material) suffice in principle to explain the knowable world, and all things can be explained in terms of physical causation. But with material explanation comes too the separation of the cause from any ends towards which the cause is directed. In other words, there is no goal, no purpose to the working of nature - of which man is a part. Matter and systems of matter are devoid of consciousness, of any directed action, and of human significance. Nature is amazingly complex in its movements, but it is merely matter in motion. The universe is neutral as regards human interests and man's role in creation. There is no place for intrinsic worth, no goals that claim any necessary consent. Bodies thus become mechanisms minus value, and there is no rational study (and no valid knowledge of the real) below the level of final mechanical workings[37].

On the other hand man is evidently a self-determining or self-interpreting creature. From the Cartesian view, even as matter exists for itself, so too does mind exist in its own realm of ideation. Each thinking being has an independent, substantial existence. Mind as separate from extension is the home of all values and the locus of consciousness, both of which the natural world is without[38]. Alternatively, in the world of individual persons man is an agent of his own powers of understanding and choice by which he decides how to act and live. Man's is a life of purpose - or at least purpose cannot be denied. The entirety of ordinary language and our conceptions of ourselves as we live and experience point to descriptions and explanations based on ends, goals, or purpose. The explanations and accounts of human behaviour based on ordinary language and

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man's self-understanding point to the realness of action through the unavoidable use of terms of aspiration, desire, or intent. It cannot be the case that, as would be so with mechanistic accounts of nature, talk of purpose and intent that constitute explanations of human action are illusory, false, or unreal. In denying such intentional accounts man cannot otherwise make sense of his own significance and his own self-understanding[39].

Ignoring the extremes, both of these positions find common consent in Western thought. The distinction is the engine for a vast debate. On the one side, the universe is an ordered neutral machine, the knowledge of which science has made possible. All phenomena, including man and society, can be explained in terms of causes material, mechanical, or dynamic, and scientific knowledge uniquely formulates these explanations[40]. Then there is the self-knowing mind or the self-interpreting person whereby actions proceed as to some final end or intent, and in which life has intrinsic worth. Both positions take effect in the institutions of Western society and its modes of thought (although there is a growing belief that the contradiction has outlived its historical time)[41].

One is tempted to discuss the influence of the mechanistic world view in terms of this contradiction. There are positions that arise from the belief in material, causal explanation, and these involve approaches to the study of man as a conscious agent. However, there are always long standing antecedents in the development of ideas, and latent positions come into prominence as thoughts change. If people actually think in terms of the two distinctions, then there may follow separate sets of influences. But on the whole the confluence of ideas in different currents of thought makes a complete distinction unworkable. A detailed tracing would show definite points of contact - although the basic contradiction would remain. Such a detailed tracing of ideas cannot be done here. In the sections that follow only overall tendencies in some currents of thought will be pointed out as they follow the lines of general influence mapped out above.

Context free thought

Descartes' project of radical doubt is well documented[42]. Part of its radical character is in the attempt to found knowledge on a basis free of the inheritance of past ideas. He divorced himself of his tradition to get at the truth about his mind-self and the world. Tradition has thus come to be seen as an obstacle to understanding. The way of valid knowledge is the way of an independent, context free search[43]. Through it can be had a clear presentation of ideas without the interference of personal fancy or idiosyncratic perspective. This includes the suspension of particular values. The best way then to study phenomena as they actually present themselves - to place the scientific observer in a position to view the universe as it is - requires a neutral science free of prejudgment. The neutral universe is to be approached on its own terms, and this mandates a context free search and a detached state of mind, if knowledge is to be had.

In the context of a context free search, knowledge claims thereby take on qualities of absolute statements or judgments about the world. The point is after all to attain to the truth. They do not admit of a world of personal values, taken as subjective and overtly relative and shifting. Hence,

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there is a conscious move away from anthropomorphic descriptions of the natural world[44]. While scientific statements are always provisional and self-correcting, they are relative only to the system in which claims of truth about phenomena are being made. The system itself is as it is and the point of the scientific enterprise is to give as full an account of the system as can be obtained. Even if knowledge is not forthcoming, future developments in instrumentation or ideas will lead to an fully detailed account.

The notion of context free search carries over to the belief in the inferiority of approaches either not based in some sense on empirical principles or exact data, or on those which attend to the realm of values, particularly religion. The relation between religion and science is typically portrayed as a battleground of conflicting world views[45]. In the historical debate, religion (specifically the Christian Church, its leaders, and their ideas about man and nature) has usually been judged the looser. In the face of an empirical approach to a study of the world, the knowledge claims of science, when opposed by one or another religious view, have proven to be the superior. This only emphasises the supposed weakness of any approach linked to a tradition of thought that is not based on the search for truth from within the scientific enterprise. In the case of religion, support is actually given to the view that the universe is a neutral machine since religious arguments based on teleological schema are at best merely false and at worst sheer superstition. Credence is thereby given to the belief that scientific knowledge is indeed valid knowledge and the best, if not only, means to truthful statements about the world. In other words, while statements of science are open to revision and hence constitute approximations to the truth, they are certainly the best approximations available (and certainly not false or relative thereby).

The notion of context free knowledge as scientific knowledge helps establish a belief in the scientific enterprise as being essentially independent of historical action. (This is a topic related to modes of scientific reasoning, and is taken up later in this chapter.) This is not to say that there is no history to science, nor to deny that its origins are decidedly European. Yet if it is the case that scientific knowledge provides statements of truth about the world as it is, then the historical age in which that knowledge was established cannot thereby change the truth value of that knowledge[46]. The scientific enterprise is partly occupied with correcting or modifying its own body of knowledge claims. However, this occurs from within the enterprise of science, based on the mechanistic view of the world, and through the work of the scientific community. Historical circumstances may speed up or slow down the process of discovery, but they do not thereby falsify scientific truths or render them dependent on nebulous extra-scientific beliefs outside the mechanistic viewpoint.

Language

This is not the place to discuss the theory of ideas. It requires an (infinitely?) extensive treatment within a more focussed framework. Yet surely the implications of the mechanical viewpoint find a direct trace to the theory of ideas. Some of these will be mentioned here, others, more directly related to objective knowledge, will be handled in a later section[47].

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Language is a central concern of the twentieth century Western intellectual tradition, but not all past currents of thought have awarded it its current preeminence. This is in part a result of the tendency in naturalistic thinking to work out what something is in terms of how we can know it. In our century language is integral to our conceptions of how we assemble ideas about the world, and therefore to conceptions of Western scientific knowledge.

Galileo or Newton had as their aim (at least in part) the intention to tell the truth about the natural world (although theirs was an age also interested in justifying science on the basis of practice - a position to be taken up again later when, during the industrial revolution, the success of scientific results re-focussed thinking onto the technological outcomes of the scientist's craft). It is an aspect of all great scientific thinking - of any strong intellect - to be the guardian of integrity[48]. Modern empirical thought is no different, and the general methods of empirical science are something of a guide to maintaining such an integrity of knowledge. Prior to the rise of the mechanical world view, the notion of forms or 'Logos' helped guide man's query into the world. The cosmos was a type of ordered symbolic expression. The things that surround men were the embodiments of the Ideas or of God, through which (or Whom) purpose is realised and meaning achieved.

Understanding thereby involved the attempt to grasp the significance of the purpose embodied in the world. Universal ideas were there to be known. In this scheme of thought human discourse must attempt to give an account of the ideas the world expresses, and language gives shape to such an account. Human intellect seeks to grasp the forms, or of the traces of God in the world, and language is a way of expressing what the soul can know. These or similar ideas went largely unchallenged until the later middle ages when scholastic thinking constructed an account of the universal much more conjoined to the actual use of language and the logic of abstractions than to a more direct apprehension of the Forms by the intellect of man.

The development of empirical science and the establishment of the mechanical world view worked to reject the notion that the world is a meaningful order expressive of some higher reality. Instead it is a material system, ordered as a machine, the reality of whose processes are explicit in principle and open to objective study and naming. In this process of study and naming mathematics plays a key function. As mentioned earlier, mathematics in the modern age and under the influence of the mechanistic world view is conceived as a system of deductive thought that sets down conditions of relations among abstract concepts having no reference to particular events. By abstracting certain aspects or properties of nature and setting down discrete concepts amenable to mathematical relations, empirical science finds a powerful tool for stipulating and formalising the particular relations of the dynamics of nature. However, without a powerful system of symbols mathematical ideas could never attain the precision of abstract analysis that is their fame.

Representation

At one level then we have mathematically precise concepts consciously held in thought (though certainly not expressive of a realm of ideal Forms). At another level we have their equally evident

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representation in a symbol system which is so rigorous in its formalism as to designate precisely the meaning of the corresponding concepts. This near perfect representation in mathematical symbols of the contents of conscious thought is one of the great creations of the human spirit. Adapted to the abstractions of natural science, mathematics has become one of the well-springs of scientific discovery and its string of remarkable successes - notably those of the twentieth century.

The notion of representation here comes to the fore, and with it the designation of meaning in science by the language of mathematics. In the neutral universe of the mechanistic world view, there are no form directed meanings and no extant universal realities open to the intellect of man. Matter exists in its particular extension with certain properties and forces acting to create a dynamic ordered system, but otherwise aimless. Furthermore, nothing in the world recurs in exactly the same way. If restricted solely to the perceptions of particular events as events, experience would be swamped by an unintelligible mass of individualities. (Of course, the point is perception cannot be so restricted if we grant conscious experience.) In the study of nature science resorts to abstractions that give rise to universals. These are not universals existing in reality as do ideal forms - they are universals created in the mind by reason, to be designated by language, but representing some ordered property of the phenomenal world.

In the context of seventeenth century thought out of which the mechanical world view arose, and which science in turn extended and advanced, when objects of sense experience are perceived, these objects are represented to the mind as images of the real world. Ideas then can be characterised as units of representation, or discrete mental images, of the thought content of experience. Consciousness in turn is the appearance of clear and precise ideas to the mind. If the ideas are present to the mind in clear and distinct apprehensions then they can be named. Through the process of naming a symbolic language (or syntax) is built up piece by piece through which can be stated in words the contents of experience (and through which thinking can be directed). A word designates or stands for a particular unit of representation of experience, and the meanings of words in language are the mental images those words designate. Conscious attention can then be directed to the named ideas. Abstraction is the process that occurs in individual minds whereby a characteristic among a set of mental images, representations, or names is recognised as similar across cases such that that similarity itself attains the status of an abstract idea - a clear and distinct mental image of that which is common within a range of experiences. From this there derives the notion of primary concepts - mental images whose names refer to actual experiences of the world, and secondary concepts - mental images attained through the process of abstraction whose names designate an object of experience in thought only and not a part of the real outer world[49].

Universals

Ideas are derived from perception and abstraction, and through the designative function of language there are built up constructs (conceptual models) about the world of experience, without which no connections among ideas could be conceived. Thinking is accomplished by assembling, arranging, or rearranging ideas through their units of language until piece by piece constructs are made. In the naturalistic stance the world is taken apart and recombined in the building of different

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theories or schema. To make sense of the world, the intellect must, after observation, disassemble it as it appears and rework it in terms of concepts wholly familiar to the mind. In such a process, symbolic logic and linguistic analysis - areas of intense interest in the twentieth century - help make muddled ideas clear and distinct. In the extreme, they render thinking a formalised and symbolic process, machine-like in its precision and definition, and a guarantor of certainty (within logical limits).

Universals then are not attained in direct experience, nor are they revelations of Forms or expressions of purpose in the real outer world. They are an effect or outgrowth of abstraction and language in the formation of classes and towards the creation of constructs or schemes of thought - first, out of similarities in objects of perception, and then out of similarities in objects of thought. A universal is a sufficiently wide class concept designated in language in a clear and distinct form (without which concepts would remain unclear and consciousness unformed) which in science is taken to be expressive of some clear analysis of ordered phenomena. Language therefore becomes crucial in any attempt to decipher experience. In the mechanistic world view the universal is removed from any reality in form or purpose, and placed in a mode of language and within a set of constructs that science uses to build abstract but precise statements of the behaviour of phenomena. Such precise formulations permit detailed predictions of particular events through the explanatory power of general natural laws[50].

Within the naturalistic stance distinctions tend to be made between the real outer world and the workings of inner thought. Analysis and study then focus on two aspects of existence: first, the nature of objective outer reality - the world machine as it is; and second, language and inner thought - a mechanism in its own right. Once the duality of existence is recognised and established as a factual state of affairs, the question becomes: How does the inner world of experience or consciousness gain access to the real outer world[51]?

Material consciousness:

The notion that the world is represented to consciousness suggests that, from the naturalistic stance, consciousness and that of which it is conscious are separate entities or events. It also suggests that consciousness monitors, keeps track, or evaluates various processes of thought[52]. This complicated subject is too involved to discuss here at length (it includes rationalist and empiricist epistemologies and the rise of modern psychology and phenomenology). However a further implication of the mechanistic world view can be highlighted. In the Cartesian separation, mind and its workings are independent of the world of extension. Particular experiences depend on perception and abstraction, but the mind as such and the way it works with these components concerns only the realm of thought. The mind exist as it exists (it is an existent entity as such), and its existence is the origin of man's intellectual being. In the middle ages, the notion of an end forming order intimate to the world acted to imbue individuals with intrinsic value in so far as they were part of the expression of that purpose. In the mechanistic world view, each individual has an independent mental existence from which or out of which the world is known and judged[53]. What constitutes that existence is thought as such, not the content of thinking nor any purpose to

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which consciousness might be directed. Consciousness is the basis of existence, not conscience, as it were. As such, and under the influence of the metaphor of the machine, the mind can be seen as a neutral thinking mechanism independent of that upon which it calculates.

In the first instance then, and granting a materialist perspective in the mechanistic world view, consciousness is no more than the complex workings of a sufficiently detailed mechanism. The entity of man is perhaps no more than matter in highly sophisticated motion. Brains are just a species of machine, and the computer becomes a metaphor for neural function. Intelligence then becomes conceivable in terms of computer-like operations. While computers are not conscious, none need discount the option that they could become so if a determinate level of sophistication is reached (consciousness is perhaps an emergent property of localised complexity in material systems)[54]. In such a mode of thinking, all explanation is conducted on the basis of material cause and mechanistic principles. Talk of purpose is avoided. Indeed, it is invalid, and the original contradiction between empirical knowledge and a life of human purpose is again highlighted[55].

Action

The notion of consciousness as resulting from a complex material process on the one hand and proceeding through forms of representation of perception and ideas to the mind on the other, has further implications in the notion of action[56]. As noted earlier, in a naturalistic stance consciousness exists independent of issues of worth or significance. The value things have and in terms of which actions are chosen come via the constructs built up out of the ideas of experience of the neutral universe, together with the process of abstraction and the building of theories within independent minds. Humans first exist as conscious beings, after which comes the choice to act with purpose. Ends are separate from conscious existence as such, and must be constructed.

The distinction between consciousness and that which it monitors, when conjoined with a notion of purpose, gives humans the power to plan actions as if an independent observer according to some prejudged outcome. Since the ends are chosen and means are various and neutral (nature is distinct from purpose), action proceeds out of some process of conscious planning. Possibilities are analysed so to be distinctly and clearly perceived, their risks and chances noted and mapped out. Standards of performance are set up so as to judge likely results of action in anticipation. Calculations are done in order to establish the best means at hand. Criteria are put forth to measure the degree of success. For this to be achieved, ideas must be clearly represented to consciousness, and a detached standpoint need be adopted as the best platform for making decisions. With detachment comes too the need for objective evaluation - part of which involves the need to be free of prior commitments to outcomes. Context is cut away so to get at the foundations of the matter, and the ends to be achieved are to be described in neutral, objective terms - hence, absolutely (not relative to particular points of view, but representative of things as they actually are)[57]. This approach is typical of many areas of thought and action. Growing out of the naturalistic stance, it has proven successful in dealing with the definition of problems, the judgment of means/ends connections, and calculating decisions for action. It is an approach of choice in analysing and moving under a wide range of undertakings within the Western tradition.

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The tradition gives central place to the belief in a self-defining subject. The neutral and mechanical universe is represented to each independent consciousness. The mind must find its own stance and construct its own ends since the world of nature is without intrinsic value. The ends so constructed require for their achievement that plans be construed and criteria of performance be set forth. The stance of the self-defining subject is the platform from which human strategies are formulated, the problems of societies are diagnosed and prescriptions made, and nature brought under human control and fabrication. Here, language is a tool for thought, thought a means for action, with all three broken into their constituent parts and then recombined to achieve a mastery of understanding of whatever problem is the focus of reason. It is characteristic of the mechanistic world view that instrumental, empirical reason proceeds through the analysis of the parts of phenomena, such that the mastery of the parts insures a mastery of the whole.

Patriarchal control

In all of this knowledge is used, and exalted, for its manipulative edge - the powers of control granted in a mechanistic mode of thought. Nature is neutral, and it is open to the productive ends of self-determining subjects. It acts both as that which must be dominated, and as the provisioner of means for that domination. The mediaeval belief in knowledge as the attempt to grasp a higher order expressed in nature is replaced in the stance of the machine by the belief that knowledge leads via analysis to prediction, explanation, and control of a value free world. 'Knowledge is power' is Francis Bacon's famed quote, and modern science has framed exquisitely the modes of thinking and the methods of investigation to make real Bacon's expression of hope[58].

Implicit in the drive for manipulative power and instrumental reason is a strongly patriarchal pledge to cultural or social control[59]. There is a demonstrable and potent connection between the enterprise of science, the values of patriarchal culture, the control of nature, and the domination of women. Nature and women both have been objects of control and manipulation - the marks of which are prevalent in the rise of modern science, industrial society, and technology. In the case of the domination of women, the consequences are so widespread as to be hidden from typical categories of thought, and this makes them particularly damaging and cruel[60].

The first part of this chapter has tried to highlight some of the main currents of the mechanistic world view - its historical beginnings, its main conceptual abstractions, the place of the material and the mechanical in the project of scientific thought. It has as well tried to suggest avenues of influence of the naturalistic stance within the more general intellectual culture of the West - the value placed on context free thought, the character of language, and the quality of action. The second part of this chapter will deal with the character of objective reason in so far as it constitutes scientific method. From this stance the search for truth about the world is the main goal of the scientific enterprise, such that if the search for truth is abandoned then so too must be science. Matters to be discussed include the validity of experimental design, the elimination of personal interpretation, the basing of results in public debate, and forms of reasoning that seek absolute claims through the uncovering of foundations. The chapter will close with brief remarks concerning the nature of the individual knowing mind in the context of scientific reason.

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Objective reason

Introduction

In one sense, much that has already been written here about the mechanistic world view speaks as well to the topic of objective reason. The consequences of the naturalistic stance and the drive for knowledge through objective modes of thought are much alike. Scientific content and methods of inquiry are scarcely separable - they constitute a common enterprise. Mechanism and the spirit of thought behind it encompass objectivity as well. In this sense then the issue of objective reason is implied by or comes out of the mechanistic world view. Such rationality is based in part on the existence in science of approaches to conceptual formation, measurement, and inference that lead to valid truths about the world. Other aspects of the issue deal with distinctions in philosophy sometimes termed 'internalist' and 'externalist' - positions about how human consciousness attains to knowledge in general, particularly given the categories of 'mind' and 'body'. Modern science and modern philosophy were established in the same age under common climates of thought, and often by the same individuals. The development of the mechanical viewpoint, the place of valid scientific methods, and issues in philosophy concerning how man attains to knowledge have a cooperative history. It is hard then to mention one without stating the other. The topic on all accounts is vast; it has been worked to subtle, complex extremes. As with the mechanistic view point, the issue of objective reason can only be briefly and partially surveyed.

The science of truthful knowledge

Scientific reason is typically held to act independently of a person's specific point of view, while the claims established by it are said to constitute truthful statements about the world. It is a work dedicated to finding the truth. Johan Mouton depicts the scientific enterprise as follows[61]:

> The search for truth is not just another option or a matter of choice. Scientists who are engaged in scientific research are bound, as it were, in a 'moral contract' to commit themselves to the search for truth. In fact, violation of this imperative implies total rejection or suspension of the notion of 'science'. This is another way of saying that the terms 'science' and 'truth' are intrinsically linked. We would argue that once we relinquish the ideal of truth, we no longer have the right to claim that we are involved in the game of 'science'.

Scientists are truth seekers, and science without truth cannot be science. According to Mouton the scientist's commitment to the truth is a moral-like imperative. According to him, it is a conviction without which scientific knowledge and the enterprise of science would loose their distinguishing character. If so, it undoubtedly stands as an equal with that other centre point to science - an instinctive faith in an empirical order to nature.

Truth and the search for it lead to two broad distinctions within science. On the one hand, there are the knowledge claims or statements in science that are true of the world (and if not true 'absolutely', then the best possible approximations to the way the world is - as valid as possible).

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On the other there are the experimental methods, community procedures, and criteria of rational argument within science which the researcher follows and by which such true or valid claims are established. This is the distinction between valid knowledge and objective methods (both of which constitute the main poles of scientific rationality). Truthful statements about the world is the end towards which the scientific enterprise is committed such that if truth is to be relinquished then so too must be science. (This need not imply that to relinquish science is to relinquish the truth, but it is often taken to be so and as such forms part of the modern naturalistic intellectual climate.) The means to achieve these truths come out of objective methods of inquiry into phenomena, and equally, the scientist's public and rational discussion within, and argumentative criterion for, the scientific enterprise.

However, objectivity is not only a matter of following processes that are known and trusted to give truthful results. It is as well a sort of stance or approach to the world from within which scientists can commit themselves to the 'epistemic imperative'. Much of this commitment involves a particular notion of rationality in terms of which the scientist is trained to think, and which largely characterises the way in which the whole enterprise of science is conducted - including methodological procedures and institutionalised norms. In one sense then objective knowledge is truthful knowledge about the world achieved by the methods of inquiry and the standards of rationality and inference to which the community of scientists adheres and which is characteristic of the scientific enterprise as a whole. To do science is also to act objectively, and not just with intent[62].

Experimentation

Experimentation on measurable aspects of phenomena forms part of scientific objectivity. It is a tradition with a long history. Galileo was among the first of the modern experiment-makers for whom the definite measurement of actual phenomena formed a basis for decoding what in fact is the case. Newton established the balance between experimental data and the processes of conceptualisation and reasoning about the data so that scientific laws might be formulated from a mass of observations[63]. For a time though men of science applied the notion not as a method of observation resulting in data about phenomena, but as a type of thought procedure so to demonstrate in reason what was already taken to be true. Robert Boyle was a key figure in setting down actual procedures (in chemistry) giving data that, through induction, might advance scientific knowledge. He wrote manuals of experimental design and reporting that helped set the enterprise of science on its journey of commitment to knowledge based in the observable facts of phenomena, and the workings of things "purely corporeal"[64].

Scientists obviously do not casually direct experiments towards this or that phenomena in the hopes of acting rationally so to find the truth. Although some scientific discoveries originate in the fortuitous event or the chance observation, the general methods of science - and there are a vast range of techniques and avenues available in the many different scientific disciplines - involve well conceived, carefully crafted approaches to specific phenomena about whose nature much must already be assumed and whose empirical study is intended to give results in anticipation.

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Powerful intellects are attracted to science both for its professional opportunities and because of the richness of ideas and refinement of approach that makes the scientific tradition such an eloquent expression of human thought. Equally powerful intellects have attempted to describe the details of the rational method by which scientists do science. Yet its complete description has proven elusive - the method cannot be formalised or confined to specifics[65]. In this sense science has been compared to a work of art. It involves an intimate linking of discursive reason with the creative, passionate act of human discovery so that descriptions of method are partial at best[66]. Yet there is certainly a broad set of approaches going under the name of science, seemingly determined by the epistemic imperative, that give it its distinct character. The demand for objective knowledge is one of the most important.

The ark of objectivity

In one sense science is designed to succeed. It assumes the world exists in a certain way, it constructs abstractions that select out specifically measurable characteristic of that world, and establishes impartial methods of study and rational criteria of evaluation whose practical function it is to tease out the demonstrable relations (in the data) that obtain in those abstractions and in the properties of that world. The surprising thing then about science is not that it succeeds, but that it is taken to succeed so completely. It is out of this success that the world view of science, its methods of experimental conception and design, and its standards of rationality have come to be adopted as the norm for a truth granting enterprise - perhaps the only such enterprise[67]. Scientists are the intellectual leaders of the twentieth century - to them falls the task of maintaining the integrity of knowledge - and this status comes out of a belief in the unequalled status of scientific method and the knowledge to which it attains[68].

The triumph of the scientific enterprise is born of a complex of techniques, approaches, beliefs, and human action[69]. However, the work itself floats on an ark of objectivity - at least as concerns its defining task of establishing the truth (or valid laws) about the properties of the world. One aspect of this ark is that the abstractions set out as the basis for inquiry into the world, and from which are designed the methods for observing phenomena (experienced in terms of that world), must be such as to give rise to experimental data upon the characteristics of which scientists can agree[70]. If none can be found to concur on what constitute the data of experiment, then nothing like objectivity can be predicated to science. In addition, if particular experiments fail to provide such agreement (or at least minimise disagreement), then the experiment (or experimenter) is to be judged faulty (or incompetent), but certainly not the phenomena of study (unless the wrong phenomena are being observed, which is a problem of theoretical conception or experimental design). Agreement is thus based on data derived from experiments which others can perform and out of which similar data can be obtained. Information must be public, repeatable, and publishable. Without this there is no reason to believe there is anything there to be seen. The results of an experimental inquiry must be such that scientists on the whole agree both on what they are and how they are obtained (otherwise, no results by definition will be forthcoming).

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Clearly, not any phenomena can be counted as a source of data for scientific inference[71]. This is in part a restriction on experimental methods, but also involves the matter of abstractions set out in the world view of science and around which its methods of inquiry are designed. For example, and for the sake of argument, there is no general agreement about what makes up a beautiful garden, nor might there be agreement that this particular garden is beautiful. Such judgments do not meet the requirements of scientific consensus as to acceptable data. There is something about the experience not open to the precision of measurement needed by science to form inferences about the world that underlie the data. Equally important, there is no agreement about what terms mean - precisely defined notions sufficient to agreement among scientists cannot here be found. The experience of beautiful gardens cannot then be the object of a scientific study nor become part of a scientific discipline - scientific truth cannot be had in this realm (unless experience is understood on the basis of abstractions that select out from the world of gardens some sort of measurable property worth studying). It is instead placed in the category of personal experience about which people may be able to converse and share, but within which no agreement about brute data and statements of fact are possible (and hence no scientific knowledge can be had).

In the mechanistic world view there are many such phenomena that do not meet the requirements of scientific data[72]. This world and those requirements demand of data an independence from the personal interpretation of the scientist, or of his or her ability to discern or intuit a 'something' there in the phenomena that is unique to a particular mental state. If such interpretations or intuitions are permitted as part of the methods of establishing data, or of the inferences about the underlying processes evidenced by the data, then there exists room for differences of scientific opinion about what the data in fact are or what are the unambiguous implications about underlying processes in the world. In such a situation scientists would be at a loss even to agree on experimental design. Scientists would thereby end up holding positions not open to rational arbitration. Once this is granted, then statements or laws about the world cannot be shown or established as true or valid, and the intrinsic connection between science and the truth is thereby abandoned. The integrity of scientific knowledge would be destroyed.

A similar style of argument holds in the need for agreement among scientists about unambiguous calculations with data[73]. If certain relations are seen in the data through operations performed on them, then there must not be any dispute about the meaning of the operations - what they are and how they were performed. If so the relations seen in the data and established by the operations cannot be shown to be true or false of the underlying processes in nature (from which the data are claimed to come and about which inferences about properties might be made). In the presence of ambiguity, there is no way to map the correlations between the data and explanatory inferences about the source of the data. This is one reason why science resorts to mathematical, or mathematical-like, resources for symbolisation and reasoning. The claim is that nowhere else can be found precise concepts that can be handled through a symbol system adequate to the logic of communal knowledge verification[74].

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The objective stance

Very generally, objectivity requires the elimination of any personal interpretations or judgments - particularly through the avoidance of bias and error. The objective stance is adopted in establishing experimental data, in calculations with the data, in reasoning about relations seen in the data, and in creating explanatory or predictive inferences about the nature of their source. It is for this reason that scientists take extreme care in the design, execution, and repetition of experiments of whatever type in whatever discipline, and submit their results about the relations seen in the data to rational debate within the scientific community. In this way can be made a scientific (not personal) interpretation of results. Objective knowledge then is not merely a matter of following experimental procedures, it is also an issue of attaining to intersubjective agreement at all levels in the chain of meaning and inference. Implied in this is a standing back from the realm of opinion, fancy, or hope to take an impersonal account of the nature of things according to the scientific search for truth - the commitment to the epistemic imperative[75]. Science posits an objectified world in abstractions, and scientists evaluate phenomena in that world from the impersonal stance of a distanced, methodical observer.

Science and context

An immediate implication of this is that scientifically objective knowledge (and reasoning) is context-free knowledge. While this is a topic already mentioned and which occupies much of the next chapter, some additional comment here is appropriate. Except for the tradition of the scientific search for truth, by which is embodied the epistemic imperative in the community of science, the claims of science need have no direct commitment to cultural or historical processes. The truths of science and the methods of reasoning by which they come to be established are believed to be largely free of context outside the scientific enterprise. Particular discoveries may be made at different times based on the happenstance of the day, but the discovery itself is not thereby void of its objective content - in either the methods of its verification or in the valid status of its claims that are repeatedly verified and refined. Conclusions must always be demonstrated through empirical and rational demands of the scientific enterprise - as they happen to be exercised at a particular time in the tradition of science. Results and methods can always be revisited and corrected in the light of new knowledge and technique. Even if the history of science might have been otherwise than it was - say Lamarkian genetics had captured the broader imagination of the scientific community - like the ether of space in the last century, or the notion of phlogiston in the attempt to make sense of heat transfer, scientific ideas that have no referent to properties in nature cannot be held indefinitely. The stubborn adherence to the concrete facts of experimental phenomena will ultimately show up faulty ideas and incomplete conceptions (which is one way of characterising the process of verification - the elimination of faulty ideas and theories)[76].

Such a schema of scientific knowledge and reason is particularly indebted to the naturalistic stance. The independent knowing mind - to which phenomena in the world are represented and by which action proceeds according to a well designed plan - consciously surveys a natural world free of necessary commitments or intrinsic value. The scientific mind must therefore take a neutral

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stance: the extended, common world - the object of study - exists only as it exists equally independently from the thinking mind. Experiences that are properly the province of the mind must not be ascribed to the world being studied. Hence, the seventeenth century contrast between primary qualities that properly exist in the world of extension, and secondary qualities which are products of the observing mind but not properly residing in the common world. Out then goes smell, taste, touch, and with them aesthetics and human expressions of emotion as experiences about which no objective stance can be attained and about which no valid statements of truth can be made independent of individual opinion[77]. With this goes as well the where-with-all to believe that rival moral stances or cultural differences can be argued in reason

Science and rationality

Another aspect to the ark of objectivity, besides methods that guide agreement about data and their meaning, is that science has created standards of reasoning in terms of which valid conclusions are to be established. These standards have become so widespread in the Western intellectual tradition that they are often seen as constituting rationality or rational discourse - that to reason means to reason as one might in science: instrumentally, empirically, from foundations, or on the basis of external criteria of judgment. Charles Taylor has used the term 'apodeictic reasoning', to refer to those arguments and modes of thought that arise out of the mechanistic world view and which have become widely regarded and adopted in the Western intellectual tradition as part of the meaning of rationality[78].

In such a stance, according to Taylor, there is a tendency to understand what something is by searching into how it is known. Reasoning proceeds by uncovering the basic principles upon which a truth claim rests, and arguing it out at the level of foundations. An argument is thereby won by establishing facts or ideas that must be accepted - all others being shown to be false. It is a type of elimination round in the ring of reason. By discarding all rivals, the one left standing must be the truth[79]. Reasoning thus works on the basis of external criteria for choice among different claims. In the absence of criteria no judgments can be made that eliminate possible rivals - unless it be by force of persuasion or authority. The ideas, data, or facts of the situation must be judged on the basis of clear criteria of inference and conclusion such that all can give assent once the correct argument is presented (or when the incorrect forms are uncovered). Standards of rationality within the naturalistic stance require then that claims of validity be absolute - there is no place for 'almost true' statements. (It is often put that scientific claims are at best only approximations to the actual state of affairs, but this is a different issue.) Among competing arguments only one can stand as true or valid, and the only way to determine this is to stand outside and work down to foundations and objective criteria. This mode of reasoning forms part of the bone and sinew of the body of scientific knowledge and argumentation. They have come to be seen largely as constitutive of the procedural meaning and function of rationality.

Objective procedures of argument therefore require a detached and non-emotional standpoint. Reason here has its best chance of finding the truth by not falling into error - a position similar to that for objective methods of experimentation. The right conclusion arrives when all possible

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errors of fact, of conception, and of reasoning have been painstakingly removed from the argument[80]. That which stands in the way of reaching conclusions in foundations is thereby irrational and must be avoided. Hence, in the naturalistic stance, arguments and their claims of knowledge must be broken into component parts, each judged as completely as possible, so that the principles of the argument can be clearly and distinctly understood. Without such clarity there is little hope of settling the truth or falsehood of the argument or position - errors will always creep in and foil reason. Reason therefore serves to dislodge people from what they already believe, or from their local prejudices about what they hope or fancy to be the truth - if such be merely a matter of personal opinion, emotion, or prior commitment. In other words, the procedure of reason must work a thinking being free of any context that makes for muddled thought or which introduces errors into judgment. The criterion for settling arguments - which is to be done at the level of basic positions - must thus be sought outside matters of the particular case and independent of those personalities and prejudices that might be involved in a dispute (or an 'interior independence' from within the thoughts of the same person - a sort of 'auto-objectivity' for dispassionate inquiry with the self). This is not to say that the matters of a case are unimportant. Background information is necessary, but the criteria of judgment operate more abstractly. Otherwise, there will be no agreement about what constitutes a valid argument, nor can there be conclusions that satisfy all in reason.

Such naturalistic procedures of argumentation work towards the uncovering of foundations, through a process of eliminating error and bias, making absolute claims between contending positions, and based on external criteria of judgment and inference sufficient to establish valid conclusions. This is part of the 'epistemic imperative' in science which has been imported generally into an intellectual tradition. Overall it is an attempt to ground knowledge in completed descriptions or explanations through breaking into parts the world and its methods of inquiry, and into component procedures the working of reason. Out of these methodological parts and rational components can thus be reassembled an objective and valid view of that world. Meanwhile, those aspects of experience failing to meet the demands of objective knowledge, and thus standing outside the completed descriptions of the naturalistic stance, tend to be dismissed as invalid - not having ground in objective truth[81].

Individuality of mind

The naturalistic temperament - the valid and superior claims of science established by objective and rational methods - can be traced in part to Cartesian claims about the nature of the world and of the human mind. As mentioned earlier, the tradition of the Middle Ages conceived the world as an ordered cosmos in which purpose is manifest in the nature of things. From such a stance man's individuality is valued for its being purposed within a meaningful world of worth and significance. Cartesian thinking however worked to reorder this scheme of belief. It placed man's individuality in the thinking mind whose substantial existence is independent of extension. The world is no longer the intimate trace of God's purpose (except to indicate the existence of a Craftsman), and man has no necessary connection to it. Value lies rather within the workings of the thinking mind as the locus of all judgment, for the extended world remains one only of motion but void of action.

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Action and the judgment of action both reside thereby in the mind. It is a world of control and responsibility wherein all is centred on the deliberations of the individual thinking subject - the locus of consciousness, the originator of end directed thought. On the other hand there is the external, objective, neutral world essentially alien to human designs, but having a palpable existence[82]. Science may be done in the mind of the scientist, but the world is represented to that mind in consciousness. Only by adopting an objective stance - free of secondary qualities, personal attitudes, error inducing inferences, or abstractions that have no referent in the common world - can authentic properties of that world be discerned[83]. The process of science is one of empirical and rational decisions that comprise the search for truth (Mouton describes the epistemic imperative as being partly realised through a process of rational decision making [84]). The scientific inquiry into nature involves uncovering properties of the common world through both a judgment of method and a justification of results. The ability of science to both explain and predict the phenomena it studies confirms the act of scientific consciousness as grounded in the real world about which it obtains factually correct statements[85].

In opposition to this way of thinking is the notion that experience of the world is a result of the act of perception itself, and is a matter dependent on an individual's act of conceptualisation. There is then no common world as such. Only common conceptual schemes are available that apply across communicable experiences of individuals, but the experience as such remain the domain of the thinking person[86]. In the end it is a person's act of cognition that grounds what is perceived. This 'internalist' perspective has a middle ground that admits of a common world shared by all and available in perception, but only as a shadowy portrayal or outline. The actual content of perception is not a part of that world, nor does it reveal an actually existing state of affairs. The act of recognition, as it were, always depends on the individual.

Countering this internalist position but avoiding too the application of reason to only the extended world is the idea that not only is there a separate common world but that the person experiencing it also forms part of that same world - together with his experiences and concepts. There are things and concepts that can be known as things and concepts. That which is experienced and the conceptions of experience together form part of a complex present - an accessible world able to be known as one moves about within it[87].

Such issues involve a vast discussion in philosophy about the nature of the relation between the phenomenal world and the realm of ideas. The theory was noted in earlier sections. The relation also shows itself in conceptions of truth - often called coherence and correspondence theories - and in the debate about subjective experience and objective discourse. It appears too in debates at the level of metaphysics, for once the Cartesian separation is adopted as factually present, thinking tends to fall into the dualism of extension and thought, or the 'monisms' of only extension or only thought. From such distinctions arise the mechanistic world view and an intellectual climate esteeming empirical objectivity and the identification of thought with discursive reason. The issue of objective knowledge thereby arises in philosophy alongside the adoption of the mechanical world view in science. Talk of mind and body, knowledge and opinion, fact and value, and particularly means and ends come out of the tradition in which both modern science and

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philosophy begin. It is a tradition that is now embedded in modes of thinking or habits of language making up the Western intellectual climate - a climate that in turn affects how science is conceived and treated as a part of society (and that society is made of constituent parts separately analysable). This is especially crucial for the way science is conceived to be a neutral or value free enterprise and which forms the basis for the next chapter.

Chapter review

This chapter has looked at the relation between the mechanistic world view and the rise of modern science. It has also tried to indicate some of the ways in which the rise of modern science coincides with the development of a naturalistic stance in general Western intellectual culture. Modern science has its first steps in Greek culture, and, as a reaction to habits of thought in the Middle Ages, adapted its concepts to an empirical study of the natural world. This was particularly indebted to the distinction in Cartesian philosophy between the categories of 'mind' and 'body', and to the rise of a rational method of investigation and analysis resulting in precise, lawful, explanatory and predictive schemes of scientific thought.

The view of the mechanical universe is the result of a series of abstractions set out by the project of physical science so to make predictive sense of the world of nature. In time this set of abstractions has been applied to a wide range of phenomena not originally part of the scientific scheme. The core idea behind the mechanistic world view is that nature is made up of parts that work together as does a machine, and that to understand nature the separate parts out of which it is composed can and must be separately studied, analysed by dissection, and recombined in some intelligible form that gives mathematically precise descriptions of the behaviour of observable phenomena on a global scale conceived as properties of an objective world. The laws thereby established locally are held to apply universally, since both space and time are the same everywhere. In this way the mechanistic view results in an attempt to understand the universe objectively, independent of time, from the outside, and in terms of absolute and completed descriptions of its properties and functions.

Conjoined with this view is the belief in the reality of matter in motion as solely constitutive of the realm of nature (or extension). As a result, the world view of the machine divorced purpose and action from the realm of nature proper. Nature is made up solely of matter in motion, of which man is a part, and the point of science is not to describe any purpose in nature, but only how it acts, for nature as such is without purpose. Purpose and action are instead to be found within the realm of the mind alone, the locus of individual consciousness, in which matters of action and right are constructed. Obviously then, the world of nature is void of such consciousness. In time these distinctions lead scientists to treat the universe as a self-consistent machine requiring only principles of matter and force to account for all that can be observed - including eventually human behaviour and the society of man.

Scientific modes of thought have a thorough-going influence on the West's intellectual tradition. The naturalistic stance is the commonplace of most schemes of rational study. The influence of the

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naturalistic stance can be characterised by four main themes: first, that scientific thought is universally valid, and that to reason means to reason as one does in science; second, that material and mechanical, causal explanations constitute the only intellectually acceptable and demonstrably rational account of phenomena; third, that bodies and minds exist as separate entities having no necessary reference to one another; and fourth, that of all kinds of knowledge, scientifically objective knowledge is to be most preferred.

These general influences can be seen in a variety of attitudes and positions within Western modes of thought and action. Such influences include the demand for context free thought, the use of language as an analytical tool for understanding, the notion that consciousness is comprised of acts of representation, that consciousness can as well be accounted for on the basis of material principles, and that action derives from the choice of ends, as separate from the means to achieve them, in accordance with some set of rational and objective criteria. These influences also involve the Western tradition in a contradiction of thought. On the one hand science adopts the mindless movement of the material in nature as the basis for all explanatory and predictive accounts of the universe and of the behaviour of man. On the other, the tradition holds that humans are self-determining, self-interpreting creatures within whom significance and agency are characteristic, and without which people cannot otherwise make sense of themselves

The mechanistic world view as well encompasses the notion of objective reason. For science to succeed it must act according to the principles of valid experimentation. However, such principles derive from the scientist's commitment to uncover the truth - to the epistemic imperative. Indeed, in the absence of this commitment there would be no science as we know it. Scientific reason proceeds along well designed and chosen paths of investigation based on a communally objective, empirical account of phenomena. Such an account relies on the common agreement among scientists of the character of scientific data and how they are obtained. If such agreement cannot be gained, then there will be no basis for a scientific study of phenomena, nor can there be any account of the properties of an observable world. A similar conclusion holds for the way scientists interpret the data they obtain. Only the minimum of ambiguity can be tolerated in the establishment of scientific laws, and this can only be achieved by general agreement among scientists within the bounds of method, prediction, and scientific rationality.

Objective procedures of scientific reason require a detached and non-emotional standpoint. Bias and error are to be avoided so as to gain the best avenue to the truths of nature and an understanding of man. Such procedures also mean that to achieve the required clarity of thought, reasoning must work down to the foundations of a position through breaking it into its component parts. By so doing can be found the explicitly correct claim between contending positions. Such a form of reasoning is an attempt to ground knowledge in completed descriptions and explanations (completed either in fact or in principle). Experiences that cannot be handled by this procedure for reasoning are held to be outside the realm of an objective account. They thereby tend to be dismissed as not arbitrable in reason.

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Summation

In general, the mechanistic world view and the commitment to objective reason provide the basis for a whole range of claims about science and the understanding of human nature - particularly in the debate about the makeup of the world and the human mind, and about what kind of knowledge is available to that mind. Talk of knowledge and opinion, fact and value, and notably means and ends comes out of a long intellectual tradition. The tradition is not entirely well. Those who espouse it have adopted a set of abstractions adept for one form of study, but have employed them in the study of a much more broad range of phenomena to which they need not (and do not necessarily) apply. The result is confusion about the range and proper application of scientific knowledge, and how it relates to other forms of knowing. This is particularly crucial in matters of values and the ends of action, since scientific knowledge is often assumed to be neutral or value free in its results and methods. Science is thought to provide the means to act with power through the application of a rational empirical method for discerning the truth about phenomena (often assumed to be the only such method). But the end or intent of action is often considered to be a different matter, occupying a much less rational (or even a non-rational) realm of values and prior commitments in which objective knowledge is believed to be slim and hard to come by. The mechanistic world view and the modes of reasoning adopted within a naturalistic stance tend to render such forms of understanding as somehow less than valid, or even invalid. Yet it is such a realm of values or commitments that in part constitute the sense of significance we have about ourselves as self-interpreting creatures, and of the social world in which we live.

Such issues have particular importance for the work of the next chapter, wherein will be discussed communal or institutional aspects to the scientific enterprise, and how they might relate to the issue of scientific knowledge and the working of society. In the second chapter the work attempted in the first will be extended through a presentation of contemporary scientific opinion on the extra-cultural character of modern science. It will then go on to treat what effect conceptions of scientific knowledge and reason have on the relation between science and society. It will also include a brief discussion of expert advice in public arenas. The third chapter will depart from tone of the two before, and, after summarising some of the main limits to the mechanistic world view and naturalistic stance, will attempt to highlight alternative constructs that might work to balance an over enthusiastic use of modern scientific abstractions.

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Chapter Two

Science and Social Integrity

Introduction

In the previous chapter much was said about the method of science and its modes of rationality as the centrepiece of what is considered to be an objective scientific enterprise. This chapter takes a further look at the results and methods of such a view of science - particularly the ethos of the scientific community and the normative institution of science - and how they relate to, or are involved with, the working of society. The first part of the chapter will begin with a survey of contemporary scientific opinion selected to highlight some of the 'traditional' institutional and communal conceptions of science. Such a survey will highlight in particular how the scientific project is sometimes conceived as an impersonal, autonomous, extra-cultural task independent of a realm of human values about which empirical reason, as derived from the mechanistic world view, has little to say. The second part of the chapter will then cover some of the ways science can be considered as an enterprise very much embedded in and indebted to society, and how science as an institution has changed to meet the changing relations in society - a change in part guided by the naturalistic stance forming its tradition.

More specifically, the first part of the chapter will focus on the belief that scientific knowledge is secure and reliable knowledge; that the project of science is a world wide institution whose results lay outside the sphere of personal interests or prior commitments. Using a selection of passages from contemporary sources, the chapter will build up an institutional view of science very much indebted to the naturalistic stance. From such a stance science can be viewed as an explicit system of laws, its rules communal and public. Explanation, prediction, and universal application constitute main communal characteristics of the scientific enterprise. In addition, science can provide for the continued progress of humankind by its search for explanatory knowledge that provides not only an account of man and his world, but the ability to control, manipulate, and fabricate it. On the whole, from within this stance science can be seen as impersonal and extra-cultural in its results and modes of reasoning. Science has found a way of investigating the world that provides valid claims to knowledge through the pursuit of a rational and empirical method.

The second part of the chapter will look at how the epistemic imperative and the goal of methodological purity can combine to build up an institutional view of science - how the norms and ethos of science are made legitimate in a scientific institution demanding the ready assent of the community of scientists and through which a general will is made evident. The chapter will then develop the notion of science as research specialisation, through which established knowledge is used to fabricate devices or processes. Such results can be considered as commodities that provide benefit to society and that can be traded through a system of social exchanges in return for the funding and resources that give specialists research teams the freedom to continue their work.

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The chapter will then make a brief study of the impact had by these various conceptions on the notion of scientific expertise and professional practice in the arena of public decision-making. A more traditional view of such expert advice will first be developed, particularly in how it relates to the rise of a professional researchers. Next will be developed the notion of expertise operating in a context where complex social issues may defy clear scientific analysis, and where techniques of analysis are held to rely more on pragmatic judgments than on what is taken to be the dubious availability of scientific fact or consensual knowledge which professions often claim to provide.

However, and closing out the chapter's argument, all of these approaches in one way or another, either explicitly or implicitly, continue to make a distinction between scientific knowledge as means only, while ends are in some sense outside the bounds of accepted rationality. In so doing they show their continued indebtedness to the mechanistic world view and the primacy of objective reason, particularly in continuing the contradiction in modern thought between the empirical objective truths of science and the attempts of man to understand himself - a contradiction apparently still played out in numerous conceptions of how science and society relate and, in how their distinguishing features are recognized.

Superior science

The folly of contradiction

As highlighted in chapter one, science is an undertaking that defies description in simple terms. It can be characterised as a place of rich and intricate acts of discovery - a project of establishing and verifying knowledge claims through a matrix of events involving concept creation, experimental observation, systematic evaluation and explanation, precise modelling, and accurate prediction. As already noted, attempts to detail its method - to give an account of exactly how science proceeds and in terms of which knowledge is thereby attained - have met with an incomplete and contentious portrayal. In spite of this many do accept that science does indeed well succeed in its epistemic imperative (if sometimes only because of a faith in the rightness of its method). Yet science in the hands of its practitioners, and when its method is examined as an object of study, turns out to be a subtle process whose features cohere so as to thwart a comprehensive description. Those who study such features do generally accept that there is such a thing as scientific method, but few completely agree on what the method is or on how it works[1].

While the method of science as an intricate process may defy precise or piece wise analysis, the knowledge to which it attains carries high credibility as a superior description and explanation of the world - particularly the physical world, and, presently to a slighter but still significant degree, the realm of human and social phenomena. The logic of scientific research, the care with which it is practised, the scrutiny of the scientific community towards any claims to knowledge, the fabrication of results derived from its theories, the autonomy credited to the institution of science, and the conviction of the community that adopts its rigours all contribute to the belief that its knowledge claims are actual and valid. While it is typically granted that scientific knowledge is approximate at best and open to revision, it is also commonly held that modern science gives

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positive knowledge of real phenomena in the factual world not dependent on (and when compared to) the whims of investigators or on any current play of beliefs, convictions, or values that periodically wash through societies and cultures over time[2]. The whole nexus of the institution of science is regarded by some, perhaps most, as being bound to the goals of universal, disinterested, impersonal knowledge. In addition, contemporary science is also taken to be constituted by specialised fields of refined and subtle research that tend to focus on the fabrication of phenomena fitting the needs of sophisticated industrial processes or technological innovation. Science then can be seen as not just an institution of discovery, but also one for providing the means to advance further the material well-being of a society. Its method and processes of thought, generated over three centuries of effort and analysis, are now well woven into conceptions of what Western society is, how it works, and the role of scientific knowledge within it. Indeed, the study of society, to the extent that, say, sociology or anthropology make claims to be part of the scientific enterprise, itself uses concepts indebted to the naturalistic stance and which thereby shape the very notions of how science and society might relate.

Thus, while there are many contending positions, Western intellectual culture in general adopts the rationality of science, its empirical stance, and its institutional forms as a superior approach for bringing cogent knowledge (and tools) out of enigmatic experience - an enigma at times claimed to be born partly of such human values and commitments as defy rational analysis, and which are often portrayed as a battle ground of unresolved and unresolvable differences[3]. From this point of view there can be little doubt of the West's reliance on the results of science and its methods of reasoning for the functioning of society and for making rational decisions. It is clearly one of the great 'forces' working within contemporary Western life. The following passage by Howard Kahane illustrates some of these general convictions about science:

> Although no information source is absolutely reliable and no theory exempt from at least a small measure of doubt, the most reliable and accurate information comes from the well established sciences of physics, chemistry, biology, and - to a lesser extent - from psychology, the social sciences, and the applied sciences such as engineering. The scientific enterprise is an organized, ongoing, worldwide activity that builds and corrects from generation to generation. The method of science is just the rigorous, systematic, dogged application of cogent inductive reasoning (mixed with all sorts of deductive - in particular mathematical - reasoning) from what has been observed over many centuries to theories about how the universe as a whole has and is likely to function. Theories falsified by experience are tossed out, no matter how comforting and no matter whose pet ideas happen to get stepped on. Absolutely no one, starting from scratch, could hope to obtain in one lifetime anything remotely resembling the sophisticated and accurate conclusions derived over time through any of the sciences, even if that person were a Galileo, Newton, and Einstein all rolled into one. *It is the height of folly to believe what is clearly contradicted by well-established scientific theory in the physical or biological sciences, and foolish to ignore what science has to say on any topic* {Kahane's italics}[4].

On this account the project of science is a worldwide institution through which results accumulate beyond the scrutiny of any one person, and which lay outside the realm of personal human interests or convictions. Sophisticated and accurate in its accounts about how the universe works, science inherits a long tradition of unquestionable integrity in reasoning, with its theories founded

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in experience, verified and self-corrected by the careful scrutiny of a continuous scientific community possessing a centuries long dedication to discovering and testing the truth. Scientific knowledge then is secure and reliable, or at least, of all possible sources of information, is the most secure and reliable that can be had. Any 'small measure of doubt' with which the scientific enterprise may be regarded is more than countered by the vastness of its institutional success. To ignore science, or to believe propositions contradictory to it, is therefore irrational.

Rational integrity

This account places the institutional aspects of science at the core of the enterprise. A contrasting but related position is useful at this point. Michael Polanyi approaches the project of science from a different stance in that he is at pains to move away from a too strict methodological or institutional conception of scientific validity to one accommodating the scientist's own act of conscience as central to the work of rational integrity. Yet he too adopts a view not unlike Kahane's idea of secure and reliable scientific knowledge:

> Now, it is true that there is a poetic truth expressed in primitive magical theory which is commonly found in our works of fiction. If a man in a novel is killed by accident, the event must have some human justification; the question of the Bridge of San Luis Rey can never be disregarded in a work of art. The naturalistic view of a man's death, say by rail accident, robs human fate of some of its proper meaning; tending to reduce it to 'a tale told by an idiot, signifying nothing'. But at the same time the naturalistic view opens such a noble vista of the natural order of things which are inaccessible to the magical view, and establishes so much more decent and responsible relationships between human beings, that we must not hesitate to accept it as the truer of the two[5].

Polanyi here makes quite clear one aspect of what he calls the 'naturalistic view', that it "robs" the life of man "of some of its proper meaning, tending to reduce it to 'a tale told by an idiot, signifying nothing'." On his account then, certain aspects of science - those born partly of its naturalistic stance - take from the meaning of human existence (and "poetic truths") some of that which properly belongs within it and in turn works to constrict (or reduce) them either into concepts that say nothing in particular about who man is, or which result in concepts that tend to portray human life as senseless or insignificant. If so the question must be asked why anyone would choose to take this step of reduction, even if only partial? Why adopt a system of thought that tends to circumscribe human meaning - 'fate'as Polanyi calls it - as something within an idiot's tale "signifying nothing"[6]?

Polanyi's answer appears two-fold: first, that science (or scientific rationality) shows to the human intellect a "noble vista of the natural order of things" that other stances cannot approach; and second, even though it be a collapsing of human meaning proper to an impersonal realm, through it can be established alternative human relations "so much more decent and responsible" when compared to the magical or poetic stance. For Polanyi then the scientific view of the world is clearly the truer alternative, demanding unhesitating acceptance. Of course his is not an isolated position, but one still commonly accepted in Western intellectual culture[7]. It is an outgrowth of that unreflected adoption of the naturalistic stance now part of an intellectual tradition. The stance

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points the way to a view of scientific knowledge as being above or outside the contentions believed to be inherent in other schemes of thought that either fail to possess a clear method, or which adopt as a starting point assumptions or convictions based in human cultural values or on contemporary societal opinion. When compared with these, science holds to ransom the means, and perhaps so too the ends, of knowledge. This is an issue which, in the sections that follow, will be raised in various contexts, and which bears directly on the question of meaning giving ideas and practice in the attempt to make holistic sense of scientific-social-technical domains.

Contemporary opinion

This next section will attempt to survey some contemporary scientific sentiments related to the views of Kahane or Polanyi, which make some claim about the universal, disinterested results of modern science, and which also see the institution of science as autonomous and extra-cultural. These sentiments can be found in a range of sources from a variety of contemporary authors. While there is an established trend in thinking about science that sees it as a socially embedded or determined institution, there remains a core belief, as illustrated by the two previous passages and based squarely on the naturalistic tradition, that regards science as an institution unlike any other, its method and knowledge claims superior to other schemes of thought. It is well worth looking at some of these opinions, for they highlight the belief that science is dependent neither on prior commitments nor on social construction for the validity of its knowledge claims or the adequateness of its method.

In general, the following passages are chosen in an attempt only to illustrate notions of scientific rationality, reliability, accuracy, and truth which indicate their author's acceptance of the status of contemporary empirical science as a descriptor of the world, generally superior to other schemes of thought not also based on its method of communal knowledge creation and institutional verification. They highlight equally well the belief that science conceived as rational method, as verified results, or as institutionalised ethic is substantially independent of any particular social condition[8]. I have chosen a somewhat broad range of quotations so as to emphasize the very decisive impact of the naturalistic stance on some contemporary thinking about science as a value free enterprise, and include interpretive comments and observations that connect and expand the theme. The intent here, however, is not to use the selections to demonstrate a consistent argument that scientific knowledge is the superior. The aim is only to illustrate the various ways in which such a position seems to be adopted and characterised in contemporary scientific culture.

While what follows is somewhat lengthy, such a survey of prevailing opinion will serve in good stead the theme of the second chapter by bringing forward the ideas of the first into an analysis of the social significance of science. It will as well help clarify discussions later on that look at the institutional norms of science and the view of research as specialist fabrication. It will also help to focus thought within the work of the third chapter wherein will be discussed the notion of modes of holistic knowledge. Besides this, the choice of selections is aimed to help address the question posed in this chapter's Introduction: Why adopt a system of thought which result in concepts that tend to portray man's existence as senseless, or his life as insignificant?

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In the first example, taken from a work of John Casti, science is portrayed as the better competitor in the game of generating reality:

> Prediction and explanation are the twin goals upon which the goals of the scientific enterprise rest. The whole point of science, along with religion, mysticism, and all of science's other competitors in the reality-generating game, is to make sense somehow of the worldly events we observe in the course of everyday life. Thus, the point of the practice of science as science is to offer convincing explanations for these events, as well as back up those explanations with accurate, reliable predictions about what next will be seen[9].

In the same passage the author goes on to state additional characteristics of scientific rationality that separate it thereby from other schemes of thought and belief:

> Basically, there are two properties tending to distinguish scientific rule based schemes for prediction and explanation from their many competitors. The first is that scientific schemes are explicit, i.e., the rules and the way they are to be applied are spelled out with sufficient clarity and in enough detail that they can be used by anyone ... The second distinguishing characteristic of scientific rules is that they are public. Unlike many religious and other belief systems, science has no private truths. The laws and theories of science are available to all interested parties ... While there is a certain degree of explicitness and public availability of the rules underlying many nonscientific belief systems, it's in science that these features are most clearly seen.

Although Casti characterises science as a reality generating game, there seems little doubt that, in so far as those involved in science are concerned, reality is there to be explained and predicted. Indeed, the working premise behind the whole of science is that the natural world is a real ordered world whose lawful behaviour can be found out in observation, conveyed in theory[10]. Science then does not so much generate reality as describe it, and the evidence (which to many indeed is most convincing) that what science achieves has a unique claim to truth is to be found in the actual success of its explanatory-predictive system of thought - that it can be used to fabricate phenomena according to human design and intent. Casti in turn states the twin properties that best serve this process: that it is an open system of rules which any willing person in principle is able to use, and that its rules are public, free of concealed avenues or covert practices[11]. It is important to note that both these distinguishing properties - that rules be explicit and public - are communal as well as institutional properties of the scientific enterprise. They can thus be seen as values to which must submit the whole social enterprise of science, that help direct its practice, and which create thereby a tradition over time that has come to preoccupy much of Western thought[12].

Simplicity of form

In Kahane's terms, "generation after generation" of scientists have studied phenomena in the realm of experience, made of them observations, built and corrected theories to explain what is observed, and made thereby models to describe the way of the world - in other words, "how the universe as a whole has and is likely to function". Certain confidence in the project of science, necessarily a communal and institutionalised effort, is thereby born of its repeated predictive success, in the clear rationality of its method, and in the ability it offers to make devices that work

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as the intellect desires[13]. The next passage, chosen from the popular text by Halliday and Resnick, and written to ground a next generation of scientists in the practice of their profession, illustrates some conditions of scientific certainty applicable to the current theme:

> The central problem of classical particle mechanics is this; (1) We are given a particle whose characteristics (mass, charge, magnetic dipole moment, etc.) we know. (2) We place this particle, with known initial velocity, in an environment of which we have a complete description. (3) Problem: what is the subsequent motion of the particle? ... The programme of mechanics cannot be tested piecemeal. We must view it as a unit and we shall judge it to be successful if we can say "yes" to these two questions. (1) Does the programme yield results that agree with experiment? (2) Are the force laws simple in form? It is the crowning glory of Newtonian mechanics that for a fantastic variety of phenomena we can indeed answer each of these questions in the affirmative. The exceptions can usually be handled using the two extensions of Newtonian mechanics, namely, quantum mechanics and Einstein's special theory of relativity[14].

The criterion of judgment specified by Halliday and Resnick deserves repeating. Results that agree with experiment plus simplicity in expression of laws form the basis of success in the project of mechanics. Both must apply to the whole of its system, and as a test of the programme they cannot be satisfied piecemeal. Of course, the authors do not intend mechanics only by stating that its programme be satisfied both in experiment and by laws simple to express. The whole enterprise of physical and life science adopts the same programme - as do much of the social and human fields of scientific study - and is one to which science as an institution is designed to satisfy.

The inclusion of simplicity of expression as part of the basis of success in the project of institutional science deserves further comment here, and will be used later in the chapter. The principle at first seems unrelated to the epistemic imperative - why should the search for truth be judged a success upon attaining to laws abstractly simple? Reasons for it come from at least two approaches.

In the first approach, some of the confidence that science inspires derives from the explanatory and predictive success it claims to achieve by expressing in relatively simple terms those component properties that make up complex systems (like particle mechanics). Were the laws or rules that science eventually establishes to be of the same general level of complexity as the systems they depict, then the advantage of scientific rationality for understanding an observed world would be lessened or lost; it would be on this account no better than some other speculative system grounded in human values. In the history of science, with its close reliance on mathematics for creative, intelligible expression and verifying calculation, any problem not approachable by the mathematics of the day was simply shelved as being beyond solution - given the resources then available to the community of scientists[15]. As mathematics, abstract physical concepts, and instrumentation developed in sophistication and power, so too, and vice versa, did grow the range of phenomena that the community of scientists could study and make sense of in some public, lawful expression, adequate theory, or descriptive model[16].

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The requirement that laws be simple then is in part the inheritance of the limited mathematical and experimental methods of solution employed by the community of scientists as they try to design, formulate, or communicate their experiments and concepts in precise form. This is part and parcel of how the society of scientists work. Theories are built up out of the available 'resources' of the day, resources created, reworked, and inherited in turn by each new generation of researchers - resources ranging from techniques of analysis, instrumentation, and existing data to fundamental concepts, models of explanation or interpretation, and institutional or social influences. Thus, a tradition of simplicity of form is established, and likewise a substantive belief in the essential simplicity of actual physical principles discovered by science. For if links among empirical data cannot be made manifest in explicit terms, if calculations do not support precise expectations, or if no relations can be abstracted from the data of observed phenomena, then nothing, as it were, is there to be seen - there is no patterned behaviour indicative of some ordered property that can be found out or controlled, be it phenomena in the realms of the natural, the human, or the social.

It is as well standard practice to study such realms as if they were composed of independent but interacting parts[17]. Within a single system there may be at work multiple forces, factors, or properties. Each of these is assumed to act independently of the others, but commonly within the system. In the case of particle mechanics, independently determined forces act on the same particle to generate a distinct motion. To make sense then of the behaviour of the particle, or whatever the object is that comprises the system, science need only make independent sense of the separable forces that act within the system, and then find a way to calculate or determine their mutual or combined effect on the behaviour of the components of the system. The assumption is that the independent forces can be described in simple terms, though it is not necessarily a simple task to actually figure out what they are. For the scientific community this is a strong assumption about scientific rationality, something more like an intuition about nature or society - that its parts must be simple and separable in principle though their interaction be phenomenally complex. Put in another way, were the properties of a system to be unresolvably complex the project of science could have never found the laws that describe the way the universe functions. But since science has discovered the laws, and the laws are simple, then part of the institutional, scientific ascent to knowledge is to search for simplicity of form that reveals real natural law existing outside the act of human conceptualisation[18].

The links then between scientific discovery and simpleness of governing laws are a long inheritance of the tradition of communal scientific rationality and its repeated success[19]. The tradition has embraced it not only as a guiding principle of research, but as an aesthetic value wherein the beauty or unity of nature are believed to be found. Some argue that a subtle scientific intuition and aesthetic plays a crucial part in a scientist's setting out on the path to discovery[20]. The method of science is at least partly thereby believed to be right and good, not because it produces results or allows the fabrication of materials or devices.

As for the second approach explaining why simplicity of laws is a sign of scientific truth, while Casti speaks of explanation and prediction as the mainspring of science, there is also a third aspect to the laws of science - that they be universal in application or scope[21]. Universality and

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generality are closely related. For a single law or set of laws to be applicable over a wide range of phenomena - or rather in reverse, for a large range of seemingly diverse phenomena to be explained under a single law or set of laws - then those laws must be simple in form if there be any hope they might accommodate all the possible conditions of application[22]. In a different sense, given that the universe is ordered, scientists will search for those basic or essential principles of operation or interaction that underlie the working of the world. These are often considered the deep discoveries of science. Such principles would apply throughout all phenomena - or at least over a vast range - and so the law or laws that express them need only encapsulate the basic principle, not its many manifestations in the observed world. In other words, the principles are abstracted out of their various disclosures, and the laws of science become the (mathematical) symbolisations of that abstraction. Of course, abstraction is also a process of finding that which is common among the many. If the 'many' involve a vast range of actually diverse instances, then only the simplest principle could apply to them all. Hence, if scientific laws have a universal relevance - if the principles they describe actually explain or account for a huge range of variable conditions - then they must be expressible in the simplest possible form. Otherwise, the more complex the form, the less likely it will be that multiple cases can be treated by the one law[23].

One last comment here is needed. Halliday and Resnick in the passage just quoted state an important proviso if the programme of particle mechanics is to work (and by extension to many other scientific schemes). It is their second condition for the problem of mechanics: "We place this particle ... in an environment of which we have a complete description". By complete description is meant in part that scientists can calculate precisely the net forces, effects, or conditions that obtain at any 'point' in the system (as its components change position in space, or as its constituents are transformed over time). It is not just any environment for which science has such knowledge. The condition of complete description is an arduous one, and few environments satisfy this without conscious (and exacting) design, manipulation, fabrication, or control on the part of the researcher. In simple systems such knowledge can be had. (In fact, simple systems may be defined as those about which such knowledge is available.) In the more complex case, scientists may adopt the 'in principle' condition or an 'only if' proviso. They assume the complex system is an extension of the laws that obtain in the simple case, or within local space, but which cannot be comfortably calculated (or which are practicably impossible to calculate)[24].

The point here is that while the laws of nature are said to be outward expressions representing deep principles of nature, they are discovered in artificial environments through measurements of highly abstracted entities[25]. Otherwise no discoveries could be made - the condition of complete description would fail to obtain. If a system - be it natural or fabricated - is opaque to observation or control, scientists either simplify it artificially so that it is no longer opaque, or adjust the abstractions they use so that it is amenable to measurement or to further experimental design. And when the community of scientific research succeeds in formulating some predictive or explanatory scheme (or when it manages to fabricate or synthesize some new material or process), faith in the validity of the scientific enterprise compels one to conceive of the scheme as a further description of the real world - in spite of the abstractions in which it is framed or the simplification that make possible its formulation. It is therefore these abstractions and simplification that overcome the

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enigma of the world when viewed, for instance, from Polanyi's 'magical theory' or 'poetic truth' as quoted earlier in this chapter, or as when approached from a view of meaning and significance rooted in a realm of human values and convictions about human significance. It is another hallmark of the precedence of the naturalistic stance that scientific abstractions and simplification that tend to make this reduction are not seen as limitations to rational study and the understanding of the human self and world, but as indicators of its resounding success and the depth of its impersonal, objective intuition about the world and humankind.

Universal science

Through the principle of universal prediction and explanation then can come the notion that the institutional project of science embodies a superior approach to understanding nature and society - that its success is real, its statements worthy of belief, its results independent of mere opinion. The following argument, written by the Nobel prize winner Stephen Weinberg, shows a belief in the universal application of natural physical law as framed by science to every aspect of life and humanity's intellectual heritage

> The experience of the last 150 years has shown that life is subject to the same laws of nature as is inanimate matter. Nor is there any evidence of a grand design in the origin or evolution of life ... In principle, no obstacle stands in the way of [the institution of science] explaining the *behavior* of other people in terms of neurology and physiology and, ultimately, in terms of physics and history. When we have succeeded in this endeavor, we should find that part of the explanation is a programme of neural activity that we will recognize as corresponding to consciousness[26].

Weinberg goes on to state:

> Isaac Newton's Principia could at first be understood only by a handful of Europeans. Then the news that we and our universe are governed by precise, knowable laws did eventually diffuse throughout the civilized world. The theory of evolution was strenuously opposed at first; now creationists are an increasingly isolated minority. Today's research at the boundaries of science explores environments of energy and time and distance far removed from those of everyday life and often can be described only in esoteric mathematical language. But in the long run, what we learn about why the world is the way it is will become part of everyone's intellectual heritage.

For Weinberg then, the laws of physics are 'news' like items for broadcast to a civilized world dedicated to learning about why the world is the way it is - first limited to a group of Europeans, but later made more global. (Indeed, is not perhaps the assumption being made here that the 'civilised world' is that into which has been diffused the conviction that 'we and our universe are governed by precise, knowable laws'?) And what is the why? Weinberg appears convinced that contemporary modern science has got hold of the laws and method by which sense can be made of both inanimate matter and life (organised inanimate matter) whether natural, fabricated, or synthesised; that the same physical laws of nature and history (by which is meant evolution) explain both in principle. Beyond this, though not accomplished in fact, there can be no doubt that an explanation of the behaviour of people in terms of the derivative studies of neurology and physiology, but finally through physics, is only a matter of time and effort for the edifice of science

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to achieve. Weinberg's stance comes solidly out of the mechanistic world view, and through it the path is believed open to a complete description of life in terms of matter and properties mechanical. Life viewed in this way is perhaps part of Polanyi's 'tale told by an idiot, signifying nothing'. If so, then meaning giving ideas (a part of consciousness) not amenable to explanatory accounts from within neurology or physiology (or physics and history) occupy a weak position as propositions about real world phenomena - or they occupy no position at all. The laws of nature known by science become both the objective determiners of the behaviour of man, society, and the universe, and the core of their rational explanatory accounts.

Revolutionary truth

If the knowledge generated and portrayed by the institution of science can satisfactorily explain both the world of matter and the realm of life (and man) by conflating them to operations within the one level through common natural causal laws, it is a short step to the premise that the project of science can successfully overturn and replace man's comforting, but false, conceptions of himself and his social world (a premise to which Weinberg alludes and which one may surmise makes up part of Polanyi's world of magic and poetic truth). One aspect of the scientific enterprise then is to continue the revolution to the end, and for truth's sake. This seems to be the gist of Stephen J. Gould's position, as presented in the quote below:

> Sigmund Freud once remarked that great revolutions in the history of science have but one common, and ironic feature: they knock human arrogance off one pedestal after another of our previous conviction about our own self importance. In Freu''s three examples, Copernicus moved our home from centre to periphery; Darwin then relegated us to "descent from an animal world"; and finally ... Freud himself discovered the unconscious and exploded the myth of a fully rational mind. In this wise and crucial sense, the Darwinian revolution remains woefully incomplete because, even though thinking humanity accepts the fact of evolution, most of us are still unwilling to abandon the comforting view that evolution means (or at least embodies a central principle of) progress defined to render the appearance of something like human consciousness either virtually inevitable or at least predictable[27].

To state the apparent in Gould's comments, part of the revolution that is the practice of institutional science and its heritage is that human existence (as a conscious organism or species) is neither predictable from the laws of science, nor a necessary eventuality of the workings of the universe. In Weinberg's terms, there is no "evidence of a grand design in the origin or evolution of life". Yet for Gould one aspect of scientific rationality is that it does reach down to the level of foundational views of reality, overturning those that are derivative or which are fictions of human culture or society. These certainly involve the 'pet theories' and 'previous convictions about ourselves' adopted in schemes of thought based less on an empirical stance and more on an assumption about human values and various interpretive schemes of thought. Such assumptions act as a starting point for passing added but not necessarily justified judgments about man, rather than adopting the avenue of science proper: to study nature and the world as it is and so let the phenomena speak for themselves[28].

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From this point of view theories of science may be seen as models of reality that provide the impersonal, universal, disinterested (hence trustworthy) stance by which human conceit concerning man and society may be dislodged and the truth be better seen - even if only in approximation or in principle. Science is positive knowledge, to the likes of which no other form of human understanding can quite compare. The beliefs about man and society that are untrue will eventually be shown by science to be fictions or conceits dependent on modes of thought or reflection wed to knowledge that is insecure or unreliable[29]. One reason why no clear knowledge can be had therein is that except for the methods of science all other schemes of thought fail to extricate themselves from the personal values and private views of their proponents. Belief in a premise by an assumption of its value or worth, but which cannot be demonstrated as objectively conclusive, cannot thereby provide any basis for the arbitration of differences in reason. Instead, it is the origin of inarguable disputes and the despair of knowledge[30]. Scientific method starts with what has been called 'stubborn and irreducible fact' and reasons them through to the most complete theory with the fewest complications that can describe what is seen (all others having extraneous assumptions or complicating premises)[31].

The religion of science

It would seem that some of the knowledge generated and portrayed by science is so successful in explanatory power, so profound in universal principle, and so revealing of human cultural conceit that it can only be seen as uniquely true and illuminating. The following two passages from the Nobel laureate biologist Jacques Monod and the well known zoologists Richard Dawkins suggest such a position:

> Chance alone is the source of every innovation, of all the biosphere. Pure chance, absolutely free but blind, at the root of the stupendous edifice of evolution: this concept of modern biology is no longer one among other possible or even conceivable hypothesis. It is today the sole conceivable hypothesis ... and nothing warrants the supposition (or the hope) that conceptions about this should, or ever could, be revised[32].

> This book is written in the conviction that our own existence once presented the greatest of all mysteries, but that it is a mystery no longer because it is solved ... I want to persuade the reader, not just that the Darwinian world-view happens to be true, but that it is the only known theory that could, in principle, solve the mystery of our existence[33].

The Darwinian world view is doubtless here taken as fact, for it possesses an unequalled explanatory power to unite the world of matter and its determinate laws with the realm of the living which, because of an unquestionable diversity, must contain much of the random or chance event[34]. Although it is adopted as truth by the scientific community and 'thinking humanity', the theory cannot predict any future natural evolutionary state. Of course, the reason is that if an event is random it cannot be anticipated in advance, but only explained after the fact. Yet Monod advances 'the stupendous edifice of evolution' as the sole conceivable hypothesis, one beyond revision. If so then presumably no observation can counter it. In Dawkins' terms, it is the one theory that can in principle solve the mystery of existence, and so none other need be considered.

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It would seem that in the view of these authors - and they espouse a main thread in scientific thought and Western intellectual culture - Polanyi's 'tale of an idiot, signifying nothing' is the only telling line[35]. The world of human action, both individual and social, must ultimately be founded on matter 'endlessly moving', made recognisable in scientific reason turned on its own source, confident in its institutionalised tradition, and assured of ultimate success[36]. From this view there would seem to be no other kind of knowledge worthy of the name.

Human progress

Not only can science provide basic answers to human existence by positing a world view that is true, scientific knowledge and the technology that changes it into "means of action" provide the superior approach to understanding, controlling, fabricating, and thereby changing the world. To this extent can science solve the problems that stand in the way of progress and the "improvement of man". The next passage from Jean-Marie Lehn is a contemporary statement of this theme:

> Science ... promises a more complete understanding of the universe; ever greater creative power of chemical sciences over the structure and transformation of the inanimate as well as the living world; an increasing ability to take control over disease, aging, and even over the evolution of the human species; a deeper penetration of the working of the brain, the nature of consciousness, and the origin of thought ... In a time when questions about the justification of continued scientific research are being asked, we must take a strong stand. Between continuing our investigations and stopping them, there is only one valid option: we must continue, because it is the fate of mankind to pursue the quest for knowledge, because it is the only way to solve problems that go unsolved, because we can not, we do not, have a right to close the road to the future[37].

It goes without saying that by 'quest for knowledge' Lehn is referring to empirical scientific knowledge, by which that 'road to the future' is planned and paved. As for 'solving problems that go unsolved', it is also worth noting that given the widespread adoption of the naturalistic stance and its corollary of objective knowledge, the very nature of problems are posed in scientific terms such that the only conceivable solutions (ones that institutions and decision-makers are willing to risk trying) are those provided by further scientific knowledge[38]. Here the place of technology and science as fabrication come to the fore within the provision of society, since the reality of the devices made possible by science, or the phenomena scientific research fabricates by design, is transferred to (and transformed into) a belief in science as the provider of a reliable and secure knowledge that opens the doors to the future.

The nebulous and changing cultures of man

The following, and final, selection (again from Stephen Weinberg) voices what seems to be a widespread idea about the enterprise of science - that not only is science impersonal (i.e. universal disinterested, and skeptical), but that although science must turn to society for the expensive tools it needs, its principles and laws are substantially independent of the society or historical times in which they are formulated (and hence free of that conflict of values which bound other modes of human thought founded upon or rooted within the nebulous and changing cultures of man):

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> All these problems can be solved [the degree to which the constants of nature must be fine tuned to make life possible] without supposing that life or consciousness plays any special role in the fundamental laws of nature or initial conditions ... Naturally, any living beings who evolve to the point where they can measure the constants of nature will always find that these constants have values that allow life to exist. The constants have other values in other parts of the universe, but there is no one there to measure them ... Still, this presumption would not indicate any special role for life in the fundamental laws ...[39]

And further, Weinberg adds:

> If the content of science is ultimately impersonal, its conduct is part of human culture, and not the least interesting part. Some philosophers and sociologists have gone so far as to claim that scientific principles are, in whole or in part, social constructions, like the rules of contract law or contract bridge. Most working scientists find this "social constructivist" point of view inconsistent with their own experience. Still, there is no doubt that the social context of science has become increasingly important to scientists, as we need to ask society to provide us with more and more expensive tools: accelerators, space vehicles, neutron sources, genome projects, and so on ... To earn society's support, we have to make true what we often claim: that today's basic scientific research is part of the culture of our times.

By holding science to be part of "the culture of our times", Weinberg clearly does not mean that the principles and laws of nature known to science are dependent on or derive from that culture-in-time. In other words, science is not part of a construction by society or the invention of culture such that its results are thereby determined, its processes accounted for on the basis of definite social forces or mechanisms. Instead, Weinberg holds science to be impersonal in its content (universal, disinterested, and skeptical) - at least from the testimony of working scientists - and thus free of cultural construction.

There are many variants to this theme, and it is hard to tell which position Weinberg adopts, but in a general form science is often considered to be detached from determinate social forces; its statements true of the universe as a whole (witness Monod and Dawkins as quoted earlier in this chapter). They are determined neither by a given form of a given society nor by the consciousness of particular intellects to be what they are or that they are. Furthermore, there is no special role for intelligent life, social or individual, in the way the universe works. Life is "subject to the same laws of nature as is inanimate matter" - laws the knowledge of which science provides, but which are independent of the whims or likes of individuals, free of the needs or requirements of society - though obviously reliant on the resources of a society and civilzation.

This is Weinberg's point. Science does need ever more expensive devices to study ever more exotic matter-energy relations (and, by extension, the fabrication of ever more exotic phenomena), and it is only from the broader wealth of society that such devices can be funded. To justify such support science - those involved in its practice - must argue that the impersonal content of science is a public good part of the heritage of an entire culture - part of the spirit of an age- and should therefore find support as part of maintaining or advancing that culture (and from which it benefits in turn). Part of his meaning here is that it is only partly true to view science as a practical activity whose results must be of some technical benefit if funding is to be granted. Science is part of 'high culture', worth funding for its own practice at the frontiers of knowledge, for showing to

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thinking humanity what the intellect of man can achieve. This carries the sense that although science is the heritage of culture, scientific results qua results claim detachment from that particular culture in which it historically develops, where the discoveries of science proceed from the work of the researcher(s) acting free of sociocultural conditions, save the practice of valid science[40].

In terms of this line of reasoning, and extending the idea somewhat, while science may be carried out in a particular human social-cultural context - one upon which it is *reliant* for support and which it in turn benefits and helps advance (where 'advance' may typically be conceived using terms rich in scientific value) - and while this is assumed to be done on a world-wide scale for all mankind, the actual content of science is not socially *determined* or constructed. The institution of science is an institution *in* society but its results are not thereby conditioned. Science is not *of* society. Results derive instead from an independent empirical method, guided by an epistemic imperative, embedded in a rigorous public logic, conducted by the judgments of researchers, and whose test is the test of nature itself. Scientific laws as such are not expressions of human hopes, dreams, or convictions but are descriptions of the observable world as it is. Although some researchers, teachers, engineers and the like may enter science out of the desire to improve the lot of humanity, and while what is discovered by science may be used to advance or fabricate a particular technological form of society (or to impede another?), science as such is not created out of social whim. Neither is science subservient to social values or other institutions *of* society - save those principles of rationality that embody the epistemic imperative and which, because of their demonstrable validity as explanatory and predictive descriptions of the world, have been adopted by thinking humanity as the best means to knowledge and informed choice. Science thereby provides as well means for making rational decisions within an ever more complex society.

In this stance, individuals and social institutions place value on the truths of science not because of prior commitments to certain ways of thought which have given rise to science, which are unreflectingly inherited by successive generations, and in terms of which its results, methods, and ethos can be explained and accounted for. Science is important because the human intellect has found a way of discovery not dependent on prior cultural commitments or the flux of social norms. It is a way that seeks always to work through objective impersonal terms outside this flux by working down to the basic conditions of discovery and argument. Its communal and universal method wrests from nature the laws that govern the behaviour of the universe and of man. Through an institutionalised, detached, and skeptical approach it expresses these laws in simple, empirical, and testable form available to all[41].

Scientific belief

The empirical scientific tradition - to question phenomena, and to let the answers speak for themselves - is a hallmark of Western intellectual culture starting in the middle ages, born out of the Renaissance, continued through the Romantic reaction, and given fuller expression in an Industrial Revolution with which the world is still involved[42]. Given its widespread use, its undeniable success in prediction and fabrication, and its deep integration into the West's tradition

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of rational inquiry, it is not surprising then that something like Howard Kahane's view is commonly adopted and to which the previous quotes give assent - that belief in propositions contradictory to science "is the height of folly", and that he is a fool who ignores the knowledge (and method) science provides. If it is true that in large part scientific rationality has become what is meant by rationality, then the conclusion makes complete sense: to contradict science is irrational, to ignore it unwise. Of course, this need not discount other schemes of thought being rightly regarded as rational, but if so then part of their rationality must be that they do not counter the laws of science nor discount the methods by which those laws are attained[43].

However, it is not unusual to find a somewhat stronger statement of the principle of scientific rationality, as some of the previous quotes bear witness - though it does not necessarily follow from the method of science as such[44]. It amounts to something like faith in the scientific project to which those intimate to the naturalistic stance may well adopt without hesitation. Namely, that the naturalistic view takes precedence over rival systems of thought, and is certainly superior to any unsystematic thought. The same belief is expressed in the notion that there is no objective knowledge that is not scientific knowledge. Science is, as the argument goes, a unique institution of empirical knowledge, and, at least in the production, fabrication, or verification of results, is free of unwarranted assumptions involving the play of human values and the effects of social construction that render other modes of thought inferior or non-viable. Simply, nothing else works as well as does the communal method of institutionalised science.

In summary, this section has attempted to highlight some aspects of an established professional scientific opinion that point to a belief that science provides secure and reliable knowledge superior in many ways to other forms of thought. Science is taken to be impersonal and universal in its content, disinterested and communally objective in its method, and substantially extra-cultural in its institutional form. The selected passages through which this scientific opinion were illustrated are part of a mainstream in scientific thinking. Their author's positions highlight part of a contemporary adoption of the naturalistic stance, and the general notion that the ontology of science carries sufficient weight to discount many everyday understandings of human significance and meaning. They as well mark an overall adoption of naturalistic modes of reasoning as representative of reasoning in general, and hence characteristic of rationality as such. In the following sections of the chapter these beliefs will be extended by taking a look at some of the more strictly social or institutional conditions often taken as constituting the work of science in (or of) society.

The society of science

Introduction

There is no doubt that the scientific project is a communal and institutional enterprise. The passages just quoted speak in one way or another about scientific method as involving a public verification of results, that scientific knowledge is beyond private discovery or individual

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ownership, that it is invested in institutional research, and that the heritage of science involves all of humankind. These passages each advance the case that science is partly communal in a way that cannot be avoided. However, the precise character and extent of communal science remains very much open to debate. The second part of this chapter will deal with some additional ways of regarding communal science. The first involves a further development (following on the previous section) of the notion of value free experimentation, and the place of scientific abstraction and simplification, as supporting the view that science is free of extraneous values save those of rational enquiry enjoined by the epistemic imperative. The second will look more closely at the position that science is a socially connected or determined enterprise. Here the initial topic of study will look at the ethos and institutional norms out of which or from which science may be viewed as social practice. This will include a review of the canon of methodological purity and the goal of the epistemic imperative, but with respect to what effects they have on the norms of the institution of science and its relation to other social institutions. This will be followed by a look at a view of contemporary science as belonging to specialist research within a managed institutional context. The results of research are here considered as commodities for trade in a social exchange requiring a balance between social benefit and research support.

Experimentation and the value of method

When viewed from within the naturalistic stance, a scientist's first commitment is surely to the method of his or her craft - a method that drives an entire intellectual approach, which has long influenced Western conceptions about knowledge and rationality, and equally the nature of the natural world, of man, and society. All of the earlier selected passages support directly or indirectly (as does much of the work of the first chapter) the view that the laws and principles of modern science derive from an established process of discovery, carried forward through the unique tradition of science, and embodied in rules, norms, guidelines, and procedures that scientists have built up, internalised, and institutionalised over long years of arduous search and research - all directed by the goal of a self-correcting epistemic imperative[45]. The result is believed to be a vast communal institution committed on its own terms to knowledge creation, certification, revision, and fabrication that shapes and directs much of modern industrial society, its technological forms, and its intellectual culture.

On this account the prior illustrations about science (that it is independent of construction by society or culture, free of unwarranted values, and universal in form) can apply equally well to its method. Experimentation is essentially distinct from the flux of opinion and values that weaken other schemes of thought. (Namely, those without a clear and distinct procedure of discovery, and particularly when a process of verification is faulty or absent. Religion might be a typical example.) From this point of view, the single-minded commitment by the community of scientists to an institutionalised tradition of methodological thought and practice is the core heritage of science - and this includes the techniques of generating and certifying experimental outcomes. The results of science are thought to be valid and factual in large part because they derive from a method held in the highest confidence. Its general procedures are now institutionalised norms, while the practices of individual scientific judgments towards empirical fact, in light of the epistemic imperative,

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ensure the integrity of reason within the scientific community. While the context of method is in the research labs, the universities, the foundations - the changing places, circumstances, and personalities wherein and whereby science is done - method as impersonal research is the consistent inheritance of an institutionalised scientific tradition involving the rational study of the empirically observable world - material, social, and psychological[46].

Research design

As emphasised earlier, in the naturalistic stance the practice of science can be seen not first as a function of social behaviour, but as originating in the discovery by the intellect of man of a way of observing and portraying the natural world not dependent on personal human conceptions or prior commitments. An important clue to this is found in research logic and design, which is intended essentially to reduce to the least possible level all bias or error in concept and experiment so as to attain the maximum possible validity in results - be they models, theories, or different levels of hypotheses[47].

It is useful here to return to the logic of scientific abstraction and simplicity discussed earlier in the chapter, since upon this can be extended an argument for the autonomous and impersonal character of institutional research. Science comprises a matrix of methodological features, and the theories it confirms can and do involve complicated models - even though they are built up from piece-wise analysis and the integration of simpler component principles. Yet, as noted before, none of these are more complicated than the phenomenal world that is the object of study. If they were, then the theories would be as enigmatic as that which they attempt to describe. Yet it is this enigma that science aims to unravel, and it does so by cutting away what is unwieldy, unyielding, or obscure. In this way does scientific thought tend to reformulate a concrete, 'palpably present', lived world in terms of well formed abstractions amenable to scientific logic and experimental design. In other words, seen through the abstractions of science, the realm of events and experience by which nature is encountered, or human significance is known and appreciated, is approached as a world of phenomena and observation, measurable and analysable in terms of those abstractions. Were it not for the abstractions that simplify and make measurement possible, little scientific sense could be made of the observable world. The imperative of science would thereby fail to obtain[48].

Experiments are designed around scientific abstractions. They proceed by isolating some measurable property of the natural, human, or social world from 'outside' influences such that the property at the focus of study might be separately observed, measured, and analysed as part of some known or knowable system. Empirical study cannot get hold of many variables at once, or of many phenomena, since the connections between them may thwart the logic that teases out of phenomena certain identifiable correlations in the properties being studied. Experiments are designed to measure piece by piece, in an artificial setting (whether actually constructed, or created in thought, or developed on computers), where an attempt is made to observe the behaviour under scrutiny in isolation from other influences that would otherwise interfere and distort. Bias and error, which frustrate the epistemic imperative, are thereby partly removed when

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the experiment is sufficiently controlled and isolated from a larger environment or other systems containing events, interactions, or influences that muddle the phenomena the experiment is designed to explore and from which certain results may be anticipated[49]. A main part of research then is to design experiments conceived within some theoretical scheme, constructed so as to reduce to their minimum any bias and error, thereby achieving maximum validity of results.

This purposeful removal of bias and error in experiment has a corollary in the claim that scientific results, which ultimately derive from experimental research, are also free of an analogous bias and error which would otherwise render them unwarranted, untrustworthy, and untrue - the source of conceit and a false consciousness (or simply bad science)[50]. When experimental bias and error has been systematically and doggedly removed, when the simplified system that forms the basis of a controlled study is shown to apply to a broader range of cases, and when the study is logically related in a consistent way with existing confirmed science, then scientific judgments are held to be disinterested, based on the facts of the case, and open to further scrutiny by the scientific community (as has already been mentioned in chapter one). Acceptance of the truth of the results of a study (or the validity of a theory or model that is being developed, verified, or extended) comes out of first, the care with which valid research is done, and second, the extent to which it can be integrated with what is already certified or adopted by the institution of science[51].

From this point of view, there is no doubt that the processes of research, verification, and the effort of scientific interpretation involves a whole community of work built up over time, as well as the communication and scrutiny of results in open debate. Indeed, knowledge is communally judged, for otherwise it could not be objective. But, as seen from within the naturalistic stance, this communal nature of the scientific enterprise is believed to have developed out of the necessities of the epistemic imperative and the growing body of scientific knowledge about which none can legitimately dispute[52]. From this stance, the results of science do not derive from prior norms or mores adopted confusedly, from social constraints imposed out of the authority of other institutions, or from the play of personal values and opinions of the scientists involved. The enterprise of science survives and thrives by a commitment to 'methodological purity'. There is an internal logic to the work of science. It dictates the process of discovery and the way science as an institution can develop. While research mistakes can happen, and scientists can pursue a line of study based on inadequate concepts or an erroneous theory, in time the empirical test of science serves to clarify and correct. All is based on the first principle of scientific rationality: to ask questions of nature and let the answers speak for themselves[53]. Indeed, far from being dependent on social constraints or extra-scientific norms, the secure and reliable results of science can serve as sure footing from which those norms and constraints can themselves be studied[54].

Social perspectives

It is ironic then that with the growth of sociology and the sciences of man - born as they are from the scientific world view and a dedication to the same epistemic imperative as moves the physical sciences - the enterprise of science as a social institution should come under scrutiny as but one among many instances of social phenomena. Looked at from this perspective, there are

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constraints on science that are decidedly social, where its method and results make sense from a broader context. This is not to say that science is socially determined, although some do conclude this, but it does admit views different from those suggested in the former argument and which form an alternative or extended sense of the relation between science and society[55].

This next section then looks at two further perspectives concerning the social conditions of the practice of science. It is a field generally far too large for as work such as this. Thus, only specific comments and observations will be made, and these are largely indebted to works by Robert Merton and Michael Gibbons[56]. The scientific enterprise has been preoccupied with the notion of the epistemic imperative and methodological purity. They often come to characterize the norms of science as an institution and its relation to society. The first perspective will therefore look at some of the ways institutionalised norms coming out of scientific method have influenced the way science is seen to relate to other social institutions. The second will move into a contemporary social scene where science can be viewed as a commodity-producing enterprise, dominated by competing professional specialisations within large scale institutionalized systems of research.

Norms and methodological purity

In this first perspective, here particularly indebted to the works of Robert Merton, science can be thought of as a body of completed results constituting secure and reliable knowledge, as well as a method for establishing and extending valid knowledge claims based on empirical evidence. Both of these involve canons or tenets that direct and govern the communal work within which the integrity of those results and the validity of those methods are first secured, and then collected, reliably practised, and transmitted. Science is also made up of associate practitioners, and so it can as well be viewed as a combination of motives of individual scientists that involve the norms and ethos of the institution of science, together with the social effects of that institution and its functioning and outcomes both on the institution itself, and on the individuals that comprise it.

The norms of the institution of science - that it be universal, communal, disinterested, and skeptical - which as well constitute the values of the community of scientists, are expressions of the goal of methodological purity: that in science the core of all work is a valid empirical method for study and research. However, this practiced goal itself comes out of the scientist's commitment to the epistemic imperative which not only commands the conscience of individual researchers, but of all the community of science and its corporate forms. In brief, out of the epistemic imperative comes the technical and normative practice of methodological purity, while from methodological purity derives the canons of the institution of science through which is made legitimate, autonomous, and valid the work of the community of scientists. This complex of institutional goals and norms can affect profoundly the conception of how science relates to society. Some of these aspects the following account will attempt to survey.

Modern science in its history and tradition has long dealt with utility in one way or another. Francis Bacon in his defence of the new and untried method referred to the power of man over nature[57]. Galileo would produce his results in part for the benefit of the Venician merchant

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Fathers and the advance of Venician trade[58]. Scientific knowledge would wait for the industrial revolution to be applied in systematic ways to specific problems of production - a main source of contemporary arguments for the support of science. Generally, scientists began the defence and justification of their labours by an appeal to other goods, and, in the early days of scientific method, the central appeal was to the glory of God and the command of nature[59].

As the project of science grew and broadened via the continued success of its predictive and explanatory portrayal of nature, science and its method began to be valued also as a body of work and a way of understanding that could stand on its own accounts[60]. In time it came to be valued and prized for what it was as science - as a new way of treating the world and of man's understanding of himself and his powers. The laws of God that had controlled the destinies of humankind, and to which scientists like Descartes and Newton did commend and appeal, turned, through the gradual ascent of modern science, into the laws of the natural universe that the human intellect could sound out through the practice of theory based empirical method. Science thereby became a core part of Western intellectual culture and society such that the transmission of that culture required in part the continuation of the tradition of that science.

Throughout the whole tradition of scientific work the method of empirical research and interpretation has been a centrepiece of the enterprise and a core of its communal and institutional life. Yet if science can be justified from the knowledge it itself establishes, then its rational method of discovery and explanation must be valued in an equal sense - not because it is productive of results (which it is and continues to be), but because, as integral to science, it too is a good in itself. Yet, as presented in the prior argument, a central tenet of rational method is that if the work of science be valid, then it must not be dependent on the personal motives of the individual or of any group (which is not the same as claiming that individuals or groups do not influence science). Neither can it be dependent any private avenues of discovery requiring a unique state of mind or thought, and certainly not on the play of a scientist's (or any one else's) own values or personal opinions. The rationality of science requires that individual scholars subscribe to the norms and practice of research as built up over generations of effort and from which comes the validity of scientific knowledge. In this way all results can be certified, corrected, or extended by and in a community of scientists who sit in final judgment. From this stance science can begin to see itself, as it were, as an autonomous and self validating enterprise which, while existing *in* society, is not *of* society - if this means adopting extra-scientific norms and practices in the pursuit of the secure knowledge science is committed and designed to achieve[61]. The community of science works by methodological canons, however implicit or explicit they might be, that are believed to ensure the continued pursuit of knowledge, and it is the pursuit of valid knowledge that separates it from other institutions *of* society.

According to Merton, such canons serve a two-fold purpose. On the one hand they are technical requirements for experimental design and procedure. On the other they are moral prescriptions for the integrity of knowledge that create largely standardized convictions or values that come to characterise or comprise the attitude of the scientific community. Their adoption, and likely acceptance, by individuals forms a main entry point into scientific scholarship[62]. From this point

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of view, the canons of method (taken as both technical and normative prescriptions) are transmitted from generation to generation of scientists through training or apprenticeship, and are reinforced by sanctions meted out to those who might ignore them whilst making some public claim to knowledge. They come then to be shared by all within the scientific community as core values and matters of conscience, giving to science a belief in its unique position and status as an institution dedicated to finding demonstrable, rational, empirical truths about man and nature.

In Merton's terms, the ethos of science - those values and norms held to be binding on a practitioner of science, and in terms of which he or she may be called a scientist - are made legitimate and transmissible over time and across generations through the institution of science wherein they appear as norms and procedures that guide and direct the enterprise as a whole. By investing the institution of science (and its particular forms) with the maintenance of technical procedures and normative values, there is gained thereby a commitment to a general will and an abstract control over the practice of the profession[63]. Thus, the institutional structure of science, in but not of society, is based on the canons of methodological purity adopted not primarily because they are productive of results, but mainly because they form the core of science as an enterprise that has come to be valued as a good in itself. The institutional goals of science are thus an extension of its epistemic imperative. Meanwhile, the norms of that institution - norms that inform a relatively stable (though in no wise static) tradition, and which make possible an inheritable body of results and procedures - come out of the canons of methodological purity[64]. In other words, out of the goals of science and the canons of method come institutional imperatives - that science be universal, communal, disinterested and skeptical - and these in turn help secure and make reliable those goals and that method[65].

Based on this argument, once the epistemic imperative finds expression in institutional norms, and once these norms become both part of a general will of the scientific community and of the scientific conscience of the individual, then two characteristics can move to centre stage in the enterprise of science: the results of science are impersonal, and its practice is autonomous. The first is an expression of the idea that scientific propositions are not dependent on individuals or groups for their truth content - not on their beliefs, nor on their values, and neither on an individual's personal interpretation. Scientific knowledge is communally defined and accepted, based on the methods and procedures laid down for the validation and extension of empirical propositions and predictive, explanatory theories. The second rejects any extra-scientific or other-institutional control over the project of science - over its definition of valid research, its communal interpretation of results, the norms by which it is guided, or the decentralised authority of its institution invested in a community of coequals dedicated to the epistemic imperative[66]. In part, these two characteristics may be held to provide for what is taken to be the integrity of scientific knowledge and the moral stature which science is believed to possess.

If so, and extending Merton's argument, science as an institution will likely resist any redefinition of its social structure that might serve to threaten the integrity of its knowledge, to weaken its dedication to the epistemic imperative, or to call into question the stability of the empirical tradition out of which it comes. Methodological purity, based in impersonal, autonomous,

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value-free research, adopts both the defence against extra-scientific control and the argument for the continued practice of science as, and in, the pursuit of knowledge for knowledge's sake (but with distinct practical benefits). A typical position (as illustrated by the quotations cited in the first half of this chapter) is that science must not become the handmaiden of the state, the economy, or the institutions of religion, for these embody values partly or largely anathema to the canons of scientific method and its pursuit of positive knowledge. Thus, the norms of political, economic, or religious institutions cannot be exported into science except at the threat of abandoning secure and reliable knowledge. Meanwhile, science surely has no need to import them into its own practice. The work of science is the advancement of knowledge. To do this it must follow the methodological ethos to the exclusion of all else, lest it risk becoming something other than science. Its core remains impersonal autonomy and universal disinterestedness, and this it must not compromise.

From this argument then, the attitude can develop in the scientific community that to maintain the purity of its methods and the validity of its results, research must focus only on problems having scientific significance, not on question of use or the social repercussions of the knowledge it certifies. These are important matters, but if science is to continue producing knowledge then they must remain outside the concerns of science proper[67]. Merton argues that this has become a main operating tenet of modern science. It has a corollary in the position that even as science cannot legitimately decide what to do outside the proper sphere of its own empirical competence, then other institutions in (and very likely *of*) society must not encroach on the proper functioning of science[68].

This belief gains support in Western intellectual culture out of the continued strength of the naturalistic stance, derived in part from seventeenth century Cartesian conceptions of extension in the observable universe of inert matter, and of thought in the arena of the perceiving mind (as dealt with in the first chapter). Here, nature is the province of the machine and of matter endlessly moving, absent of value and significance save only that of material motion. Sentient mind is the locus of consciousness, the subject of experience, and the maker or holder of value and purpose not present in the observable and mechanical universe which science seeks to study (and which has been extended over time to the sciences of man). Scientific reason then obtains knowledge of the common observable world, but has no authority over the private experiences of the mind, nor of the values and judgments to which the mind subscribes and which are not any property of the extended world. Since scientific reason does not operate in the realm of private experience, or in the determination of purpose, value, and right as conceived in and by the mind, then scientific knowledge, which within Western tradition claims a certain priority over other schemes of thought, cannot here be properly applied. If so, then from the position of the mechanical world view modern science finds added support for its disinterested and distanced stance from matters of society and of human values. In that realm of beliefs and prior convictions no sure knowledge is to be had, only speculation and the play of authority. At best science can offer an analysis of the possible and serve as a provider of means, but it cannot give scientific judgments about why to proceed or to where[69].

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On this account, to avoid bias and error, and so to continue to produce results of maximum validity, science must stand on its commitment to a value-free method. As an institution it cannot get involved in matters of politics or of state, ethical issues behind the use of what it discovers, or the battle ground of competing economies or religions. This will simply produce bad science, or no science at all. Scientists as individuals may well adhere to one or another of a variety of positions or opinions, but as a community, and upon entering the laboratory (or the domain of theory-making), science must shed these and don instead the coat of objective research. As a consequence, the view may often be adopted that scientists should not, and institutionally usually cannot, guide, shape, or otherwise influence the direction in which their discoveries will be used or the circumstances within which they might be applied. (A corollary view is that there is no bad knowledge, only the bad use of knowledge.) Instead, the first task for the scientist and for science is to apply impersonal methodological goals and canons to research problems and matters of theory and experiment - to produce knowledge proper, and proper knowledge. In other words, science and the methods of science revolve around the epistemic imperative; its purpose is to advance positive knowledge about the observable world. To achieve this it must adhere scrupulously to the procedures for gaining such knowledge, and not let other concerns enter and cloud judgments about what constitutes valid research.

Technology

It is of course true that the vast majority of people cannot evaluate the results and theories of science since the work scientists do is largely intelligible only to themselves. Reliance is therefore placed in the legitimate institution(s) of science, and in its decentralised control over scientific judgments. But much of a people's willingness to accept these authoritative judgments comes from the daily demonstration by technology of the power in science[70]. Technology provides a substantive display of what science claims - that it finds explanatory and predictive truths about the observable world (natural, social, or human) that can be used to understand, manipulate, fabricate, or control that world. And certainly it is hard to ignore or gainsay this claim when all around is the appearance of that knowledge in technological artifacts that amplify truly and well the human powers. Technology is also an added defence for the institution of science whose authority may be threatened by other powerful institutions of society - institutions with which it must compete for the limited resources available within a society upon which it and they rely. Thus, in return for support for science, society bears to gain in evident and proven ways. If science is allowed and enabled to do what it does best - provide knowledge about the phenomenal world - it can furnish the basis for material well-being through technology and expert information.

This reasoning has its reverse side. Clearly not all consequences of technology lead to well-being, and hence science cannot be the furnisher of solely productive outcomes. To the extent that technology is held to involve society in increased hardship or taxing problems, then science, by arguing technology as one reason for society's support, faces hostility for the problems it thereby helps create. Yet there still remains a powerful working assumption - at least among scientists and to a great extent in larger society - that in the end and in the long term the social effects of science must be beneficial. Again, this is expressive of the belief that there is no such

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thing as bad knowledge, only the bad use of knowledge which humanity must eventually learn to use well. This is precisely the position taken by Jean-Marie Lehn as quoted earlier: "... it is the fate of mankind to pursue the quest for knowledge, for it is the only way to solve the problems that go unsolved, because we can not, we do not, have a right to close the road to the future"[71].

Looking at such assumptions more closely, and in the first instance, there is but one way to solve the problems we face, and that is the continued application of more sophisticated and powerful scientific knowledge. In the second, it is mankind's fate to pursue knowledge, for what will happen to a civilization not committed to the quest for (scientific) truth[72]? On this account then, and despite the mixed results in decades past from the festal board of science, contemporary science remains the holder of twentieth century intellectual integrity. Its results, its methods, its norms, its institution are claimed to form a stable source of continued progress through a kind knowledge that provide the means to prosperity for humankind. [Evidently, the means of scientific knowledge in such an argument are taken as necessary, and in time perhaps even sufficient, to provide solutions for social problems. It may also be that so thoroughgoing has become the influence of sophisticated and powerful scientific knowledge and techniques that even the ends of that prosperity are thereby determined - ends defined as achievable outcomes that science can provide, such that not only are other ends not considered worth achieving, but that eventually none others can be effectively contemplated given the vastness of the means provided by scientific schemes of thought, practice, and influence which have become part and parcel of social action.] From this account then, failure to recognise science for what it is - an institution in but not of society - and so refuse to give it its due can only lead to a degradation of knowledge. And since, in the social sphere, science is conceived both as the means for the control of nature according to human purposes, and as a basis (or model) for making rational social choices, then any degradation of that knowledge can only lead to the degradation of humanity.

This points to an incongruity in Western thought that was central to the theme of the first chapter, and which is worth taking up here again in closing out this section. It will be visited further in the next chapter. Namely, there is a sense that science as such, inseparable from its method, is to be taken as a good in itself (to the extent that knowledge is valued for what it is). It tends to eclipse thereby all other conceptual schemes in Western modes of thought - it carries a kind of tag of sophistication and exactness to which must yield other attempts at making sense of the world, and which makes them more or less just matters of opinion when compared to the results of science. Yet the project of science tends to distance itself from a realm of human values and social issues as being beyond the province of its knowledge and judgment. In such realms science is a means only, offering at best only a study of the possible; its results thereby, and in principle, provide only tangential knowledge about what human goals and commitments to pursue, and why. These are outside the province of science proper; for science to become involved in them is to compromise the stance of methodological purity, and this is to compromise science itself. The same difficulty is reflected in matters of scientific reason and the Western portrayal of rationality as being foundational in spirit. On the one hand, scientific rationality is prized for all the reasons discussed earlier - its abstraction, disinterest, and autonomy (as well as its working down to basic premises). As a characteristic of reason it is certainly taken to be a good in itself. Indeed, scientific rationality

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has generally been adopted in the West as the *sine qua non* of reason, and so has an even wider influence over Western intellectual history than does the scientific enterprise as such. However, in the realm of ethics, social issues, and human commitments it is taken only as a means for arguing out different positions so as to make thereby rational, but singly instrumental decisions. In the domain of human values no actual attaining to truth is attained, nor can it be achieved.

The general belief seems to be that given the factual diversity of ethical and value commitments and the evident inability of reason to arbitrate the gap in those commitments, then rationality does not here apply. Such a diversity of ethical views suggests values occupy a realm outside the working of reason since, in social issues and matters of worth, positions are adopted on the basis of differing sets of prior commitments. However, reason is notoriously inept at affecting or bringing about a change of view in a person's ethical beliefs. The incongruity is that science, when working from within its own historical stance, is taken by Western intellectual culture to be a good in itself, worthy of pursuit for what it is - an expression of that to which the human intellect can attain (and yes, productive too of useful results). To this extent it is an expression of culture as such, though it is not dependent on any particular culture for what it is, only reliant on the wealth of a particular society for the costly tools and resources it requires. Yet outside this stance - in realms of social issues and human commitment - it is regarded as a means to ends, but where ends are undecidable on its own principles of validity. Human goals are beyond scientific judgment or rational arbitration, and so too, therefore, are they outside the province of rationality and of knowledge proper. This paradox of end in one domain, instrumental means in another, with separate considerations determining both, is born largely out of the abstractions of the mechanistic view and the assumptions about, and the priority given to, instrumental reason within the naturalistic stance. The situation cannot be resolved here. Noteworthy only is that the contradiction appears equally strong in both the characterisation of scientific knowledge from within the naturalistic stance, and the ways in which the institution of science is often taken to interact with larger society. Both are born out of the consequences of a rational empirical method that is inextricably bound to the naturalistic stance. The third chapter will focus in part on such matters as these, and will attempt to set out some ideas concerning holistic modes of thought that may serve to re-characterize and reinterpret the issue in a less instrumental way.

In brief summary then, the overriding concern from the perspective of institutional norms and methodological canons guiding the project of science and the community of scholars is for science to pursue its first research goal of validating knowledge. Such a goal implies separating research in science from the social or ethical consequences of that research. It implies as well a distinction between results and reason in science (and in its institutional function) conceived as means, and the ends to which they may be put. Given this separation, which can be traced in part to the origins of the naturalistic stance, science provides the means to knowledge and the instruments to the prosperity of society, but it cannot decide which goals to pursue or why. That is the province for institutions of and about society, and is as well the place of personal values and prior convictions typically believed to be unarbitrable by both scientific judgments and rational arguments, both coming out of the Western intellectual culture's inheritance of the naturalistic stance.

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Science as profession

Introduction

While in the previous perspective science was characterised as a unique institution in society, there exist alternative views that regard it as very much indebted to complex social processes. From within such a stance science is not a single entity nor is it an isolated enterprise. Modern science has existed for three hundred years through an extended commitment to an arduous task requiring constant attention and dedication to the transmission of its changing tradition. Yet this cannot occur alone through the personal commitment of scientists or the stability of institutionalised norms. Perhaps at one time it was possible for scientists to pursue their goals relying largely on themselves, their resources, and the community of a relatively small number of compatriot scholars. However, contemporary science has developed into a range of specialist disciplines centred on subtle and obscure research problems. These require support from an equally large range of institutions and controls in society that extend far beyond the dictates of methodological purity[73]. In this second perspective, largely indebted here to the previously cited work of Michael Gibbons, current science is a rich social enterprise connected to various economic or political concerns and constraints (among others)[74]. As a late twentieth century institution, science is anchored to other social processes without which it would cease to function, but from which it also deviates. The notion of science in society, but not of it, can be opposed by the argument that the character of science is changing into a set of specialisations dedicated to experimental results taken as commodities that must be traded for the continued support of those same specialisations (and hence for their continued 'free' existence).

This clearly is a change from the traditional view more explicitly related to the naturalistic stance - that science is the pursuit of empirically based truths about the world. To the extent that this alternative view has credence in society, and to the extent that science has migrated to centre stage in the working of society, then the issue becomes (and which Gibbons poses) what must be the new role of knowledge in the economic, cultural, political, religious, scientific life of society? While there may be good reasons to doubt the accuracy of the traditional view, it may be that in this alternative position a new role of knowledge is just as deeply, though perhaps more implicitly, related to the naturalistic stance.

Specialization

From this alternative perspective science can be viewed as a knowledge production enterprise, as a set of specialist knowledge disciplines, or as a collection of professional research groups in which the results of scientific effort are taken as information capital. Here, the method of approach is guided by functional norms aimed at garnishing support from society for the continued work of science research teams. The support research specialisations can expect to achieve depends on the value of the knowledge they produce as measured by an exchange for the social benefits that knowledge is likely to achieve. In contemporary society, information has become the new capital,

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while the enterprise of science has grown in complexity, importance, and cost[75]. The price is such that for the most part only the collective wealth of society channelled to science is capable of providing the support needed by research teams to continue their line of work. Failure to secure support spells the end of that specialisation. Institutional science has now become professional business that must be defended, organised, managed, and promoted so as to obtain a share of society's wealth (while specialisations compete among themselves for the chance to continue to exist). This it does by being involved in the creation of knowledge as a commodity to be traded in exchange for the social support its specialist disciplines require. Research must thus be managed within an institutional setting. In such a setting the choice of specialist study depends on the functional goals of the institution, determined with respect both to the needs of an entire social system also based on the exchange of relative goods, and to the funds it can obtain as a result of the exchange value of the knowledge its specialist teams are likely to produce. However, even in this view the method of research remains a core factor of professional science.

The method of specialist research is in part dedicated to producing techniques, data, sophisticated information, or applicable models. But since research is invested in specific institutions, credible science comes from credible institutions that produce useful results in the creating, handling, and explaining of data, or in the fabrication of new phenomena[76]. As with the 'traditional' science argument, there is a clear distinction here between research as means and the ends of scientific production. A methodological ethos dominates. Science produces ever more useful or powerful tools for society, industry, or government, and for their increased wealth or power. Within the institutions of research (for there is no need to speak of science as such), the choice of which knowledge amongst knowledges to pursue is based on likely institutional benefits within the *de facto* needs of society. The point is still to do valid research, and in this sense science still remains committed to the norms of methodological purity. However, which research is actually done is a practical concern involving the wealth and power of other institutions also competing for limited social resources based on the production of their own goods for trade, and the likely outcomes a particular research method or approach might achieve. It is no ethical valuation or moral choice, but a methodological one, based on knowledge judged as a commodity. Science as research results thus remains an instrumental tool, a neutral resource, or a consumer good of society[77]. The ends to which these results will be put is not the decision of the researchers. The research system remains distanced from social issues. Theirs is to worry about the methodological approach and the exchange worth of the knowledge produced by a research team (and so continue to exist). The ends or consequences of that knowledge are matters undecidable by scientific method, and so the role of the profession in society is generally restricted to issues around the creation of knowledge and the promotion of technology by which it earns its keep[78].

Utility

Science has long been committed to making, doing, controlling, manipulating[79]. When imported into the argument regarding science as professional research specializations, this tradition of utility takes on an added characteristic. The development of professions in the last century as the creators and holders of specialist skills, information, and know-how was the result in part of the

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application of knowledge to knowledge itself - to the methods of systematic invention and research in all areas of thought - and to the processes of training[80]. Progress in knowledge could thereby be institutionalised because it became a matter of system and organisation, not genius, effort, or good fortune. When conjoined with the rise and pursuit of industrial wealth and the business of technological benefit, there began the rush to systematic knowledge. Not just any knowledge was sought (though surely the knowledge explosion has encompassed all areas of thought), but practical knowledge that could be useful for material advancement leading to social well being and profit[81]. Contemporary specialist research thus exists in part because of the levels of sophistication achieved by the rapid application of science to the practical[82]. Scientific knowledge is now subtle and sophisticated know-how, and is daily becoming more so. It is the consequence of a kind of mass production approach to scientific discovery.

In this context, and given sophisticated research, the efforts of science have moved from explanation and prediction to the work of fabricating materials, processes, and devices that meet the needs and demands of an industrial society based on the exchange of goods. Research is centred on making that which was unknown before; on fabricating or synthesising some technical phenomena not otherwise seen in nature but of possible or desirable use to humans. When placed in the context of knowledge production, the systematic fabrication of phenomena (or information) through the funding of sophisticated specialist research is catalysed by the quickened pace of technological innovation which in turn requires a corresponding rise in the rate of production of specialist know-how. If so, there is here then a powerful engin for movement into ever more productive fabrications of technical phenomena, or new information, from scientific research.

As fabrication, science and technology share the same method[83]. While this contemporary role erodes the view that science involves a commitment to the empirical truth, both still come out of the inheritance of the mechanistic view of nature, beginning with Descartes. As Gibbons argues it, Descartes started with his fundamental doubt: that acquired knowledge is suspect, values are to be questioned, and tradition is to be discounted. Instead, mathematical-like reason, operating in the province of the mind, is the one means to obtain secure and reliable knowledge. In order to be known, nature must be reconstructed out of deliberate empirical observation, and made sense of out of the universal concepts in our minds. Since first knowledge is knowledge constructed in our minds based on reason, then the one thing we can best understand is that which we ourselves make and control. Be it matters of thought only, or in practice, our intelligence is most powerful when applied to those uses we choose and make for our own chosen ends[84]. Thus, the procedure in science is to reconstruct for ourselves the mechanical processes in nature we seek to know, and thereby make them intimate to our understanding by reworking them in terms wholly constructed by ourselves. In the perspective presented here, contemporary research as the construction of needed results or as the fabrication of desired phenomena is thus in a direct line of thought leading back to the mechanistic world view. Indeed, the work of contemporary science leads to ever more sophisticated methods and results as does increase the subtlety of our understanding of nature and the continuing refinement of our mastery over its forces. From within the naturalistic stance, these we can take as our own, and make of them what we will.

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Thus, from this point of view both science and technology (which share the same method) aim to make something that serves a chosen goal in fabrication, synthesizing, or construction. Both as well are involved in instrumental research towards fruitful tools for society. Gibbons holds that these involve three aspects: an increase in practical understanding, the provision of a competitive advantage, and the achievement of a profitable outcome in power or wealth[85]. Here, research becomes a resource that must be used and managed, and may well become organised around national political policy for either the advantage of the state or of society. Research thereby also becomes more akin to a commodity than to the search for knowledge. Gibbons defines commodity as "any kind of thing that people want or need and can be traded"[86]. Hence, science and technology both become valued for the phenomena they can fabricate or for the information they can provide or transmit, but only to the extent that such phenomena or information is wanted or needed by government, industry or the consumer corps, and can be traded. Research in turn is no longer directed by the free exchange of ideas so as to advance the truth, but functions from a competitive exchange of useful knowledge or products within a society also based on the relative valuation of exchanges. This it does in return for a continued existence and possible growth through social funding and the provision of resources required for its fluid functioning (i.e. systems of education that produce highly skilled individuals who can enter specialist domains and continue the work of research). Hence, scientific autonomy is closely related to the pursuit of specialist research results (based on the valuations of its practitioners who alone can judge its esoteric content), but which can be achieved only through providing goods that can be exchanged in a society for continued recognition and support[87].

The argument in summary is that science has become an institution of specialist research based on a methodological ethic whose task is to fabricate or synthesize phenomena useful to a society. The results of such a task must be available for trade in exchange for continued funding and the provision of resources required to continue its work. Research whose prospects suggest they will end in results not open to trade will not be supported. However, this takes place in a larger social sphere where the entire social system functions on the basis of the exchange of relative goods for the sake of the benefits that can accrue. The main value then for research, both within scientific institutions and in the broader community, is in its function as a provider of neutral 'tools', seen as commodities, for the "efficient functioning of society", meaning the continuous process of technological innovation and the scientific fabrication of new phenomena[88]. Questions of end use, the judgment of consequences, and the value placed on what we know cannot be addressed by the ethic of specialist research nor by the institutions that direct it. Since the notion that knowledge is factual, not evaluative, has become part of the structure of professions generally and of Western society at large, and since concepts of rationality remain indebted to norms of scientific thought, then these questions are taken to remain outside the realm of rational arbitration or scientific formulation, even though science in this view is much more intimately connected with the whole of society.

Indeed, by viewing science as research leading to the fabrication of neutral goods whose worth is to be decided by exchange values, then the value of knowledge is made relative to that for which it can be traded. If so, then to the extent that various goods throughout society are viewed as

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commodities for trade in exchange for relative benefits, and to the extent that human values are considered to be such goods, then human values as well may be judged not for themselves but what one can get out of them[89]. Judgments of knowledge and human values are thereby reduced to the ethos of the market place wherein standards of choice are entirely relative to the rise and fall of commodity stature. In such a social exchange, nothing is valued for what it is in itself. Indeed, such a notion is disfavoured. Its only creditable value is based on how it compares to some other desired product with which it can be traded. Therefore, the question of human significance, and the implications of knowledge for that significance, is lost in the midst of a vast commodity exchange. Hence, the notion that an analysis of means and ends acts as a basis for rational, even ethical action becomes in this view conflated to the play of means only - means which scientific research may be taken to provide in a most effective form as a good for equitable exchange in a sea of parity.

Expert advice

These final sections will take a look at the character and role of expert advisors in public decision-making. This will help bring together some of the ideas discussed throughout the chapter, and will serve to highlight some problems of the nature of scientific knowledge in society. In addition, it will serve as a starting platform for the work of the fourth chapter wherein will be discussed issues of technology education policy.

The notion of expert advice turns out to be an extensive topic, with many possible views on scientific or professional expertise in decision making. It involves as well complex debates about the kinds of knowledge needed to make decisions in public arenas. The field of policy advice or analysis has become institutionalised in many settings, and can itself involve a high degree of specialist professional training[90]. But it also depends on particular conditions that obtain in different societies or nations. The issue is complex both globally and locally, and only a rough survey of some limited but general ideas and themes will be presented here.

The notion of expert advise is in some ways connected to the belief that an individual, through years of training, apprenticeship, and experience can achieve an accomplished, competent mastery of a specialist field of study. While it may be possible to speak of an expert musician or an expert politician, the term here is taken to have a connotation coming out of the existence of contemporary specialist knowledges. Such experts, at least in the realm of public decision making, may often be thought of as professional knowledge workers whose career is spent gaining command over some otherwise unintelligible area of subtle and sophisticated research. They possess such knowledge, skill, and experience as is only uncommonly available, and which is specific to a very particular domain of study seen as crucial, or at least important, to an issue under public scrutiny and about which some decision must be made[91].

However, as suggested by the previous sections, specialist professional knowledge is not something an individual acting alone can obtain. It is invested in institutions of research, and carries strict professional norms for entry and practice. Professions are the carriers of specialist

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knowledge and skill; they create or fabricate it, and provide it in the form of a good or service to society in exchange for some type of recognition or support. An expert exists within the working realm of an organised profession, since scientific knowledge and skill is conditioned upon the collective judgment of coequal holders of technically obscure theory and research method. A specialist field of study is delineated and determined by that collective of peers in knowledge who, acting corporately, establish professional norms to define the extent and practise of their research and skill. The initial assumption here is that the knowledge they possess is of a level of sophistication such that none but themselves can claim to understand it, and, by implication, to evaluate possible contributions it might make to resolving some issue or policy problem. Contemporary specialist knowledge is consensual. In this regard, Gibbons characterises a profession as "... a socially rooted and supported vocational enterprise of full-time practitioners who can earn their living by providing a vital service through the utilization of expert and esoteric skills"[92].

One perhaps evident consequence of this description is that while a research profession is constituted first out of its esoteric skill (since without this it would have no reason to exist and nothing to trade), it cannot be just any skill based on any type of specialist research knowledge. In some way it must conform or be relevant to what is needed by society, and what is likely to be supported by government, industry, or the public consumer - at least if the profession is to continue to exist and to have a chance to grow. At the same time the profession must follow the dictates of valid research born of an epistemic imperative, plus the requirements for socially useful results (if one likes, socially valid results). A profession must thus pursue valid knowledge and skill, while finding ways of presenting that knowledge in socially relevant forms that in the end will provide justification for the claim of expert knowledge. Under such circumstances it is clearly not an independent institution, but one both in and of society. On this account professions are very much bound to the social requirements of useful knowledge.

Gibbons attempts to highlight other qualities of a profession that are worth stating[93]. According to him, a profession must have the autonomy to pursue its own expertise by organising itself as it chooses - setting standards, defining or imposing training requirements, applying sanctions over members, or enacting codes of practice and conduct. This is required in part because of the esoteric or unintelligible nature of the knowledge in which professions trade. As an institution of research, the codes of practice ensure that professional trust is maintained among the coequal members of the profession. Trust must also be established and kept with the public, or some institution vital to the work of the profession, lest suspicion arises over the quality of the expert skill or knowledge the profession claims to provide. This could well threaten its autonomy, and could lead to an enforced change in training and practice, with consequences for those already in the profession and upon whose livelihood they depend. A profession therefore is keen, as it were, to maintain the quality of its member's skill and to be convincing in the fulfilment of its tasks (from which it gets its legitimacy). On the whole then, professions must balance their internal standards of knowledge and skill with how they relate to the social needs for what they provide and the perceptions of how well they do it. A research profession is weakened (in power, influence, stature, or wealth) by being discredited on either account. Research professions must thus be

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active in practical political society to ensure the respect and support they need, while internally adhering to the norms of valid research defined out of the goal of methodological purity (thereby distancing the respectable professions based on normal science from any pretenders to knowledge).

As already mentioned, to a large extent specialist professions were born in the last century with the invention of how to apply research in systematic and organised ways so as to produce by design useful knowledge and skills[94]. This lead to wide ranging breakthroughs in fabrication and in the production of information that are now the bread and butter of professional practice and specialist research teams. However, in spite of the argument that science is now part of the trade in knowledge seen as a commodity for exchange in a society, there remains a core belief among professional practitioners and within Western society at large (whose intellectual culture remains indebted to the naturalistic stance), that to the extent that professional institutions are the carriers of scientific research, then the knowledge produced therein must strive to be universal, disinterested, and valid - that specialist knowledge must remain secure and reliably true. If this were not the case then no claims to expert skill could be made. This highlights the position that the practice of such skill should result in real consequences, since the realness of the consequences are in direct proportion to, and rely upon, the validity of the knowledge that is obtained. One obvious corollary here is that as an institution, professional expertise should be factual and communal. In other words, first, true to the canons of methodological purity, research coming out of the specialist professions should be free of bias and error, and hence distinct and independent from any personal values or prior commitments to the results forthcoming. Second, since all results in research are based on the communal checking of procedures, outcomes, and interpretation, then a sign of secure and reliable results should be wide scale consensual agreement among professionals about what is and is not the case in a particular study or circumstance about which they have knowledge.

From such beliefs come the common perception of expert knowledge, and the expertise of knowledge workers, as independent of the various conflicts and disagreements commonly faced when decisions are made in public arenas. In this view, the accumulated results of a profession, and the statements of experts from within that profession, are more like declarations about an actual state of affairs in whatever issue is under debate. Theirs will be a balanced, coherent, disinterested testimony from which some truth will be had amid the contrary commitments and intentions of the opinionated and the involved. Although this is a position that can be countered when experts having common knowledge espouse contrary advice, it remains an important assumption about the quality of research results, one not easy to ignore given the commitment Western culture has to the project of scientific knowledge and reason as secure and reliable (wherein it is folly to discount well established science, and foolish to ignore what scientists have to say)[95].

However, decisions made in contemporary society are usually taken to involve highly complex states of affairs, which when approached in democratic terms must include in some way the interests and concerns of a variety of groups, institutions, or communities. As a result, even should

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experts be in possession of valid knowledge from within a confined specialist realm, it need not have direct or evident connections with the matrix of concerns that characterise, qualify, and predicate the problem or issue[96]. The statements of experts then may well appear irrelevant, inconclusive, dated, or wrong, created as they are for a highly specific centre-point of knowledge, but employed to speak out on diverse and complex states of affairs.

Scientific guidance and counsel

William Dunn has attempted to address this issue by placing the nature of scientific knowledge in the context of complex decision making (and problem and policy analysis) within a post industrial society - a society "increasingly dominated by an educated professional-technical class"[97]. In his discussion of such a 'knowledge society', Dunn holds that it is characterised in part by the "centrality of theoretical knowledge" as provided by the social, physical and biological sciences. However, such science has been increasingly made part of the bureaucracy of knowledge in which the work of research is subordinated to instrumental goals that provide benefits to society. In addition, the increase in sophisticated knowledge in "soft" and "hard" technology leads to the use of mathematical modelling and various types of systems analysis in the attempt to solve problems in the public arena. Yet information is becoming a scarce resource, given the business-like character of competitive specialist research as regards the attempt to understand problems and pose solutions, and hence a certain secretiveness for competitive advantage[98].

In his attempt to relate scientific knowledge to the complexness of decision-making within public arenas, Dunn makes a distinction between expertise regarded as "technocratic guidance", to be contrasted with that regarded as "technocratic counsel"[99]. He argues that the nature of decision-making has become complex enough for the creation of professional policy analysts, since 'off the shelf' scientific expertise is often too difficult to place within the problem solving context. Given this there are two broad schools of thought. In the first, complex problems can be analysed as intelligible systems. Decisions about solutions are to be guided by the use of ever more sophisticated knowledge gained from a systematic analysis within the context of the problem. This prompts the use of individuals and institutions well versed in the technical intricacies of problem definition and solution, and whose skills and experience are considered unique and necessary to resolve the issue. The considered judgments deriving from the analysis guide the decision that will be made. This in turn helps establish a relation between government and the community of experts wherein expert knowledge is provided a degree of independent influence, while to government is given some basis of legitimacy in the decisions it makes (and a scapegoat should events turn sour). In the second, technocratic counsel, decisions to be made are seen largely as political and a matter of a conflict among differing values or desires, some of which must be compromised or lost in the overall victory of one (or some) camp(s) against others, depending in part on their relative power and influence. Scientific knowledge is required to inform the political choice and then to give it some measure of legitimacy once made. Here, scientific experts, but particularly policy specialists, are required to give counsel to the public on specific questions under debate, and to provide a measure of balanced advice based on impartial and value free analysis. Still, the decision remains largely political.

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However, in both of these approaches, scientific knowledge as such is not suspect. In the first, the primacy of expert knowledge comes to the fore and is based on a relatively complete analysis of the problem by technical and analytic means. In the second, scientific knowledge is still considered valid, but plays an ancillary role to the decisions that must be made. Indeed, the fact that such scientific knowledge cannot decide the issue is because in the realm of values scientific rationality has no actual say. The real issue is in the arbitration of prior claims and the play of power and influence. Neither case therefore serves to bridge the traditional gap, embedded in the naturalistic stance, between knowledge as neutral means and the choice of ends not arbitrable in reason. This is perhaps not too surprising since, in the context of a 'knowledge society', such fields as provide theoretical knowledge in the social, physical, and biological sciences constitute the working capital of that society. If so it seems likely they could as well import into notions of valid knowledge similar valuations of means and ends as obtain within the naturalistic stance from which they come.

Pragmatic knowledge

An alternative analysis of expert advice is given by Yarin Ezrahi, and is taken up elsewhere in works by Arie Rip[100]. In this case, two main questions decide the character of expert advice needed in problems of public decision making: to what extent is there agreement on the goals or desired outcomes for the problem, and to what extent is there expert consensus in its definition and analysis? The way these questions are answered sets out categories of approach for expert advice (for example, an issue that has high agreement on goals and high consensus on the character of technical knowledge about the issue requires a specific avenue of expertise). Of course, these two classifying questions themselves exhibit the assumed distinction in naturalistic thought between knowledge as ends and goals as values, and the 4-option matrix for characterising expertise advice (nil to substantial agreement of goals, nil to substantial consensus of definition and analysis) might also be expected to exhibit the same distinctions. Still, given the four categories obtained from these classifying questions, then there may be four different routes to expert advice. Three of them will be briefly summarized. The fourth requires a closer look.

If people agree substantially about goals and if there is clear and substantial scientific consensus about the nature of the problem, then expert advice is taken as the means to achieve the chosen end. Ezrahi calls this first case "utopian rationalism". It is perhaps most often found in small scale projects where there are few differences among those groups or individuals involved, and the specialist knowledge exists to decide how to proceed. It as well can occur on very large scale projects of national priority where national leaders focus attention and energy on attacking some reasonably well defined task. The second case occurs if the goals are substantially clear or at least fixed or urgent, but there is vacillating or nil consensus among specialist researchers. Decision-makers must then decide which scientific position carries the greatest weight, and choose a course of action after balancing differing or conflicting expert advice (and taking into consideration other non-scientific factors). Such an approach is termed "decisionism". The third case occurs when there is little agreement on social or political goals, but scientific consensus is believed to be strong in fields related to the problem. Experts may then take the position of neutral or balanced providers of solid advice about possibilities and handicaps. Ezrahi calls this "expert neutrality".

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However, given the pressures born of multiple goals, and if the problem is a matter of broad importance, then experts may end up as co-opted advocates of a position based on their personal convictions about the best end to pursue, and hence become involved in rival debates. Such debates are likely to reveal the fragility of supposed consensual knowledge among researchers involved in what is in fact complex issues and open systems about which knowledge may be provisional and incomplete.

The last case, called “pragmatic rationalism”, is often taken to be the most common in decision-making within public arenas. Here there is little or no agreement about goals or ends, and only limited scientific support for any one position. The issue is believed to be complex in a way too difficult to unravel; knowledge about the issue is hard to come by and is at best insecure. Indeed, in this view the claim of secure and reliable empirical knowledge is a myth since scientific rationality does not have the tools to cope with the complexness of such socially constituted problems. (Even if it did, time is too short to construct it.) Their character is such that existing specialist research has little direct bearing, while the intricacies of the problem work together (or fail to work together) in a way that makes even problem definition a task never completed, let alone solved. The issue is taken to involve an interwoven, connecting web of diverse factors, social, scientific, political, etc., as well as myriad assumptions about the nature of the problem, including an array of values and prior commitments, which is irresolvably complex[101].

The notion of ‘pragmatic rationality’ incorporates expert knowledge as but one part of the attempt to get a hold on an issue. The approach for making decisions must as well include political differences, strong prior commitments among multiple opposing proponents of different courses of action, as well as non-agreement among specialist researchers. The emphasis then is on a pragmatic balance among many factors that come to delineate a real world problem. Scientific knowledge is but one aspect, and even likely valid research may be ignored if it does not advance some overall pragmatic understanding of the problem rooted upon the social grounds of what can work. Each issue then is to be depicted on its own terms, with choices of action emerging from the effort to get a functional grip on the character of the problem and its own possibilities.

From this stance then it seems there are no prior rules of analysis, no abstract organising principles that must apply. Expert scientific or technical inputs, even if compelling, need not be entertained if other factors outweigh them. While there must be displayed some type of organisation to the way the problem is understood, decisions would be made from some socially acceptable interpretation delimited by the situation at hand, hammered out in the process of coming to some comprehension of the problem. Each case is unique. The professional experts, the research knowledge, the decision-makers, the private concerns, and the public interests must construct a working ‘solution’ to the issue. This would be done without scientific consensus - there are no hard facts upon which all can agree - and so either traditional scientific rationality is circumvented, or is taken to be inadequate to the task[102].

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From this view then, information is to be judged on pragmatic social grounds, not on the legitimacy of specialist research institutions who ensure the validity of esoteric knowledge based on the norm of methodological purity. Gone is the notion of secure and reliable scientific results. The claim is that the constructs for understanding the world made available by science operating from within the naturalistic stance cannot be used to make sense of the communally complex, interwoven situations faced in many public decision-making contexts. Further, if society possesses multiply competing groups holding different but incomplete levels of power or authority, then decisions cannot be enforced. They must be sought in courses of action that, in the best estimate, work by fitting together contending components within a particular situation. In the absence of organising principles, the only choice is to seek out pragmatic avenues within a process for making decisions about needed action in each particular case.

While this approach suggests a view of scientific knowledge embedded in society and free of the naturalistic stance, there may yet be here an implicit adoption of some main features of classical rationality and objective method. In the approach of pragmatic rationality, research knowledge, human values, various political positions or constraints, community history etc. may be seen as tools, devices, inputs, components, even symbolic tokens, to be used for, or incorporated into, the fabrication of pragmatic social results - the conditional resolution in some acceptable way of a complex policy problem. If so, then the play of these factors, taken as social commodities (be they assets or liabilities), could be regarded as relative to what might be usefully achieved by them from within a set of mutual social exchanges productive of that resolution. The end may be viewed then as the act of constructing a workable arrangement of inputs taken to be commodity-like, to be traded off one against another. From this stance traditional notions of rationality, based on scientific norms, the discovery of statable relations (in this case between science and society), and their incorporation into some abstract scheme of thought, is replaced by a contextual game delineated not by knowledge (nor by human values) but by the attempt to fabricate the practical and pragmatic outcome in some achievable social strategy or manoeuvre. Knowledge has become politics and power to be kept in balance for the sake of action.

Since each situation is taken to be socially unique and uniquely complex, the employment of research knowledge or of scientific method is taken to be but one among a host of inputs. Hence, there can be no theory of complex social policy issues. They can only be described, grappled with, and manoeuvred about. Classical rationality appears to be circumvented, and some other rationality employed. However, it was earlier argued that science as the fabrication of goods for social exchange is thereby also indebted to the naturalistic stance, and this same argument can be used here in a pragmatic combining of various social inputs.

As just noted, the point of combining inputs such as scientific knowledge, human values, or various political constraints (seen also as tools, components, or symbolic tokens) is to fabricate a pragmatic social outcome. None necessarily need be considered as more or less valuable, and so they are open in principle to parity exchange and negotiation as the situation requires. Although none of these factors are neutral in the sense applied within empirical science, they begin to appear as 'chessmen' in the actual rearranging of component factors so far as concerns a pragmatic result.

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They are 'neutral' in the sense of being in principle open to equal negotiation and parity exchange. But now they appear simply as means for a pragmatic manoeuvre. In this sense then there seems to be involved a conflating of the naturalistic distinction of means and ends into the play of means only. Certainly the place of human significance is taken to be but one of a variety of elements to be used in the effort to reach a pragmatic outcome, as is also scientific knowledge. While in this view they are coequal components of the pragmatic strategy, this establishes no relation between them that might overcome the separation between knowledge and human values, and hence help clarify conflicting issues of human significance and the mechanistic, instrumental view point.

In addition, specialist scientific knowledge is but one of a host of factors in a pragmatic strategy. As such its validated results may or may not be used, or be of use, since in the context of complex social issues specialist knowledge occupies no secure and reliable space. If so, then pragmatic rationality may actually serve to maintain the separation of scientific research from the consequences of that research in society. If, because of the balancing of various interests, scientific research need not be taken on board in the resolving of policy issues, and if its own claims be viewed as defective or inadequate to the work of resolution - that there are no 'hard facts' in such a complex social arena - then it is a short step to conclude that scientific knowledge may have only a weak connection to both creating and resolving problems in the public arena. Once this is granted, research work may be viewed as working independently of social consequences, since the nature of those consequences from research is nebulous or vague within the context of a complex social issue. (Even if the consequences are more directly evident, research as commodity driven may well be directed towards those enterprises that will be more likely to regard its results as tradable.) Research can at best only contribute some part to the resolution, and it is not the role or place of the scientific enterprise to become involved in such debates. Yet in this can be seen one aspect of the inheritance of the naturalistic stance in modern intellectual culture laying implicit in the notion of pragmatic rationality.

The attempt then to circumvent concepts indebted to the mechanistic world view - particularly in the distinction between neutral scientific knowledge as means and the goals of human action - is not actually carried off since the distinction remains by adopting but one of its poles. This is done in the hope of working through to a pragmatic strategy, but what that might be is totally defined or delineated by what useful relations can be gotten out of the separate factors involved. Knowledge and values have use only in the sense that they fit in to an overall pragmatic resolution of competing interests and decision factors.

However, if the intent of pragmatic rationality be not to circumvent scientific rationality (because its use is in fact impossible) but only to recognize that it is inadequate for resolving complex policy issues - that some other approach need therefore be used - then three observations are in order. First, the claim that scientific rationality and research knowledge are inadequate to the issue cannot be taken as an axiom. If each issue is unique, then there exists the possibility that existing research may be crucial in a particular case. In addition, new areas of study might be developed that speak more cogently to an issue at hand. Whether or not such cogent knowledge is available, or might one day be so, must be worked out for each instance. Second, given the relative

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immaturity of the notion of complex social issues and pragmatic rationality, there may occur over time some recognition of commonalities in divers instances of complex social debates such that abstractions may be set out and further study initiated along the lines of those abstractions. In other words, growth in the knowledge of complex states cannot be ruled out in advance, and so therefore neither can be neglected the possible development of some sort of systematic explanatory account. (Recall, the argument here is not about the impossibility - because of the nature of knowledge - of applying scientific research, only that what scientific knowledge currently exists of is inadequate to the task.) Third, and more important to the argument, the priority given to pragmatic rationality seems, paradoxically, based in part on the belief that scientific research is a superior form of knowing. For if science is the source of secure and reliable knowledge, and if such knowledge cannot be had, then some other approach must be taken that does not look to knowledge for the resolution of issues. One choice is to attend to what is achievable pragmatically through negotiation and exchange. But this is just the point to the naturalistic stance. Science provides the superior approach to knowledge. If conditions are such that it cannot be had, then some other (inferior) form must be adopted, namely, the appeal to particular, non-repeatable pragmatic outcomes. This appeal is not made on reasons of principle or the impossibility of scientific knowledge, only that our practice is poor and so some other way must be followed once the ideal cannot be achieved.

Chapter review

This chapter has looked at how the scientific community and the institution of science are related to or involved with the working of society. There appears to be a strong commitment among contemporary working scientists regarding the success of the scientific project and the essentially extra-cultural nature of scientific knowledge. This is in large part a derivative of the subscription by science to the mechanistic world view, and the adoption within Western intellectual culture of the naturalistic stance. Science remains secure and reliable in the valid and value free knowledge it obtains through the pursuit of methodological purity and the epistemic imperative. Scientific knowledge on this account constitutes rational and neutral means, superior to other systems of thought, by which socially chosen ends may be pursued.

While there is no doubt that scientific knowledge is unavoidably communal, differences exist about the character of this communal quality. Science is an institution that some regard as in but not of society, providing as it does superior knowledge independent of particular persons, groups, or cultural settings and the prior commitments they may have. On the other hand, the institution of science can be considered as one instance of a class of social phenomena in which norms and canons serve to direct the role and function of the institution and its community of members. The institution is largely determined by the working out of these norms. In this case, other powerful institutions of society can conflict with science, particularly since it defines itself as autonomous with respect to the knowledge it produces. This leads to the requirement that scientific knowledge must remain separate from social, ethical, or value issues about which its method has nothing to say, and which, should it get involved, would open itself to extra-scientific control and hence the loss of its self-defined priority on producing valid research.

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Contemporary science may also be regarded as an institution of sophisticated and professional specialist research. In this view, research is a commodity among other social goods that must be traded in a social exchange for the support and resources specialist teams require to survive and grow. In return for the goods it produces, society can expect to benefit from the knowledge research provides, and from the fabrication of devices, materials, and processes that now become central to the project of research. Hence, while experimental procedures need to remain within the realm of methodological purity, the research done and the value placed on its results are chosen by research institutions whose purpose is to produce goods for trade in a system of social exchange. The pursuit of truth is taken up by the need to produce results valued by society in exchange relations. It also implies the need to separate the goods research produces from the use to which they will be put, since the decision is one that is business-like. This may lead to the making relative of knowledge and human values to the extent that society itself functions on the basis of the trade of various goods for the exchange of benefits. In such a social sphere, goods will not be valued for themselves, but for the benefits one can get out of them, and this may include both knowledge and human values.

Finally, expert advice can be viewed as the relation between valid scientific knowledge and the need to solve complex social problems. From one stance, science plays a key role in the solution of such problems since only by obtaining and applying ever more sophisticated knowledge can mankind progress. Experts then are individuals working out of institutions of professional research who possess esoteric knowledge and skills that can be employed in the task of solving social problems. Such knowledge and skill may be applied in order to guide the way to a systematic and scientific solution, or it may serve as counsel to the political choices made between contending parties and opposing values. Alternatively, expert advise may be taken as providing one of four approaches to decision-making: it may be seen as scientific means to achieve chosen ends; as lacking in coherence and thus requiring a practical choice among clear goals; as being a matter of presenting coherent and neutral input into a problem characterised by conflicting aims; or as a matter of grappling with a complex situation for which neither scientific knowledge is clear nor where the goals of the problem are evident. In the latter case - the most characteristic of actual social practice - expert knowledge must be balanced on pragmatic terms with other inputs to the problem in the attempt to fabricate workable, socially determined outcomes. In such a socially defined situation, scientific knowledge is neither a matter of hard fact nor consensual agreement. The only option is to seek a pragmatic balance of multiple inputs so as to achieve some practicable social action. While this approach appears at first to move towards overcoming the gap between scientific knowledge conceived as ends and the uses to which will be put that knowledge, it suffers from the limits of fabricating some outcome from component inputs whose only principle of choice is what can work in the exchange of power and position among contending claims. Again, and in similarity with the prior case of scientific fabrication, knowledge and values have worth only to the extent that they can fit into on overall pragmatic balance of competing interests.

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Summation

In general, all of these examples relating science with society involve a weak or inexplicit link between the project of science, the working of society, and the place of human significance in how man comes to understand himself. There is in all of them a direct or implied distinction between science and rationality on the one hand, conceived as neutral or value independent, and on the other the purpose or ends to which that knowledge and reason will be put in society. (Gibbons, as already mentioned, observes how values are made entirely relative in a society whose functioning centres on the exchange of goods seen as commodities.) They as well imply, in one form or another, some weakening in the meaning or place of human significance (either by reducing it to the functioning of scientific abstractions, or by conflating it with other inputs in a pragmatic manoeuvre), originating in some way on the naturalistic stance and the mechanistic world view.

Based on these accounts, the problem of scientific knowledge and the working of a complex society revolve around the issue of theory and praxis. Dunn, for example, sees his approach as a matter of applied social science. Ezrahi's is in some sense an attempt to make all knowledge and action a pragmatic concern (for instance, by arguing that hard facts and consensual knowledge are social myths). Gibbons argues that while the research system of specialist methodologies working in an exchange relation with society provides the knowledge required for the continued functioning of an industrial society, it does so by treating knowledge and method as means only, while making relative thereby human values.

However, Gibbons also suggests that the question of ends must become a matter of conscious and directed discussed so as to bring about a change in the way science works in society - not the sort of approach that can solve all moral problems, but one based on praxis through the developing of methods adequate to those problems. Questions of use must begin to be asked, since, argues Gibbons, it is no longer possible to assume that the tradition of scientific rationality is an unqualified good. It has its good and bad parts, its rational and irrational approaches, its authentic and inauthentic views. Since we cannot assume to know in advance what will come of specialist knowledges, then, according to Gibbons, discussion must centre on which are the right uses to make of "our knowledge of nature and man"? In other words, to what extent is the method of the specialist research system intellectually rational or irrational? Does this or that knowledge meet the requirements of significance, meaning, and human development? Gibbons' point here is not to needlessly criticize or reject the entire project of science, but to choose to support such knowledge that "promote what is authentic in human development and search for what is good" - to decide if "the contemporary scientific ideal is, historically, an instance of progress or decline"[103].

The next chapter will pick up on this theme and will try to map out a different approach, or at least offer a set of alternative constructs, based on the notion of holistic knowledge and meaning giving ideas and practice in the attempt to balance both the limits of the abstractions involved in the mechanistic world view and the problems behind making sense of social practice that treat both rational knowledge and scientific utility largely as a neutral good, as a value free result, or as a commodity for open trade.

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Chapter Three

Holistic Modes of Thought

Introduction

Contemporary arguments favouring holistic thinking have been made in a variety of ways from a host of perspectives. The arguments often proceed out of the view that a broad range of existing constructs in the Western intellectual tradition are insufficient to deal with levels of complex, rapid social change and the explosion of new specialist knowledges as is occurring in twentieth century society - particularly Western society. Established disciplines of scientific and scholarly study by which human knowledge and discovery have long been categorised, and in which constructs are highly developed and refined, are seen now as at least partly inappropriate or inadequate to the task of understanding some complex social-scientific terrains that make up human fields of thought or action. Holistic arguments call for a type of understanding or approach evidently not provided by existing fields of study and specialisation. Individual researchers and groups of scholars appear to be active in formulating many such approaches. For example, various disciplines, courses, and professions have appeared in the wake of such limits as are believed to obtain in established research domains (though these domains continue along, and still constitute, the main-line of vigorous scholarship). Multi-disciplinary and cross-disciplinary studies are more prevalent, their work based on the notion that a combining of existing fields is relevant and required for an improved approach to an unavoidably complex knowledge-terrain. New fields of study are also being worked out by moving beyond both established domains of knowledge and their various linkages. These take as a point of departure the interconnections that exist in many phenomena and which make them work as a whole, thereby possessing properties not evident in their individual constituents[1]. One consequence of the growing popularity of holistic, or ecological, thought is to slowly soften the image of the machine. This leads to a more organic view of knowledge about the world and to a growing unity of treatment of thought and action - what in the thesis introduction was termed matters of meaning giving ideas and practice in the spheres of knowledge, action, interpretation, and values[2].

However, despite such moves towards holistic forms of knowing, naturalistic modes of reasoning remain commonplace in Western intellectual-scientific-scholastic culture. For example, some quarters work out notions of complex interconnections in terms of causal mechanical linkages among a variety of material parts[3]. Equally commonplace is the inheritance of the modern scientific view of reality, the ontology of the machine. Given the history to their development, these two influences or stances can hardly be separated. Their combined influence cements a strong intellectual habit in Western thought: to reason out what something is in terms of how it is known[4]. When this is conjoined with the assumption in science that the only adequate explanation is one that accounts for phenomena on the basis of the mechanisms working behind

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them (that the phenomena is a resultant of action at a more primitive mechanical and material level - a hidden structure), then the hold of naturalistic thinking can be quite strong.

As suggested in the previous chapters, the manner of reasoning offered by modern Western science (and from which like principles have been embraced in a range of other schemes of thought) is often taken to be the primary, valid explanatory approach; all other rivals adopt some assertion that merely begs the question about alternative explanatory modes, thereby making them circular[5]. A main axiom of scientific reason remains unchanged: what cannot in principle be refuted is void of explanatory content - where refutation means something like capable of being shown up as an inadequate mechanical account against the test of nature[6]. In addition, scientific reason, in what is often termed the classical mode, continues to shape broader, contemporary conceptions of rationality, objective knowledge, and the nature of reality (or the reality of nature). These assumptions in turn affect or cohere with beliefs about both the nature of the individual and of society, and how we come to know the properties and composition of the natural world - both largely decided by procedural scientific reason. Hence is derived the undoubted stature of knowledge science attains in such natural and human realms via its rational empirical method.

Given the stature of scientific reason and the accomplishments of its explanatory-predictive approach, such accounts are often regarded as factually descriptive, hence preferable and wholeheartedly acceptable when compared to other accounts not indebted to the test of an empirical method, communally objective procedures, and theory-making as obtain in the project of science. Simply, the claim is that those descriptions relying on prior commitments must eventually fall afoul of their own assumptions. In addition, those that seek explanatory accounts not centred on the assumption of 'primitive' material constituents of mechanical nature can be taken as phenomenological at best - descriptive yes, sometimes predictive, but fundamentally incapable of offering any account of actual occurrences[7]. The real cause of the event remains hidden until there is given an exact mechanical enumeration of how the constituents of the phenomena behave, and in terms of which the phenomena themselves can be recounted and reconstructed[8]. Nearly all science in the naturalistic mode adheres to some such basic starting point about how to acquire knowledge of a sort that is abstract, dispassionate, empirical, hence valid (and sometimes universally so). While this is particularly true for the natural sciences, the human sciences too adopt similar constructs for the creation and verification of knowledge[9].

However, such a view is open to question. It need not be denied in total, but neither can it properly be applied universally or comprehensively. The overall position outlined in this chapter is that the empirical scientific account is not necessarily unique, certainly not final, but which given its wide acceptance in the Western intellectual-scientific-scholastic culture can too easily lead to confusion first, about the nature of knowledge and reason, and second, about how to portray matters of human significance in the relation between science and society[10]. The intent behind this chapter then is to take a few steps, tentative at best, on the path of exploring some example approaches or schemes of thought that are alternatives to the mechanistic and the naturalistic, and which in some way involve notions of holistic thinking. Two example approaches will be selected - those of self-organizing systems, and an interpretive, or hermeneutical, framework. Even among

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these, only specific accounts will be outlined. The intent is not to provide a broad analysis of alternative frameworks from a host of perspectives. In other words, the chapter will not survey current research in the areas of systems and interpretation. The point is to look at two relatively specific accounts that at least suggest ways of dealing with the issue of knowledge and the relation between science and society that are not overly naturalistic in character.

Chapter preview

The work of this chapter will be set out in three sections. In the first section, recent developments within science itself point to ways of thinking that move outside the classical scheme. Relativity, quantum mechanics, thermodynamics, and systems thinking (among others) each contribute an alternative idea of scientific explanation and objective knowledge. While falling far short of any technical account of these fields, the chapter will simply try to stress some main ideas within them that help move scientific thought out of a naturalistic mode and into one more holistic-like[11].

Secondly, the sciences of man, and the way Western thought provides for a rational account of ourselves and of our societies, rest largely on the priorities, categories, and abstractions of modern science coming out of the naturalistic stance and the ontology of the machine. These favoured approaches make certain assumptions about how to go about giving an account of human nature and behaviour, and, hence, of who or what man is. Some of the inadequacies of this approach were highlighted in the previous chapters. Here the argument will be extended by taking the position that such accounts miss out on essential aspects of the human reality, and so point to an incompleteness in the naturalistic stance and the ontology of the machine. As an alternative example, indebted to the specific account developed by Charles Taylor, the section will highlight a view of man as a self-interpreting creature for whom meaning and significance are constitutive of human action, and an attempt will be made to suggest how such a view might lead towards more holistic thinking (or at least less naturalistic) so far as concerns our accounts of knowledge and rationality[12]. As noted earlier, the point here is not to offer a comparative or comprehensive account of various interpretive or hermeneutical schools of thought. Nor will there be any attempt to give a critical analysis of Taylor's work. The aim is to only give an illustrative example of a way of thought that lies largely outside the mechanistic and naturalistic, and which can be used to highlight some of the defects in the latter.

This will lead into the third and final section that will attempt to work out some alternative ideas for thinking about science and society. The second chapter highlighted notions that science is seen by some as a neutral or value free enterprise; that as an institution and a method of generating knowledge it has little or no direct investment in social or ethical issues except by way of analysis from within its own research stance. Although science is taken to provide the means for technological-social change, the ends of action are held to be unarbitrable in reason, based as they are in prior commitments or social habits about which science, and hence rationality, must remain largely silent. This section will attempt to offer some notions, both from a systems point of view and from the account of man as a self interpreting creature, that might serve to redirect thinking towards a more holistic appreciation of the relation between science and society.

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Holistic views from science

Introduction

This first section will attempt to highlight a few contemporary scientific views that in some way make a move away from naturalistic thought and the inheritance of the metaphor of the machine[13]. Of course, these views are still within the modern scientific tradition. While there is a general turning towards what is considered non-Newtonian, non-Cartesian constructs, there are very definite points of contact with prior work. Movement within science can only go so far before it reaches what are considered the limits of normal research[14]. Still, work in fields such as quantum mechanics, relativity, thermodynamics, and systems theory point to ways of viewing the world that differ from the classical perspective and which suggest modes of thought not nearly so indebted to the image of the machine. Such a shift in thought in effect works towards reducing the historical contradiction in the naturalistic stance - that between notions of the view of the natural world as the resultant of abstract, purposeless matter in purposeless motion, and of human agency as a locus of action and intent.

There is of course a vast arena of research and interpretation in such contemporary scientific domains as might shift emphasis away from the metaphor of the machine. These are accompanied by a general explosion of discovery over the last century and a half. This makes it impossible to present a detailed or in-depth treatment in a work such as this. The point is only to highlight a few developments in contemporary science that suggest a change of perspective (often referred to as a shift in paradigm), and to look at possible connections they might have with holistic notions and a developing view of knowledge pictured as more ecological or organic in character.

Certainty in science

> The ambition of Newtonian science was to present a vision of nature that would be universal, deterministic, and objective inasmuch as it contains no reference to the observer, complete inasmuch as it attains a level of description that escapes the clutches of time[15].

Scientific certainty seems to come in two forms. Both derive from the abstractions in terms of which the project of science originated and developed. In the first, certainty is part of the enterprise of science such that over time we come to ever more complete portrayals of the universe as a whole. The laws of physics that work so well on earth, and in all our present observations of the heavens, are assumed to hold everywhere. The supposition is that first, scientific conceptions of matter and energy, together with their modes of interaction, are factually correct (that they satisfy the test of nature, though are open to refinement or revision); second, that the universe is everywhere made up of the same kind of matter and energy; and third, that the empirical relations between matter and energy science establishes locally must also apply generally and universally. Classical and some contemporary science has made no compromise in its suppositions about the human ability to gain a god's-eye view of the workings of the universe, and whose exponents have seen no need to change the abstractions in terms of which were couched its

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first and leading visions of nature[16]. The second sense of scientific certainty deals with the way in which research gains a definitive understanding of some particular aspect of nature such that first, there exists an exacting, detailed understanding of the properties of phenomena based on clear and evident research, and second, that the knowledge thereby gained shows up in our ability to predict, manipulate, control, or fabricate what we understand. This is the sort of certainty all research teams seek when sporting the codes of empirical study, and which result in beliefs about secure and reliable scientific knowledge - especially when demonstrated in technology.

However, some developments from within contemporary science suggest that both these notions of certainty fail to capture the delicateness of human knowledge. Ironically, this idea comes from the discovery of the existence of universal constants[17]. In a strong sense quantum mechanics and Einstein's relativity theories emerged out of the twentieth century discovery that energy comes in quanta, and that there is an absolute limit to velocity - the one dealing with matter-energy interaction, the other with the geometric properties of space and the transfer of information over time. Planck's constant and the speed of light limit forced a reworking of physics in the first half of the century. This work has urged in turn a rethinking of scientific method as regards the assumed avenues to secure and reliable scientific knowledge, and which lead to notions of scientific discovery - and the objects of that discovery - at least more open to holistic modes of thought and portrayal.

Twentieth century time

Newton's two main works centred around the dynamics of bodies and the properties of light. These concerns have dominated much of physics ever since, other rivals being the development in the latter eighteenth century of the concept of macroscopic energy and its conservation (brought to the fore of scientific thought by the early industrial revolution[18]), and of the importance of the properties of space in the determination of natural law (although this turns out to be partly dependent on the nature of light). It is probably true to say that from all of these areas contemporary science gets its deepest inspiration in the intimate relation between matter and energy - heat and motion on the medium scale, radiation, gravity, magnetism, and charge on the scale of either the very small or the very large. To study matter is to involve necessarily the various energies as mediums of observation, while energy is revealed only when it touches and transforms matter. As it happens, contemporary science has sounded out a relation between the two that implies a change in thought about the nature of the world and how it can be known[19].

It was towards the end of the nineteenth century that scientists developed a notion of light that could be used as a sophisticated tool of investigation - not just as an observational precondition for the study of matter[20]. For example, in 1881 A. A. Michelson used the properties of light to specify the standard unit metre. (To be precise, he determined the metre length to be 1 553 163, 5 wavelengths of red cadmium light[21].) All such experiments with light require well developed techniques of measurement - being generally as well both a test of a scientist's skill and knowledge and part of the advance towards a more sophisticated probing of nature. But more fundamentally, behind such measurements stands the theory of electromagnetic radiation, light being one instance.

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The theory comes largely out of the life work of Michael Faraday and James Clerk Maxwell. Indeed, Maxwell's equations are today among the very building blocks of contemporary scientific understanding[22]. Yet, as with all scientific theories, Maxwell adopted certain assumptions about the nature of the physical world which latter scientific workers abandoned (although his equations remain unchanged). In particular, the aether was taken on as a necessary factor in the propagation of radiation in space - a type of mechanical medium required for the transmission of light. The analogy here was with other forms of energy transmission, such as sound through air or water. Such analogies were based on classical scientific constructs. 'Action at a distance', the transmission of light without any intervening mechanism of conduction, was debated even in Newton's time, and remained suspect into the mid-nineteenth century. Simple empty space simply could not exist, and so the aether was taken as vital for the mechanism of light to proceed. It had all sorts of odd qualities - it was without mass, having no effect on the actual propagation of light whose transmission through it leaves it as well unchanged. At the same time it was present everywhere but nowhere discernible as such, save in its standing potential to transmit radiation[23].

Regardless of the assumptions behind the theory of light, scientists had long attempted to measure its speed - for light was early suspected and then presumed to not traverse any distance over instantaneous time. Remarkably, Galileo was among the first to attempt to measure it. (His considered judgment of the speed of light was "if not instantaneous, it is extraordinarily rapid"[24].) His efforts to measure the velocity of light employed lanterns and shudders some distance apart that would be open and shut at speed. The technique might have been crude, but the approach had merit. Latter scientist's attempts at measurement - giving answers close to current accepted values - used toothed wheels or rotating mirrors; techniques really no different in principle from Galileo's conception of what was required for the experiment to succeed.

The same A. A. Michelson who specified the unit metre also attempted to measure the speed of light, first in 1880 and again in 1883. His attempt here, as with his efforts to determine an exacting standard of the unit metre, may well have been part of that test of a scientist's skill pitted against the obstacles of a technically difficult task[25]. However, one experiment he did perform (in 1881, and again in 1887) had as its aim a much more substantive goal - or at least its effects were substantiative. This was to try to confirm the presence of the aether using light to sense the movement of the earth through it. The idea was that since the earth is moving through space and the aether everywhere homogeneous, then by firing beams of light in different directions and determining their relative speeds - first in the direction of the earth's motion and then perpendicular to it - the speed of light, according to the Doppler principle of addition of velocities, should show up an inferred presence of the aether. Michelson's reputation as an experimentalist was above suspicion (even so it was later repeated with Moreley). But the speed of light turned out to be everywhere the same, regardless of the direction of measurement, as if the earth was in fact standing still. The result was out of step with expected results, and constitutes a first murmur at the heart of classical accounts of light - that when it comes to electromagnetic propagation, velocities are not additive. Newton's founding assumptions, taking both space and time to be absolute, are those out of which the mechanistic stance and its assumed 'god's-eye' view of the

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natural universe took scientific shape (a universe in which there need be no observer intimate to the formulation of the world as it is, and in which concepts once formulated and verified can be used equally everywhere)[26]. But here, at the height of nineteenth century perfection of classical form - for Maxwell's equations are thoroughly mechanistic in inspiration - was found a result so surprising as to be completely out of tune with a major harmonizing cord of scientific thought[27]. The fact of it could not be denied, only its meaning for physics.

Albert Einstein (in 1906) set out to interpret its meaning. By then the aether had been abandoned as an unnecessary assumption (the sense of light today is that it actually takes its own electromagnetic field with it as it traverses space, otherwise empty of a medium of conduction), but the constant speed of light remained. Einstein built his relativity theories around the puzzle of light and its meaning for the constructed world of the physicist. Given that its speed is constant everywhere - for no mater how fast one is travelling the velocity of light is the same for all observers - what does this say about the way our knowledge of the world is put together? As noted earlier, the existence of the universal constant is actually the starting point for deriving a scientific view in which there are no absolute perspectives. In order to fit into a world with a maximum possible velocity (velocity vectors are not additive beyond the speed of light), other variables that work together to provide a scientific account of nature, such as length and mass, will have to change as one approaches that speed. The key notion is that, near the speed of light, different reference frames of observation will produce different data of experimentation. Since they must all find the same speed for light then something else must change, such as the relations between mass, length, and time[28]. In this sense, all scientific descriptions are dependent on the actual state of the observer who no more can be considered irrelevant, as if standing outside the world being described.

Einstein worked this out using the notion of simultaneous events. He showed that there does not exist any consistent notion of simultaneity - it is impossible to characterise the condition of the universe as a single entity at a single time. The passing of time turns out to be different for different frames of reference since information, and hence observations (about, say, the timing of an event between two observers), cannot be exchanged faster than the speed of light. In order to make equivalent calculations and determinations of mutually observable phenomena, one must adopt the same frame of reference with respect to the speed of light. Outside of this there are no determiners of simultaneity. Different frames will produce different specific results, depending on the state of motion of the observer and the fact that information cannot be communicated at an instance. In other words, the condition of the observer is part of the process of determining the various relations among the scientist's physical constructs - they must always combine to give the same velocity for light. The scientist then cannot be excused from his equations[29]. There are no universally applicable relations, no unlimited range of considerations that will permit a single scientific account of the universe as it is now. Absolute space and absolute time do not exist, and so too then must classical assumptions be false about what can be known of such a space or time[30]. This is a non-classical view; classical science can now be seen as but one form of a set of descriptions of nature - its specific abstractions do not everywhere apply - whose concepts of objectivity and the determinations of data need to be reworked at certain scales of description[31].

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A universe of stories

The adoption of the notion that energy-matter or (radiation-matter) interactions are not continuous but come in constant, discrete-like quanta, can be characterised as a break-away development from the norms of naturalistic thought. The idea has taken hold so much so that both matter and energy have been portrayed - in the realm of the very small - as possessing a common quantum character. This starts a long chain of thinking that ends with a different characterization of matter, and a different sense of physical location. Planck's constant is the analogue for the world of particles what the maximum speed of light is for distance, time, and space[32]. It states that the movement of energy through matter occurs in universally constant steps. This makes impossible, at the level of the microscopic, a characterisation of transformation or change based on the continuum. Only specific states are possible. There is no in between whatsoever. The interactions between matter and energy are such as to permanently condition and qualify both with respect to the quantum. The notion of a well located particle existence must be abandoned in favour of dynamic, probabilistic patterns of interaction and relation between matter and energy. The classical notion of some simple substratum to nature open to explicit scientific account is less evident in the quantum world[33]. The complexness of interaction and observation are such as to thwart any picture of simple matter. Energy-matter exchanges in such realms are distinctly other than those conditioned by an experience of nature at the level of the everyday. From this stance the quantum domain appears as a place of paradox, and, overall, such understandings have had vast implications for the way scientists think about a human knowledge of the natural world.

In the first instance, quantum theory can only make sense of both matter and energy as a wave-particle duality. For example, sometimes light behaves like a wave, sometimes like a particle. It depends on the circumstance of observation. This is not to say that it *is* a wave or *is* a particle, only that its behaviour is such as to suggest such characterisations. It is simply impossible to look at a photon of light (the quantum equivalent of light radiation), no matter the instrument, and see exactly what it is or what it is not. The relation between matter and energy - which in larger scale domains can be mapped out with clarity - cannot in the quantum world be separated. Scientists make observations of matter through the use of various forms of energy, and come to knowledge of energy types through their interaction with gross matter. This distinction is impossible in quantum domains where matter and energy are intimately related such that to affect one is to affect the other. Indeed, the distinction between matter and energy must often be abandoned in the equivalency of their interactions. This leads to a central tenet of quantum mechanics, that the observer of such matter-energy realms cannot not affect the very phenomena being observed. The choice of experiment, the very property under study, will influence or determine the sort of 'answer' thereby obtained. The phenomenal world and the observation of that world constitute a single system. In the second instance, and hence, language cannot be used to state facts only. It must be used to suggest images and provide illustrations[34]. The contents of daily experience that might have served well certain abstract formulations of science, those making up thereby the world view of the machine, do not necessarily extend to the type of matter-energy interactions that occur among the very small. It turns out to be impossible to place scientific thought in clear contact with the quantum world. Scientific knowledge has therefore become a realm of constructs

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and abstract picturing that must be interpreted or sensed out from the complex intertwining of matter and energy (and observation). In the end, language, and no matter how sophisticated be the mathematics used by quantum physicists - actually, because of the necessity for such sophistication - must be used to paint pictures or tell stories[35].

Tolerance as uncertainty

This leads to a third implication for human knowledge. First, scientists cannot observe quantum phenomena without also affecting the 'course of events'. As just said, a choice of how to observe is also a choice about what will be observed - what state(s) of relation will actually obtain in a matter-energy interaction. Second, wavelength and frequency on the side of radiation, position and momentum on that of mechanics are related in common by Planck's constant (through the mathematics of it all)[36]. Here two things happen. Through common mathematical relations both energy and matter display a wave-particle duality - both work via discrete levels of interaction different from that which obtains at the level of the everyday[37]. The character of this interaction is determined by the universal constant for quantum phenomena - Planck's constant. As was the case for the speed of light, this means that not just any relation can occur between quantum properties or particles. In particular, it turns out that in classical constructs the position and momentum of objects can be determined mutually independently of each other, and hence absolutely. In other words, of a given body position and momentum can be measured to any possible degree of accuracy (in principle) without regard to the other. This is a consequence of the classical assumption that space and time are taken as absolutes with respect to how all other properties are formulated - that space and time are independent of the observer.

However, in quantum domains properties are related by Planck's constant - say, the momentum and position of an electron. These are not mutually independent, and so one cannot be ignored in the determination of the other. In the end the mathematics dictates that both the momentum and the position of an electron (or any particle that express a wave-particle character) cannot be specified arbitrarily - they always combine to give an 'area' of uncertainty or scatter[38]. The measure of the minimum dispersion is to the value of Planck's constant. We can never be sure within the range of the scatter where the electron is or what is its momentum. (This idea is named after the scientist who developed it: the Heisenberg uncertainty principle). If the measure of its momentum is made more precise, then less is known of its position, and so too for the reverse. Should an exact determination of the one be possible, then no knowledge could be had of the other. (Mathematically, the product of uncertainty in the probability distributions cannot be less than Planck's constant. It can always be more.) Of course, this is not to mean that scientists abandon certainty as such, only that they can be certain to within a prescribed degree of tolerance[39]. Still, this implies that for quantum phenomena exact prediction is impossible - it is not just a consequence of inferior instrumentation or bad experimental design. There is in quantum worlds an unavoidable vagueness, a limit of clarity of knowledge, an inability to possess or exchange information without uncertainty, hence, necessarily via interpretation.

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Human knowledge of the quantum world is joined to a certain fuzziness (a minimum tolerance in the degree of exactness of any information) that cannot be breached, even by the perfect instrument could it be conceived or constructed[40]. Instead, use is made of probabilities in the handling of quantum properties - not because measurements are erroneous (all observations face an internal scatter amongst themselves that mark out an area of ignorance due to error), but because in the quantum domain a different characterization of nature is necessary. For example, the concept of exact or simple location must be abandoned; so too the idea of solid unit matter (these coming out of both uncertainty and wave-particle duality); and finally must go the notion of a materially strict causal course of events, singular as to beginning and end, and locally determined. These have formed the essential prerequisites for the conduct of classical science, and the formation of the mechanistic world view. In quantum mechanics the assumptions first, are now seen as assumptions, and second, another irreducible characterization of nature is added. Probabilities and process become the only avenue by which sense can be made of quantum phenomena - not because instruments are imprecise and human observation erroneous. Hence, quoting from Prigogine and Stengers[41]: "The irreducible plurality of perspectives of the same reality expresses the impossibility of a divine point of view from which the whole of reality is visible ... Each language can only express a part of reality". Therefore, no one conceptual framework can possibly account for nature. A similar view is expressed by Jacob Bronowski[42]: "The world is not a fixed solid array of objects, out there, for it cannot be fully separated from our perception of it. It shifts under our gaze, it interacts with us, and the knowledge it yields must be interpreted by us. There is no way of exchanging information that does not demand an act of judgment".

Nature still yields knowledge - the test of nature remains the essential prerequisite for science - but language, as noted earlier, must now offer pictures, stories, or interpretations, not facts only[43]. The real is real enough , but it is not the stuff of classical scientific thought. There is a necessary interaction between the observer and the object of knowledge such that what is known requires choice and an act of judgment - the world does not present itself as an independent, fixed entity, but as a process of relation and interaction. There is no consistent description of a single state of all of nature. Of course, the interactions can be worked out, even deterministically so - it is not a merely arbitrary choice or just any act of judgment or interpretation that decides our knowledge of the natural world. Yet there must be a coherence, a fitting together into a whole, if knowledge is to be had, where the fitting is to be done partly by those who seek to know and who are themselves a part of that whole.

Such terms suggest a movement away from the metaphor of the machine - objectively free of an observer, universal, foundationally certain - and so it is as twentieth century physics entertains concepts not reducible to modern science's originating abstractions. However, the movement, while surprising, is not total and is certainly far from comprehensive. Dominant (and indomitable?) notions still obtain of scientific theory as valid and superior, the knowledge gained thereby secure and reliable. While relativity or quantum mechanics offer terms that support a more delicate sense of what it means to know, they have not abandoned thereby the ideal of attaining to a complete description of nature (even a realm as odd as the quantum realm can be known in detail). There

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can be no question that what's being done is still empirical science - it is not a matter of abandoning the tradition[44]. The test of nature remains the starting point of all science - ask a question of nature, listen to the answer. On the whole then, while the ontology of the machine is somewhat softened, as it were, by new notions of knowledge and observation, as well as by a different characterization of the material, it is mechanistic and naturalistic thought that predominates the overall world view of science.

Thermodynamics and systems

Besides relativity and quantum mechanics, work done in the thermodynamics of complex systems at states far-from-equilibrium has come to the fore in scientific work[45]. The three are connected in a number of ways, some of which lead towards notions of holistic thought (or holistic modelling) as part and parcel of a description of nature. Systems thinking is as well involved with contemporary thermodynamics. Both are worth a brief review.

A main development in thermodynamics - often taken to represent the *sine qua non* of a complete theory - is in the area of irreversible processes. Such processes introduce an arrow of time into the fabric of nature where open systems, non-linear interactions, and fluctuations at far-from-equilibrium states are non-negligible factors in the description of natural processes. Classical thermodynamics conceives irreversibility as a product of error in human measurement, or as a result of the inability of our devices to treat levels of complexity in systems containing large numbers of particles[46]. It is thus considered to be a consequence of ignorance of real physical states. The second law, treating entropy, is taken to be a phenomenal relation, not a statement of some underlying mechanism of actual natural processes. This has changed somewhat with the advent of probabilistic states of quantum phenomena. Probability is not used because of ignorance, but because it is the only adequate account of actual quantum processes.

Given this, work has been done to bring into thermodynamics the idea that probability distributions, and hence irreversibility, is actual in nature. Statistical accounts adopted at the micro scale can be seen as talking about actual descriptions of nature, not as techniques to deal with systems in which we are unable to calculate real individual trajectories of real individual entities that make up the system[47]. Here, the passage of time (and evolution) is a one way process that occurs for only large collections of entities because probability states necessarily involve actually irreversible determiners of those states[48]. Such systems involve more than just point entities, calculable trajectories, and determinable collisions. As mentioned earlier, such classical concepts as simple location, solid matter, and strict causal events do not apply in the new conception of quantum material. The notion of a point entity is an abstraction that no longer satisfies a new understanding of nature. The same is true for trajectories. What does apply is probability locations and uncertainty relations[49]. Density born of collectives is more real than are point pieces of matter (in the same sense, time and evolution of species exist only for collectives). A natural system cannot be treated as a large collection of individual entities since the abstractions that accompany the notion are not adequate to the properties of the world at that scale of analysis.

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As already noted, the classical interpretation of thermodynamics claims that irreversibility (expressed by the notion of entropy) is a consequence of ignorance of the vast number of collisions and trajectories of a system's constituent particles. Though entropy may be practically real, in the lab, and if enough knowledge be had, then any process can be reversed. This new interpretation holds that irreversibility is real, but not universally so. There do exist reversible processes. Indeed, they are commonplace, and the standard interpretation of thermodynamics (where the notion of point entities, trajectories, and causal collisions do apply) is sufficient to treat them with all the generality and determinable precision desired[50]. But there also exist systems in the particular that reveal real irreversibility, and this because of the nature of the complex, non-linear, far-from-equilibrium interactions that obtain in them. When combined with probabilistic relations, irreversible processes create novel and unexpected effects that cannot be reversed or repeated (and which in turn act as a source for possible future novelty and order)[51].

The standard interpretation rests on classical notions of deterministic cause, and the formulation of general laws sufficient to account for all phenomena. But the fact that irreversible processes are real means that there also exist particular cases not covered in principle by the general. Some spontaneity and novelty, unpredictable and unexpected, must be factored into descriptions of nature[52]. At this level holistic notions must come to play an increasing part in attempts to grasp the character of the non-linear or far-from-equilibrium fluctuations. Here, connections within the system are not direct, and small changes can be amplified into unexpectedly large results that move the entire system to some suddenly new ordered state. An analysis of the parts of the system, or of even its constituents, would fail to reveal or suggest the sensitivity to change and response inherent in the processes at work within it. For such systems the past is no necessary indicator of present behaviour, and so any knowledge of a present state - even an infinite amount - is insufficient to predict a subsequent one. Such an impossibility means that not just any initial condition can be chosen in abstraction. Some states are simply impossible to attain from the general case, and hence uniquely particular ones are realisable - there is no necessity that they be deducible from a general theory in order to have a consistent picture of the universe[53]. Therefore a purely theoretical mapping of natural phenomena is not sufficient to account for all that may occur. In particular, the arrow of time is part of the probabilistic and novel character of nature. It is not a matter of the impossibility of calculating arbitrary states of position and direction for constituent parts. The unique and particular case is also part of reality, and to understand this is to require not only abstract theory but an interpretive grasp of what is happening. Holistically organised systems, because they can be novel, and because of the complex interactions that characterize them, do not always support a clear identification of cause and effect. (Neither then are separable the notions of means and ends.) Such a view "does not suppose any fundamental mode of description; each level of description is implied by another and implies the other"[54]. In other words, every part is a whole, and every whole is the part of another whole[55].

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Systems thinking

Similar notions are also suggested by current work in systems thinking, of which irreversible processes forms a part. Some additional main organising ideas in systems thinking need to be highlighted since they develop further the idea of holistic modes of thought, and help provide one way of rethinking the relations between science and society. Much of what follows is indebted to the ideas of Eric Jantsch as expressed in his book *The Self-organizing Universe* (1980).

According to Jantsch, general systems theory began with an emphasis on static equilibrium, and stable or rigid 'structures'. The theory accounts for a wide range of configurations that can remain stable if initial conditions are maintained[56]. Since the initial conditions are those considered requisite for equilibrium, there need be no limit on how long a given state can be maintained. Stable systems (like computer programmes) are necessary for many design processes and the control of complex machinery. Here design and control means that some device or phenomena to be constructed or maintained must be done so as to not degenerate or fluctuate over time. Should there be some deviation from stable conditions, than knowledge must be had that can return the system to its original state. Such control of stable systems is achieved via negative feed-back - providing information or inputs that dampen any change from an original or intended state, and returning it to normal operating conditions that are predictable and determinate[57]. These options were generally applied to 'solid' or 'rigid' systems and their various components[58]. DNA is an example of what is considered a stable system, as is the silicone logic chip used in computers. In both these examples, the spatial structure of the components determines the types of processes that can be accommodated. The system then is seen as a particular spacio-temporal structure, or as a set of components whose relations can be altered in some predictable way, in which the system and its environment are taken as distinct and separate[59].

More recent work in social and biological systems has pointed to the place of non-equilibrium conditions, fluctuations, and positive feed-back in their organisation and creation. Such complex systems are seen as self-organising and self-regulating wherein complex, non-linear interactions occur in a wide variety of ways across a broad range of levels and components. The emphasis is on process and the ways in which order is achieved out of extremely complex interactions at far-from-equilibrium energy exchanges. This has led to a new characterisation of systems as "a set of coherent, evolving, interactive processes which temporarily manifest in globally stable structures that have nothing to do with the equilibrium and solidity of technological structures"[60]. Self-organising systems are interdependent and interactive such that both the 'parts' out of which they are made and their place in an environment are non-linear and partly undifferentiated. The whole system shows ordered properties based on the interactions and the processes of change, not on its material components. Structure exists but not in a rigid form. Structure instead is the result of the ordered interaction of many processes. In such structures there need be no fine line definition of an individual and its environment - both attract connections in interactive ways that make up part of what each is and can become - though there are levels of stability in which specific structures take on specific ordered forms or properties. Such stable levels of order are the individuals or units that may be said to constitute a system. From this particular systems view, living beings exhibit

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structure and behaviour out of the processes that constitute life. Should life cease, then so too will those systems-based phenomena. The process has a reality not apparent in an inert state.

The processes that constitute self-organising systems work to continually renew themselves. This is true both of individuals in a larger system, and of the larger system itself - both of which may be self-organising wholes composed of complex interactions and interrelations. (At some level this process of self renewal is thought to be mirrored in the process of self-reference and the appearance of human consciousness[61].) Self-organising systems exhibit both self-renewal (largely a matter of a restoring interaction that recopies or recycles) and self-transcendence (an interaction that takes the system far from an initial state or boundary). Both are present in a system at far-from-equilibrium, since there exists mutually interdependent interactions among all components of a system, and no two systems are necessarily totally isolated[62]. The emphasis then is on relationships, not individual entities, born of necessarily dynamic interactions. The picture presented in systems thought is of organic patterns, not individual parts, components or pieces out of which something is made (and analysed in turn)[63]. In such organic patterns, and given non-linear interaction (where small changes can produce big effects), there is no determinate chain of single cause and single effect. If a self-organising system 'breaks down' or changes, no one cause can be found to explain what has happened. The cause is complex, systemic, and open (since a system is never isolated at far-from-equilibrium conditions). Causal knowledge of the system through breaking it into its parts, or via an analysis of determinate effects, is not possible.

Self-organising systems present a different model of evolution. In the first instance, given the intimate connectedness of all natural networks and the place of fluctuations and amplification of small changes in the creation of order in complex systems, then random changes can be the cause of the emergence of complex order. This is true for both the micro- and macro-scale universe (the realm of chemical and physical thermodynamic action at the scale of the very small, and the realm of large scale collectives and whole ecologies). In such a situation both are said to co-evolve. It is not the case that the micro systems are subsystems of the larger whole that make up its environment. This is an inner-outer distinction that does not necessarily apply in this example of systems thought. The subsystem and the larger whole both interact and influence such that each creates further conditions for both to evolve[64]. They are aspects of but one process, where life is not a part of an otherwise dead universe. Both bring out life together by evolving together. Prior concepts of evolution posited random and chance events at a molecular level as the beginnings of life, building up by further chance events to more complex, less likely, and more rare forms. Here, complex life forms are seen as those of less likely occurrence at the far end of the tail of the distribution of complexity from the body of the most likely cases - those life forms that are the most simple and preservable because of the chemistry and physics of it all [65]. In a systems view, self-organisation and far-from-equilibrium thermodynamics are factors in evolution, where small fluctuations can be the source of entirely new order. It is not the case that life arises out of blind and sequential random events that produce a plethora of options, only a few of which survive the test of the environment. Instead, the environment too is open to evolution, and both it and the wholes that make it up cooperatively develop together. The creation of evolutionary order out of chance events occurs as does self-organisation out of far-from-equilibrium states[66].

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Evolution (or co-evolution) as well involves cooperation, symbiosis, communication and inter-connectedness. While the view of evolution as necessarily involving the struggle for the survival of the fittest has become commonplace in Western intellectual culture, in systems thought based on principles of self-organization it is not seen as the main pole of evolution. Evolution occurs within a matrix of systems whose dynamics is based on interaction and relation (where competition is but part of the interaction). Evolving systems are made of interconnecting wholes that work together to create the conditions for further evolution of both the individual wholes and the interactions between them (which is also a whole). Some of these interactions work to restore and maintain an organism, a species, or an ecology. Others serve to create new possibilities for organisation and a transcendence of prior boundaries. The complementary play of interactions that both maintain and transcend result in living systems that work in stratified levels of interaction, or stable levels of self-organisation[67]. Such levels come about in far-from-equilibrium states of great complexity - what might otherwise be called random or chaotic states. Each level has a reality of its own, with different modes of interaction, stable processes, or unique relations.

Assuming such multiple levels, and given the human attempt to make sense of them, there is a need to develop whatever language is called for to describe or account for the different levels and types of interaction that obtain and are observed. While each level can be taken on its own as a whole, and hence as an individual, it must also be seen as a part of a larger whole with which it mutually coheres and interacts (it therefore mutually and cooperatively interacts with all other parts). A language of description then will not be some unique and isolated account, but have coherent connections too with other modes of description and analysis. Each system will have properties unique to it, but share interactions that make up a larger whole. While this is a type of hierarchy, it is not a control process but one highly non-linear[68]. Nor is it a 'chain of being'. There is self-determination at each level, but so too deep level systemic relations. No one level will be more fundamental than another, and there is no 'outside' point of view from which the whole in its entirety may be seen as it is in reality - though one level of description (or a combination of interactions) may provide a particularly useful or clarifying perspective from within which the whole may be portrayed and interpreted in some coherent way.

Ethics and science

In systems thinking based on self-organization, these sorts of ideas have implications for the world of human consciousness and social life, as well as ethics and science. The human brain is taken to be a system of extreme complexity and self-organisation. It is made of various biological components, but is also the seat of wide ranging interactions (where both mechanical and organic patterns apply). There is a tendency in systems thought regarding living networks to regard 'mind' not as the opposite of matter but as any "multileveled, integrated pattern of processes leading to dynamic self organisation"[69]. "Mind ... is that quality of self-organisation of the dynamic processes characterizing the system and its relationship with the environment. Mind coordinates the space time structure of matter"[70]. "Mind is self-organization dynamics proper"[71]. At a complex enough level of interaction, consciousness arises, and further to this, some sort of self-awareness, or self-reflexion in which the outer world is made apparent in some symbolic sense to

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an individual mind now freed of the strictly biological/metabolic/physical processes that form a particular stage of evolution. There is also talk that since such mental systems cannot be closed, then the interactions among them as well constitute some form of multilevelled patterns or processes, resulting in another level of self-organisation, or mind - sometimes called collective mentation (or collective consciousness)[72]. Such collectives influence the individual human consciousness that comprise them, and the individuals in turn influence the larger whole. This level of interaction has evolved out of the way the brain itself has evolved over time as a system of embedded levels of organisation (there is talk of three brains within a brain[73]).

However, since the interaction occurs between self-conscious individuals, the evolution of the interaction is one of culture, communication, and representation, not only biology. Still, because of the way systems are interconnected, it is faulty to discount any role for biology. There exist interactions between individuals and society, between culture and nature, and between the individual's self-reflexive consciousness and a world of shared experience and biological history that can contribute back to the character of that self-reflexion, as well as to the way the larger collective experience is understood or interpreted. Because of evolutionary connections wherein the entire history of evolution is preserved and is made apparent in the particular way the brain works, and because out of evolution has come human self-reflexion, then patterns of evolution and patterns of thought are connected in some way. At the level of self-reflexive mind, and in the process of interaction, learning, and development, new levels of complexity are reached, as are new types of organisation and patterns or modes of thought (such as symbolic language, art, music, values, an enhanced awareness of past and future[74]). These are equally expressions of the pattern of nature as well as the patterns of mind, for both have co-evolved over time in some novel way.

If the metabolic processes of evolution reach a stage of self-organization wherein self-reflexion is possible, then individual consciousness enters a different regime. A new rule of evolution is created where a symbolic world appears, and where patterns of experience affect not only how the world is interpreted, but influence what is actually perceived in that world[75]. The self-reflexive mind can remake the metabolic world according to patterns of representation that free it from an only metabolic past. Evolution moves from the metabolic to the sociocultural, with human designs and values taking the lead in a new evolutionary regime.

> It is of great importance here that the processing and organization of information become independent not only of metabolic processes, but also of a direct sensory impact. The self-reflexive mind may now become totally emancipated and set out on its own course of evolution. Mind becomes a creative factor not only in image-forming, but also in the active transformation of outer reality. Reality may be changed by our mental image of the situation, as it may also strongly influence this image from its side. A direct grasp of reality in the way we grasp a solid object is not possible - it emerges only in the experience of mutual, cyclically organized processes[76].

Such levels of complexity and human self-awareness allow for the "inclusion of the past and the future in the direct, alive experience of the present"[77]. If so, the future appears as multivariate and indeterminate in its possibilities.

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> Self-reflexive mentation in its higher stages of development is capable of the symbolic representation not only of the inner world (as already in the self-expression of the organismic mind), but also of the outer world. In this way, the outer world becomes manipulable - first in thoughts, ideas, plans and finally in the direct physical and social reality. With this potential power the technology emerges for enacting this power, physical technology as well as social technology. The newly gained flexibility in the symbolic representation of reality gives the anticipation of the future its full importance. Out of dreams and visions grow plans, out of wishes goals and out of hopes creative action[78].

Such symbolic representation and the creation of a sociocultural existence is part of the evolutionary process of self-organizing systems - systems that have no discernible purpose or telos, but in which organised interactions and new levels of complexity spontaneously and creatively occur. At a level of complexity allowing for self-reflexion, the time-horizon is open to human consciousness wherein a future reality does not yet exist, and which can therefore be influenced or determined by human actions. The evolution of living systems leads to the creation of new, other than biological, sociocultural futures in a world of thought and representation (achievable through the powers of manipulation open to that representation)[79]. Evolution has created the novel, sociocultural world in which humans live, but which they also make and direct, and which has now set off on its own evolutionary course into an open future[80].

Such ideas in science as quantum mechanics, relativity, irreversible processes, and systems thinking contribute to and support the sense that the abstractions of the mechanistic world view and the procedures of reasoning inherent in the naturalistic stance are not the only valid scientific-social-technological approach to knowledge. Science can still be science without remaining strictly committed to the ontology of the machine. This at least opens the way for alternate avenues to kinds of knowledge, beyond the naturalistic, that may too be considered as offering valid accounts of the world. These may then be employed in an attempt to make a more holistic sense of human practice, and in particular the relations between science and society.

The human sciences and mechanism

Introduction

In an article titled *Will Robots Inherit the Earth?* Marvin Minsky(1994) answers in the affirmative "as we engineer replacement bodies and brains using nanotechnology. We will then live longer, possess greater wisdom and enjoy capabilities as yet unimagined." Elsewhere in the article Minsky writes: "Hearts are just clever pumps. Muscles and bones are motors and beams. Digestive systems are chemical reactors. Eventually we will find ways to transplant or replace all these parts"[81]. The author goes on as well to speak of the brain as a machine which, given time and new technology (nanotechnology), could be copied and reconstructed atom by atom, molecule by molecule and thus produce "truly identical parts" to replace those in the brain worn out by aging[82]. The robots referred to in the article's title concern a sort of hybrid creature of man and micro-machine that could be given specific abilities by design, and which result in a definite improvement to human capabilities and the quality of man's social life.

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Minsky's use of images suggests his is an account well rooted in constructs born of the mechanistic view. This is so although his cybernetic theme appears radically modern, and perhaps in a way comfortably familiar to those who see in the progress of science a coming true of the imaginative speculations of an 'enlightenment' type of scientific vision of human and social advancement. For all its surprising or challenging ideas, Minsky's article belongs in the mainstream of scientific thought, indebted to the inheritance of the abstractions born of a naturalistic and still mechanistic stance - although his particular conception of mental functioning posits multiple structures in complex relation[83]. This is particularly so regarding the continuing rise of technology (nanotechnology) as a means of social change and the improvement of the race. Minsky's approach is representative of the point of view that the epistemology of natural science and its procedural reason is a superior approach to not only make sense of man and his social universe, but to improve them. There are, however, other worlds and other epistemologies[84].

It is typical of the human sciences to adopt the same epistemic imperative and the same notion of methodological purity as have developed in the sciences of nature, and by implication a similar ontological view of the world. The way of approach to the knowledge of nature is taken to be intellectually acceptable for all areas and objects of study[85]. It has however at times also been taken as the only respectable approach. No doubt this comes out of the undeniable success of the method of science for establishing secure and reliable knowledge (note Kahane's and Polanyi's views discussed above in chapter one). Given the commitment of the West's intellectual tradition to such knowledge, and its adoption of the naturalistic stance involving the character of reason, then it is not surprising to see such an acceptance of an empirical scientific epistemology as descriptively real of human social life. The implication then is that the status of the real world is given factually through empirical accounts[86].

An alternative example

Many but not all schemes of thought in the sciences of man adopt a disengaged, empirical view. It is the point of this second section to highlight one alternative example to the naturalistic account of how to depict human thought and action - or human social practice. The example comes from the work of Charles Taylor within the broad hermeneutical, or interpretive, tradition. There are many other interpretive frameworks besides those developed by Taylor. Each has its particular strengths and weaknesses[87]. The point to this section is not to survey the range of interpretive frameworks available, nor to give an account of their historical development or overall relation. Neither will an attempt be made to give a critical accounting of the tradition as such, nor of Taylor's works in particular. The intent instead is to look at but one instance that might offer insight (thought not without shortcomings) into a view of reason and knowledge not wholly indebted to empirically inspired accounts. The notion here is not that naturalistic accounts are wholly mistaken. Their weakness is a presumed superiority such that they are considered the only respectable account. If so, they are often inaccurately applied to domains in which their modes of reasoning are not best suited[88].

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The position of Taylor's to be highlighted is that procedural and instrumental accounts need not be the only option for reason to follow when making ontological sense of the human world. In other words, one need not necessarily adopt the assumption that what *is* is to be worked out according to how it is known in detached, empirical terms In addition, the ontology posited in natural science, translated into the human sciences, is not sufficient to account for the world of human experience. This can be exemplified by regarding man as a self-interpreting creature, to whose significance in making sense of human action an empirical account and procedural reason are partly blind. The world is not just an object 'out there' to be studied for what it is - approachable by a single principle of knowledge. The human world and human practice is partly constituted by self-understanding. The position as it will be highlighted shows important implications for the realm of knowledge, action, interpretation and values - the realm of human practice - both with regard to natural scientific accounts and those coming out of the sciences of man. The implications as well point to further considerations for holistic knowledge about science and society, which will be treated in the third section.

Instrumental human science

Martha Nussbaum describes the human sciences as often following, or falling into, two main analyses of social phenomena[89]. In the first, the sciences of man are often pursued as if a type of natural science. The assumption is that the human world is approachable as a world of objects for study, about which empirically rational conclusions are to be constructed as part of a description of a state of affairs as it is. Supposed too - as dealt with at some length in chapter one - is the belief that for such accounts to be available, then research and theory making must be conducted from a disengaged stance, where the abstractions formulated do not depend on some local perspective, individual stance, or a unique state of mind[90]. Nussbaum notes that such scientific knowledge offers hope of finding rational solutions to human-social problems by getting at some truth behind the appearance of things. It is usually taken that in such knowledge, human values and prior commitments play no objective role in research since such considerations are notorious for being closed to inter-subjective agreements, clear conceptual abstraction, and procedural reason - except to the extent they can be operationalized in, say, a survey that establishes correlations among responses dealing with what are considered to be matters of human values[91].

According to Nussbaum, for many this approach appears intolerable, and has led to what is now an alternative but equally entrenched approach to social study and theorising. Here, human self-understandings are to be given their full importance such that any social account must treat them in their richness and variety. This involves a hardy attempt to understand people, their commitments, and their practices according to their own best understanding. A viable accounting of some human realm must thereby involve a representation of a point of view from within that point of view - not from some outside or detached stance. But once the perspective is uncovered as it is understood from within, it also becomes apparent that cross-cultural or cross-perspective judgments are not possible - at least they cannot be made legitimately, without some ethnocentric bias. There is, after all, really no outside point of view in terms of which some objective or coherent ruling can be had. Judgments and criticisms of different perspectives or cultures cannot

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therefore be made from the basis of secure and reliable knowledge since there are no external criteria of absolute assessment. At best there is simply a diversity of views, moral stances, attitudes, or practices worth knowing for what they are and for an appreciation of the richness of human life, but no arguments are possible as to how they might compare. Reasoning that attempts to do so is actually an attempt to demonstrate or rationalize superiority and power. (Furthermore, any actual agreement in values or commitments that is shared by individuals or groups is only a happy coincidence.) In the examination of some society's tradition, no criticism from the outside, using standards that only apply properly elsewhere, can be supported as being rationally based. The tradition or commitment must be taken for what it is as it is; each is constructed out of its own resources and is to be understood using those resources.

However, Nussbaum holds that both these positions - the 'empiricist' and 'relativist' - actually adopt the same view on reasoning. This view accepts that there is a divide between factual accounts and the place of values, such that if one is taken then the other must be made questionable. Such a view is the inheritance of the West's centuries-long commitment to a scientific epistemology when coming to give an account of things (as was discussed at length in chapter one). It takes the natural world to exist in a certain way by positing a neutral material universe in purposeless motion. Meanwhile, the human world of mind and consciousness is one constructed of own ends for own productive gains. By positing such a view judgments of values are separated from the determination of causally related facts. Causal explanation provides a language of neutral descriptions of the actually real. The problem then is to recombine such a neutral descriptive procedure with the actual experience of human attitudes (perhaps described in terms of psychological states) so as to give an account of social life and human commitments[92]. The effort typically ends in the adoption of either the empiricist or relativist account.

Self-interpretation

Charles Taylor has attempted to work out a third position, based on a view of man as a self-interpreting creature. Here, human self-understanding involves a tacit knowledge of who we are as agents of original purpose. As Taylor writes, there does not exist "an adequate description of a human being in respect of his existence which does not incorporate his self-understanding"[93]. In other words, human persons are partly constituted by an own- or self-understanding. We cannot make sense of ourselves fully and lucidly without also recognizing that the way we understand who we are or what we do (in a world communally given) is part of what it means to be a person. It is not possible then to separate out the question of human existence from the workings of self-understanding. Part of that reality is made up of our self-interpretations, and hence, and crucially, as those self-interpretations change then so too does some aspect of our practice [94].

Human purpose and intents are not separate objects 'out there'. A person's knowledge of them forms a different kind of awareness in which human meaning or significance is original and given - not to be deduced or decided out of some instrumental procedure or a simple matter of choice. From this stance there is no question of separating out what a human being is from the expression of his or her hopes, significances, aspirations, fears, etc.[95]. Taylor argues that to be a person is

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not first to obtain to consciousness, to which is then added some derived, representative scheme of understanding into which commitments and values are to be 'bolted on'. In his view, the quality of self-understanding as purposeful or meaningful beings cannot be accounted for by some delineation of ourselves in abstract, representational terms. Humans live in a world of meaning and significance such that to be disengaged from it is only to distort it.

Action

A brief comparison with naturalistic thought is useful here (again, worked out in some detail in the first chapter). Consciousness is distinct from an objective, extended world, and a purposeless movement of the material. Such a consciousness derives from building up out of experience representations or models of that world in the mind. To make sense of that world one must attain to clear and distinct ideas of what it is and what it is not. In science this can be accomplished by concept formation that provides a non-relative, disengaged stance for descriptive and explanatory content, rational accounting, and instrumental thinking. From such a stance a human person is one to whom the world is given in representative consciousness that is particularly adept at learning, performance, and survival. This in part requires prediction, control, and manipulation, and so too therefore the ability to plan and to act on the basis of plans. These plans and actions are based on the formation of clear-cut procedures and performance criteria for success in achieving goals. Such procedures and performances make up human intelligence. The better they are, the higher the intelligence, and the more successful the outcome. What makes humans distinct then is an ability to formulate rational decision procedures and strategic plans, and so accomplish whatever end might be desired - chosen by the individual himself through his own representative consciousness or given naturally as some component of evolutionary survival or reproduction[96].

From Taylor's stance, actions and purpose are not separable. It is not the case that on the one hand we have a set of abilities and performance capacities available to the human species, and on the other some set of possible goal states achievable by an intelligent use of those abilities. When it comes to man as a self-interpreting creature, the world does not decompose into such divisions. There is no ontological separation between action and purpose. Emotions, moral agency, are not 'out there' like some natural resource. How we deal with them, how we act in regard to them, are partly decided, partly known, and partly constituted by the quality of understanding of what they are in their meaning for us. Human awareness is of a reflexive sort - not representative but direct and tacit[97]. Meaning is constituted by human practice in a world open to interpretation. The distinction then for a person who is partly constituted by self-understanding is that he or she be sensitive to original purposes and meaning as given in a world of thought and action - itself partly constitutive by a person's self-interpretation. The requirement then is not the ability to achieve own productive purposes, but to be sensitive to, to be open to, to try to make more interpretive sense of the peculiarly central practices in which inhere human significance[98].

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Consciousness and significance

Taylor is at pains to emphasize that the difference is not that human life can be described in the characteristics of some clear and distinct human consciousness (be it either a system or mechanical reckoning), but that to human persons things have direct significance. To make sense of such significance an interpretive understanding is required. It is not a matter of grasping something out there, but of bringing to light aspects of meaning and significance that are at best only partly grasped. There is no completed or absolute portrayal or presentation (sometimes termed articulation) of human significance. As agents of self-understanding, what is true about us is partly constituted by the understanding we have, such that as our understanding changes then so too is transformed what it is about ourselves we are trying to understand. The point then is to achieve some clarity of the significance something has for us - a significance we cannot not avoid - but which is always partly tacit, incomplete, or symbolic. Such a tracing out of significance is shown up in human practice, where that practice expresses what it is we are trying to interpret even as its interpretation can change the quality of the practice. Here there is no absolute descriptive content to explanations and descriptions. The intent instead is to articulate an account that helps clarify some awareness of meaning or purpose as is shown in human practice - to offer an articulate view of ourselves and our world that presents itself in some coherent way. To have 'consciousness' in this human sense is to point at that which we attain when we come to formulate the significance of things for ourselves[98]. It brings to light what was only partly or confusedly understood or appreciated before, and which cannot but involve additional re-interpretation[99].

Explanation

Such views as Taylor's may be questioned on the basis of secure and reliable knowledge as is had in the empirical sciences. Does not talk of 'original purposes' really account for nothing except that language can be used to paint some incomplete picture of the human enigma? When compared to the explanatory and predictive accounts available to science what more needs to be described? However, the assumption here is that a mechanistic explanation is what is meant by explanation - that any other approach is an exercise in non-explanation by missing the point. From this stance we can account for all that is - not just the material universe but also human behaviour and consciousness - in terms of physics and chemistry, and the derived sciences of neurology and physiology. Such scientific accounts will perforce be mechanistic in inspiration, and will lead to an increase in the human ability to control, manipulate, fabricate, plan, and act. Accounts not based on mechanistic principles - accounts that take phenomena as presented and for what they appear to be - is to stop short of all deep level understandings of the workings of things. This view is bolstered by the assumption that in a neutral universe, where matter is in endless, purposeless motion, a satisfactory account must not involve (avoid and do away with) language of purpose and meaning. The search is for causal explanations that are mechanical in explanatory detail and ultimately material as concerns the status of objects under study[100]. Anthropocentric accounts are but part of the projection of subjects, not part of a world inter-subjectively real. They at best provide vague, halting, descriptions ending in dissimulation.

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The success of the scientific project makes this a substantive objection - although it suffers some from a myopic view that tends to see the scientific stance as providing the only respectable explanation of things. However, Taylor insists that some comparison here must be made with ordinary descriptive expressions. Humans have been talking about themselves and their world for ages, and such talk is always, in part, purposeful and meaningful - described in terms of desire, aims, wishes, etc. As regards purpose, action is (can often be) portrayed in terms of what aim the action is intended to achieve. When the purposes are sufficiently clear we have an explanatory account at the level of the everyday. No more than this is expected in such accounts, but that they speak to the goals, feelings, desires of the person intended. Relating some behaviour to the purposes behind it, where it holds out some significance for a person, constitutes an explanation *for* self-understanding subjects because as agents they dwell in the same meaning domains as that *of* the self and world whose interpretive account is the focus of explanation.

On this account, explanation is the process of filling in the context of purpose or meaning relations that make up a person's interpretations of self and world[101]. Apparently, the point Taylor is trying to make here is that such accounts, based on purpose and meaning-giving fields of action, are in fact causal, non-mechanical explanations of action through the articulation of coherent purpose and meaning. In the realm of beings for whom the world and self is partly constituted by self-understanding, actions are about purpose and meaning, and their articulation can give a satisfactory causal explanation. There is no need to separate out the phenomena from the mechanisms working behind it. If persons are creatures of original significance, then it makes no sense to offer causal explanations that in fact explain away that significance[102].

The hold of the naturalistic stance is quite strong, and many adopt it as valid. However, while we might be mistaken some of the time, Taylor argues that it is a sort of *reductio ad absurdum* to presume that all ordinary talk based on self-interpretation is ultimately nonsense, and has always been so[103]. Our best understanding of ourselves cannot support the contention that we are deep down just a host of cortex firings, perceptual influxes, and neurological feed-backs[104]. Taylor argues that a richer ontology is required, for him based on significance, to make sense of all that a human person is or can be. This richer ontology is that posited in original human meaning[105].

[This sets up a main difference between an interpretive account, compared to one based on irreducible fact and rational reconstruction. Human goals, aspirations, intents, emotions, and purposes are real and moving. Self-lucidity does exist, and it serves to change a person's self-understanding. However, it is not a matter of simply choosing for oneself some interpretation according to own desires. An error in self-understanding is not a matter of using wrong words to describe how a self feels. Self-clarity is not a matter of internal self-consistency, nor does it flow from personal tastes, whims, or desires. Some goals and acts have an inescapable claim on a person such that were one to cease attending to them, then there could only be a falling into confusion about oneself and world. If so, then the norms of the naturalistic model cannot apply. Empirical social science entertains a host of abstractions that cannot make full sense of human experience because it does not recognize a world of meaning-giving practice available to humans in an original sense and where the norm of explanation is in providing a gain in meaning[106].]

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Language

Much of Taylor's position, as is so for all interpretive frameworks, involves the way language articulates or expresses a person's self-understanding. As noted in the first chapter, the naturalistic stance tended to base a notion of language on the way the objective world is represented to consciousness through the formation of universals. Via abstraction, clear and distinct mental images - units of representation - are formed, to which names are given, the meaning of which is the 'object' of perception or abstraction designated by the term. Thinking is the process of mental discourse whereby we assemble and manipulate ideas in some clear-cut manner, and so build up for ourselves some sensible scheme representative of the observed world. Language (via syntax) then becomes a tool for the manipulation of ideas and the formulation of schemes of thought that model in the realm of mind processes in the objective world. Syntax keeps ideas in distinct order, and provide for complex chains of reasoning that can be made explicit, corrected, and codified. Language is used to designate and govern the formation of evident, explicit representations of the world in the realm of mind - so that control, manipulation, fabrication, planning and action of either thoughts or deeds is made humanly possible[107].

As just noted, Taylor thinks the distinctly human capacities do not involve only the ability to make strategic plans for manipulation and control. They also involve how we assess our sensitivity to certain significances that make up the peculiarly human goals[108]. If so, our capacity as humans is a matter of being open to what meaning and purpose is to be had in our human practice - to seeking them out and making clearer sense of them. It is through reflexive awareness that we attain to the articulation of these capacities. Here, such awareness and a language of articulation form a medium of signification, where language is used to help uncover or articulate - to express in real terms - not only our self-understandings but also our world[109]. But in so using language we as well speak out the reflexive awareness implicit in language that says something about ourselves. Each turns on the other. Reflexive awareness is not 'in here', meaning 'out there', and language a correspondence between the two. Neither is it a tool of 'authentic' expression. Since we are partly constituted by self-understanding, such that to become articulate about ourselves is to change something about who we are, then both our best understandings of a meaning-filled practice, and what we actually are or become (which is an ontology other than that posited in the natural sciences), cannot be separate from a medium of language.

One consequence of this, according to Taylor, is that we need the whole of language to express our self-interpretation and to realize our world. There is here a circle of interpretation, transformation, and reinterpretation (or expression, awareness, re-expression) where the whole is never fully to be made explicit. It is always being transformed as it is being understood, and each affects the other in turn. Although the whole meaning is never to be fully expressed, it cannot be compartmentalised from other meaning relations. The whole field of meaning relations, embedded in culture, realized and made reflexively aware in the language of expression, are needed to articulate any particular aspect of meaning or world. In other words, it is through the whole that any particular sense is to be made of world and self. The language of a particular self-interpretation serves to express and realize an entire way of being, while a particular awareness or

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realization of who we are calls upon the entirety of language to express it[110]. No one interpretation can claim finality. Indeed, the notion of certain fact beyond further judgment is an import from empirical scientific abstractions and the ontology of the machine, and can here only be used with equivocation.

Reasoning

From the point of view of a disengaged understanding, reason provides the liberty to select or to design a host of actions within a world of neutral resources. Disengagement from the parochial, and clarity of thought and action in a neutral universe, offer the self-defining subject (as opposed to a self-interpreting person) a place to stand on outside the enigma of experience, and a way of reasoning things out beyond their appearances down to a level of clear and evident understanding. Taylor argues that such reasoning seeks to uncover the foundational ideas behind an argument or position. It separates the various inferences drawn from out the basic premises hidden behind the complex chain of ideas making up some stance (or theory) - a stance perhaps at first only indistinctly perceived. The task of reasoning from such a platform is to make fully explicit all avenues of thought and implication making up a position, and so uncover the essentials of the argument. It is at the level of basic ideas, exposed in a full and responsible analysis, that debates about validity are to be held[111]. Personal or private attitudes and beliefs cannot be brought forth to adjudicate knowledge claims. In a world made of objective processes, the test of nature secures the logic of single-valuational propositions open to inter-subjective judgment through their clear and distinct analysis.

Taylor attempts to offer a different set of implications for rational thought - at least as it involves the status of human persons. In the first instance, there is no 'outside' stance, no platform from which the world as objective process can be surveyed from a disengaged perspective, since humans are agents who are partly constituted by self-understanding. The attempt to come to clarity about peculiarly human significances is never able to be completed, never static. Obviously then, there are no external criteria in terms of which rival positions are to be judged in absolute terms, one being superior. The rationality of such accounts relies on interpretations of purpose and meaning for agents of self-understanding from positions that already assume much and are only partially open to expression. Reasoning here involves an articulation of some field of meaning so that a more coherent grasp of that field is made possible. It involves a gain in clarity - not an absolute demonstration of what is and is not the case - from what is an already interpreted stance. For Taylor, the point then is to offer a reinterpretation that can arguably provide a more coherent self or world than what was had before[112].

For example, an interpretation of a field of meaning relations brings to light some new realization. How well has it been expressed? To what extent does it cohere with previous articulations in similar fields of meaning? What implications can be drawn from the new meanings adumbrated in it? How do these affect neighbouring fields? What new realizations does it offer? Can we find meaning relations in them that link with the first and help illumine it further? Crucially, in what ways might human practice be affected, or are likely to be affected? What are the consequences of

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this? Can they be regarded as a gain in the human capacity to be open to crucial human significances? How might such a change in practice lead to further reinterpretations? Do they hold out some promise for a more illuminating understanding? In the end, does the new understanding arguably provide a gain in coherent self-understanding compared to what was had before?

Such are the general sort of questions that might be asked in reasoning - in an attempt to argue out, analyse, discuss some or another proposed interpretation of self and world. The questions of course are not those that would be posed in some empirical study in the human sciences, but this is because the objects analysable in terms of instrumental reason are unlike those posited in an account based in some interpretative framework. Clearly, such an interpretive stance makes no distinction between means of action and the purpose to the action. Purpose and action are not ontologically separable for persons of original significance. The purpose and the action cohere in meaning-giving practice. The rationality of self-understanding is bound to the way in which language is used to express the interrelation between awareness or realization, and self-interpretation that allows the one to transform the other, and so in return.

Finally, if to be human is in part to be persons of original significance, then coming to know who we are is not different from what we do. Reasoning then inherently involves some kind of moral deliberation - or practical reason. Here, there is no necessary inner-outer distinction, no mean-ends analysis or the calculation of utility. Human persons are present to themselves as given in an already-at-hand world of communal significance. Reason then must start at the given person in his or her culturally embedded field of meaning-with-significance. Moral deliberation then involves seeking out the meaning-with-significance, so as to make it as lucid as possible, and to offer some other account, or the illumination of some error, that might lead to a gain in self-clarity. It thereby involves a change in view as to the meaning and significance of some practice, and hence, becoming more lucid about some level of moral self-understanding[113].

Taylor's approach provides one example of an articulation of human practice not reliant on a naturalistic rendering of fact, using language as a tool of designation, and instrumental reason as the basis of explanation. However, an interpretive account is not based on the use of language as an expressive tool of human feeling. It provides instead an entire way of being-with-meaning in the world, where action and reason are bound up with a whole sense of self and world partly constituted by meaningful practice. It provides a way of thought that follows neither the course of demonstrable reason, nor the adoption of relativity in judgments with respect to human values. It as well provides one way of thinking about the realm of persons that connects aspects of meaning and purpose with the very character of human existence. In so doing it helps to rethink the assumptions of a naturalistic stance and the world view of the machine, which abstracts meaning from the world as an objective process. It thereby provides one example of a holistic approach to human practice. The next, and final, section will return to this notion of human practice, as well to the notion of living systems as self-organizing wholes, in an attempt to make a more holistic sense of the way science and society may be conceived to relate.

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Science and social values

Introduction

As noted in chapter two, the institutions of science - both natural and human - have a strong investment in the epistemic imperative, and in the goal of methodological purity. As a result science is often taken to provide knowledge claims from a disengaged stance, typically described as neutral and free of unwarranted values. Given its strong commitment to research based on the use of abstractions considered universally available, the institution of science is thereby a value free enterprise, *in* but not *of* society, one not based on prior social values or commitments - save those required for a rational study of the natural and social world as they are. (Alternatively, science is seen as the producer of knowledge as capital for trade in a society based on exchange relations, and from a variety of knowledge production sites.) Scientific reasoning is often held to be a powerful tool for strategic planning, research design, or the fabrication of goods and information, but must remain silent on the ends of action since these are based on the play of human values and emotions not open to scientific analysis.

This third section will take a brief look, following upon the work of the second chapter and the first two sections of the third, at the assumption that science has a claim to be a neutral and value free institution, in but not of society. The attempt will be to see how such a view can be countered by a more holistic approach - namely from the systems view based on self-organization and from an interpretive framework. This topic is particularly complicated. Many differing views exist. As before, specific examples only will be highlighted so as to suggest a holistic approach.

A systems account

A brief revision of pertinent ideas is useful here. As noted in the first section, a view based on self-organized systems portrays (some) phenomena as complex interrelations among interactive wholes making up a system, which is itself a whole. The analysis of either its constituents, or the system in an inert state, may not reveal the properties that make up interactive processes. When applied to the evolution of living systems, an account based on self-organization provides for the central and complementary role of conservation and regeneration on the one hand, and novelty and openness to new and unpredictable order on the other. Evolving systems are self-organizing wholes that interact with a vast range of other systems - molecular, metabolic, genetic, ecological, social-biological. The process of self-organization is a dynamic, richly orchestrated connectedness that develops into and through a historically acting, multileveled organic process in which both the material and the biological are said to co-evolve. Life arises out of the dynamics and energy of interaction, not out of inert matter populating a universe moved by blind chance.

Evolutionary and collective biological processes have worked over time to self-organize and create intricate levels of interaction. In this regime, both micro-scale and macro-scale processes are mutually at work, involving chemical and physical self-organization, and the creation of whole ecologies. In this systems view, self-reflexive mind, and the resulting human individual, has been

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created by such organic events. Yet the interactions that appear at this level are neither chemical nor physical - they are not material in this sense, but conscious. The collective biological world (out of which mind has come) becomes secondary to sociocultural evolution powered by self-reflexive mind and human individuality in collective interaction. In such a view the sociocultural reality becomes central to further development. Human cultures and societies become shaped by the mind, its technological forms, and the human commitment to values.

At this level interactions between community values, knowledge structures, and social institutions come to the fore in human evolution. Obviously, this involves the relation between science and society. These systems are the creation of conscious minds through open communication and symbolic representation (not all of which is at a fully aware level). Out of the plans, hopes, and dreams of individuals come the larger systems of community values and knowledge structures with which they cohere (or fail to cohere), and which in turn affect the lives of individuals. Civilizations and sciences have appeared from this complex evolutionary interaction.

> Ideas, plans, world views and ideologies include values or whole value systems which may now enter exchange processes ... At the level of self-reflexion, values are frozen into their structures to a much lesser extent than they are at the level of feelings ... The autopoetic [self-renewing] structures of self-reflexive mind - the single ideas, plans, visions as well as the macrostructues of religions and ideologies - regulate the life and evolution of our societal macrosystems. As individuals we live, so to speak, in *co-evolution with ourselves*, with our own mental products[114].

Since the human mind is the source of sociocultural life, it also must take on responsibility for the world it helps recreate and to which it is related. Such a world is made of a variety of levels of interaction and complexity, including the biological and ecological - it is a multilevelled reality all of which work in ways that are interconnected and non-linear. Communal concerns, and the place of human values as part of an evolutionary process, cannot be ignored by individuals freed from an only metabolic regime. In such systems thinking this freedom does not support the contention that 'I exist' in here, and 'the world' is out there. A systems view such as this supports complementary interconnections and interaction, not their separation[115].

Looking at evolutionary trends, Eric Jantsch (1980) suggests there can be seen a three fold direction to the process of self-organizing systems, but recognizable only after the fact (since evolution is an open process). First, evolution leads to an intensification of life. An awareness of past evolution and the anticipation of future possibilities "vibrates in the present"[116]. There is an intensity of awareness that connects what humans have become with what might yet be achieved, and which gives to life a realness in the present. Second, the fact that we come from a diverse phylogenetic past, but that the future is an open system together suggests a rich potential of possible life structures. These can be made real in a sort of cyclic dance joining an opening up to the future with a linking back to the past. Here, each form of individual and sociocultural life is the summary of the whole of its evolution, but which must remain open to future change, new possibilities, new ways of evolutionary action. Third, the universe is becoming more self-reflexive or self-knowing. The rise of consciousness that can look back into past time and anticipate future existence makes it possible to view the total process of evolution in the experience of the present.

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Humans have become aware of the way evolution acts in holistic ways; that to be human is to be part of that process, and that it is acting 'within' us as a part of who we are. This means that humans have the ability to first, observe the process of evolution as a process in the world, second, that we can think, plan, and act in such a way as to manoeuvre and guide our future evolution (now sociocultural) along that process, and third, that we can see ourselves in our actions as being part and parcel of evolution that has made us who we have become and what we will become[117].

This triple sense of man in his connectedness to the process of becoming means that his own self and cultural history must be integral to the way he understands human society. The realm of sociocultural life becomes a self-organizing whole consisting of non-linear connections among diverse multiple levels - law, tradition, art, state-craft, science at institutional levels; emotions, ideas, values, reason at the level of individuals. As a complex system, man's sociocultural life posits structures of great creativity, novelty and fluctuation that must be complemented by processes of regeneration and conservation[118]. At the 'top' of such structures are to be found an openness to evolutionary possibilities and creative futures, invested in part in values, value systems and the institutions that provide for their effect in the sociocultural world. At their 'bottom' are the stable, reinforcing, regenerating aspects of life - structures for the manufacture and distribution of energy, food, transportation, communication, etc.

If so, then views portraying science as existing *in* but not *of* society, (detached with respect to the knowledge it provides) tend to short-circuit, as it were, the actual interconnections that obtain in society as an interactive whole. There is much innovation in both science and technology, but this works largely at the bottom of the sociocultural process. Indeed, they are often seen as providing the means to invent new technology or to advance an existing social-industrial system. To the extent that its relation to society as a whole is seen primarily as a provider of rational means and neutral tools, but having nothing in principle to contribute to the *problematique* of human values, then science tends toward the conserving and maintaining interactions, not those that open up possible futures for human life. This is not at all to hold that science fails to provide secure and reliable knowledge, nor that its method is not right and rational. The claim instead is that first, such knowledge is at best partial and incomplete as concerns the human and sociocultural world, and second, may thereby fail to do justice to the nature of holistic systems and the appearance of levels of reality based on interactions not present in compartmentalized schemes of thought[119]. Here, 'innovation' at the level of values is taken to be something about which science and technology are presumed to have little or nothing to say[120]. Of course, the institution of science has played a vital role in providing a wealth of knowledge and technique for the control of nature and the construction of society. The epistemic imperative pursued in the project of science has as well given to the search for truth its high water mark as a goal vital to the life of society. Nevertheless, from the view of self-organizing systems humans must assume responsibility for acting with evolution, now primarily sociocultural; for making choices and enacting them in such a way as to enhance evolution towards an open future. Hence, ways need to be found that enhance the living out of the evolutionary process - a process necessarily involving man and his history as part of what has become the forefront of the co-evolution of life.

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Evolutionary planning

According to Jantsch, multileveled planning is needed for lived action. Planning is ethical, not just rational or scientific[121]. The responsibility for acting with evolution involves doing, creating, becoming. Should this result in behaviour that enhances an opening up to evolutionary futures, then such conduct is ethical. Different levels of interaction involve modes of action that enhance evolution. Hence, no one depiction of ethical behaviour will suffice. At the level of sociocultural life, ethical debate cannot be limited to but one, or even a few, levels of interaction. Hence, value considerations need to involve more than matters of self-preservation and how the survival of the fittest might dictate human responses to the environment. They are other than attempts to ground human values on a genetics, as may be argued from a Darwinian stance, and include more than desires based on food, sex, pleasure, and the avoidance of pain. Such considerations tend to focus on the metabolic regime of evolution. Given the human ability to view both the past and the future in an active present, choices and values must be alert to the workings of the whole system[122].

Jantsch also highlights main aspects of planning towards an open future - or process planning. Such planning involves an interplay of manipulative, strategic, and valuational levels based on time horizons and modes of thought. A summary of the main ideas is as follows[123]:

Level of reality	Level of planning	Time horizon	Logic	Organi. & management	Basic attitude	Levels of description
Values						
	Policy	Long-range	Evolutionary: dynamics of whole systems in context	Catalysing social processes and novelty	Evolving (being the stream)	Interrelation between structure, function, and fluctuation
Policy (system dynamics)						
Social functions	Strategy	Medium-range	Mutual-causal: structuring relations in a system for viability	Maintaining survival	Mytho-logical (steering in the stream)	Relating structure and function
Tactical targets: (products, services)	Tactics	Short-range	Linear-causal: reaching targets	Production, mechanisms, and control	Rational problem solving (observing the stream)	Structuring
Resources (people, knowledge, materials, energy, etc)						

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According to Jantsch, "In this kind of open ended planning, as in all open evolution, the purpose is not waiting at the end of a path into the future, but is immanent in the process itself. Knowing is ultimately possible by doing. Planning, in this view, imposes new rules upon sociocultural dynamics and thus gives rise to the self-generation of new patterns"[124]. One main point Jantsch is trying to make here is that since future pathways of evolution are unknown, and cannot in principle be anticipated, then the only way we can know evolution is by getting involved in acting out evolution - something which is consciously possible in the realm of the sociocultural. In open systems, it is practice that brings out further knowledge of their state. The end toward which evolution moves is instead to be found within an active present. It does not exist 'out there' waiting for us to reach it. The end of action and the action itself are part and parcel of one process. Such a view presents in a different light the relation between knowledge as means and the ends of action, taken to be based on values, and hence long standing attitudes about the role of science in society[125].

The absence of an end state 'out there' has definite implications for the distinctions typically made between means and ends, and which reflects back to the contradiction in modern thought between a neutral universe and a realm of human values, and the way the institution of science is conceived to act in society. There are a variety of ways of pointing to what effects the positing of an 'immanent end' has on the means-ends division. A few of these will be mentioned, in an order progressing away from the classical position. First, 'immanent ends' suggests that every means is an end, and every ends the means to another end. There is more to action than a choosing of ends, and a calculation of means. Not only is action a connected chain, but each 'means' and each 'end' can launch ideas, plans and action along a host of possible directions. There is a compactness to action - a spreading out as does a spectrum instead of discrete steps - that the terms 'means' and 'ends' only belie. Second, there is no such thing as 'only action' and 'unitary end'. Action takes you somewhere, as it were, and so what is required to realise it is termed a means. But given the compactness of action, progress along the way also accomplishes something - there is not just one end to be realised. Action opens up a multitude of possibilities for affecting others. The terms means and ends do not signify trajectories for action - they at best can suggest a marking off of progress, and this only in subtly changing progression. Third, it is artificial to say 'here are a set of means, there is what I want to achieve', and then be single minded about a course of action (a trajectory). Not only will many other things be accomplished along the way, but what is called for is not that some end be completed, but that directed movement be taken. It is the action that is called for, not some final delivery of a well defined, 'encompassable' end state. Fourth, it is often mistaken to distinguish a linear means-ends analysis of consequential action. There are multiply connected effects in what we do, what we want to do, how we see ourselves as we do it, and how others see us and respond. Taking action initiates consequences from the start, and these cannot be categorized before the act. They may be such as to bring about change in the intent of a person, in the context of the field of action, and in relations with others - any or all of which act upon the judging, interpreting, or valuating of the action-in-progress, and changing it in turn. Fifth, and lastly, knowledge of what can only be loosely termed means and ends reflects back to the three types of human relation with evolution: that it can be observed and analysed from an outside, disengaged stance, that of manoeuvring and controlling human actions in the process of moving

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along the evolutionary stream, and that of attaining to an awareness of being part and parcel of the evolving process. The distinction between means and ends is usually taken from the stance of the first type of knowledge. This is where instrumental reason comes to the fore. However, as was noted earlier knowledge of open systems can only be had in the course of their being enacted, and so acting within and being a part of evolutionary development is key to grasping unavoidably important aspects of acting in the world. The end is in the doing.

Given this range of views regarding immanent ends and problem solving, then the value placed on scientific institutions as providing secure and reliable knowledge for the control and fabrication of distinctly achievable ends is at best but part of understanding the relation between science and society. At its worst it can partly blind modes of thought about scientific knowledge and the project of science. Relations to the whole, to the importance of human values, and the place of man and history in making sense of science and society all remain obscure or obliquely conceived where knowledge and the institutions that produce it are mainly understood either as distinct neutral means in a value free project, or as information capital to be traded in a social exchange.

An interpretive account

The systems view based on self-organization offers a substitute rendering to the idea that the institution of science is in but not of society, or that it is primarily involved in the production of knowledge capital for exchange purposes. However, the systems view does take on certain assumptions that can be traced back to the origins of modern science, and which invest it with characteristics that remain naturalistic. (This is not surprising since systems thinking has come out of the fields of thermodynamics, biology, and ecology in the natural sciences.) The emphasis on representative consciousness in the mind's attempt to make symbolic sense of experience is one case in point, as is the emphasis on consciousness *per se* as the defining characteristic of human life. Another is the assumption that man is self-defining, his world open to control, manipulation, and fabrication for own productive purposes. While the theory of systems supports the use of multiple descriptions of a multileveled reality, the language of systems theorizing is often couched in abstractions inherited from the natural sciences, and so tends towards a naturalistic, even though not wholly materialistic, account of man and the universe. This gives to such systems accounts a certain indebtedness to the notion that what something is must be worked out in terms of how it is known - an emphasis on epistemology in coming to terms with what exists. In the systems view, there remains a certain separation between values and knowledge in the sense that values must be chosen and imported into a world view (to be freely created by representative consciousness in sociocultural life), while knowledge must be built up out of the experience of evolution. The positing of a free individual who can make his or her own (sociocultural) world for own ends is a further inheritance of the naturalistic stance.

Accounts based on interpretive frameworks tend to call into question these naturalistic precepts, and provide another way of thinking about the relation between science and society which in its own way can be called holistic. Different implications obtain for the way the relation between science and society may be understood. The following pages in this third section will attempt to

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accent what some of these might be[126]. The argument here will begin with a comparative look at an interpretive account of social phenomena, and the view of human sciences modelled after the epistemic imperative and notions of methodological purity. This will lead by implication to a review of both what the human sciences are and what the project of science in society might be.

Fact and meaning

Much of the human sciences rests on the study of irreducible fact, with which some explanatory theory is co-developed. In other words, the objects of a study must not be open to a change or shift in definition depending on how they are considered. From an empiricist approach, knowledge of the social and human world must be a rational reconstruction from experience such that one can say what is and what is not the case about some phenomena. In turn, the goal of methodological purity works to ensure that the path to such knowledge is traversed according to established criteria for valid research and theory formation[127]. Language then is used to frame terms distinctly, to provide a clear description of data, to designate precisely the various correlations the data supports, and to offer a structure of closely reasoned propositions that provide for a fairly definitive account of both what is observed and its explanation. Hence, if, in the language of description, differences of conception arise, the dispute is settled by turning to irreducible fact.

As noted in the prior section, in interpretive frameworks the world of human action and social conduct does not decompose into factual objects of empirical research. The field of study is instead made of human persons living normal lives, understanding themselves and others, acting with meaning, and being attentive to the meaningful acts of others with whom they relate. It is a "pre-interpreted domain in which processes of understanding and interpretation take place as a routine part of the everyday lives of the individuals who, in part, make up this domain"[128]. In such a domain significant acts take place, crises of understanding and misunderstanding daily occur, and symbolic forms convey a host of senses to things, uttered (or otherwise produced) by someone and for someone[129]. Taylor holds that to make sense of some act or utterance is to replace what was a confused, partly erroneous, or inexplicit reading with one more lucid, and so achieve a gain in understanding and self-clarity[130]. This in turn lends a new sense to the quality of some practice and to the meanings it might have (but may also throw into confusion some other field of meaning)[131]. In such a view the kind of knowledge had in interpretive accounts comes from gains in coherence, not absolute judgments, as in the naturalistic stance[132].

Social practice

Social scientific theorizing is generally assumed to provide a description of some aspect of the human world. It does so by providing a platform for making explanatory claims about social behaviour, while avoiding the error of proffering any judgments of that behaviour. In an interpretive account such as Taylor's, based on human meaning, social theory is social practice. A theory offers a rendering of some social phenomena. But obviously the theory does not merely stand above the phenomena in some 'meta-phenomenal' realm. It is understood, debated, publicized, read. It comes to the understanding of people for whom human action is

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meaning-filled. Hence, gains in self-understanding may thereby involve coming to terms with the ideas of the theory. Taylor argues that it can enter the field of communal meaning relations in which interpretation and practice are united. Some future action is thereby conditioned by the way the theory has come to be understood[133]. In other words, the theory changes the practice of the phenomena it was intended to explain. In accounts such as Taylor's, it is not possible to divorce *a priori* some proffered theoretical model from changes in purposeful human conduct. Not only is it not possible, there is no good reason to think it worthwhile since human practice is partly constituted by self-understanding. It makes no sense to try to formulate a 'stand alone' theory that offers an explanation of human conduct in such a way that it has nothing to do with actual social phenomena. And if a theory does offer illuminating ideas or insightful accounts of what is going on, then who would not anticipate that it might provide grounds for a more successful human practice, and should thus be tried? Indeed, part of the test of such a theory is to see what comes from the way it has informed practice[134].

If so, such a conclusion brings to light the connection (unavoidable, according to Taylor) between what social scientists, and the institutions of social science, do and the place of human knowledge for agents involved in a self-interpretive social practice. Because of this neither a particular social theory nor the institution of science can be neutral. In the first instance, a theory cannot be neutral in the sense of being disengaged from the object field of study - a standing back from the phenomena under question so to see it in its factually correct light. In the second, institutions of social science cannot be neutral in the sense of not being involved in the evaluation of human goals, about which instrumental reason is often believed to have nothing intrinsic to say. From this stance, social science is part of a world in which symbolic forms convey meaning and influence the significance things have for persons, since both the knowledge it produces and the very fact that it has a social existence are part and parcel of human interpretive practice. (The same is true of the institution of natural science, to the extent that it is part of a social world.)

Structured contexts

In addition, since science is a human institution (as is technological development) it embodies a host of symbolic forms that convey meaning in structured social contexts, and hence, constitute historically embedded cultural phenomena[135]. John Thompson (1990) discusses the character of such symbolic forms[136]. Thompson argues that symbolic forms may be objects, actions, gestures, texts, or text analogues that convey meaning. They say something about something for someone. But meaning is not conveyed by a single act or in a single text. Meaning is conveyed in structured social contexts out of which coherence is to be found (or not). Inquiry then offers a reinterpretation of symbolic forms in what is already understood as part of a larger process of a situated self-understanding. But structured social contexts do not come from nowhere, neither do symbolic forms. There is a history to their development which, if ignored, can only lead to a lack of clarity about the meanings conveyed. If sense is to be had, then inquiry must attend to a social-historical analysis of the way in which meanings have come to be expressed in structured social contexts. Besides this, Thompson holds that symbolic forms themselves have a structure that requires careful consideration before one can say this set of symbolic form conveys these

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meanings in this way. The structures of social contexts, historically and culturally situated, and the meanings and structures of symbolic forms both are closely connected. Interpretation brings to light some of these connections. It involves the explication and elaboration of symbolic forms and their possible meanings, and relates them back to the already interpreted meaning they have for people in the context of a history and culture which is a precondition for their meanings to be conveyed. In so doing further realizations may be developed, and these may affect practice in turn.

Such a form of inquiry definitely applies to science as an institution, where its historical development sets up structured social contexts, and where a host of symbolic forms convey meanings about science (and technology) to people who have an already interpreted sense of that context and those meanings. However, the meanings such contexts and symbolic forms convey may not be innocuous. Thompson argues that meaning may serve to establish and sustain asymmetrical relations of domination. Symbolic forms may then serve to mobilize meaning in the service of power[137]. Interpretation may be able to highlight or uncover the way such meaning is mobilized in structured social contexts, and among people who actively receive, incorporate, and appraise them in their lives. Language is used, relations are established, actions are conditioned, and, intentional or not, these may serve the purpose of some over others. As an institution, science is not immune from such mobilization of meanings. The claim here is not that science necessarily employs meaning in the service of power. This can be decided only after careful study in specific situations based on a historical and cultural analysis. The point is that science is a human institution unavoidably connected to society and having a historical development active in current practice. It is impossible to make sense of science as if it were an isolated phenomena, in but not of society. This means that it plays a part in creating structured social contexts and symbolic forms that are open to interpretation that can change the way those structures and symbols are created, sustained, and conveyed (and through which meaning may be so mobilized as to serve relations of domination)[138].

Intersubjective meaning

One of Taylor's main organizing ideas is that social reality need not wait for a rational reconstruction in social science. He instead introduces the idea of intersubjective meaning, as constitutive of the socially real. In other words, it is a reality found in such meaning relations as are constitutive of social practice - not consensual, neither collectively shared personal meanings, nor a happy convergence of beliefs. Intersubjective meanings, according to Taylor, are "ways of experiencing action in society which are expressed in the language and descriptions constitutive of institutions and practices"[139]. Taylor is trying to argue that social practices and institutions are constituted by the way people understand and realize them as part of a world (it is not a matter of reducing them to stubborn fact), but which cannot be separated from a medium of expression and being-in-the-world. Here the language of expression is not the sum total of the individual languages of expression of persons making up a social practice. There is no such individual language, and no sum total. The social practice carries with it a language of description by which people both make sense of it, and out of which it is constituted. To understand the practice is to grasp the meanings that constitute it, and this is not separable from how the practice is made real

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Part of the point Taylor seems to be making is that social reality as factual reality, intersubectively available through the abstractions posited in a natural scientific model of inquiry, is not what is needed in a social world of persons partly constituted by self understanding. Humans are not objects like stones and mortar, and subjective beliefs and values are not the remainder after social reality is defined in terms of scientific abstractions (as it were, intersubjective meanings are not the shadow standing behind the objectively real). To use the ideas of subjective, hence relative, beliefs and objective reality to make sense of how humans understand and conduct themselves in a social-cultural world is to misconstrue the way humans exist as beings of original significance in socially constitutive meaning-giving relations. For Taylor, the socially real is constituted by the reality of intersubjective meaning[140]. Hence, in the case of intersubjective meanings, human sciences based on the naturalistic model have no abstraction sufficient to treat them, let alone recognize them as real. Human values and meanings, if recognized, are placed between inverted commas so to maintain the logic of a disengaged study[141].

If so, and in 'mainstream social science', as Taylor calls it, the institutions of that science may tend to see all aspects of social life and cultural expression from the one stance of secure and reliable scientific knowledge - a stance that tries to move outside the common world of human commitments and the place of history, culture, and language in the way human social life has come to be what it is. One consequence of this is that both the institution of social science and the social theories treated within it seek absolute judgments of social phenomena. They tend to posit an objective social reality valid for all societies and all people. Languages of description must then work a being free of the provincial and limited views of a host of different phenomena, to be explained instead in terms that are abstractly true for all, hence real for all (or, in what is really the reverse of the same stance, from the position of relativity of all social judgments or cross-cultural studies). But this is a consequence of the strong commitment in the social sciences to instrumental reason, and its general influence in Western intellectual culture. Far from being a view void of the provincial, it is decidedly selective in the way the world is seen. It therefore lends itself to an ethnocentric view of other societies and cultures based on the working out of instrumental reason.

Arguments about the institution of science often support a disengaged relation to society, or a practice based on exchange relations of knowledge capital, since only in this way will it be able to produce secure and reliable knowledge. But if something like intersubjective meanings makes sense, then such an attempt cannot come to grips with the way persons make sense of themselves and their lives as social beings. Not only will the relation of the institution of science to society be seen in the partial light of an only instrumental analysis of society, the very theories by which society is understood will fail to make the connections with human self-understandings that are partly constitutive of what it means to be a person in society. Attempts to improve social practice or to solve social problems, which are themselves understood in terms of instrumental reason, may well misconstrue the nature of the problem, the corrective needed, and the whole range of connections and consequences that flow from a society that is partly constituted by an interpretive understanding of human meaning. If so then required here is a re-working of the sense that science somehow operates in a kind of sequential relation to society, where it provides the abstract knowledge *of*, and where needed is the application *to*, social phenomena.

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The truths of various social and ethical existence must be seen from somewhere. To see things through the eyes of instrumental reason only, where what something is is to be decided by how it is known, is to adopt a notably Western fact-driven stance. But this need not lead to a conclusion that such truths are either to be shown up as false against some demonstrably true position, or are wholly relative with respect to values. Judgments are always comparative and coherent, based on the meaning, sense, and significance things have for people and for human practice. Approaches to rational discourse, to the socially real, and to the relation between science and society are here unlike those in naturalistic modes of thought. On this account they are instead decidedly holistic.

Chapter review

This chapter has looked at ways in which holistic modes of thought might serve to soften the image of the machine as the metaphor of choice when coming to grips with understanding man and the universe. In addition, the West's intellectual tradition has long adopted the approach that works out what something is in terms of how it is known. The world view of the machine and the naturalistic stance have been developed in tandem with the view of the world as an objective event consisting of purposeless matter in purposeless motion. Such a world is represented to a conscious mind which uses instrumental reason to form a rational reconstruction of experience out of scientific abstractions amenable to various precise intersubjective formulations.

Contemporary developments in science, such as those in relativity theory, quantum mechanics, thermodynamics of irreversible processes, and systems thinking, have moved thought away from this classical mode of scientific reason towards a less mechanistic, more holistic conception of not only how nature works, but how humans gain knowledge of it. By positing universal constants, both relativity theory and quantum mechanics provide for a conception of nature in which no 'god's eye' view exists. The status of the observer becomes thereby an intimate factor in the determination of natural law - either through occupying a particular frame of reference that cannot be ignored in any characterization of space and time, or in the way an act of observation becomes part and parcel of the system being studied, thereby determining in part the outcome of observation. Quantum mechanics in particular adopts a view of matter for which neither the idea of precise location nor the concept of determinate trajectory hold. Instead, probabilistic descriptions are a part of the very reality of the workings of nature. As a result facts must always be evaluated within a tolerance of unavoidable ambiguity. In such a realm language is better used to present images and pictures, instead of specifying concrete facts.

The thermodynamics of irreversible processes provides for the existence of both time and novelty as aspects of nature - not the consequence of human ignorance about the motion of its constituents. In systems at far-from-equilibrium, self organization dynamics comes to the fore, where small fluctuation can produce whole system transformations and the creation of new states of order. Such events cannot be predicted in advance, and the order thereby created cannot be anticipated from a prior theoretical accounting. The unique and irreversible particular state must thereby be incorporated into an understanding of how thermodynamic systems operate. Systems dynamics treats self-organizing processes as a natural part of the workings of nature. Such systems

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exhibit properties of the whole, taken as a complex, multileveled set of interactive tiers, which are not present in an inert state. Non-linear feed back provides for the complexness of systems, an aspect of which includes the fact that in many cases a single cause, or a chain of causes, cannot be found to explain a particular change in state within the system. Such a view as well supports a unity of interaction between many systems, or wholes, that make up a complex spectrum of relations across many levels and kinds of interaction.

Systems theory based on self-organization also supports an alternative notion of evolution where molecular chance, genetic mutations, and natural selection among the fittest for survival is only part of a much broader set of interactions that are more properly characterized by cooperation and co-evolution. Evolving systems do not require random mutations among chance events, but the gradual building up of more complex states of self-organization between the micro- and macro-scale interactions, each supporting the other. Life is not something that can be accounted for by inert matter forming random collections in a dead universe. Life co-evolves out of the interaction of complex systems for which self-organization is a natural process.

The sciences of man adopt many of the same features as their natural or physical counterpart. The epistemic imperative and the goal of methodological purity play the same central role in the working out of the project of the human sciences. Abstractions are adopted that permit the founding of data on a basis not open to further judgements. Social theorizing seeks a detached stance from which to view social reality as an objective process. Explanation is largely a matter of uncovering the inner mechanical workings of human social and mental life through a rational reconstruction free of the play of human values and personal judgements. However, such a stance fails to take notice of the character of human life as being partly constituted by self-understanding.

In such an account human persons are agents of original meaning and purpose - judgments of significance wherein goals have an inescapable claim on what it means to be a person such that to ignore the claim is to fall into confusion about one's self and world. In such a realm, the standard of rationality is not attaining, via abstraction and the data of empirical observation, to a disengaged theoretical treatment of the universals of social existence. Instead the goal is to offer an interpretation of what already has an original significance, the point being to provide gains in coherence or understanding. Humans are self-interpreting creatures whose understanding of the meanings and significance involved in the world itself changes that which is being understood or interpreted. Persons then cannot be considered as things 'out there' to be solely analysed via the abstractions of empirical science. Knowledge and action then do not proceed on the basis of absolute judgements and performance criteria, but on gains in clarity or self-lucidity between positions that are not fully explicit and which are open to a variety of interpretations. Judgments about such interpretations work on a search for coherence, while human capacity consists in a being open to the various forms of significance for human practice.

In the case of science as an institution, the systems account advances the view that evolution has now entered a sociocultural stage, not bound relentlessly to the requirements of a metabolic and sociobiological regime. Evolution has created reflexive consciousness, the human mind, which

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recreates the world in symbolic terms thereby freeing it from the rues of earlier evolutionary patterns. As such, humans have become responsible for their own evolutionary future since to reflexive mind can now appear in understanding both the comprehension of the past and an anticipation of the future. In such a multileveled existence, human values play a key role in directing the path of evolution towards an open future. However, the institution of science at times acts to conserve attempts to sound out new values for the directing of human life and knowledge. It tends to distance itself, through a disengaged stance, from the directing of human society towards an open and evolving future. Science instead works in the realm of a neutral and value-free method of knowledge production. Yet reliance on a single mode of reason, as is posited in the project of science, while immensely successful in some domains, also hinders work in others. This is notably true in the way planning is done, since in systems accounts planning cannot avoid deep level considerations of ethics - the adopting of actions that best release the potential for opening up evolutionary futures in human life. In a multileveled, sociocultural reality, neither scientific knowledge nor the institution of science can be conceived as 'inhabiting' a level free of the key position ethics and values takes in directing man's evolutionary future.

In an account based on interpretation, meaning and purpose constitute part of human social existence, and are available to human persons before any rational reconstruction. However, the project of social sciences largely relies on a disengaged stance and the view of social reality as being founded in intersubjective and irreducible fact. Social theorizing then involves constructing theories that treat the universal and comprehensive categories of social existence. For an interpretive view, this can only lead to confusion over the meaningful relations out of which social practise is partly constituted. Such practice originates in a domain that is already understood by persons for whom significance is a very part of what it is to be human. In addition, self interpretation changes social practice, so that any theory that attempts to make sense of some realm of social life cannot help but change the very practice that theory is designed to explain. It is unavoidable then that the institution of science, to the extent that social theorizing is also social practice in a meaning-full world, be involved in matters of purpose and intent as regards judgements and interpretations of human significance for a social reality partly constituted by self-understanding persons.

Summation

Instrumental reason is a necessary adjunct to understanding, but the understanding it offers is partial, and is inadequate for making sense of life and experience when taken as a whole. The assumptions that coming to knowledge entails a linear, if complicated, procedure, that means provide for ends, that what something is is to be worked out according to how it is known, or that language designates what we know of the world as modelled in a conscious representation are all aspects of a view that on its own forms an incomplete and faulty picture of man and the universe. While this may be true of any account - that it remain incomplete and faulty - the world view of the machine and the naturalistic stance towards reason have been adopted in Western intellectual culture with a resolve hard to gainsay. Nothing in the history of the world works as well as does the methods of knowledge available to science, and if the intellectual respect due to such a feat is

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ignored, then all one needs for proof is to look at the technology such a science makes possible. However, while to science may be due its abstract reconstruction of experience through empirical observation and the test of nature, the epistemic imperative and the goal of methodological purity has proven less than competent in making sense of knowledge, action, interpretation, and values in the realm of meaning giving ideas and practice. The tendency to rely on a single mode of thought, no matter how rich it might be, can only lead to failed understanding when distributed throughout a wide range of knowledge and fields of endeavour. The human reality is such that it cannot be accounted for from within a single stance. Mechanistic explanations and material cause alone cannot suffice. Self-organizing systems and accounts based on human meaning provide a characterization of how more holistic approaches may be construed.

Yet as a result of the success of the modes of thought available to scientific understanding and know-how, and true to the goal of methodological purity, science as an institution has come to be seen as the provider of valid knowledge for the accomplishment of whatever ends may be chosen by a society. It is seen either as a neutral institution in but not of society (and so a guardian of intellectual honesty), or as the producer of knowledge capital for trade value in the construction, manipulation, and fabrication of a world of social exchanges. On the one hand this has placed it thereby in a position of relative conservation as regards the search for values that might direct the path of human social and cultural evolution, and this at a time of vital need to put practice to a moral consciousness. On the other, the disengaged stance towards knowledge as adopted by the institution of science is imported into its relation with society - a society which is in turn analysed and portrayed by the same disengaged stance required for a rational reconstruction in scientific understanding. This tends to distort, or to even discount, the place of social history, culture, and the expressive use of language in an accounting of science and society - including the ways in which human self-understanding involves meaning as constitutive of human practice. To miss this aspect of human social reality is to fall into confusion about both science and society. The relation between them is far from being neutral. To make sense of it requires in part that one be open to such knowledge, action, interpretation, and values as are found in human values and meaning - a significance which holistic modes of thought can serve to accent and reconnect to how we make sense of our world.

The next chapter will take a look at technology as a kind of social practice, but one which remains largely indebted to the modes of thought as obtain in naturalistic reason and the world view of the machine. In such a stance technology is often seen and analysed in instrumental terms, its methodology taken to be similar to that in empirical science. In addition, technology is taken to amplify human powers for the neutral control, manipulation, or fabrication of phenomena useful to an industrial society. Yet the holistic accounts given in this chapter serve to rethink such a view of technology. Systems views, and accounts based on interpretation, hold out a different view of the way technology relates to social practice. This has notable consequences for technology education, still largely an extension of mechanistic modes of thought and instrumental reason in the South African education system. Some of these consequences will be highlighted and discussed in the next chapter, with the hopes of pointing to an alternative approach to South African technology education.

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Chapter Four

Technology and Education

Introduction

The previous chapters have attempted in part to critique some central characteristics of Western intellectual culture based on the metaphor of the machine, instrumental reason, and naturalistic thought. They have treated as well some of the ontological and epistemological underpinnings of this broad tradition, including some implications for the way science and society are believed to relate. In addition, ways of thought that can be termed holistic were presented as an alternative to the mechanistic stance derived from a overly enthusiastic adoption in the Western intellectual tradition of modes of reasoning characteristic of modern science and its specific forms of abstraction. This final chapter will attempt to treat aspects of technology that relate to the inheritance of the ontology of the machine and instrumental reason on the one hand, and on the other to ways in which holistic ideas might be used to reevaluate the place of technology as an aspect of social practice. The chapter then is in part a bringing together of ideas already discussed throughout the whole thesis, and involves in part a restating of them so as to focus on the theme of technology and education. The chapter is divided into two main sections. The first section treats the more general considerations of technology, seen from views of intelligence, interpretive frameworks, and self-organizing systems. The second section will deal with technology education in the South African education system, beginning with a brief introduction to the new curriculum, followed by an analysis of the technology learning area from the point of view of instrumental reason, interpretive frameworks, and self organizing systems.

Technology

Technology, evolution, and intelligence

In the article, Life in the Universe (1994), Steven Weinberg includes a visually illustrated time-line for the emergence of life. Its first section treats the large scale organization of the universe from the creation of elementary particles to the structuring of galaxies as are seen in the modern universe. It is portrayed on a time scale of billions of years. The second section presents the emergence of various water and land based life forms, beginning approximately three and a half billion years ago and ending with the evolution of early man at about two million years in the past. The third details the emergence of intelligence. In this section, beginning at 1.9 million years before the present and ending in 1993, Weinberg pictures various artifacts of man's inventive skill, including stone tools, writing, the earliest farming, the invention of paper in China, the astrolab and Gutenberg's press, the microscope and the telescope, Watts' steam engine, Charles Babbage's computer, the first heavier-than-air flight, the theory of relativity, transistors, the discovery of the structure of DNA, and modern communications satellites[1].

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Three observations are noteworthy about Weinberg's illustration. First, and obvious, is the fact that intelligence and its emergence is accounted for by the building of devices, tools, and technologies (except for the theory of relativity and the structure of DNA). In other words, tools and machines are used almost exclusively to picture the way in which human intelligence works, and the steps by which it has developed. It is portrayed as one and the same intelligence, bringing forth inventions over time. Second, that over this time the inventions of intelligence have served to amplify and diversify human abilities or powers. For example, flight, on the one hand, gives to man an ability not otherwise available without the tools and machines required for it, while on the other the steam engine serves to amplify long practiced human powers and to extend them in scales of size and pace. Third, and particularly noteworthy, is that from the invention of the Gutenberg press in 1440 until the present, Weinberg pictures all intelligence as emerging out of the work of individuals and inventions that are Western in origin - although items like the computer, the transistor, and communications satellites are now made and used by peoples all over the earth.

As it happens, it seems fairly typical in the Western scientific-scholastic tradition to relate technology with intelligence, and intelligence with survival (note the connection with learning here). This link with intelligence is clearly evident in the pictures chosen by Weinberg. The view that connects intelligence and technology to survival is not particularly surprising since it is embedded in part in the modern view of evolution, which links the evolution of the brain with the use of tools for survival and the expression of characteristic human behaviour. For example, the educational psychologist Jerome Bruner offers the following account:

> Man's use of mind is dependent on his ability to develop and use 'tools' or 'instruments' or 'technologies' that make it possible for him to express and amplify his powers. His very evolution as a species speaks to this point. It was consequent upon the development of bipedalism and the use of spontaneous pebble tools that man's brain and particularly his cortex developed. It was not a large-brained hominid that developed the technical-social life of the human; rather it was the tool-using, cooperative pattern that gradually changed man's morphology by favouring the survival of those who could link themselves with tool systems and disfavoring those who tried to go it on big jaws, heavy dentition, or superior weight. What evolved as a human nervous system was something, then, that required outside devices for expressing its potential[2].

Bruner is quick to add here that, insofar as concerns the use of tools, "... when one speaks of man as dependent upon them for the realization of his humanity ..." it is important to think not only of the actual inventions and mechanical devices but the skills needed to bring them about - both the "software" and the "hardware", as he states[3]. Burner considers language to be such a tool, one of the most general type, "... in the sense that it provides direction and amplification for the way we use our muscular apparatus, our senses, and our powers of reflection[4]." He is particularly emphatic in holding that "Language is perhaps the ideal example of one such powerful technology, with its power not only for communication but for encoding 'reality', for representing matters remote as well as immediate, and for doing all these things according to rules that permit us both to represent 'reality' and to transform it by conventional yet appropriate rules"[5].

It is perhaps a fairly standard position to view evolution as being driven in part by the brain-hand connection, adding considerably thereby to a species' ability to survive. With the use of stone tools (as well as upright posture and hence eyes set straight in front of the head so as to provide for

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stereoscopic vision) comes a rudimentary social structure, the use of linguistic communication, and a step towards culture[6]. Of course, stone tools - or for that matter any kind of tool - do not simply appear, they must be thought out and made use of. As Jacob Bronowski has written:

> I believe that as soon as the forerunners of man began to be nimble with their hands in making tools and clever with their brains in planning them, the nimble and clever enjoyed a selective advantage. They were able to get more mates and to beget and feed more children than the rest ... it explains how the nimble-fingered and quick-witted were able to dominate the biological evolution of man, and take it ahead so fast. And it shows that even in his biological evolution, man has been nudged and driven by a cultural talent, the ability to make tools and community plans[7].

In such evolutionary arguments the human nervous system is central - how through it is made possible the expression of our various powers, community planning, and nimble-fingered and quick-witted action. Such arguments point as well to learning, and to the making and use of tools, as a basic human trait. In other words, humans are characterized by that plasticity of mind that is often termed intelligence, and which has made man the most adaptable, subtle, and successful species ever. By all such accounts, the human potential is there in the nervous system. Hand-brain coordination, speech, advanced planning, and the delay of gratification have developed in an evolutionary climb, driven in no small part by the design and use of tools and technology (i.e. by the direct use of intelligence). Humans have evolved as the most gifted of species, possessing a marvelous flexibility of mind and expression, while having available the most adaptable of survival strategies[8]. The human brain then is an instrument for planning and action, and the intelligence of the brain is shown up in the tool and in the planning of the tool.

This connection between evolution and intelligence is often presumed in contemporary thought - the only question being how it transpired. For example, in an article titled The Emergence of Intelligence (1994), William H. Calvin notes that the human ability to anticipate and plan "may have come about as a result of the need to organize throwing or other ballistic movements, which cannot be modified as they are executed"[9]. Calvin goes on to relate intelligence with cleverness, versatility, foresight, and social interaction, but also supports the position that, while intelligence - whatever it is - deals with the "high end of our mental life", the more elementary neural mechanisms "are probably the foundations from which our abilities to handle logic and metaphor evolved"[10]. He argues that "intelligence arose primarily through the refinement of some brain specialization, such as that for language", and goes on to suspect that the same process of specialization deals as well with the "planning of hand movements, music, and dance"[11]. Part of this specialization involves the ability to plan things in a sequence, which, when supported by the use of syntax to evaluate possible sets of action, raises intelligence to new heights. Calvin states that: "Language is the most defining feature of human intelligence: without syntax - the orderly arrangement of verbal ideas - we would be little more clever than a chimpanzee"[12]. By implication, brain specializations that lead to language are also strongly connected with planning and action in sequential steps, and so too then with the coordinated movements of the hand or body (as in the act of throwing or making tools). These of course cannot but improve the chance for survival, since a proper sequencing of actions or thoughts is surely required for any successful outcome. The problem then becomes one of planning and foresight. In other words, how do we

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manage to work out in thought a proper sequencing before-hand, so that when it is enacted we do not make mistakes in reasoning, or ruin or loose our tools, or throw ourselves into harms way?

Perhaps not surprisingly, Calvin argues that the answer lies in the way mental processes, and hence intelligence, operate in a Darwinian fashion. "Just as Darwinian evolution shaped a better brain in two million years, a similar Darwinian process operating within the brain might shape intelligent solutions to problems on the timescale of thought and action"[13]. A Darwinian model of mind, or what Calvin also calls a 'Darwinian machine', would have six aspects. First, it would operate on patterns of some type, say perhaps, patterns of brain activity. Second, the patterns would be copied. Third, there would have to be occasional variations in the copy (via errors, reshuffling, or mutations). Fourth, once a variety of patterns exist, they would compete for some sort of limited 'workspace'. Fifth, environment would affect the relative success in the way variations in the pattern are able to continue or to grow in number. Sixth, those patterns that survive the competition and the environmental pressures determine the makeup of the next round of pattern copying and variation.

In the case of the evolution of intelligent sequences in the brain, Calvin holds that:

> Thoughts are combinations of sensations and memories - in a way they are movements that have not happened yet (and maybe never will). They exist as patterns of spaciotemporal activity in the brain, each representing an object, action, or abstraction ... Evoking a memory is simply a matter of reconstituting such an activity pattern ... Long term memories are frozen patterns waiting for signals of near resonance to reawaken them ... A Darwinian model of the mind suggests that an activated memory can compete with others for 'workspace' in the cortex. Perceptions of the thinker's current environment and memories of past environments may bias that competition and shape an emerging thought[14].

In this view, coded patterns in the cortex move through the brain by making copies of themselves, and, depending on the competition, one pattern eventually reaches a threshold level that 'trips' the action circuits that say 'reach' or 'turn' or 'choose the roast beef'. In any event, the general point here is that in such arguments intelligence is linked to aspects of language, planning, and foresight that have an origin in evolutionary survival, and in the way brain-hand coordination has driven the pace of intelligent tool use, construction, and design.

[A similar idea arises in the requirements of constructing devices to aim and fire battlefield projectiles. The problem of tracking a target is often conceived as one of eye-hand coordination and timing. Here, the brain makes a model or representation of the external world - in this case the battlefield. It is a model that must be continuously corrected by experience, and whose perceptual information is required for any successful act of targeting. The problem then is not just one of perception, but of aiming and fire control - the actual directing of weaponry in a particular direction at a particular time and at a particular rate. The soldier in the battlefield must control a 'slave motor' that amplifies his commands and so direct a machine many times beyond his size and normal ability or strength to command. How are such controls to be designed? In part they must be based on the feedback of information to the soldier about the consequences of a whole sequence of decisions made and commands given. The analogy here is with the human nervous system. The control of limbs and resulting actions derives from a perceptual field and the feedback

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to limbs via the brain that continually updates the progress of action. Errors in the feedback thereby account for some failure in motion. The task of intelligent design for machines of war then is to devise some method and device that enables the soldier to control the battlefield weapon with the minimum of error and a maximum of feedback information or 'feel' about the status of his targeting process. (These might involve questions such as what gearing is needed for the most efficient control; how many controls can be effectively managed at one time; where should they be situated with respect to the soldier's posture and flexibility; and what is required for the most accurate field of vision? Of late such design problems have been answered through the use of computer circuitry. While the technological approach may differ, the questions of target control remain largely unchanged.) Here then is a case of clear, directed control, communication, and coordination based on equally clear perceptions and evaluations in thought of what is needed to successfully orchestrate a changing perceptual field with targeted actions within that field. From this view, the targeting of battlefield weapons is precisely the process used by hunters of old to communally stalk and successfully bring down their prey.]

Practical and theoretical intelligence

Taking up again the notion of tools as both 'software' and 'hardware', and further illustrating the close connection made in Western thought between technology and intelligence, Frederick Ferré (1995) makes a distinction between what he terms 'practical intelligence' and 'theoretical intelligence'. For Ferré, intelligence in general is related to at least seven aspects or characteristics of thinking[15]. First, it involves a flexible and appropriate response - not one incapable of modification. Second, intelligence is related to the speed of the response - the faster the response the higher the intelligence (hence, the term 'quick-witted'). Third, intelligence involves being able to make refined and subtle distinctions in concepts or mental categories. Fourth, there is involved in intelligence an ability to infer or to plan for future events based on current actions. Fifth, intelligence includes the ability to grasp complex combinations and to see in them some connecting pattern. Sixth, intelligence concerns finding an effective means of achievement through the calculation of a course of action towards some outcome or goal. Seventh, and finally, intelligence also concerns the ability to assess and choose goals that can be effectively achieved.

Given such characterizations, and according to Ferré, practical and theoretical intelligence can be distinguished by the following purposeful qualities of mentality[16]:

Practical:	Theoretical:
~ to survive or to thrive	~ to know or to understand
~ quickness of thought to avoid danger or to take advantage of some circumstance	~ quickness in unraveling a conceptual obscurity
~ discriminating subtle differences in the environment to plan more successful actions	~ discriminating subtle differences among ideas to provide itself with better analyzed premises
~ inferring remote consequences to prepare for or to avoid events	~ inferring remote conclusions so as to follow the argument where it leads

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~ the synthesizing of data to provide a coherent battle-plan for life
~ involved with surroundings and is interested in outcomes
~ cares about what works as a successful procedure
~ ideas judged by their practical use, their application to the given task, and to the degree of reliability needed
~ success decided by net effect of ideas in action
~ principles of action need not always be made explicit to achieve best performance
~ tacit knowledge required for actual performance
~ used as a means for achieving other ends

~ the synthesizing of data to provide an abstract understanding
~ works best when disinterested or impartial, free from the passions of daily affairs
~ cares about why things are and what really is true
~ ideas judged by depth of understanding, precision of concept formation, and the uncovering of the argument by essential ideas
~ success decided by arguments based on the norms of reason
~ principles of thought to be made as explicit and transparent as possible, down to the foundations of reasoning
~ critical clarity required for the achievement of understanding
~ is required for its own intrinsic value and the speculative play of ideas

It is worth noting here that such distinctions could well serve as classical characterizations of instrumental thought on the one hand, and foundational reasoning on the other. Hence, such descriptions are located well within the Western intellectual tradition that adopts the naturalistic stance and the world view of the machine as the assumed mode of thought and image of reason. Such characterizations also cement a strong distinction between aspects of reason as means or calculators of action, and the chosen goals of that action. The same distinctions support as well the use of performance criteria in the evaluations of outcomes, and the central place of strategic planning as a prerequisite to action. (Indeed, given these descriptions then what has been argued in this thesis about naturalistic reasoning would be equally true of intelligence.) In both these categories intelligence is everywhere procedural, methodological, and foundational.

On the one hand then, intelligence is the means to productive ends. Practical intelligence provides a "regular way of achieving some abstractly envisioned aim ... Motivated by the urge to live and thrive, practical intelligence sorts these envisaged possibilities into orders of relevance for realization and attempts to guide action into fruitful channels of regular method"[17]. Learning occurs when, once a method has been found to enhance living and thriving, it is recalled on the occasion when some new need arises and possibilities for action must again be searched out and selected. To this sense of intelligence Ferré connects the creation of artifacts that implement a methodology. (For example, finding an arrow implies that those who used it had a method for hunting, part of which involved the making of the tool by design.) As Ferré writes: "Wherever there are practical artifacts, there is technology; wherever technology, there are artifacts"[18]. Practical intelligence then involves "implementing envisaged practical possibilities"[19]. The use of practical intelligence - and the discovery of a method of making and doing - is thereby associated with the development of human culture, tradition, and craft in which such intelligence is embodied and preserved, as well as reflected back upon the thought of man showing to him his own potential and ability.

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On the other hand, and from a disengaged stance, intelligence ensures the clear presentation of ideas that must be analyzed down to essential premises or principles for the truth to be found, recognized, and employed. Ferré uses the terms disinterested, curious, detailed, self-critical, and explicit to describe such a theoretical intelligence[20]. He goes on to distinguish between 'unimplemented theoretical intelligence' (the surveying of the whole world from above, as it were, so as to understand it for what it is through abstract principles of knowledge), and 'implemented theoretical intelligence' (the application of abstract principles of knowledge to the systematic discovery of methodologies for the construction of tools and artifacts in culture)[21]. Unimplemented theoretical intelligence is perhaps fairly close to what has been termed 'foundational' reasoning in this thesis, and which has become in Western intellectual culture partly synonymous with reason or rationality. Implemented theoretical intelligence on the other hand serves to create a "method for the systematic and deliberate pursuit of new inventions" through mental envisionment, the articulation of possible consequences, the manufacture of some artifact, the empirical analysis of outcomes, the evaluation of outcomes, the reworking the theoretical base, defining the fault, modifying the artifact, and seeing again how well the invention works[22]. In other words, a method of invention reliant not on tradition and tacit understanding, but on abstract principle and systematic, rational, empirical procedures, which raises craft thereby to a level of knowledge[23]. (It is noteworthy that such characteristic methods of intelligence - closely aligned with technology - are as well often considered to be part and parcel of decision-making for planning policy actions and rational conduct[24].) It is on the basis of such principles and procedures that technology and science share the same method, and by which have developed the inventions and technical practice of contemporary society. Through such an approach the "contributions of theoretical intelligence to technology have changed the world"[25].

Created thereby, and as a consequence, is a mode of theory based practical know-how - a kind of scientific-technological intelligence - characteristic of much of modern Western culture in terms of whose categories that culture is itself typically understood, and which has served in large part to define the institutions of modern social life. It is often used as well to characterize the relations between science and society. It is a mode of thought hard to gainsay on any account, and, as has been noted repeatedly in these chapters, is often adopted unreflectingly in the Western intellectual tradition. Finally, Ferré defines technology as "practical implementations of intelligence", where the denotation of the terms include various tools and craft artifacts, in addition to the plethora of modern industrial products and techniques[26]. Technology is implemented, embodied, and intelligent. It thereby implies the concrete use of devices, contrivances, and instruments as means to practical ends that are to be manifested in the world as material objects or artifacts, all being expressive of some kind of planning or intelligence[27]. While Ferré seems to hold that such notions thwart a view of technology regarded as an end in itself, it seems hard to exempt the idea of intrinsic technology from the arena of modern Western development.

In a culture and society whose criteria for knowledge is based in no small part on instrumental rationality (or intelligence), and where knowledge is still regarded as worthy for what it is, then it seems hard not to view technology as an enterprise equally worthy for what it is. The productive means of science and technology, as well as the adoption of the characteristics of instrumental reason as the characteristics of reason per se, are widespread and are typically presumed to be the

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best, if not only, means to find solutions to human problems. They can often be viewed as being so effective as to put in the shadows, as it were, alternative modes of thought and vision about the character of human knowledge and practice, and hence what is required in understanding a problem and prescribing a remedy. If so, and if it is taken that there is really only one way of acting rationally and effectively in the world, then this cannot but set down in advance the broad characteristics of all ends to which such action might aspire. This has direct importance for the way interpretive accounts such as those as Taylor's, as discussed in the previous chapter, are received and treated. This is also true for the way learning, knowledge, and education are viewed and pursued. A few characteristics of both aspects will be drawn out in the sections that follow.

Intelligence and interpretation

As argued in this thesis, the ontology of the machine has widespread influence in Western modes of thought. Instrumental or foundational reason are often adopted as reason *per se*, and it is commonplace to reason out what something is in terms of how it is known. The notions of intelligence and technology fit happily into this view. Indeed, and as noted before, the features of intelligence are those of reason as well, with technology a kind of implemented intelligence. Also argued in this thesis is the idea that such views can be conceived as part of a holistic stance - that they do not have comprehensive explanatory power - and that much of human significance is left out of the picture of man and society when portrayed by an only, or even mainly, scientific and empirical account. This certainly applies to the view of intelligence based on the evolution of brain-hand coordination, the Darwinian explanation of thought, and the character of sequentially planned action and practical intelligence. From this point of view many ideas discussed in the third chapter - such as Taylor's conceptions about human significance - would no doubt be greeted with suspicion[28]. Yet in a reading such as Taylor's, this suspicion exists because the notion of artifact as implemented intelligence, and the equivalence of technology and artifact, leaves out main aspects of meaning giving ideas and practice for persons partly constituted by self-understanding. However, it is possible to trace a few ideas that might import into an understanding of technology something of an interpretive framework and the place of symbolic forms in structured social contexts. As was the case in the previous chapter, the notion of self-interpretation and symbolic forms are adapted from the works of Charles Taylor and John B. Thompson, respectively. Theirs are particular formulations of a very broad field of inquiry, and are taken here only as an example, among many, that may suggest an interpretive approach to the study of technology.

There is a tendency to view the technological world as factually given - as a set of objects 'out there' - even as empirical science looks upon nature as an objective process. Whatever else technology might be, it is centred in an empirical grasp of the world. It comes in part from an attempt to use scientific representations of nature in the fabrication of artifacts for human productive purposes. Technology, notably its artifacts, serve to amplify human powers through 'prosthetic devices', which thereby enable humans to control and manipulate processes found in nature, and fabricate new ones according to their own ends[29]. Here the world is seen as a place of neutral resources that humans can use as they choose in the building of a technological and industrial society. Intelligence is shown up then, and shown to be correct, in the way scientific maps of the workings of the world are applied to the production of technologies by human design.

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While science models the objective process in nature, technology is recreation through fabrication and construction of these objective process, but in accordance with the productive purposes of a given society. The products of such a society may tend to reproduce therefore a sense of the objective status of both the ideas by which nature is comprehended, and in terms of which it is manipulated and controlled by a technology whose very designs revolve around the efficient running of an industrialized economy (the laws of economics are as well seen partly as an expression of some objective economic necessity - often metaphorically related to the human struggle and competition for survival in the evolution of the species). If so, then the rise of technology and the character of intelligence tend to reinforce each other, and support in turn a host of related views concerning human nature, performance criteria, rational action, and social structure. Such a use of technology and intelligence demonstrates as well the ways in which tools did drive the evolution of the human nervous system, such that 'outside' devices are required for the expression of human capabilities and the amplification of human powers.

However, views such as Taylor's and Thompson argue to the effect that technology is connected to a social-historical past, existing in a social sphere where meanings are transmitted, received, and interpreted by persons who already understand their world and themselves[30]. Technology is made by people for people, and so has about it an evaluative and interpretive sense. (It may be considered in some ways as a text-analogue.) Thinking indebted to the metaphor of the machine, however, shows a tendency to conflate machine performance and intelligence[31]. The fact that machines are objects of purpose by fiat, as it were, is often thereby carried over into characterizations of human intelligence as being based upon performance criteria - where brain action is accounted for on the basis of Darwinian mechanisms. However, and using here Taylor's notions of human agency, persons are as well a locus of original purpose, where the matter of importance is significance, not consciousness and rational reconstruction. From this point of view, technology cannot fully be accounted for on the basis of such 'practical implementations of intelligence', as views such as Ferré's might hold, because they fail to consider matters of meaning as substantive. Attempts to offer 'intelligence accounts' can therefore lead to a misidentification of the real, at least as regards the way technology may be presumed to belong to a world of human purpose and intent[32].

Technology can also be understood through the operation of meaningful symbolic forms[33]. Through such symbolic forms can be conveyed between persons a host of significances and senses. John Thompson (1990) presents them as operating within structured social contexts, having a historical and cultural past, and which serve to create, maintain, and sustain various fields of meaning and organized social practices. Such practices may in part involve relations of domination, which Thompson characterizes as "meaning in the service of power"[34]. Symbolic forms are thereby accessible to various interpretations, and are open as well to realizations of new meanings not only as symbolic forms *per se*, but in the way structured social contexts operate[35]. The result is that interpretations of symbolic forms can in turn alter the shape of understanding of technology and its practice. In addition, and from the point of view of Taylor's argument about significance and meaning, the object of reason is not to achieve own productive purposes in a world of neutral means and chosen ends for human survival. Reason instead is to seek out the proper forms of human meaning - to find ways of being open to, to being able to be transformed

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by, the peculiarly human significances[36]. As noted in the previous chapter, Taylor argues that reasoning provides for differential gains in self-clarity, for an increased understanding of self and world, and for an improved coherence of meaning relations that, once articulated or expressed, serve to change the practice of that which is being interpreted[37]. Since the social and technological world cannot be completely characterized as an object domain as might obtain in an empirical scientific account based on irreducible fact, technology need not be understood on the basis of 'intelligence' alone, whose character is derived via prior notions of instrumental and foundational reason, and the metaphor of the machine.

An interpretive study of technology might then focus on the character and significance it has for self-interpreting persons living in a meaning-filled world. Technology as human practice would not be an objective practice in the empirical scientific sense, and modes of naturalistic reason would be insufficient to account for it from this point of view. If so, then accounts of technology based on intelligence and performance would tend to fall into confusion regarding the place of knowledge and action when making sense of human practice. Technology is received and interpreted by people in a host of ways from a variety of societies and social positions. Its influences are various and diverse, and the history of a people and culture cannot be excluded from the way it is understood (save at a loss of comprehension or a possible falling into ethnocentrism)[38]. This however need not land an analysis of technology into the either-or fallacy of choosing between the search for universal standards of technological knowledge on the one hand, or of adopting relativism as regards its place in different societies, on the other. As noted before in chapters one and three, such a distinction is based in part on notions of what constitutes certainty in argumentation, and this is derived from a view of reason as being primarily foundational and procedural. Once this is given, then an analysis of technology as a social phenomena may well tend to follow one or the other of these two avenues[39].

The view of human significance as formulated by Taylor, and which was earlier developed as a way of thinking more holistically about the place of science in society, offers one alternative to this either-or fallacy in the study of technology. The point here again is that both options actually derive from an idea of knowledge based on a mechanistic world view. If so, technology is thereby particularly prone to this dilemma. It is easily taken to be a kind of machine-like expression of intelligence based on the assumption that tools serve as neutral implements for action in a perceptual field (and which enhance thereby the chances for human survival). However, in an account such as Taylor's, reason need not be discursive or procedural, but substantive as to human meaning. Notions of certainty that obtain in knowledge derived from irreducible fact tend to view human values as something 'bolted on', as it were, to an understanding of the world taken to be an objective process. Issues of valid knowledge verses relative perspectives then occur when one or the other of these poles is adopted as primary. But in an interpretive account, comparatively blunt distinctions as between thought and action, theory and application, means and ends tend to fall away in the way language is used to express meaning.

Seeing technology as social practice, be it one's own or someone else's, may lead then to both a more coherent understanding and a more self-evident practice, and hence to an alteration in one's own point of view. The issue then is not certainty or relativity of understanding, but differential

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gains in meaning and sense. If so, then following an interpretive sense to technology could involve matters of meaningful practice and moral deliberation in the way technology is understood and used. It could open up avenues for evaluating technology not only as a work of human intelligence in a world made of artifacts, but as a form of practice that may advance or hinder human well-being. Such interpretive views could therefore help foster conceptual schemes more open to questions about the ways in which, and whether or not, particular aspects of science and technology are instances of progress or decline in the social-historical-cultural reality of human life[40].

Issues of institutionalized power and its use are particularly urgent in our times, given the existence of forms of knowledge that serve to amplify disproportionately the various human powers. Much attention has therefore perforce been given to matters of practical reason in the step and pace of a modern technological dance. Of course, such issues are by no means new. They have been asked in a variety of ways from a host of contexts at numerous historical times. The argument here is only that such modes of reasoning as are indebted to the naturalistic stance and instrumental reason are insufficient to account for all that may be asked and spoken regarding the use and choices for science and technology. Reasoning from one or another of an interpretive framework may bring to attention necessary matters of meaning and conduct in the way technology might be evaluated as social practice. Such evaluations could then provide for a broader, and more holistic, approach to understanding the relation between science, society, and technology.

Technology and systems

In the previous chapter, various aspects of systems thinking were described in terms of self-organization and non-linear feedback. In such a view, sociocultural processes work in multilayered aspects each one itself a dynamic whole. Here, each part is related or connected in a variety of complex ways with all others, such that characteristics of the whole are distributed throughout each of its multiple layers of interaction. The relation between the parts of an evolving system is one that provides for both autonomy in each part as well as some kind of global coordination via self-organization. As a system grows in complexity of interrelation among its parts, no one dominant character can be isolated or be said to guide the system in its entirety. The system is characterized by a pluralism of dynamic realities, connected but autonomous, where boundaries between the system and its environment become obscured. Here, the use of notions such as 'inner' and 'outer' lead to confusion, since the distinction no longer applies.

As also noted in earlier sections, levels of complex self-organization have co-evolved into levels of self-reflexive thought. It is here that community and culture begin a new evolutionary pattern based on conscious understanding, an awareness of the very processes by which evolution works, and a bringing together of the experience of the past and an anticipation of the future into an active present. Evolution becomes sociocultural, not metabolic. In such a regime human's are now responsible for creating their own evolutionary futures, since the ability to form symbolic representations of life and experience frees thought from an only metabolic past. This in part means that societies need to be structured in ways that enhance the potential for opening up

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possible future courses of action that advance an evolutionary form of life. It is not sufficient to attend to only those conserving aspects of life that provide the resources for a biological or metabolic existence. Ethical considerations, the awareness of human values, and the practice of a moral consciousness become as well main patterns of expression in an evolutionary inheritance. They form one of the keys for perceiving and evaluating evolutionary futures at the forefront of sociocultural action. This is so because patterns of thought that help direct action towards metabolic survival are no longer sufficient for the requirements of life at the level of self-reflexive mind.

However, while values may on this account be part of an open evolutionary future, the institutions through which they find social expression often seek to preserve or conserve them as original guiding images. One such guiding image is the metaphor of the machine, which has served well the work of empirical thought and rational calculation from the early development of modern science[41]. It is true that to modern technology is often attributed, with justification, a sense of innovative thought and discovery. There has indeed been a vast expansion of various implements or 'prosthetic devices' by which human powers have been amplified and given new expression in technology. However, at least as regards the pattern of evolution in a sociocultural setting, the focus of thought and discovery in technology tends to be on what is something like the strategic control of material resources necessary for maintaining structural and economic stability within a society (as in the areas of transportation, communication, and energy). Here there is much innovation, and new sites of knowledge production. But at the level of values there seems to be a crystalizing of ways in thought about modes of production that provide secure and reliable knowledge and know-how. The epistemic imperative and the goal of methodological purity that often obtain in science and research remain key for the practice of any study in technological design and construction. In addition, the institutions that provide for science and technology also tend towards a conserving and preserving role or attitude in an attempt to maintain established standards of rational and empirical study and technological knowledge production.

Part of the explanation for such conserving roles to technology rests in the belief that the intellect of man has got hold of a method for investigating and fabricating nature that provides a painfully exact description of the workings of the world, and substantially powerful techniques of control. If so, then technology in particular can be used to secure greater material or metabolic well-being for people. Although in a systems account man's evolutionary future is open, and while humankind must take responsibility for constructing an own future using the best tools available, the preponderance of knowledge of a 'mechanical' sort tends to put in the shadows the practice of the ethical and moral at the higher levels of human thought. Yet, from this point of view, it is here at the cusp of the practice of values that the human evolutionary future will be created. Part of the problem is that such values are themselves made sense of by the same modes of thought and guiding image that provide the exacting knowledge of empirical and technological science. Other types of possibly creative advances in evolutionary understanding - those that may provide for a type of process planning in which values play an unavoidable part in a multileveled sociocultural future - are proportionately discounted as the view knowledge remains indebted to assumptions that obtain in the ontology of the machine.

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Technology then, while involved in various innovative and creative advances (many giving to the various human powers a novel form of expression or amplification), tends to operate in a mainly metabolic or social-biological regime. There is no requirement that this be so. Values and meaning operate throughout the multileveled reality of sociocultural life, and serve in each to help direct the open evolution of the whole of that life. Of course, technology in some sense is preferentially directed towards the infra-structural requirements of societal processes. However, that technology (and many forms of science) tends so strongly towards the conserving side of evolutionary practice is in part the result of an over enthusiastic adoption of the world view of the machine in both how the world is described, and how humans best make explanatory and practical sense of it

Education

Education and intelligence

Among the institutions that tend to preserve established modes of thought, universities and systems of education often play an unusually important role. Universities remain largely disciplinary in their organization and in the ways they certify learning and scholarship[42] . Schools as well often adopt the same divisions of study that obtain in the specific disciplines of human knowledge. There is good cause for this. Such disciplines have provided, in the modern era, the kind of secure and reliable knowledge people have come to associate with the character of science, and systematic and rational thought in general. The thought processes, aspects of discovery, and strength of understanding available to science are highly valued for the successful working of a society and its economic productivity. Universities provide an institutional expression of what is considered to be valid knowledge. Schools at one and the same time 'feed' universities with talent, and certify learning of a publically demonstrable sort. The personnel to accomplish all this are therefore trained and educated along the same disciplinary lines. Indeed, some 'theories of instruction' propose that what children learn be the very schemes of thought by which scientific knowledge is discovered and made secure[43]. While there is movement towards a combining of disciplines in the approach to learning, disciplinary knowledge, or subject specific training, remain well established in education practice.

Technology as craft knowledge has not always been part of this disciplinary order. Until relatively recently it was not even considered to be a kind of knowledge as is had in the sciences[44]. However, the rise of a systematic study of the design and production of industrial goods, and the inclusion of abstract principles of theory in the conception of what constitutes craft knowledge, has given to technology its claim to rank as a science on its own, sharing the same epistemic imperative and methodological goal, while being as well unavoidably practical and commercial in its approach [45]. As technology becomes a subject of study and an object of practice on its own and for what it is, so too does technology education become a candidate for inclusion among modern systems of public schooling and within institutions that certify learning and scholarship.

The remainder of this chapter will attempt a brief, and necessarily incomplete, portrayal of some of the aspects of technology education in the South African national system of public education.

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Such a summary account will treat on the one hand the general framework of the new single national system of education, and on the other some of the specific traits of technology education as a part of national curriculum policy. The attempt here to describe technology education can at best be partial as the field is too broad for any brief study. In addition, the system of education being developed, termed 'Curriculum 2005', is still to be worked through in its details, and in some key areas. Many documents are in a developmental stage. There are good reasons to think that things will change, though perhaps not in the broad purpose and direction to outcomes based, learner centered education. In addition, since the curriculum itself is in part based on an open or flexible development of learning programmes, there will be no 'final print' to the curriculum story.

General principles

The adoption of Curriculum 2005 as national education policy has sparked a new and growing literature. The original documents outlining the new curriculum leave many areas undecided. They as well open up a variety of possible developments in the practice of education which cannot be determined at this stage - either because the time is not right or the ideas they treat are not well developed. In this sense the documents are open to a variety of interpretations. The characteristics of Curriculum 2005 then are not something that can be specified beyond a certain level, and so too then as well a specific analysis of those characteristics. This of course makes it difficult to pass comment on the curriculum, except in somewhat general terms. The following remarks will not attend to matters of methodology of delivery, assessment, school governance, or funding. The point of this section is not to examine classroom practice and the various approaches to daily teaching and learning at schools. The focus will be on some of the generating ideas that give Curriculum 2005 its main tone and style, and which carry over into technology education.

The document Curriculum Framework for General and Further Education and Training (1996) offers a set of guiding images and organizing ideas for the way curriculum design should proceed.

> It is now accepted that successful modern economies and societies require citizens with a strong foundation of general education; with the desire and ability to continue to learn, to apply and to develop new knowledge, skills and technologies; to move flexibly between occupations; to accept responsibility for personal performance; to set and achieve appropriate standards, and to work co-operately[46].

The general framework for education involves building an education system that can help create a successful society and economy. Part of this requires that education be of a general sort, while involving aspects of training and skills that provide for a economically mobile citizenry. This is particularly true for an economic world in which changes in the workplace make the capacity for learning a life-long demand. The curriculum as well is to provide for a redress of past practice, so as to create a society free of various forms of prejudice and limitation as were imposed on a host of peoples in South Africa under apartheid. The new curriculum therefore is designed to provide basic steps leading to a productive and competitive economy, and improved societal well-being.

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In general, the focus of education should be on developing knowledge, skills, attitudes, and values that support this overall direction. Education is to concentrate on the requirements of the individual learner, while at the same time following overall outcomes that give commonality and continuity to all learning programmes[47]. It is a learner centered, outcomes based system of education assessed on the basis of performance criteria and the achievement of various competencies, but which is conducted at local levels and in response to circumstances and choices.

Such a programme for education has a host of additional characteristics. It is not an evidently easy task to speak to the needs of learners in their specific context, but at the same time meeting the requirements of the whole society. One main aspect of such requirements is in the arena of commerce and industry, and the need for people to possess skill and independent judgment in the creation of social well-being. However, education must not serve to maintain such occupational and class structures as were used in the past to delimit a peoples sphere of work and influence, while doing damage to their sense of self-worth. To break out of such categories education planners have adopted an integrative approach that is supposed to bring together perspectives of social action, knowledge, and human relation. By so doing the process of education is intended to help work free those habits of thought and social control that have been a source of malaise. This integrative focus involves as well aspects of logical, analytical, holistic and lateral thought processes in the reworking of societal organization[48]. The integrative approach in learner centered education is a central tenet of the new curriculum, and places it generally within a holistic view of knowledge, understanding, and action[49]. The working out of the details of the curriculum plan revolve around finding ways of making explicit this notion of integrated learning.

Perhaps inherent in an integrative approach is the requirement of flexibility and relevance[50]. The new curriculum prescribes both general (termed 'critical') and specific outcomes (specific for the eight spheres of education and training, learning areas, which are set out in the curriculum). These outcomes, together with an analysis of competence, are probably the main operating guidelines for the actual practice of education, giving it thereby a specific character and direction[51]. While the outcomes are prescribed nationally, the way they are approached and used is a matter of choice among those who put them to practice. Flexibility is also encouraged in the search for innovation and variation in the design of programmes for a variety of learners at a variety of levels.

As regards relevance, the curriculum framework document offers the following guidelines:

> Curricula should be relevant and appropriate to current and anticipated future needs of the individual, society, commerce and industry. Ever-increasing evidence suggests that economic growth in a competitive international economic system depends fundamentally on a generally well educated population equipped with the relevant competencies and skills required in the economy at any point in time but also with the capacity to continue learning and developing new skills, and acquiring new competencies.
>
> These imperatives imply not only that education and training policy and strategy should be linked to economic policy and strategy but also that learning programmes should enable learners to become technologically literate (especially with respect to information technology), as well as environmentally aware and responsible. Furthermore, the boundaries of knowledge which learners are accustomed to need to be expanded to include areas with which they are unfamiliar [52].

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Competence and the critical outcomes

Curriculum design is learning-outcomes based, but is to be measured, or assessed, by various performance criteria in the achievement of certain applied and integrated competencies using performance indicators[53]. These competencies point overall to a demonstrable ability to integrate theory and practice, or to combine understanding with action. The applied and integrated competencies serve as standards of learning performance, and are divided into three broad areas - practical, foundational, and reflexive[54]. Practical competence involves decision-making and certain actions at specific levels of performance. It includes the demonstration of real ability in actual contexts, and it involves making considered decisions about possible courses of action, followed by the actual performance of those acts. Foundational competence treats in part the ability to act on the basis of some thought-out plan, or prior analysis and evaluation. It as well concerns the ability to adopt action to different contexts and to changing situations. In other words, action must be 'founded' on such abilities so as to plan and adapt. The focus then would be on ways of thinking and kinds of knowledge that work to guide or determine actions. Foundational competence works to develop the kind of understanding upon which action is based. Reflexive competence serves to connect decision-making and various types of performances with the knowledge required to bring them about. (In other words, to link the practical and the foundational competencies.) 'Reflexive' refers to adapting to change and the unforseen, to evaluating and adopting creative options in ones own's life practice, and to explaining the reasons for those changes and choices. Once again, the point of developing and connecting these three competencies is in demonstrating the ability to integrate theory and practice[55]. They would be developed with different emphases depending on the programme of learning and the outcomes of choice. In this sense the notion of applied and integrated competence also applies for the way in which the practical, foundational, and reflexive are themselves made a part of the process of learning. In other words, they are approached in such a way that what is learned is not a host of discrete actions and isolated explanations, but a working together of a variety of competencies into a more comprehensive explanation, a more successful performance.

The national curriculum policy sets out the prerequisites for designing a programme for education. It carries with it, as an underlying theme, an emphasis on developing the broad and particular skills needed for an economically active population that can compete in modern economic behavior and in the running of an effective and working society. A main part of this theme is dedicated to the place of technological know-how and the skills of the various sciences, both natural and social, in the operation of a modern economy and society. Not only is this shown up in the wording of the selections from the curriculum framework document already quoted, but it appears as well in the way the eight critical outcomes and eight learning areas are described. The eight critical cross-field outcomes for 'General and Further Education and Training' are as follows[56]:

1. Identify and solve problems in which responses display that responsible decisions using creative and critical thinking have been made.

2. Work effectively with others as members of a team, group, organization and community.

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3. Organize and manage oneself and one's activities responsibly and effectively.

4. Collect, analyze, organize, and critically evaluate information.

5. Communicate effectively using visual, mathematical and /or language skills in the modes of oral and /or written presentation.

6. Use science and technology effectively and critically, showing responsibility towards the environment and the health of others.

7. Demonstrate an understanding of the world as a set of related systems by recognizing that problem-solving contexts do not exist in isolation.

The eighth critical outcome is sometimes extracted from five additional guidelines as chosen by the South African Qualifications Authority (SAQA), and added onto the critical outcomes. The curriculum framework document states[57]:

> In order to contribute to the full personal development of each learner and the social and economic development of the society at large, it must be the intention underlying any programme of learning to make an individual aware of the importance of the following:
>
> ~ Reflecting on and exploring a variety of strategies to learn effectively.
>
> ~ Participating as responsible citizens in the life of local, national, and global communities.
>
> ~ Being culturally and aesthetically sensitive across a range of social contexts.
>
> ~ Exploring education and career opportunities.
>
> ~ Developing entrepreneurial abilities.

While the sixth critical outcome deals directly with science and technology, and the fifth speaks of mathematics, the language used in three other outcomes may arguably apply too to matters of science and technology. The first outcome refers to identifying and solving problems. While there are certainly many kinds of problems and many possible types of solutions, the ability to actually identify and solve problems is often taken to be the province of science and technology. It is an ability scientists and technologists have refined to a degree of exactness that many other science professionals seek to emulate. Indeed, science and technology are often believed able to 'solve' problems that are otherwise taken to be intractable. At the same time, the seventh outcome treats the notion of systems and problem solving, with the rider that the world is a set of related systems, and that, by implication, problem solving cannot be conducted in isolation. Aspects of systems thinking were treated in the previous chapter. While the argument in that chapter was that systems thinking went beyond the classical modes of explanatory cause, it was also noted that systems thought is a further development of science and scientific reasoning. It is an attempt to place scientific and rational thought on a platform of empirical research from which past scientific knowledge can be expanded into new phenomena. Of course, the seventh outcome does not speak of non-linear feedback and self-organization, so it is impossible to know from the statement of the

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outcome alone if this was relevant to the curriculum writers. Yet even if the meaning refers to control and information systems (closed and linear), this too is highly indebted to scientific norms of enquiry. Finally, the second outcome speaks in general terms about collecting, analyzing, organizing, and evaluating information. 'Information' suggest quantifiable, realms of knowledge and research. The other four terms all have connotations that are strongly 'scientific' in character. Hence, five out of seven outcomes treat scientific and technological interests in some way.

Some of the observations in the previous chapters noted the way in which instrumental reason has had a broad influence on patterns of thought that set out various performance criteria for the accomplishment of productive ends. This is in line with notions of action as being matters of choice, given various means in a field of neutral resources. In such a view, the world is given to representative consciousness, which must use tools of thought to analyze and evaluate perceptions, set out a range of possible action-consequence connections, and chose the right or best course of behaviour. Given that South African public education is highly indebted to Western models of learning, and assuming this broad influence of instrumental reason, then there may be reason to think that many of these critical outcomes are formulated (or may be interpreted in practice) via some such notion of representative consciousness and performance-based action. The notion of performance is an important part of the design of the new curriculum. This is certainly suggested by the use of 'performance indicators' that are to map out exactly what and how much learning is acceptable as a level of achievement, what planning is necessary to reach this level, and how to track the progress of a learning curve[58]. This is perhaps why there is a need to integrate theory and practice in curriculum design, since, under the assumptions prevalent in instrumental reason, action and thought (or planning) occupy different categories that must be combined in consciousness. The third critical outcome too may well serve to support the notion that managing one's actions implies being able to think things through and deciding among the best choice from among a set of possible ends, to be followed by some calculated course of action. This is supported by the way in which competencies are described as leading to types of action depending on the level of analysis conducted beforehand. In addition, the assumptions working in instrumental reason may also be reflected in the eighth outcome. Here education must develop an individual's awareness of cultural and aesthetic sensitivities in various social contexts. This can mean and imply much for education practice, and from such brief descriptions it is impossible to say what the authors meant. However, given the inheritance of the view in the Western intellectual tradition that the universe is neutral with respect to human designs, and that therefore values and goals are not the province of objective processes but are matters of choice and belief in the minds of men, then being sensitive to a range of cultural contexts may imply paying purchase to one form or another of moral scepticism and the impossibility of formulating judgements in cross-cultural situations[59]. In addition, the three competencies - practical, foundational, and reflexive - exhibit in many ways the characteristics of intelligence noted earlier in this chapter. These are clearly derived from a strongly instrumental sense to thought and action.

Much of the new curriculum supports a holistic approach to learning and experience, and to an integration of the disciplines of human knowledge via a combining of the different specific outcomes[60]. This is particularly so in the foundation phase of the general education and training band[61]. Although the intermediate and senior phase should also work to integrate the various

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outcomes, at the same time they are to begin a more focused study of the eight learning areas and of the specialized knowledge they contain. While such integration is the intent of those who established the basic guiding principles of the new curriculum, the statement of the broad competencies that are to be developed, and much of the content of the eight learning areas, may still inherit the type of assumptions that come from within an instrumental view of intelligence. The curriculum then arguably adopts well established notions in Western intellectual culture about what constitutes thought and action, reason and competence. It is certainly possible to integrate the different sciences and ways of thought and action as come out of instrumental rationality. However, what may be missed is the fact that the curriculum may at least in part fail to make clear that these are assumptions, and that other modes of thought are available. If so, the noteworthy emphasis in the new curriculum on holistic approaches and integrated learning may be weakened by implicitly assuming that reasoning is, by and large, based on the model of procedural thought. Integration may occur in the actual practice of teaching and learning, but it may do so on the basis of a restricted sense of what constitutes knowledge and reason, and their relation to values and human meaning. Such a prospect is partly shown up when one looks at the specific outcomes for technology education.

Technology Education

The specific outcomes for technology are as follows [62]:

Learners will be able to:

1. Understand and apply the Technological Process to solve problems and satisfy needs and wants.
2. Apply a range of technological knowledge and skills ethically and responsibly.
3. Access, process, and use data for technological purposes.
4. Select and evaluate products and systems.
5. Demonstrate an understanding of how different societies create and adapt technological solutions to particular problems.
6. Demonstrate an understanding of the impact of technology.
7. Demonstrate an understanding of how technology might reflect different biases, and create responsible and ethical strategies for addressing them.

Within such outcomes, technology is defined in the curriculum as "the use of knowledge, skills and resources to meet human needs and wants, and to recognise and solve problems by investigating, designing, developing and evaluating products, processes and systems"[63]. Investigating, designing, developing and evaluating products and systems is termed the 'Technological Process'. The rationale for the technology learning area also seeks to develop:

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~ an ability to solve technological problems by investigating, designing, developing, evaluating as well as communicating effectively in their own and other languages and by using different modes.

~ a fundamental understanding of and ability to apply technological knowledge, skills and values, working as individuals and as group members, in a range of technological contexts.

~ a critical understanding of the interrelationship between technology, society, the economy and the environment[64].

The rationale for technology education as well involves attaining an understanding of technology that contributes to:

~ the development of learner's ability to perform effectively in their changing environment and to stimulate them to contribute towards its improvement;

~ the effective use of technological products and systems;

~ the ability to evaluate technological products, processes and systems from functional, economic, ethical, social and aesthetic points of view;

~ the designing and development of appropriate products, processes or systems to functional, aesthetic and other specifications as set either by the learner or by others;

~ the delivery of quality education and access to redress through:

- relevance to the ever changing modern world

- integration of theory and practice

~ the development of citizens who are innovative, critical, responsible and effective;

~ the demystification of technology;

~ the recognition of and respect for diverse technological solutions and biases that exist; and

~ creating more positive attitudes, perceptions, and aspirations towards technology-based careers[65].

Each of the seven specific outcomes has been expressed in terms of assessment criteria and range statements. These give to the outcomes a more detailed construction and clarity. The assessment criteria and range statements for the senior phase are stated in the appendix.

The specific outcomes, their rationale for education, and their more detailed presentation in assessment criteria and range statements offer a glimpse into the various assumptions and underlying characteristics to both how the curriculum writers think about technology, and how it may well be put into practice. While there is much that is worthy of note in these various outcomes and rationales - for there is an evident attempt at integration - there is also appears to be a tendency to think through technology in terms of the assumptions operating behind instrumental reason. In addition, while there are references to ethical and responsible learning, to the

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demystification of technology, and to its social implications and consequences, the more detailed assessment criteria and range statements also suggest that much thought in these areas may proceed along notions common to the naturalistic stance. There is of course nothing the mater with instrumental reason or the naturalistic stance. They provide a platform, together with the world view of the machine, for the development of what is considered to be secure and reliable scientific knowledge. However, they are not the only forms of reason and knowledge. As has been repeatedly noted in these chapters, an unreflected adoption of them results in a discounting of other kinds of thought, and hence a distorted view of the world built up only or mainly from such reason and knowledge. The remainder of this section will attempt to highlight some of the ways technology education, as shown up at least in a few of the basic documents, appears indebted to the assumptions of procedural reason or the view of action as obtains in the naturalistic stance.

Technology outcomes

Much of the work in the technology learning area treats what the document writers call the technological process - investigating, designing, developing, and evaluating technological products and systems. The technological process as a whole, together with its component aspects form much of the work in at least five of the specific outcomes. It is probably fair to say that the new curriculum characterizes it as the basis of all technological endeavors. As a result, understanding the process is held as fundamental to achieving technological literacy.

The whole of the first outcome focuses on the technological process as such. The intent is for learners (at the senior phase) to show detailed, logical, and articulate work that demonstrates an understanding of the process. This is to be done using the example areas of housing, energy, communication, water, transport, textiles, tourism, health, agriculture, manufacturing, media, and sports and recreation. The technological process itself is said to involve identifying problems, wants, or needs from which a range of possible and relevant solutions are considered. From this an informed choice is made, a design is developed, and solutions realized - all to be followed by checking and evaluation. Such steps are very much like those used in rational decision-making and policy formulation[66]. As such they reflect fairly well some of the assumptions behind viewing reason as instrumental and procedural.

The second outcome refers to the application of knowledge and skill, but with the rider that this be done ethically and responsibly. However, the assessment criteria and range statements tend to focus on knowledge and skill only in order to achieve a certain competence and confidence in working through the technological process as it is used in a technological world. The approach to application is to be conducted in a wide variety of topics, with an emphasis on integration - at least as far as the topics go. The topics themselves appear almost wholly mechanically and materially technical in character. For example, some of the topics treat safety, information, materials and energy via a study of their nature, function and application. These broad concerns are to be assessed in areas such as technological systems and control (i.e. open and closed systems, components and devices, and mechanical, electrical, and hydraulic interconnections), technical communication, static structures (such as shelter, transport, storage, and container packaging), and processing raw materials. It includes as well types of energy and energy transformations,

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storage and distribution, types of materials (together with their costs, waste and selection requirements), various aspects of safety - which amounts to the responsible use of technology - and the use and care of different types of tools. The only explicit reference to social concerns seems to be an appeal to sensitivity for problems, dilemmas, issues, and choices in society[67]. Yet compared to the numerous references involving direct technological considerations, matters of social importance seem distance and ill developed. While the title of the outcome mentions ethical considerations, it is not clear where in the more detailed presentation of the outcome such matters arise - except perhaps to say that within the technological process itself there are norms and guidelines for the proper development of technology that must be followed in, say, the construction of houses or in the way energy distribution devices are selected and installed.

The third outcome is a direct use of technological data and information - visual, numerical, audio, and electronic - in the making of decisions. Again, this topic is presented as part of that training necessary to come to grips with the technological process in a world in which scientific and technological data and information play an evermore crucial role. This outcome seems very much indebted to empirical data analysis, particularly in how it can help the technology process.

Outcome four is intended to help learners become confident and discerning consumers and users of technology. This will involve working with, selecting, and evaluating a range of technological products and systems. Selecting and evaluating technology is held to involve understanding the need, understanding constraints and putting them in priority, comparing a range of similar products with respect to the constraints, and testing those products and systems. Such an approach to selecting and evaluating technology is reminiscent of the sequencing of thoughts or actions for the accomplishment of some outcome, as was discussed earlier in this chapter in the section on the evolution of hand-brain specificity. The context there was how hand-brain coordination drove the pace of human evolution, and established the basis for what is today considered to be intelligent action for survival. The use of similar ideas in the choosing of technology for use by consumers in society is certainly striking, although it cannot be excluded that this is something of a coincidence. Still, the fourth outcome certainly offers no added evidence to the contrary that technology education tends to focus on instrumental reason and the naturalistic stance in the way technology is considered and applied.

Indeed, in all of these outcomes thus far there appears to be a strong assumption that what is needed in this learning area is the application of an objective like process - the technological process - to particular circumstances. In other words, the technological process is a universal-like description of technology under all circumstances. In the curriculum, what is needed for an assessment of learning is first, an understanding of the process *per se*, and second, how it can be applied in different and particular technological circumstances. This distinction between an abstract grasp of an objective-like process on the one hand, and its various ways of working in specific situations on the other, is a distinction held in common with the natural sciences, and is characteristic of the way in which scientific knowledge is often held to proceed (by assuming that out of a developed theoretical account proceeds some applied action).

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Outcome number five holds that technology is connected with the economic, cultural. and social conditions that obtain in different societies (the metaphor used is that of technology being interwoven into the fabric of society). It is through such connections that technology evolves in time and place. The point of this fifth outcome is to achieve an understanding of the various ways in which technology has evolved. There are only a few details in the assessment criteria and range statements, and this makes it hard to infer the sense to what such evolution entails. However, the notion is divided into areas of content and process. Learners are to show detailed, logical, and articulate work in historical, geographical, cultural, and economic content. They are as well to treat aspects of research, observation and analysis as matters of process. The statement of content is very broad, and correspondingly vague. It could therefore include an approach not squarely indebted to the assumptions of instrumental reason and the naturalistic stance. However, the three level description of research, while also broad and vague, may lean towards a 'classical' stance as regards the development and confirmation of knowledge. There is some support for this in the criteria for assessment, where different technological solutions are to be compared and new solutions predicted. This includes a study of the causal relations between the factors that influence the development of technology. Again, technology seems to be presented as something of a universal expression, whose solutions are many and various, but with a common character. The point here then seems to be more on what technology is and how it develops - its products and systems as they appear in different societies - rather than on the character of multileveled social life and human meaning. (In other words, and using the metaphor adopted in the outcome, the focus is on the thread that is technology, not the woven fabric that is society.) However, as just noted, this outcome is described in very wide terms, and it could accommodate alternative approaches to the study of technology. Nevertheless, and given the focus of the previous outcomes, there may well be presumed here - by both the document writers and perhaps too by the teachers who will put it to practice - an approach towards content and process, solution, prediction, and cause that subscribe to notions of instrumental reason and naturalistic thought.

The last two outcomes focus on human values and the biases that may be part of the use of technology. (The outcome states it is preferable that they be integrated with the first five outcomes, but are nevertheless written separately[68].) Values are said to influence technology, and technology in turn effecting society, the economy, and the natural environment. The aim of the sixth outcome is to develop an appreciation of the ways in which technology influences all these aspects of life, both in intentional and unintentional ways. The focus here is on the impact of technology from a host of different settings - that learners be able to research, analyze, draw conclusions, and make predictions about such impacts. The terms used to describe these settings are context (social, environmental, or economic), perspective (local, national, or global), time scales (short, medium, or long term), and consequences (intended or unintended)[69].

While the introduction to this outcome speaks of human values, it remains unclear in what ways the term is being used - especially since the notion of technological impact is not evident from the assessment criteria or range statements. The former consists only of the statement that learners present work that reviews technological impact from different contexts. In the range statements this can be extended to learning outcomes such as the 'unintended short term local impact of technology on society', or its 'intentional long term global impact on the economy'. But the ways

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in which human values play a part in this, what meanings they might have, or how values might be rejected or embraced remain unstated and unclear. This makes it hard to judge the influence in curriculum planning of the naturalistic stance, and on the ways in which human values are taken to operate - either in general, or with particular respect to technology. However, there certainly seems nothing that suggests an interpretive framework to human significance be used, such as the example of Taylor's, as highlighted in the previous chapter. Nor is there any indication of how a systems view might be used, such as that of self-organization, with its consequent, and vital, role for meaning and values in making ethical choices at the cusp of an evolving, sociocultural future. In addition, while 'technological impact' is a well established term, in the curriculum its meaning is vague. The metaphor suggests, however, some external force acting on or affecting society or the environment. In this sense the indication may again be that technology, while an interactive part of society, is also something that works external to it - as an objective-like process based on established steps of development and use that can be describe in general and abstract terms.

In the case of technological bias - the topic of the seventh, and last, outcome - learners need to be aware of the ways in which technology has been used to promote or to counter bias. They as well need to attend to notions of how bias has influenced the use and development of technology. In this outcome it is important to understand the ways in which bias affects groups based on notions of gender, race, age, and the disabled. It involves a grasp of how access to, and the benefits of, technology have been denied to such groups, and includes as well a study of the consequent impact of bias on these same groups. In addition, learners need to appreciate how the use and application of technology reflects different social interests or priorities. Learners should be able then to identify strategies that work to reduce bias and to attend to its effects. This outcome again presents an opportunity to use various interpretive frameworks to gain greater openness to the ways in which human meaning is connected to the working of bias in social structures - such as Thompson's notions about the ideological use of symbolic forms. However, the same lack of clarity of terms makes it hard to judge aright the place of such views in curriculum thinking. It is perhaps more likely that the mainly material and mechanical emphasis of the first five outcomes, particularly their focus on the technological process, serves to place too much attention on technology as an infra-structural part of society, rather than on a study of human value, meaning, or bias. This speculation is supported by the fact that the last two outcomes, in which such matters are explicitly raised, are just that - the two separate (and separable) outcomes that speak directly of such matters. As such, the task then would be to integrate them into the 'real' work of the technological process - the main focus of the learning area. In other words, since matters of values can be stated separately from the technological process as such, then they can only come together in thought by an act of integrative construction. This is not to hold that curriculum writers believe values to be unimportant. It is only that in the very statement of their case they tend to acknowledge, if only implicitly, that the technological process is one thing, values another, and so reinforce what are often unreflected assumptions inherited in the world view of the machine and instrumental reason.

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Integrated learning

In the new curriculum there are sixty-six specific outcomes combined from all eight learning areas. However, five out of eight of the learning areas treat the various sciences, natural and social, including economics[70]. The design is such that specific outcomes and learning areas are to be worked into the learning process in an integrated way - not necessarily tied to grades, but within broad phases of learning and among children who differ as to experience and capacity. The curriculum may well be taken to endorse some kind of interdisciplinary approach, where capacities and outcomes, such as those found in literacy, thinking skills, numeracy, collaborative learning, and research skills, are developed and assessed through 'visiting', as it were, the different disciplines (or leaning areas). Such a framework for learning could be pictured as a wheel, with the various competencies at the centre, and the disciplines as spokes[71]. Connections across disciplines are made through work within the central competencies, while assessment is a more global aspect, treating both the competencies and content specifics. While this may in principle apply to the overall curriculum design, the case of technology education seems to operate in a kind of multi-disciplinary approach. Here, different themes dealing with technology, or more precisely, with the technological process, are understood via the study of different established bodies of specialized knowledge making up technology (such as products and systems in energy, materials, housing, transportation, etc.).

In one sense it is not fair to evaluate technology as a learning area without also viewing the other seven, and seeing how they might connect. This in fact seems to be what practioners at schools are supposed to do - to look at their learning context and to try to link the competencies with learning areas in the creation of learning programmes that provide for the most successful achievement of the sixty-six outcomes. However, the earlier summary analysis of the technology learning area of specific outcomes suggests a strong disciplinary approach based in no small part on prior assumptions about distinctions between research knowledge and human values. Such assumptions are shown up in part in the emphasis given to the various methods of observation and research as are used in technology - say, for instance, in data analysis. The curriculum clearly supports an integrated approach - indeed, it insists on it - in the sense of creating connections among different learning areas. It also calls for the recognition of the changing and contested nature of knowledge[72]. However, and it is worth stating again, in so far as is indicated by the specific outcomes, the curriculum writers appear to inherit overall the procedural assumptions of instrumental reason and the naturalistic stance. This is notably true for the character of abstract knowledge and the application of theory, in that in the curriculum understanding everywhere is to be applied. The same holds for a strong disciplinary attachment, particularly indebted to the sciences, where much of the content of the curriculum focuses on long established areas of scientific knowledge and know-how[73].

There is also the problem of a professional corps of teachers who really only know specialist subjects taught to them from within what is most likely a university (or higher education) tradition heavily indebted to the same assumptions of instrumental reason and the naturalistic stance. If so, then the various suppositions towards knowledge that teachers have inherited or adopted may very well be continued and passed on in the way they put into practice the guiding images used in the

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new curriculum[74]. Alternative frameworks, such as the examples based on interpretation or the deeper implications of non-linear systems and self organization, may simply be passed over.

This is one reason why it may be particularly unfortunate that those who constructed the outcomes, in this case for technology, placed matters of human values in separate statements which must them be reworked back into the core study of the technological process. The assumption seems fairly evident - that technology is the result of an explicit method for the development of knowledge and the construction of products and systems. Of course, other concerns must enter the process, since technology is an inherently applied area - one that is to provide solutions to human problems - but these typically involve the actual design or construction of technology. By placing matters of values in the last two outcomes, numbers six and seven, and adding the rider that they should "preferably be achieved by integrating them with tasks and activities designed to achieve outcomes 1 to 5", the specific outcomes for technology actually make integration more difficult[75]. Given the powerful inheritance of disciplinary thought in South African education, it probably would have been much more illuminating to place matters of human values and meaning at each point and level in the study of the technological process, and in the various competencies to be assessed. But this assumes that the definition of technology, upon which is based the entire learning area, is the one required in the curriculum.

Interpretive learning

The definition of technology adopted for the new curriculum deserves repeating. "Technology is the use of knowledge, skills, and resources to meet human needs and wants, and to recognize and solve problems by investigating, designing, developing, and evaluating products and processes" [76]. The sequence of investigating, designing, developing, and evaluating (i.e. the technological process) results in the fabrication of devices or systems, according to criteria of human choice. In this respect science and technology use the same basic method of research, and so too then a common core adoption of the norms of methodological purity. As an alternative definition, Ferre calls technology 'implemented practical intelligence'. Yet these two characterizations are not particularly far apart, especially since the first is intended for a programme of education, the second a philosophical treatment. Both view technology as a kind of action by design, but which results in the creation of tools (implements) and systems of tools that serve to satisfy some need or otherwise advance some aspect to life. The first seeks to develop competencies, the second to put practice to human intelligence. Most importantly, both come out of a common intellectual inheritance that sees science and technology as kinds of knowledge that can be used to manipulate, control, or fabricate natural processes for human ends, to amplify human powers, or to further the survival of the human race. The success of science and technology then serves as evidence of the exactness with which humans understand these processes of nature and the various human powers. It is an exactness that is hard to gainsay on any account, and in terms of which other forms of knowledge and action may often seem ineffective or inferior.

A main theme in this thesis is that the world view of science is often adopted too enthusiastically. Its abstractions work well in certain and limited domains. The success had there, and the developed sense that scientific accounts are the only intellectually respectable accounts, means that

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its modes of instrumental reason are used for areas of study and experience that may in fact serve to distort them. However, the point in this work is not to put up against science alternative modes of knowledge to act as rival for the heart of reason. It involves instead an attempt to broaden the boundaries for making sense of the world, and so too therefore of what reasoning might be and achieve. The attempt to integrate a variety of disciplines, often based on the epistemic imperative and methodological purity, and so achieve a sense of competence in understanding that goes beyond only specialist knowledge, is an important and valuable approach to learning in the new curriculum. It does however tend to rely still on notions of reason, action, theory, and values as part of the inheritance of a Western intellectual tradition that has its origins, in part, in the mechanistic world view and in the naturalistic stance.

An interpretive type of learning, while acknowledging ideas about the world as an objective process and of values as relative matters of human decision, could also involve an interpretive understanding of human meaning and symbolic forms. It would treat an object domain unlike that which obtains in a science based on irreducible fact and foundational reason. The place of human concerns and values, not as items to be bolted on, as it were, to human consciousness through a rational reconstruction, but also as matters of an already interpreted significance for human persons, can be an important part of a holistic approach to learning in the new curriculum, and in technology education in particular. If so, it could serve to clarify the sense in which matters of practice are inseparable from the expression and realization of new meanings for that practice. The character of reason would then need not only be seen as discursive analysis, but also as being open to aspects of meaning that lead to gains in understanding and self-clarity.

Instead of treating the technological process as the core of technology education, the interpretive character of technology as human practice needs also to be explored. Otherwise, the sequence of investigating, designing, developing, and evaluating technology may fall afoul of the attractive power of the metaphor of the machine - a metaphor that fits well and truly into established images of technological action and economic development. But because the image is overly charged, it therefore needs a substantial balance in approach. If not it may result in a curriculum that adopts modes of thought that tend to overlook views of human meaning and practice for which the image of the machine is wholly inadequate. This is particularly true for matters of understanding and application which the curriculum adopts as a particularly crucial focus. An instrumental account sees applications as flowing out of some prior level of understanding and planning in a world comprised of objective and neutral processes (of which technological products may be a part). In an interpretive framework, such as that developed by Charles Taylor, self- or re-interpretation can serve to change in practice those very aspects of reality that are being understood. In such a view, language plays a key part in holistic learning - not as an object of study itself, but as a way of expressing and realizing new meaning and significance, and hence of greater self-clarity in the significance of some practice of technology.

In this sense then can a kind of interpretive approach lead to a more open and aware practice of technology - one less indebted to accounts based on the metaphor of the machine - and hence a more balanced curriculum. Such naturalistic accounts tend to filter out issues of meaning, ethics, and responsibility through the designative use of a language of neutral descriptions from a

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disengaged stance. The task then is to reconstruct the place and function of values as perceived in a representational consciousness that is used to make sense of science, society, and technology together. As noted before, in the new curriculum this means that areas of content and values that are stated separately for the sake of clarity of thought and planning, as in the technology learning area, must then be integrated so as to help overcome the limitations of ideas that separate out theory from practice (or ethics from action). The knowledge of technology that an interpretive approach can add might serve to create a more open awareness of the ways practice is a part of meaning and significance, and hence how technology (or any science) as human practice in fact makes no sense when separated from matters of ethics and responsibility.

For example, the statement in the technology learning area of the last two outcomes dealing with values and bias would instead have to permeate all aspects of the way the technological process is taught and learned. Here it is not a matter of integration, but of recognizing that technology as human practice cannot be made sense of when the importance of values and meaning for technology are taken as part of a rational reconstruction. However, and in another sense, the whole notion of the technological process as constituting what technology is and does might need to be questioned. First, the process itself inherits ideas that need not be granted as regards the nature of knowledge, the practice of reason, and the character of purposeful action. In the curriculum outcomes these need to be explored and made as explicit as possible. Second, while there is no doubt that technology secures for human living certain powers and abilities not otherwise available, yet in an interpretive approach (for which there are a host of possible frameworks), the practice of technology may itself be affected by the ways in which such powers and abilities are received and interpreted by persons for whom meaning is an unavoidable, constitutive aspect of their lives. From the point of view of technology as human practice, it is not the case that one can simply study the technological process as an objective-like procedure - one that rests on matters of irreducible fact needing no further judgments to be what it is (or as a method that obtains equally in all cultures, differences being a matter of application to the specific circumstance). Technology as human practice can also be bound up with the ways in which people make sense of their world - ways of understanding that, for instance, include the operation of symbolic forms which when analyzed in their social and historical context, and reinterpreted, may change the character of that practice[77]. In achieving the outcomes in the new curriculum, it may very well be faulty to focus on the technological process as such without attending to such issues as the logic of self- or re-interpretation[78]. An interpretive study of technology may not provide for a greater collection of problem solving techniques, or more effective abilities in development and design. But often this sense of problem solving is not what is required of understanding. What is needed as well is a being open to matters of human significance and meaning in the way technology is practiced, and therefore to an approach across cultures that allow for interpretations that illumine one's own practice in the attempt to gain a greater sense of others.

Learning and self-organization

Self-organizing systems present as well a rich notion of holistic learning available to curriculum policy and technology education. The critical outcomes, which are intended to influence the way all specific outcomes are achieved, speak in part of the need to demonstrate an understanding of

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the world as a set of related systems, and hence, that problem solving contexts do not exist in isolation. This seventh outcome is related to the first and sixth - that learners be able to identify and solve problems, including the use of critical and creative thinking in decision-making, and that science and technology be used effectively, critically, and responsibly. It is difficult not to note that a systems approach is in large measure an outgrowth of contemporary scientific developments. That five out of the eight learning areas are science related suggests that the curriculum is heavily weighted towards systems, science, and problem solving skills and approaches. Indeed, only the learning areas of science and technology are directly involved in the wording of the critical cross-field outcomes - outcomes that are to influence the way all learning areas are to be developed and implemented [79].

It is also worth noting that only the sixth outcome treats characteristics of the world as such. The others speak of identifying, working, collecting, communicating, or using - various types of skills or abilities that learners must develop for themselves. But the sixth deals with attributes of the world as constituted by systems in relation, and this the learners must *understand*. The curriculum therefore gives preferential weight to a particular construct in terms of which the world can be approached or made sense of - one could say in terms of which the world might be reconstructed. This does not mean that other constructs cannot also be employed, but only the systems view is made explicit in the critical outcomes. If so, then work within the sixty-six specific outcomes and eight learning areas must aim towards the development of this sense of systems.

As noted before in the discussion on the specific outcomes for the technology learning area, it is by no means clear from the wording of the sixth outcome what its writers intend by the term 'systems'. There are of course many approaches to systems thinking, and to the ways in which phenomena may be analyzed from a systems point of view (the notion of self-organization is one of these). What is common to all such thought is the notion of events in relation and interaction. Yet how this is to be developed in integrating the learning areas and competencies remains unstated in explicit terms[80]. It is an open problem for curriculum practitioners, and will likely be clarified only in the attempt to see what comes of it in the process of daily teaching and learning.

Of course, the way the curriculum is conceived may itself be seen as reflecting a systems approach, with the various learning areas working in concert according to the critical and specific outcomes, and within the sphere of the three competencies - practical, foundational, and reflexive.
If so, then the evident commitment to the notion of integration in the curriculum may well serve as a guiding conceptual example for understanding to follow. The eight learning areas could be seen as systems of knowledge by which different senses can be made of the world. The world is mathematical in character, or technological. It is artistic and cultural, or scientific, social, and economic. The task of an integrating system then is to see how and that these different viewpoints make connections among themselves, and so highlight thereby the ways in which problem solving works in relation. It must be granted that this is an admirable, multi-disciplinary approach[81].

However, the emphasis in the curriculum on systems, problem solving, and the sciences (human, social, economic, mathematical, natural, and technological), may steer a system of integrated learning towards the adoption of certain assumptions about the character of the world and the

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nature of knowledge based on instrumental reason and mechanical explanation. Once the curriculum becomes weighted towards sciences that derive from this tradition, it is hard not to adopt such instrumental and mechanical views of knowledge and the world as they inherit. This at once makes systems thought appealing - since it too is drawn from the same tradition - but it also makes it more likely that conceptually one will look at the world as composed of phenomena reconstructed in scientific terms, and hence as a system of procedural knowledge. (This is one good reason why technology education fits so well into the new curriculum.) There is of course nothing wrong with scientific knowledge, nor a view of the world as a network of sciences with its know-how implemented in technological systems. But it is a distinct position based on well established assumptions about the character of knowledge, reason, and action which need not be granted as comprehensive in a systems approach to curriculum design and its stated outcomes.

Of course, technology and science are not static enterprises. As discussed in the third chapter, recent work in relativity and quantum mechanics suggests a sense of knowledge, and a account of the world, that is distinctly other than that adopted in classical modes of thought founded on the metaphor of the machine (and which technology uses to great success). They offer views that extend the vision of a scientific world, thereby softening the machine metaphor. Such views could be used in the curriculum to counter what might be a strongly classical slant from which the sciences involved in the learning areas originated (but from which, due to contemporary research, many are also migrating)[82].

The work in the previous chapter on self-organizing systems was an attempt in part to highlight a way of thought that, while still admittedly scientific in origin, also held out prospects for understanding to proceed beyond traditions of analysis working within the world view of the machine. It offers a more organic conception of the sorts of processes at work in the world, and which in turn gives rise to new scientific conceptions of the patterns of both matter and evolution. While these ideas have already been reviewed earlier in this chapter, it is worth restating their main points of emphasis here where the focus is on curriculum and technology education. One implication of self-organizing, non-linear systems is that at the level of the sociocultural, values play an unescapably important part in making sense of evolutionary futures - a future toward which all contemporary human life is moving, and creating in turn. The evolution of reflexive consciousness, and thereby the creation of human community life other than the metabolic and social-biological, means that humans are involved in a conscious and responsible creation of their own evolving future. In such a view, values need not serve mainly as guarantors of existing institutional forms - those that have served well or ill the requirements of human life - but are also involved at the cusp of evolutionary practice. They are to be debated and queried, discussed and evaluated, rejected or adopted. Their implications and consequences call for a prescient analysis, however halting or unsure it might be, since in some way upon them will depend the character of an evolving community life. Such a view could have substantial effects on the way the new curriculum, including technology education, is thought through and put to practice.

In such a view of sociocultural evolution, it is important to not rely only on, nor solely to support, modes of thought and knowledge production as might furnish results that are secure and reliable. Evolution is in part advanced by an interaction between the maintaining, conserving processes, and

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those that create and make new. Both are complementary, and the failure of one leads to the degradation of the other. Over time the scientific enterprise has tended to form for itself, as it were, a picture of its own procedures as unique and important. Such beliefs are encapsulated in the ideas of methodological purity and the epistemic imperative. While the origins of science placed it at the forefront of a historical revolt against an overly deductive analysis of purpose as obtained in the science of the middle ages, it has now become, through its own success, the protector of valid knowledge claims and legitimate knowledge production. This is not at all to propose that science has become obsolete - it has always been a source of imaginative enquiry - only that as an enterprise it has tended towards the conserving and maintaining process in the evolution of sociocultural life.

The notion of self-organization, and its implications regarding evolutionary processes that together both conserve and create, can add much to an understanding of the world as a set of related systems, and hence for a balanced grasp of the new curriculum. This is particularly true for a curriculum heavily weighted towards the sciences and problem solving as a way of regarding the world. Science and technology, cast as conserving or maintaining processes, serve as the platform for both a mastery of established disciplinary learning and cross-disciplinary skills, and as examples of systems of knowledge. These provide for a particular focus on the world, and its technological control, manipulation, and fabrication. Such systems of knowledge and know-how offer patterns of secure and reliable knowledge to learners who are only beginning to make sense of their world, and how to act with and within it. In addition, the creative, open forms of evolution need also to be addressed when trying to understand the world as a set of related systems. In the curriculum this is often treated at the level of innovation and change in the way science and technology are practiced. But these operate more at the level of the material and structural forms of metabolic and social-biological processes - what was earlier called the infra-structural aspects of society. The evolution of reflexive consciousness places values at a kind of centre-point or cusp for all levels in a multileveled, sociocultural life, including the scientific and technological. Values and the expression of other and various forms of human potential become keys to an evolving future. If so then they need to become a focal point of curriculum design and practice As noted before, such values - and the way they find expression in society - need to be debated and queried, discussed, evaluated, and interpreted in the curriculum at every level, not just in technology education.

However, the argument here is that in the new curriculum the language in terms of which education's guiding images are expressed, and its main outcomes described, is not emphatic enough in its insistence that matters of human values and meaning be pondered, interpreted, and discussed in the attempt to understanding the world as a set of related systems. Yet clearly, that meaning and significance are involved at all levels of a living world is part of what it means for systems to be in relation. Values have indeed been spoken of in the new curriculum, and stated as necessary to the process of education. But they have been written in a way such that, if the choice is made, they can be dealt with on the side, as it were, or as an addendum to the main tasks in teaching and learning. Such is the case with technology, where the technological process occupies the main focus in the specific outcomes. The emphasis on values is there, but often, as again in the case of the technology learning area, it is put in separate outcomes, and so is left open to inclusion or not through the choices teachers make in the way a learning programme is designed or enacted.

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Of course, and bluntly, in the push of time and daily schooling, and given that the teachers themselves are trained in subject specific disciplinary knowledge, the substantive and central place of values in an evolving set of open systems will most likely be lost sight of or even ignored.

There is no doubt that science (and technology), systems, and problem solving are main points of emphasis in the new curriculum. It would be irresponsible for them not to be, given the usual assumption that science and technology are requirements for economic advance, the solution of social problems, and the need for skilled manpower training. They also form an undoubtable story of success in the way their methods of inquiry have provided decisive and commanding accounts of experience, and the technological talent to control, manipulate, and fabricate the world. On this account as well would it be irresponsible not to accent them in the new curriculum. But perhaps the emphasis is overstated. When the choice is made to understand the world as a set of related systems, then assumptions may be brought to bear that preferentially marshal and direct thought towards a rational reconstruction indebted to mechanistic explanations, instrumental reason, and performance based action. While it may be that the curriculum planners did intend to avoid this, yet mechanistic assumptions about knowledge and reason are hard to gainsay, especially when a scientific view is adopted. But then this is the strength of a view such as that based on self-organizing systems. By positing an organic account, substantiated by developments within science itself, a systems approach centred in self-organization can outrun the race to make sense of the world on overly mechanistic terms. However, and repeatedly noted, for this to be a success in the new curriculum the substantive and central place of values and meaning becomes decisive. It needs to be part and parcel of every statement of every outcome for all learning areas, not left to a set of separate declarations whose intimate relation with the whole may be misconstrued.

Chapter review

This chapter has attempted to treat technology and technology education from the point of view of intelligence, interpretive frameworks, and self-organizing systems. The notion of intelligence is often associated with the use of tools, and the evolution of specialized brain functions driven by hand movements and tool use. Such specialized evolution is connected as well to sequential and community planning, and the use of language syntax. As a result the human nervous system has evolved such that it requires 'outside' devices to express and use its various potentials and abilities. These abilities are often shown up in tools, inventions, and technologies that are taken to demonstrate man's intelligence and adaptability for survival, as well as his progress in demonstrating a superiority over nature in the development of ideas and implements that permit the control, manipulation, and fabrication of his world.

Technology can as well be seen as practical implemented intelligence. Theoretical intelligence involves, in part, a standing back and surveying of the world from a disengaged stance so as to comprehend it for what it is. Principles of abstract knowledge are constructed that permit the development of explanatory and predictive schemes of thought. Practical intelligence involves the ability to move about in the world in directed ways so as to accomplish various tasks, or to achieve distinctly conceived goals. It consist of a host of skills, instruments, techniques for the execution of various productive ends. Technology is built up from the combination of theoretical

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and practical intelligence. By bringing abstract principles of knowledge into the use and creation of tools, a systematic method is created that raises craft know-how to the level of rational knowledge. This can be used in coordinated, planned, and practical ways so as to create systems of technology that are artifacts of the intelligence by which they were designed and produced.

The use of well established notions in the scientific world view, such as foundational and instrumental reason and naturalistic action, tend to build up a view of technology highly indebted to the metaphor of the machine. The character of artifacts and intelligence may lead to a neglecting of issues of significance and meaning in the way technology is understood and practiced. This is amplified by the emphasis placed on Darwinian notions of survival and the view of technology as part of an objective process. The success of scientific-technological intelligence in the formulation of social norms of action, and in the very building of institutions and social systems, reflects back the very views by which they were created, thereby making both the practice and the principle appear right and rational. An interpretive framework can give to the study of technology an awareness of the central place of meaning and significance in technology as human practice, and of the ways in which symbolic forms in socially structured contexts can convey meanings about technology.

Here the object domain of a study of technology as human practice relies on the logic of self-interpretation and the analysis of symbolic forms - not on irreducible facts. Meaning and significance are given prior to any rational reconstruction. The way the world has sense and significance is itself involved in how that world is expressed and realized in practice for persons who know it and live within it. Persons are thereby involved in interpreting its meaning - an interpretation that can change the practice that is being understood. Reasoning about technology results in gains in clarity about one's own practice, and can be interpreted by persons for whom the world is already a place of meaning and sense. While such a study of technology may not provide a better engineered system, it does offer a sensitivity to, a being more aware of the place of values as an requisite aspect of technology-based action.

Self-organizing systems provide an organic view of the way human sociocultural life has evolved, and hence the way technology might be conceived. The evolution of reflexive mind creates patterns of thought and action no longer dependent on only metabolic or social-biological processes. At such a level the world can appear in conscious and symbolic representations. This in turn gives rise to community life whose evolving patterns are cultural, not metabolic. Humans have thereby become responsible for their own evolutionary future, since the patterns of evolution are now evident to man's conscious understanding and are expressed in directed action. At such a level values operate at the cusp of an open and evolving future. Evolutionary patterns are a balance of the conserving and the creative. Both must be active. However, science and technology have tended towards the conserving, material, or structural regimes. Technology may be innovative in its own sphere, but a technological future for an evolving human sociocultural life must attend as well to the way values give creative sense and direction to the whole.

The value placed on science and technology for the effective running of society means that they are important aspects in the education and training of a skilled workforce. Technology education

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is now part of the new national curriculum, which focuses on the development of capacities and outcomes that permit learners to express and demonstrate the skills they actually know. The new curriculum aims to provide the educational basics for a productive and competitive economy, and improved societal well-being. This is to be done through the development of knowledge, skills, attitudes, and values. Technology and the various sciences play vital roles in this process.

The curriculum is divided into critical and specific outcomes, applicable to eight learning areas. Various levels of competence and assessment are also involved. The aim is to provide integrated learning programmes though the guiding image derived from the critical outcomes, and as they influence all specific outcomes for all learning areas. Core competencies are to be developed throughout, in addition to learning area specific knowledge.

The technology learning area has seven specific outcomes. The first five of these concern understanding and applying the technological process - investigating, designing, developing and evaluating products and systems. In general the specific outcomes tend to adopt instrumental and procedural approaches to reasoning, performance, and planning. They tend to focus on understanding and application as aspects that require integration for achieving technology literacy. In addition, the technological process is spoken of as if it were an objective-like event, having general characteristics essential to its description, and which when applied or used in specific circumstances can account for the different forms of technology in different societies. The last two outcomes in the technology learning area speak of human values, technological impact, and social bias. These are referred to in broad terms only, but the assumption may be that such values and impacts are to be understood from within the same instrumental and procedural stance as was assumed in the study of the technological process as such. The outcomes are written in such a way therefore that matters of values must be consciously reconstructed onto the study of technological products and systems.

Such a view of technology is based, at least in large measure, on the world view of science and the metaphor of the machine. An interpretive sense to learning and the study of technology can include matters of human meaning as expressed by a language of interpretation. By so doing it can lead to a more open and aware practice of technology. The consequence here is that in viewing technology as an interpretive human practice, the place of values in the technological process can be made greater sense of since they are not taken as factors to be 'bolted on' in a rational reconstruction of the importance of technology. In addition, the object domain of such a study is not an objective-like process, but one constituted by meaning and symbolic forms for persons who already understand their world. Technology as human practice is an already interpreted domain that is open to reinterpretation, and the expression and realization of new meaning which can in turn alter that practice. In such a framework it is impossible to separate out matters of ethics and responsibility from a study of any technological process.

Self-organizing systems provide additional ways of viewing the process of technology education. Among the critical cross-field outcomes is the requirement that learners demonstrate an understanding of the world as a set of related systems. Just what sort of system or type of relations is left unstated. One option is to follow the multi-disciplinary example illustrated by the curriculum

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itself. However, such an example involves substantial debt to forms of empirical or instrumental rationality, since technology and the various natural and human sciences constitute five out of the eight learning areas. As such the formulation of the specific outcomes tends to place matters of meaning and values as separable considerations, with the onus for integration placed on the choices teachers make and the way they work out a learning programme. Given the various stresses of daily school instruction and the fact that teachers are themselves trained within subject specific disciplines, this integration may falter.

Systems taken as self-organizing wholes evolve through the complementary interaction of conserving and creating processes. Values play an important part in all levels within this interaction, but particularly so at the cusp of an open and evolving sociocultural future. Science and technology are largely conservative, though still innovative, in that they operate in society in largely material and infra-structural ways. The organic view posited by self-organizing systems provides a counter to the image of the machine that can be used in the curriculum in general, and in technology education in particular, as a basis for understanding the world as a set of related systems. However, since values and ethics play such a substantive and central role in sociocultural evolution, they need to permeate every statement of each specific outcome from which the whole of the curriculum is constructed.

Summation

Technology demonstrates a substantial relation between intelligence, tools, and action - between evolution and performance for survival. Its patterns for design and production are similar in many ways to the methods of science. Both are procedural and instrumental. Technology is particularly indebted to the metaphor of the machine, since its various artifacts are nearly always seen in mechanical-like terms, and its use viewed as a tool for productive purposes. It therefore gives to the modern age a notable reliance on control and manipulation - an amplification of human powers - for the way social and human problems are both conceptualized and solved. To this extent then is the pace and step of our technological dance heavily indebted to a mechanistic world view and the naturalistic stance towards rational problem solving

However, this need not be the only view of technology and human action. Self-organizing systems and an interpretive framework give to the view of technology a sense and meaning other than a machine-like working in rational problem solving. Values and meaning are an inherent part of the way technology may be adopted or rejected as an instance of advance or decline in human well-being. In a creative evolutionary stream, ethics and a vivid accounting of values is a necessity for living in an active present, and for opening up future potential for a sociocultural life well lived. The ways in which meaning is constitutive of human practice ensures that technology, and the institution of science in general, can be analyzed in a social-historical-cultural context. Technology as human practice concerns the way its symbolic forms can be interpreted, new meanings realized, and the practice of technology changed.

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The same mechanical-rational problem solving view of technology is adopted in technology education programmes. The continued reliance on disciplinary thought is part of the way technology is seen as a separate area for study, one having its own distinctive technological process as a focus of learning. Yet here too can self-organizing systems and an interpretive framework bring added richness to the way learning about technology must involve values and meaning for human practice and human futures. Discussion, consultation, interpretation, and the discovery of new meanings for practice are needful at all levels in the learning process. Approaches such as evolutionary self-organization and an interpretive analysis of human life also provide a sense that holistic modes of thought can bring to the learning process added understanding for the way human and natural worlds are intimately linked and related beyond the metaphor of the machine.

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Conclusion

"The perfect image is still as remote as the distant stars"[1].

The arguments in this thesis have in part both relied upon, and worked towards certain notions of holistic modes of thought. There are at least four such notions involved here. First, there is a unity to the world of existence and experience that no set of abstractions is adequate to portray. Second, life is not material, but is also made of transformations and transitions that are complex and particular, that defy characterization in static terms, and which co-evolve into novel states of dynamic order. Third, different levels of reality comprise the world in connection and interaction, and that different aspects of those realities present themselves differently depending on how they are approached - depending on what sorts of questions are asked. Fourth, human knowledge cannot get away from the fact that humans are not objects 'out there', but are partly constituted by self-understanding. (The knowledge we have of ourselves, of the way our world exists, and the meanings given therein, cannot be divided without loss of generality into objective processes and subjective states.) From all these comes the broader notion that in understanding the world and self we cannot be limited to a single presentation or portrayal - a single grasp - of what is real. Put differently, no one language is sufficient to describe experience, to express our status as persons, or to reveal the character of our world. In this sense then is knowledge always joined to judgments or evaluations. There is no such thing as a comprehensive understanding or a final rendering of a situation. Something more can always be leaned, and something is always left unsaid.

In the tradition of science - whose ontology is based on the metaphor of the machine and whose reasoning is often procedural and foundational - such ideas may be hard to grant. Science, after all, still seeks the perfect image of the world as an objective process, and holistic modes of thought seem to suggest that there is no such image. Jacob Bronowski has written: "We are here face to face with the crucial paradox of knowledge. Year by year we devise more precise instruments with which to observe nature with more fineness. And when we look at the observations we are discomfited to see that they are still fuzzy, and we feel that they are as uncertain as ever. We seem to be running after a goal which lurches away from us to infinity every time we come within sight of it"[2]. The paradox is first, that an ever more refined image of the real shows up always to be fuzzy, and second, that such discoveries discomfit us. Being baffled by this discovery points to the assumption that scientific knowledge is taken to be secure and reliable in a certain way - that the intellect of man has discovered an approach to understanding the world which grants knowledge of a demonstrably accurate sort, one hard to gainsay on any other account. If so, then to find the world always fuzzy means to abandon something held dear in the project of science.

There is nothing the matter with science. The mistake is in the assumptions that empirical science explains what really is, that how it proceeds is what is meant by reason, and that all objective phenomena can be accounted for by procedures of instrumental research. The problem in part is in the assumption of universal applicability of theory, which distorts the sense to both 'application' and 'theory'. This results in conceptions of knowledge and action based on a view of the nature of

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reality and the character of reason taken to be comprehensive of experience, but which, like every attempt at understanding, is only partial. Much of these ideas are based on the contradiction in modern thought created by the distinction between factually real objective processes in nature (to which scientific knowledge attains), and the character of values or human meaning as constructs or perceptions of the mind only. Such views are the overall inheritance of a mechanistic world view, one that shapes many aspects of thought as regards the character of reason, and the way knowledge of the world is obtained through some kind of rational reconstruction. This was introduced and discussed at some length in the first chapter, and appeared again in the second in the way the institutions of science and society are conceived to relate. It has particular implications for the way means and ends are connected and calculated, and how rational decision-making is to proceed. Both these ideas were stressed in chapter two. In addition, matters of intelligence and technology adopt the distinction as basic to the ways in which systems of technology and technology design are held to operate - ideas that often adopt the notion of performance criteria and the coordination of thought and tool for survival value. As noted in chapter four, this in turn is taken as a main characterization of intelligence - one that influences in substantial ways the whole process of learning, and so too then technology education. One main attempt in this thesis has been to not only highlight different instances of this contradiction in modern thought, but to try to work through it in ways that are less naturalistic, more holistic in character.

Holistic ideas can add at least two things here. They can highlight the limits of any one mode of thought, and they can urge a way of approach that seeks connections, as well as pointing out differences, in attempts to make sense of human practice. In so doing, and as suggested by both the systems approach seated in self-organization and accounts based on an interpretive framework and the ontological character of a meaningful world, something of human values and ethics is brought into a centre-focus of human understanding. This is particularly so in the relation between science and society (the point of discussion in chapter two) in which many commonplace distinctions in Western intellectual culture - such as between means and ends, theory and practice, fact and value, reason and emotion, present and past - only belie. As noted repeatedly in chapters three and four, the fact that values are a necessary part of any evolving sociocultural existence, or that human persons live in a world of signification and a being-with-meaning, can only help make more open and rich the way we might come to understand our self and world. If so, then holistic attitudes can as well accentuate the notion that in a world said to be growing smaller, Western modes of thought can be seen as but one aspect to any attempt at understanding. To insist on them, or to implicitly adopt them without discrimination, can prove to be unwise.

From a holistic stance, at least as it has been developed in this thesis, the paradox of knowledge - that there is always a disk of ambiguity no matter how precise might be the attempt to specify what is observed - is simply a part of what it means to make sense of human life. In this context then 'holistic' simply means to take on a broader set of ideas concerning knowledge and reality that are not exclusively those derived from the ontology of the machine and naturalistic reason. While this broadens the base for understanding experience, there is no base broad enough to attain to complete descriptions of the whole of that experience or existence. Instead, the sense here emphasized is that in seeing things from only one aspect, in expressing them in terms of a particular descriptive or explanatory language, a false and distorted picture is necessarily built up.

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This suggests another connotation to the term, that no theoretical account can do justice to the character of what is observed and experienced. In the first instance, particular cases exist that defy an accounting *a priori*. As noted in chapter three, novelty is a part of the way an evolving world fits together. In the second, any theory must abstract from experience, and so give weight to one form of conceptualization over others. Chapter one served to highlight the way in which the mechanistic world view accomplishes just this. Something is thereby always to be excluded since in the abstraction some type of selection and isolation takes place. But in a holistic sense, things are connected in complex ways, and so theory truncates some aspects of experience, rendering incomplete the picture of the real it might otherwise build up - no matter how illuminating or persuasive. Even a theory that is particularly convincing can remain incomplete in vital ways, as is demonstrated by the contemporary commitment to the abstractions of modern science. Here it is generally believed that what something is to be determined by how it is known - an observation made many times in this work. It is a main approach to theorizing in Western thought, and is one way of accounting for the great amount of 'theory making' that goes on in its intellectual culture. As was noted in chapter two, one view of knowledge places science and its various competitors in a game of generating reality, and this makes sense only by supposing that attitudes in the West to what is real requires some kind of procedure to find it out before it can be recognized for what it is. Charles Taylor's account in chapter three, based on an interpretive framework, is one attempt, within a broad hermeneutical tradition, to describe a substantive approach to meaningful experience and existence, rather than procedurally via rational reconstruction.

'Holistic' as well indicates two avenues of general approach to understanding, though both relate to an interpretive character of knowledge. In the first instance, truth is always to be seen from somewhere. There is no absolute, disengaged stance from which to view the whole of existence. We live within it, interact with it, and are apart of it in such a way as to make a complete description impossible. In the end there is no 'god's eye' view. As pointed out by Eric Jantsch, discussed in chapter three, we live in an evolutionary stream, and therefore we must offer an interpretation, or a picture or portrayal, of the meanings and connections we see. There are therefore always other different connections to make sense of, but which may either complement or correct what has gone before. However, this position need not pay rent to relativity - that one cannot judge between a host of views in a culturally or morally diverse world. Such a view of relativity - skepticism really - comes from an assumption about what constitutes certainty, and is itself a reflection of that contradiction in modern thought mentioned earlier in this conclusion. This particular implication was discussed repeatedly in chapters one and three, but it also concerns much of the argument in chapter two, in the distinction between means and ends taken as a guiding image for the way science and society may be conceived to relate. There is of course no need to adopt the standards of certainty as are used in empirical science to evaluate experiences not properly open to the abstractions of such a science. 'Certainty' is not always what is called for in attempts to characterize what we can know, or what exists. Sometimes understanding requires a gain in sense and meaning that can find expression in the reality of practice, or in the way in which there is no justifiable inner-outer distinction in living systems.

In the second instance, 'holistic' implies taking everything into consideration, finding a unity in diversity, that gives a more coherent interpretation or articulation to what is seen. It provides a

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way of seeing living systems that highlights the kinds of organic connections that make them whole. One task then is to look for as many links and connections as one can among differing views, fields of knowledge, or pictures and portrayals that concern whatever may be the particulars of the case at hand. Understanding is improved when judgments are made from the attempt to unify a host of perspectives. This is a move away from specialization as such, and towards either an inter- or trans-disciplinary approach, or one that takes phenomena for what they are, to try then to make sense of them by building up their particular and possibly unique senses or coherence. Our conceptions of technology, and so too technology education, may benefit particularly well from such a move. This point was made in chapter four. It is one area seemly well embedded in a mechanistic stance. Of course, this has in part given to both science and technology their particular strengths in control manipulation or fabrication, and the amplification of human powers, for productive ends. But perhaps the strength has become something of a bully, rendering respectable thereby only one approach to human knowledge and action. This can only dim the insight into other valuable aspects of human living, particularly as regards knowledge, action, interpretation, and values in the realm of meaning giving ideas and practice.

One aspect highlighted in all four chapters is that classical distinctions between theory and application, often described in terms of a means-ends analysis, is not an adequate base from which to account for human action. In a holistic sense, 'theory' need not be divorced from 'practice'. Even to use the terms is to trip us up. If we seek in our actions the accomplishment of productive purposes - the control, manipulation, or fabrication of our world - then instrumental reason has a lot going for it. However, the success of the mode of explanation and prediction achieved by science can convince us both that action is to be conceived in terms of performance towards some chosen outcome, and that to achieve that outcome we must apply piecewise and analytical understanding to the requirements of the task. When this happens instrumental reason and the way of abstraction in both science and technology can be used in domains for which they are not properly suited. However, both interpretive accounts and self-organizing systems offer example approaches to human action that do not make such contrasts. Here the distinction between theory and practice comes to nought, as do notions of means and ends as a calculation for action (neutral means, chosen ends). In the first, action and practice are cyclically related to aspects of meaning and interpretation such that they form a unity of expression or realization. In the second, an open, evolving sociocultural life can only be made real by living in an active present. Only here does an understanding of the past meet the novel possibilities of the future in a kind of ethical dance in which ends are immanent to the way human practice proceeds.

A similar result, thought not as explicit, comes out of developments in contemporary science. As noted in the first section in chapter three, the whole range of abstractions surrounding point location and linear trajectories must be replaced in quantum mechanics with probability uncertainties and complementarity. In the end these lead to a more organic view of physical reality and a new conception of matter. The basic assumptions about what constitutes a mechanical explanation is thereby called into question. This is notably true in the way the act of human observation in part decides what will be seen, and therefore how the world will be made sense of and explained. This then opens the way to an alternative notion of how to makes one's way about in a world that is not just factually given, but which shifts under our gaze - and this

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implies human action is not just a matter of clear calculation towards distinctly conceived ends. Of course, rational reconstruction is part of the way we can make sense of the world, and one can try to account for human action and practice from within the logic of that reconstruction. Yet in the case of the ontology of the machine and instrumental reasoning, this posits a distinction between theory and application, between means and ends, and the uses of intelligence based on modes of thought that assume much - perhaps too much - about what constitutes understanding and explanation on the one hand, and action and application on the other.

It is also largely true that holistic ideas point to the connections inherent in all aspects of life - that each part is a whole and every whole is in turn part of another. If so, then each particular meaningful act or living event holds within itself some aspect or character of the whole from which it comes and upon which it interacts and relies in turn. The patterns that are found in each part reflect, in some way, characteristics of the whole. This was noted in the discussion of language in interpretive accounts - that the whole of language is needed to realize a way of meaning-in-the-world. Sequential descriptions, or a designative use of language, often fail to do justice to the world of human persons. In addition, self-organizing or evolving processes make up an interactive whole apparent only in relation to that whole - they possess characteristics that are not present in an inert state. If so, then notions of direct or linear cause would fail to account for the changes that take place in living systems. In general, this view of life as meaningful and organic, where each existing aspect touches or reflects back on the whole, is a primary point of departure for holistic modes of thought, and has been a main organizing theme in this thesis.

This work has attempted in part to unmask some of the assumptions behind a mechanistic world view, and its associated stance on naturalistic or procedural reasoning. The point has not been to discredit such a position, but to highlight ways in which such an accounting of the natural and human worlds suffer from an overenthusiastic use of abstractions indebted to the metaphor of the machine and foundational modes of thought. The Western intellectual tradition often adopts this stance unreflectingly. It has become part of the way we understand not only the natural world, but so too both human society and the individual self. One result of this is that certain conceptions are adopted about the relation between science and society that also assume many of the main categories of naturalistic reason and the ontology of the machine - particularly in the way means and ends are distinguished in an account of human social action. The same is true for the conceptions of technology, and technology education, through their indebtedness to notions of intelligence and tools. This thesis has looked at how holistic modes of thought furnish a counterpoint to this overabundant use of a mechanical metaphor. Contemporary science itself points to ways of thought that rework conceptions of physical reality and our knowledge of it. In addition, two examples were given of holistic-like approaches to the reality of human practice. These gave an account of human knowledge and action that illuminate differently ideas such as means and ends, theory and application, or facts and evaluation. They treat human and social life as open, evolving processes, and meaning as constitutive of ourselves as human persons. Both offer an approach to understanding the world that seeks neither to control nor manipulate. The task instead is to seek out, appreciate, and discover how human life might be made sense of by its being interconnected to the whole of that life. By so doing the relation between science, society, and technology is conceived to be unavoidably ethical and meaning-filled in its human practice.

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Appendix

Assessment criteria and range statements
for the senior phase of the technology learning area

(Adopted from: *Curriculum 2005: Specific outcomes, assessment criteria and range statements grades 1-9* pages 86-105)

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1. UNDERSTAND AND APPLY THE TECHNOLOGICAL PROCESS TO SOLVE PROBLEMS AND TO SATISFY NEEDS AND WANTS.

The Technological Process refers to the cycle of investigating problems, needs and wants and the designing, developing and evaluating of solutions in the form of products and systems. The technological process is the basis of all technological endeavour. An understanding of the process is fundamental to the acquisition of technological literacy. The Technological Process is an integrated and indivisible one and therefore assessment should apply to the whole process.

ASSESSMENT CRITERIA

Learners should indicate an understanding and application of the Technological Process by presenting work in which:

- problems, needs and wants are identified and explained
- a range of possible and relevant solutions are considered
- an informed choice is made
- a design is developed
- solutions are realised according to design
- realised solution is evaluated
- process is recorded and communicated

RANGE STATEMENT

At this level learners should show detailed logical and articulate work indicating understanding of the integrated nature of the Technological Process. Learners should engage in processes of:

- investigating (research, etc.)
- planning and designing
- developing (constructing, making, modelling, etc.)
- evaluating (measuring, testing, deciding, etc.)

Learners should apply the Technological Process in respect of the following **South African and global themes:** housing, textiles, communications, water, transport, food, energy, health, tourism, agriculture, manufacturing, media, sport and recreation;

and in the following Learning Contexts:

<u>Perspective</u>: local, national, international
<u>Modes</u>: individual, pair and group work
<u>Presentation styles</u>: oral, written, graphical modelling, products, artefacts and simulation
<u>Resources:</u> texts, interviews, observation, experimentation

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2. APPLY A RANGE OF TECHNOLOGICAL KNOWLEDGE AND SKILLS ETHICALLY AND RESPONSIBLY

Technological knowledge and skills form the backbone of this learning area as it increases the learner s capability to engage confidently with the technological process and within a technological world. This outcome further seeks to develop the learner s ability to apply this acquired knowledge and skills in an ethical and responsible manner.

In this outcome evidence of achievement should show the acquisition of knowledge and skills in respect of the nature, functions and applications of:

- safety
- information
- materials
- energy

in

- Systems and Control
- Communication
- Structures
- Processing

In practice learners will engage the above in an integrated way.

ASSESSMENT CRITERIA

Learners should present work in which:

- knowledge and understanding of:
  Systems and Control Communication Structures Processing is reflected
- knowledge and understanding of:
  safety, information, materials, energy as they manifest in Systems and Control
- a range of hand and power tools and equipment are used
- sensitivity to possible ethical issues and dilemmas is demonstrated
- responsible behaviour is demonstrated

RANGE STATEMENT

A) SYSTEMS AND CONTROL; COMMUNICATION; STRUCTURES AND PROCESSING

At this level learners will practice and develop:

- investigation skills which include researching, recording, investigating, etc.
- design skills which include planning, communicating, graphics, etc.
- manipulation skills which include creating and modification according to specifications
- evaluation skills including testing, drawing conclusions etc.
- sensitivity to problems, dilemmas, issues and choices in society

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Systems and Control
These skills will be applied within an understanding of:
- input, process, output
- open and closed systems
- concepts of technological systems
- components and devices
- the way signals and information flows in and between systems
- the multiple and complex nature of interconnections between and within as well as the control of
  - mechanical
  - electrical and
  - hydraulics/pneumatics systems

Communication
These skills will be applied within an understanding of:
- the use of appropriate technical design and development skills, technical language and conventions for product development to meet given purposes and specifications (eg layout, printing, graphics and data presentation)

Structures
These skills will be applied within an understanding of:
- Complex, made structures
- Reinforcing within
  - complex made structures
  - composite materials
- Internal and external forces
- Simple calculations and formulae associated with volume, force, and other structural theory concepts

Context: Shelter, transport, storage, containerisation etc.

Processing
These skills will be applied within an understanding of:

The activity of processing raw materials into refined materials and into products, with waste as a by-product.
Processes:
- conversion
- preservation
- reduction
- combination

Context: biotechnology, manufacturing, agriculture, mining

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B) ENERGY; MATERIALS; INFORMATION AND SAFETY

Learners will develop a sensitivity towards, an understanding of and appropriate application skills in the use of energy, materials, information and safety as common features of all technology.

Energy

- Types and sources
- Energy transformation
- Energy storage and distribution
- Energy as a resource - renewable, available and cost
- Application

Materials

- Sources
- Types - natural, synthetic and composite
- Techniques
  - Processing (separating, combining, converting, joining, shaping and forming)
  - Storage and Preservation
  - Distribution
- Properties (physical, chemical and aesthetic)
- Selection (form, function, potential and suitability)
- Cost
- Waste management of materials

Information - Refer to specific outcome 3.

Safety

- Housekeeping, organisation and management
- Occupational safety
- Appropriate behaviour, dress and procedures
- Safe use of toots, equipment and materials
- First aid

Tools and equipment
Understanding the operating principles of tools and equipment. Selection, use and maintenance of tools and equipment:

- hand tools and power tools
- simple and complex
- electric, pneumatic, electronic, mechanical
- applications (cutting, soldering, cooking, etc.)

Learners should apply the Technological Process in respect of the following **South African and global themes**: housing, textiles, communications, water, transport, food, energy, health, tourism, agriculture, manufacturing, media, sport and recreation;

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3. ACCESS, PROCESS AND USE DATA FOR TECHNOLOGICAL PURPOSES

One of the features of a rapidly changing world is the accumulation of vast amounts of information and data which has an increasing impact on technology and all other aspects of modem life. In order for learners to engage effectively in the Technological Process, they need to be competent and confident in working with various forms of information and data.

ASSESSMENT CRITERIA

Learners should produce work in which:
- various types of data are accessed
- various types of data are processed
- various types of data are used

RANGE STATEMENT

At this level learners should produce work that is articulate, logical and detailed. They should use combination of data types in an integrated way investigate, analyse and make decisions Learners should understand:

Data storage and communication forms
- verbal /non-verbal
- audio
- visual
- electronic

Data types
- numerical
- text
- graphics

within the context of the following processes:
- access (identify, observe, research locate etc.)
- process (collate, communicate compare, evaluate etc.)
- use (apply, make choices, accept, reject etc.)

Learners should apply data for technological purposes in respect of the following **South African and global themes**: housing, textiles, communications, water transport, food, energy, health, tourism agriculture, manufacturing, media, sport and recreation.

and in the following **Learning Contexts**:
Perspective: local, national, international
Mode: individuals, pairs, groups
Presentation: oral, written, graphical modelling and simulation
Resources: texts, Interviews, observation experimentation

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4. SELECT AND EVALUATE PRODUCTS AND SYSTEMS

All learners are exposed to a wide variety of products and systems. They, therefore, need to acquire the critical skills necessary to operate as confidently as discerning consumers and users of technology.

ASSESSMENT CRITERIA

Learners should be able to present work in which:
- Products and systems are effectively selected
- Products and systems are effectively evaluated

RANGE STATEMENT

Learners at this level should produce work which is logical and articulate indicating evidence of the selection and evaluation of products and systems

Selection and Evaluation
- understand the need
- derive and prioritise the constraints that may influence the choice
- compare the characteristics and function of a range of similar products in respect of prioritised constraints
- test and evaluate products and systems

Products and Systems
- a range from simple to complex designs
- a range from simple to complex applications
- mechanical, electrical and electronic
- services (eg. postal service)

Constraints and Factors

In drawing comparisons learners should consider factors such as:
- costs and value
- aesthetics and ergonomics
- social
- environmental
- materials
- durability
- life expectancy
- fit to purpose
- availability and maintenance

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5. DEMONSTRATE AN UNDERSTANDING OF HOW DIFFERENT SOCIETIES CREATE AND ADAPT TECHNOLOGICAL SOLUTIONS TO PARTICULAR PROBLEMS

Technology is interwoven with the economic, social and cultural fabric of societies. These other factors have influenced the way technology has evolved in different places and at different times. Learners need to understand the complex and diverse ways in which technology evolves.

ASSESSMENT CRITERIA

Learners should be able to present work in which:

- Various factors are considered
- Different technological solutions are compared
- new solutions are predicted?
- Causal relationships between main factors influencing technological development are reflected upon
- A variety of perspectives, modes, presentations and resources are used

RANGE STATEMENT

Learners at this level should show detailed, logical and articulate work which reflects:

Content

- historical
- geographical
- cultural
- economic

Process

- research
- observation
- analysis

Context

Perspective: local, national, international
Mode: individuals, pairs, groups
Presentation: oral, written, graphical, modelling and simulation
Resources: texts, interviews, observation, experimentation

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6. LEARNERS WILL DEMONSTRATE AN UNDERSTANDING OF THE IMPACT OF TECHNOLOGY.

Human values and other factors influence technology. Technology in turn shapes and influences the nature and well being of society, the economy and the natural environment, in both intended and unintended ways. Learners need to appreciate the ways in which technology effects all aspects of life. Outcomes 6 and 7 should preferably be achieved by integrating them with tasks and activities designed to achieve outcomes 1 to 5.

ASSESSMENT CRITERIA

Learners should be able to present work in which:

- technological impact in a variety of contexts is reviewed

RANGE STATEMENT

At this level learners should be able to research, analyse and draw conclusion and make predictions about the positive and/or negative impact of technology in the following:

Contexts

- society
- the environment
- the economy

Perspectives

- local
- national and
- global

Time scales

- short
- medium and
- long term

Consequences

- intended and
  unintended nature

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7. LEARNERS WILL DEMONSTRATE AN UNDERSTANDING OF HOW TECHNOLOGY MIGHT REFLECT DIFFERENT BIASES AND CREATE RESPONSIBLE AND ETHICAL STRATEGIES TO ADDRESS THEM

During the course of human history technology has been used to both promote and counter bias. Bias has also influenced the development and use of technology. Learners need to be aware of these relationships and aware of possible bias in their involvement in technological activities.

Outcomes 6 and 7 should preferably be achieved by integrating them with tasks and activities designed to achieve outcomes 1 to 5

ASSESSMENT CRITERIA

Learners should be able to present work in which:

- The concept and types of biases are understood and identified
- Biases limiting access to and the application of technology are identified.
- Strategies to address biases are developed.

RANGE STATEMENT

At this level learners should:

- understand the nature and causes of bias
- be sensitive to and understand the complex ways in which bias affects important groups such as:
    - gender
    - race
    - age
    - disability

At this level learners should:

- research and analyse how access to and benefits of technology have been denied to various groups
- understand the impact of this bias on such groups.
- understand how the use and application of technology reflects, interests, priorities and biases in society.

At this level learners should identify existing and suggest possible strategies to counter biases and address their effects.

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Notes

Introduction notes

1. See D. Makenzi 1991 for a discussion of the way in which guidance systems for weapons of mass destruction were invented, not only as efforts of engineering but as part of the interplay of social constraints and concerns as equal determiners of technical devices.
2. Robert Jungk, in his history of the atomic scientists, quotes the following observation about the use of nuclear weaponry: "Because of the quantum jump in the destructive power of the thermonuclear warhead, not to mention the still greater area of lethal fall-out, delivery within eight or ten miles of the centre of the target becomes militarily acceptable". (Cf. R. Jungk 1956: 276-277.) Jungk goes on to note that the scientists whose work made possible this 'quantum jump' in destructive power "participated in these progressively more desperate manoeuvres of threat and counter-threat [as expert advisors to the military whose members had difficulty in keeping up with the implications of the changing technology of nuclear weaponry], because of their belief that it was the only by so doing that they could hope to preserve peace". (Cf. R. Jungk 1956: 276-277.) He also notes elsewhere the recommendations made by a group of scientists working on the first atomic bomb concerning the manner of its first use - recommendations largely adopted by the political leaders of the day. As Jungk writes about the findings of this team: "...targets for this peculiar type of bomb must satisfy the following conditions: a) Since the atomic bomb is expected to produce its greatest amount of damage by primary blast effect and next by fires, the targets should contain a large percentage of closely built frame buildings and other construction that would be most susceptible to damage by blast and fire; b) the maximum blast effect of the bomb is calculated to extend over an area of approximately one mile in radius. Therefore the selected targets should contain a densely built up area of at least this size; c) the targets selected should possess high military and strategic value; d) the first target should if possible be one that has escaped earlier bombardments, so that the effects of a single atomic bomb can be ascertained". (Cf. J Jungk 1956: 163-164.) It is worth noting that this was a first time use of atomic bombs, and the thinking here shows both a desire to find out just what sort of a weapon is this new device - how destructive is it actually - and a pattern of thought about air-attack that perhaps goes back to the mass-bombing campaigns of the war with Germany - that attacks on cities is somehow part of the waging of war. By the early 1960's, the United States had developed what was called a Single Integrated Operational Plan, or SIOP, for the use of nuclear weapons in the event of war with the Soviet Union - the only other nation at that time having nuclear weapons capability. There were five main options for the targeting of nuclear weapons against the Soviet Union. The first was to target "Soviet strategic forces, including missile sites, bomber bases and submarine tenders". (Cf. D. MacKenzie 1990: 200.) The four other main targets were "II. Other elements of soviet military forces and military resources, located away from cities -

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for example, air defenses covering U. S. bomber routes. III. Soviet military forces and military resources near cities. IV. Soviet command and control centers and systems. V. If necessary, all-out urban-industrial attack". (Cf. D. MacKenzie 1990: 200.) The first of these targeting options was part of what was called the counterforce option - to destroy the Soviet nuclear attack capability by hitting its strategic nuclear forces and so render it possible for the U. S. to survive a nuclear war. In public debate in the United States such an option was considered to be destabilizing, and would actually increase the chances of nuclear war. In private, the U. S. military and government supported the notion of mutual destruction, thereby making nuclear war an unthinkable option for either side. Still, the counterforce option was never completely abandoned as one way of actually using nuclear weaponry. It did however become more difficult to see how it could be used successfully, as the Soviet military continued to 'harden' its own nuclear weapons sites and systems, making it unclear to the military planners in the United States just how effective might be a counterforce attack, and hence beyond acceptable levels of risk as a targeting option. See D. Mackenzie 1990:196-203 for a discussion of this issue.

3. The issue of interpretation of science and technology, and their significance to human life and society, is taken up as a focus of chapters three and four.

4. Here I mean the neutron provides the buffer that guarantees the electrical stability of nuclei. However, since neutral, it can also negotiate the clouds of electrical charge that nearly define the atom. As such it can be used to interrupt that nuclear stability and transform the atom itself by transforming its nucleus. Three years after the discovery of the neutron Frederic Joloit-Curie, speaking in Stockholm upon his receiving (with his wife, Irene) the Nobel prize for the discovery of radioactivity, is quoted as saying: "We are justified in reflecting that scientists who can construct and demolish elements at will may also be capable of causing nuclear transformations of an explosive character ... If the propagation of such transformation in matter can be brought about, in all probability vast quantities of useful energy will be released". (Quoted in R. Jungk 1956: 53.) The key idea to the conception of such a discharge of nuclear energy was given by the Hungarian scientist Leo Szilard, who was the first to realise (in 1933) that if a neutron was emitted in a nuclear transformation and if it in turn could cause the release of two additional neutrons from some surrounding nucleus, then a vast reaction could occur through a whole chain of transformations. Szilard coined the term 'chain reaction' in the patent he applied for so to document his discovery. (Cf. J. Bronowski 1973: 368-369.)

5. By 'we' I mean both the community of scientists who possess the technical savvy, and the women and men of the everyday whose lives that knowledge and those devices (and their derivatives) has unexpectedly and profoundly affected. Historically as well, the construction of the earliest set of atomic devices - both reactors and weaponry - needed the most costly concentration of talents and of an entire society's material resources. It also took the force of will born of the second world war to commit to the effort.

6. This is perhaps a good characterisation of what is involved in the act of creating - to imagine, conceive, and execute. It is an indictment of an age that in the years since the first creation of atomic energy such efforts as devising ever more powerful thermonuclear weapons did become commonplace because it was seen as necessary for national survival against attack - whatever be the risk to humankind.

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7. Once discovered the history of our knowledge and use of the neutron seems to suggest that the creation of nuclear power was something of the inevitable. A sophisticated knowledge of the neutron, its use as a probe, the refinement of radioactive ores went hand in hand in Europe with the rise of Nationalist Socialism and the tide of war. See J. Bronowski 1973: 369 for a discussion of this. However, Makenzi notes that caution is needed in seeing such developments as a natural trajectory. (Cf. D. Makenzi 1991: 385-388.)
8. Not all scientific knowledge can be labelled in this way, only its revolutionary forms - those created by the scientists about whom we marvel, and admire in turn. (Clearly, we do not marvel at the mundane, and we would not know the scientists in their greatness had they not discovered and made what they did.) We also tend to forget that they did not make their discoveries as if on an island. Modern physics is in fact group physics, more so than any other past scientific work.
9. In stating this I do not want to imply that in the sphere of science, technology, and society important ethical or moral questions - such as the use of nuclear weaponry - concern the consequences of deep scientific knowledge alone; I only hold that such knowledge will certainly involve us in difficult questions of will and action.
10. It is common to describe those dreadful effects of our science and technique as symptoms of a diseased civilisation. Of course, this is not correct if we seek comparisons with the health of our own bodies, for the symptoms of bodily disease are often an expression of the healing process - it is a sign that the body has recognised an imbalance and is righting itself. In this sense the consequences of our science and technology are not usually interpreted as issuing from some sort of healing process, but are part and parcel of the disease. Of course no analogy is exact, but it may suggest faulty thinking, or thinking that may be questioned.
11. See J. Bronowski 1961:14. Robert Jungk 1956, has written of the "irresistible itch" shown by the United States military establishment, but also its political leadership and some scientists, to use the first atomic weapon. Although conceived, designed and motivated out of the fear that the National Socialist Republic may be the first to obtain such a weapon, towards the end of the war with the Axis powers it became clear to those working on the bomb in the United States that Germany had no such weapon, nor had it ever planned to construct it. Despite the removal of the original motive for creating the weapon in the first place, those in functional control of the atomic work insisted on an ever quickening pace of construction before the war with Japan might end. The whole point to building the bomb was to counter the German threat. Now that the threat was over and the weapon nearly completed, the main task became to finish it before the pacific war did so that it might be used over Japan. As Jungk writes: "... factories had arisen at Oak Ridge that were longer than those to be found anywhere else in the United States. Works inspectors had to use bicycles to patrol them. At Hanford 60 000 labourers had built one of the largest chemical works in the country. At Los Alamos seven divisions were employed on the mysterious 'end-product'. Literally thousands of new inventions and patents had been developed in the course of the work. The description alone of the most important new processes developed at Hanford would have filled thirty stout volumes. Was the practical application of the result of years of strenuous efforts by 150 000 people, the introduction of a weapon that had involved the expenditure of two billion dollars, now to be voluntarily renounced?" (Cf. R Jungk 1956: 162-163.) The military and political answer on most sides was no. Many of

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the scientists who worked on the project were ambivalent - they did not work on the bomb that it might be used on Japan, yet so much of their personal scientific effort had been put into it that they wanted to see if the device really worked. One scientist stands out, Leo Szilard, whose early efforts helped get the work on the bomb stared (out of his fear of Hitler's designs on Europe), but who worked equally hard to put the bomb away once he knew Germany had no such weapon. Jungk writes, quoting Szilard himself: "During 1943 and part of 1944 our greatest worry was the possibility that Germany would perfect an atomic bomb before the invasion of Europe ... In 1945, when we ceased worrying about what the Germans might do to us, we began worrying about what the government of the United States might do to other countries". (Cf. R. Jungk 1956: 164.) The point here to my including such passages is to highlight the tendency to adopt, in both corporate and personal action, the stance that the ends can justify the means - "That push-button philosophy, that deliberate deafness to suffering, has become the monster in the war machine". (Cf. J. Bronowski 1973: 370.) Such a stance is often born of our notions of absolute knowledge in the certainty of what we know, and the power that can accompany it. The belief that one can think in different terms about means and ends - that they specify more than an analytical distinction in Western intellectual culture - is a main topic throughout this entire thesis.

12. Given the general belief that knowledge is power, and the growing awareness by various leaders of nations during this century that science can put into the hands of the state very considerable forces, it may become appealing for scientists, and the institutions of science, to court fancy with the wealth and status of national political houses of power. The work of R. Jungk (1956) can be read in no small part as a history of the atomic scientists who first worked out the requirements of controlled nuclear reactions (in large measure, they were the same individuals who developed the scientific theory of atomic and nuclear structure), and then proceeded to construct atomic bombs under the funding and direction of the United States military-political leadership. The more the wealth of nations becomes necessary for funding the work of ever more costly scientific projects, then the state authorities will be able to(and will want to) exercise control over what is done in houses of science. See S. Weinberg (1994) for one view on the requirement that science get funding for its projects in return for various benefits that will accrue to society and culture. Jacob Bronowski (1973) makes the point, from a particular perspective, that the choices made in science - and how people come to judge and evaluate it - cannot rest on the various requirements of funding or the desire to control from seats of power. The ethical and the place of human values in human nature cannot be ignored if a 'democracy of the intellect' has any hope of flourishing. See J. Bronowski 1973: 432-438.

13. This idea comes from a work of Charles Taylor, *Explanation and practical reason*. See C. Taylor, 1993: 208. To quote directly: "Our modern conceptions of practical reason are shaped - I might say distorted - by the weight of moral scepticism...In this practical reason falls into line with a pervasive feature of modern intellectual culture: the tendency to think out the question of what something *is* in terms of the question of how it is *known*". It is worth noting that many aspects to the work of the thesis have been influenced by the way Taylor identifies and approaches this issue.

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Chapter one notes

1. I am not arguing for relativism. This is only a statement of the recognition that ideas do change about who and what man is.
2. Cf. J. Bronowski 1973: 429.
3. This account of the life of Eratosthenes has been adapted from the work of C. Sagan 1980: 12-15.
4. Eratosthenes was a man of genius, and this makes it hard to say what he might have done if his life's circumstances had been otherwise.
5. The term is taken from Charles Taylor's discussion of modes of reasoning unreflectingly adopted by Western culture. It is used throughout this chapter. See C. Taylor 1993.
6. See A. N. Whitehead 1926: 7.
7. A whole galaxy of thinkers can here be included. See C. C. Gillispie 1960, for one account of the rise of modern science, scientific ideas, and the men who made them.
8. By rationalistic I mean something like the discovery of the principles of thought by deduction based on the apprehension of the purposeful end of things (not how things work).
9. These very simplified descriptions come out of my reading of A. N. Whitehead 1926: 1-24; 49-70, F. Capra 1983: 37-67, and F. Copleston 1963 Vol 3 part II: 229-250.
10. See A. N. Whitehead 1926: 20.
11. The reaction of the early modern scientists - men like Galileo or Descartes - was not to the designs of God, but to the thorough going teleological explanations of nature by those scholastics who purposed to study it (in the end and in its own way the scientific anti-rationalistic/pro empiricist reaction reached extremes equal to the scholastics). Such a teleological explanation was in part an inheritance of Greek thought, particularly of Aristotle's notions of end-forming cause, which were imported into Christian theology. The place of God in the world needed not to be denied or denounced - only the methods of how His creation is studied. The modern question is not why do things happen as they do - of what purposes are they the traces of in nature. The question is simply, how precisely do they act. Witness Galileo's frustrations at trying to explain to his contemporaries how motion 'in fact' occurs, contrary to their notions about why things happen. (See A. N. Whitehead 1926: 10, and J. Bronowski 1973: 198-219. See also F. Copleston 1963 Vol 3 part II: 85-122, and C. C. Gillispie 1960: 1-53.) The exactness of modern science derives first from the passionate interest, the focussed attention given to observable (and detailed) phenomena, and second, from the measurement and study of their tangible properties and the ordered relations among them.
12. Newton would later state: 'I do not make hypotheses', meaning 'I do not attempt to explain why nature is as it is. I only put forth the laws in terms of which we can describe what in fact occurs.' See J. Bronowski 1973: 234.
13. Science has a great faith in both the importance of empirical fact and in the order of nature. The one is obtained from the other through induction (at least in part), and in particular causal explanations derived from the relational order of the data. As concerns causal explanations and inductive inferences about antecedent events and predicted consequent outcomes, Hume's analysis has shown up the difficulties of such reasoning and

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explanations. However, this has not stopped scientists from continuing with the unqualified success of their method, though it may have caused a few to questions the relevance of philosophy.

14. It is certainly not the case that Galileo was the first to use mathematics, or quantity if you like, in the study of nature. The point I am making is that his genius for experimental thought helped set the stage for what was to come. The mathematics we typically use today to state the results Galileo established did not exist at the time he did his experiments. This had to wait for Descartes. See E. T. Bell 1937: 35-55.
15. See A. N. Whitehead 1926: 22-24; 37-42; 54-57; 74-80 for a discussion of classification, induction and the place of general principles. Gillispie makes the point that the physiological works of William Harvey, a younger contemporary of Galileo, provides "the first faithful marriage on equal terms of inquiry and empiricism". "Galileo", adds Gillispie, "... conducted most of his experiments in his head and on paper. They are beautiful examples of models of physical thought, but not of experimental science. When he did perform one, it was usually to demonstrate properties of the behaviour of bodies he had already deduced ... from geometric consideration of motion or equilibrium ... But Harvey was the first to use observation and experiment to find out something fundamental instead to demonstrate it". Cf. C. C. Gillispie 1960: 68. Gillispie later notes that with Robert Boyle, circa 1660, (of Boyle's Law fame), "experimental physics came into its own". See C. C. Gillispie 1960: 103.
16. In the sense that as science progressed and new areas of study came into the orbit of its empirical study, mathematics was nearly always a precondition for the accepted portrayal of the phenomena. An empirical study not amenable to mathematical expression was thus at least inadequate, if not suspect.
17. The conceptual objects derive their characteristics from the conditions that obtain in the relations stipulated among them. They are not defined as such.
18. Pythagoras is arguably the first to understand what constitutes a proof in mathematics, and that mathematical facts rest on proofs. See J. Bronowski 1973: 155-162.
19. Whitehead calls this the full scientific mentality.
20. While first published as a mathematical system in 1637, analytic geometry was invented by Descartes in 1619 - at least in its essential ideas. See E. T. Bell 1937: 40.
21. The coordinates of analytic geometry have but a single characteristic, namely, point position. They are thereby the perfect conceptual tool for establishing relations among objects in space (conceived as points), and particularly objects moving in space over abstract time. This is impossible with the 'points' of Euclidian geometry, which sets up static relations among formalised shapes, none of which are isolated points.
22. It is not surprising then that in Galileo can be found that first distinction between primary and secondary qualities - between properties essential to nature, and those manners of perception by which we ordinarily, but, according to the conceptions of science, inadequately see our world. See C. C. Gillispie 1960: 41-42.
23. Descartes' distinction between thought and extension is the object of a vast commentary. See B. Williams 1978. For opposing points of view about the intellectual inheritance of Descartes' separation see F. Capra 1983: 41-48, and A. Khursheed 1995: 18-32.
24. Leibniz wrote, perhaps in response, 'I hold space to be something purely relative, as time

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is.' Quoted in J. Bronowski 1973: 241.

25. Galileo was preoccupied with circular motion, but inertia is conceivable in a universe of infinite extent in which matter can move in unending straightness. See C. C. Gillispie 1960: 90.
26. Descartes' vortices were inadequate to the task of the new science. It is not his scientific speculations that influence, but his setting out of a world view into which the scientific enterprise could fit with ease, and whose broad successes seemed repeatedly to confirm.
27. The prior comment about the physical nature of light, and this and the following quote from Newton are taken from J. Bronowski 1973: 223-230. Francis Bacon as well offers similar sentiments about achieving a completed project in science: "I take it that all these things [the work of natural history] are to be held possible and performable, which may be done by some persons, though not by one alone; and which may be done in the succession of the ages; though not in one man's life; and lastly, which may be done by public designation and expense, though not by private means and endeavours". Cf. C. C. Gillispie 1960: 80-81. As regards Newton's preoccupation with the science of optics, the grinding of lenses and the building of telescopes was an important problem of the day - particularly the aberration of light around the edges of the lens which distorted the image thereby projected. Newton gave his attention to this. He also ground his own lenses. But Newton would not have studied lenses and diffraction only because they posed a technical problem in the manufacture of instruments. The study of matter and light was his preoccupation. In physics, phenomena under study consist of an unavoidable interaction between matter and energy such that the study of one leads to further discoveries about the other. See W. Heisenberg 1962. See also, J. Gribbin 1984: 33-49, and M. Born 1951: 106-165.
28. See C. C. Gillispie 1960: 82-95.
29. It was no accident that Descartes saw the world as a machine (nor was the material stance taken by scientists a matter of chance). At the time - and always since - machinery was a favoured home for the inventive. Marvellously honed automata entranced the courts of Europe, and helped Descartes conceive the human body as a finely tooled machine An immense interest in telescopes and time keeping came to occupy the thinking of many - especially in the seafaring countries of Europe where ocean navigation, and hence trade, depended both on celestial observation and a careful keeping of time. (Contests were held and prizes given for the creation of clocks of sufficient accuracy.) Galileo lived in Venice, and the keen entrepreneurship of the town's merchants and merchant fathers ensured both that he take a practical view of his discoveries, and they take an interest in the inventions he provided. The scientific question of the day was what kept the planets in their orbits. The mechanical clockwork of the heavens convinced those who would look, and men created precise working machines to measure, imitate, and model the heavens. In their efforts can be seen the immense labour of interest in the search for knowledge, and the pride of the craftsman's trade. The instruments themselves - the astrolab, the quadrant, the nocturnal, the armillary sphere - are everywhere mechanical and entirely exquisite in design and execution. The idea of a mechanical universe is there in the scientific models of its workings, and the working exactness of the models no doubt gave credence to the idea.
30. See E. T. Bell 1965: 155-154, and A. N. Whitehead 1926: 76;78. Some scientists of the early age could not have avoided religion even had they desired to do so - and most saw no

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need to avoid it. Kepler's mother was accused of witchcraft, and would have been killed were it not for her son's expert 'legal' defence. The trial of Galileo is famous. Descartes resisted publication until the very last, fearing treatment similar to that which was meted out to Galileo. But these were painful and confusing times, where men both of faith and science had to manoeuvre around both the social centralness of Church doctrine, and the wars and conflicts of the day. Yet even then some could hold what was to become a modern line of thought. Christiaan Huygens, contemporary of Newton, spoke the words: "The world is my home, science my religion" whose sentiment is now commonplace. See C. Sagan 1980: 143.

31. However, the notion of a naturalistic stance is not static, but takes on added meanings as ideas merge and change over time.
32. See for example A. N. Whitehead 1926: 49-70, for an account of the broad impact on thought generally of the new view of the world being hammered out in the seventeenth century.
33. Hannah Arendt(1961:18), quoting Jacob Burckhart, writes: Only beginning and end are, so to speak, pure or unmodulated; and the fundamental chord therefore never strikes its listeners more forcefully and more beautifully than when it first sends its harmonising sounds into the world and never more irritatingly and jarringly than when it still continues to be heard in a world whose sounds - and thought - it can no longer bring into harmony".
34. Whitehead treats these ideas in some detail. Noteworthy is his comment: "What is the sense of talking about a mechanical explanation when you do not know what you mean by mechanics?" See A. N. Whitehead 1926: 20-24. He then goes on to state: "Thought is abstract; and the intolerant use of abstractions is the major vice of the intellect ... Faith in reason is the trust that the ultimate nature of things lie together in a harmony which excludes mere arbitrariness", from which he goes on to insist that reason must unite the respective harmonies of logic and aesthetics. (Cf. A. N. Whitehead 1926: 20-24.)
35. One direct consequence of this position is the separation of science into the study of the material, and philosophy into the study of the thinking mind. Here metaphysics and epistemology have been dominated by the Cartesian abstraction of extension and thought. One is either a dualist, or a monist of two types - only material exists or only thought exists. It is a dilemma of choice with which all of philosophy has dealt, and which has now reached the end of its viability as a specific set of abstractions. (Cf. A. N. Whitehead 1926: 70.)

36 I am particularly indebted to the writings of Charles Taylor for these distinctions and their many implications. See in particular C. Taylor 1985a, and C. Taylor 1993.

37. Here the distinction between primary and secondary qualities can be mentioned as part of the foundation of the scientific view of a neutral universe of material extension. See A. N. Whitehead 1926: 172-194.
38. In the extreme, the belief in independent minds leads to a private world of experience and a private world of private morals, i.e. solipsism.
39. See C. Taylor 1993: 212, and C. Taylor 1985a: 45-76. Also, see B. Williams 1985: 132-155.
40. This is no outdated position but a mainstream of scientific thought. One can read for example that "As physics developed in the present century, the picture showed that these

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particles interact with one another through the effects of four forces. But the forces themselves are now seen, in the picture derived from quantum theory, as being 'carried' by other particles. Two electrically charged objects, for example, exert a force on each other because photons, the carriers of the electromagnetic force, fly between them. *Everything* can be explained in terms of particles, although there is a distinction between particles that carry forces (called *bosons*) and what we might loosely think of as 'material' particles called *fermions*. {The italics are those of the authors}". J. Gribbin and M. Rees 1991:103. Similar sentiments are expressed by S. Weinberg 1994: 22-27. This idea will be taken up much more completely in the next chapter.

41. It is a contradiction that influences many areas of thinking and action in Western culture - economics, psychology, medicine, education. Education is the specific study of the fourth chapter. For an extensive discussion on the historical limits of the contradiction and the need for alternative ways of thinking see F. Capra 1983.
42. See, for example, B. Williams 1978.
43. See A. Macintyre 1977, for a discussion of the requirements for contextual thinking to make sense of scientific theories, and not the other way around.
44. In the sciences of man, this carries over to the use of absolute-like or culture free terms, such as in descriptions of man being involved in a universal struggle for survival. Darwinian theory is taken as the factual basis for all modern life sciences. For a discussion on this see A. Khursheed 1995: 67-83. The October 1994 edition of *Scientific American* 'Life in the Universe' is a good example of an entirely naturalistic way of thinking (as used in this chapter) and the importance of Darwinian notions in modern scientific conceptualisations of life.
45. For an account of the battle theory see A. Khursheed 1995: 18-33.
46. See A. Macintyre 1977.
47. Many of these ideas have come largely from discussions in Charles Taylor's book *Human agency and language*, 1985.
48. See J. Bronowski 1973: 411-439.
49. Examples of primary concepts are location, magnitude, motion and mass. While secondary concepts include colours, sounds, odours, or tastes. See A. N. Whitehead 1926: 67-68. In some contemporary psychological circles, primary concepts are mental images derived directly from sense experience. 'Blue' is a primary concept. By abstracting that which is common from a variety of primary concepts, such as 'green', 'yellow', 'pink', etc., and making thereby that which is common into a mental image (a concept), one can obtain to the secondary concept 'colour'. See R. Skemp 1986.
50. For an extensive discussion on concept formation see R. Skemp 1986.
51. See C. Taylor 1985a: 225. This is the preoccupation of rationalist and empiricist epistemology for 200 years and the battle ground of rival philosophies. See Edmund Husserl's *Cartesian meditations*. Hume's thought is often taken to be a radical working out of this issue.
52. See C. Taylor 1985a: 199-203.
53. See A. N. Whitehead 1926: 242.
54. See M. Minski 1994: 90-91.
55. See C. Taylor 1985a: 162.

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56. See the discussion in C. Taylor 1985a: 97-114.
57. An example of the working of absolute judgments is found everywhere in biology (oddly, one of the most consciously materialistic of the sciences), and particularly evolution theories. An objective stance means all humans, regardless of culture, are involved in the struggle for existence, or in the attempt to balance their drive for pleasure and their avoidance of pain. Even more clear is the case of molecular genetics, where it is not humans that reproduce, but genes. See J. Monod 1971 for an almost creed-like mechanistic view of biology. However more recent work in morphogenetic fields is an attempt to move away from mechanically causal accounts of biological forms. See G. Nicolis and I. Prigogine 1977. Also, refer to J. Casti, 1991: 132-191.
58. The rise of what is called the new physics, particularly in the first third of the 20th century, is often taken as a departure from the mechanistic stance of classical science. It at least shows the possibility of a mechanistic model that is not based on what is usually thought of as materialism. This need not imply that the aims of 20th century science are no longer directed towards control and manipulation, only that some of its ideas don't fit the materialist base of previous scientific thinking.
59. See for example C. Merchant 1980 for a discussion of the influences of patriarchal thinking on the domination of women.
60. See F. Capra 1983: 18-31. See also C. Merchant 1980. Other social consequences of the mechanistic world view are also vast. These include systems of economics, trade, and production, numerous issues in modern Western medicine, and the way entire systems of education are conceived, planned and conducted. Except for education, which will be treated in the final chapter, these matters are far too complex to be dealt with here.
61. See J. Mouton 1996: 31.
62. Hence the phrase "let's be scientific" which equates to "let's be objective in our approach".
63. See J. Bronowski 1973: 221-236, and C. C. Gillispie 1960: 117-150. Also, there is an extensive discussion of not only objectivity but also of the rise of science in I. Prigogine and I. Stengers 1984.
64. See H. Putnam 1981: 195-196. The quotation is from C. C. Gillispie 1960: 103: "When I speak of the corpuscular or mechanical philosophy, I ... plead only for such a philosophy, as reaches but to things purely corporeal, and distinguishes between the first original of things, and the subsequent course of nature ..."
65. Feyerabend, Polanyi, Popper, Lakatos, Kuhn - all try to make sense of what actually goes on in science (and in rationality), but there is no full convergence in their views. See H. Putnam 1981: 174-200.
66. Bronowski's *The ascent of man* 1973, and his *Science and human values* 1961, are in part attempts to give to an understanding of science those aspects that defy formal descriptions.
67. In the sense that phenomena not amenable to scientific study will not have an objective status in a common world and thus will be subjective experiences real only to the individual.
68. Charles Taylor looks into the relation between the modern identity as having invested into the scientific view such that its evidently implausible accounts of man as merely material and mechanical are accepted because of a deep belief in the independent, own-formulating individuality that is implied in the mechanical world view. See C. Taylor 1985a: 215-247.

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69. It is perhaps worth noting here that whatever limits are put to science, it seems to break through them. A case in point is Comte's suggestion that man could never know the compositions of the stars but which was countered upon the discovery of absorption spectra. It is common to hear expressed the idea that science is ever expanding and thus none should suppose to set it its limits. One must grant that scientific reason can solve problems that otherwise seem insurmountable. It is indeed astounding the subtleness to which logic can reach in the resolving of riddles. This is part of the success of science, and which has become part of a cultural climate of thought that regards the enterprise of science as not only adequate, but as essentially comprising the core of what is meant by explanation and reason. Out of this stance can grow the view that those riddles not solvable by scientific-like reasoning are not riddles but nonsense.
70. There is no simple basis for agreement among scientists as to what constitutes valid data. Scientific research has perhaps tended to move away from the work of the individual to the collective results among a group of scientists. Howsoever the work is actually done, the results that are validated must pass through the mill of scientific credibility. But at no time is there complete agreement among all scientists without exception. This is true in the natural sciences, although 'Khunian' notions may suggest that agreement is fairly consistent during times of 'normal' science, but certainly not in transitions. Agreement is less apparent in social or human sciences, although the similar standards of scientific credibility apply here too. The attempt to verify results is always a long and protracted one - whatever the scientific discipline - not immune from politics, squabbles, and common error.
71. See. C. Taylor 1985a: 117-138.
72. In spite of many such phenomena, there remains a tendency in the naturalistic cultural mode of thinking to discount these experiences not as unreal but as not having a basis in a common world about which rational agreement can be had. In other words, the set of scientifically valid statements and the set of experiences in the world about which people can agree in reason (can be shown to be true) are one and the same set. C. Taylor 1993, A. Macintyre 1977, and B. Williams 1985 highlight this in their works. In addition, phenomenology subsequent to the work of Husserl has attempted the project of an objective description of the 'life world'. Also, while Wittgenstein's earlier works supported the notion that the only meaningful accounts are those based on scientific rationality, he later repudiated this. See Edmund Husserl's *Cartesian meditations* and *Ideas; general introduction to pure phenomology* 1969 and Ludwig Wittgenstein's *Tractatus logico-philosophicus* and *Philosophical investigations.*
73. 'Calculations' here is taken in a very broad sense - whatever the linkages, patterns, inferences, or relations.
74. It is not uncommon in fact for mathematical discoveries to provide the means for scientific advance. This was true for Newton and his 'invention' of the calculus (fluxions) by which he reasoned out many of his results. It is likewise true of relativity and quantum mechanics - their way was opened in part by the existence of mathematics that provided substantial structure for the requisite thinking needed to work out the theory. Most modern physics is more mathematical than 'physical'. Calculus, statistics, matrix algebra, group theory, computation theory have all provided science the conceptual means to advance its work.
75. Mouton deals at length with this requirement in his *Understanding social research* 1996.

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Putnam includes it as part of what he calls science's 'ultimate goodness of fit'. See H. Putnam 1981: 64.

76. There is in 20th century physics the rise of the quantum theory which holds, in part, that not all of anything can be described - there is a distinct quantum limit to the know-ability of phenomena. This, together with the place of statistical theory in many areas of physics gives to modern science a different rendering of the notion how data refers to phenomena.
77. See F. Capra 1988: 39.
78. See C. Taylor 1993: 209. Much of the discussion that follows originates in ideas discussed by Taylor. See. C. Taylor 1993: 208-231.
79. This is a common guideline in contemporary problem solving techniques in mathematics.
80. Mouton makes this point at length throughout much of his book. See J. Mouton 1996.
81. They are as well often ignored as being unnecessary to reason or as an obstacle to it, and certainly part of that shifting world of private opinion about which argument is futile.
82. Here too is found the conflict between the neutral and value free scientific view of the universe and the requirement of man that he be purposeful and have significance.
83. This includes both a common outer world of public experience, and the common inner world of consciousness. The theory of evolution becomes the broad schema in which thinking along these lines often flows. Man's intellect comes out of millions of years of adaptation to the physical world. Language, strategy, tools, and the brain itself are all built around the survival of the species. Undoubtedly then, the brain is the seat of consciousness but it has evolved so to provide for the survival of the species in a real world of real threats and opportunities. Wired into the brain is a direct perception of the world which man's scientific consciousness has refined in method and reason.
84. See J. Mouton 1996: 31.
85. Much of science has taken a 'realist' position which in the end attempts to explain all that is on the basis of material principles only through ideas that treat the world as existing external to the mind and which science describes as it actually is. See H. Putnam 1981:1-48.
86. This 'subjectivist' position is often taken to be one that supports relativism - that ultimately there is no common cord to reality and in the end we just take what seems right or useful to us as individuals. However, it is also adopted in some sense by quantum mechanics. The observer of quantum processes cannot be separated from that which is being observed. The act of observation decides in some way the outcome of the event. The interpretation given to this is not that it is a matter of limitations on experimental design, but that the quantum world cannot be broken into components for separate study from an objective stance. At the quantum level, the observer is part of the experiment. See J. Gribbin 1984: 81-100.
87. See A. N. Whitehead 1926: 108-109. It is well worth noting that this discussion is only a crude outline of what is a very subtle topic. Putnam discusses such issues at length. See. H. Putnam 1981: 49-74.

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Chapter two notes

1. See for example H. Putnam 1981: 174-200 for a discussion of this idea. See also P. Feyerabend 1975: 158-161, M. Polanyi 1946: 21-41, K. Popper 1990.
2. Science gives truthful answers to the questions it asks, but not to any degree of exactness. In science, as in all other fields of study or communication, there are limits to knowledge. There is never complete certainty or exactness; no knowledge is perfect. There is always a degree of tolerance or uncertainty in any proposition claiming to state some experiential or phenomenal truth. This is taken quite literally in quantum mechanics where the position and momentum of any elementary particle occupy a region of tolerance such that knowledge beyond this is impossible. (In logic, a different field from empirical science, similar results are true. Gödel has shown the limits of reasoning within a system of logic sufficient to represent the truths of arithmetic. See E. Nagel and J. R. Newman 1958.) However, what modern science does often claim is that among all schemes of though it can supply knowledge having the least degree of uncertainty. In other words, it defines the most acceptable form of tolerance in knowledge. See J. Bronowski 1973: 353; 364-365.
3. As described in the first chapter, the naturalistic stance has become unreflectingly adopted in much of the West's intellectual culture. See C. Taylor 1993.
4. See H. Kahane 1995: 30-31.
5. See M. Polanyi 1964: 25-26. It is worth noting that Polanyi seeks to establish that a democratic form of thought, in which conscience plays an important part, is best suited to the scientific search for truth. This he opposes to any submission of thought to any single or intolerant authority. Democracy is the best means for establishing those 'decent and responsible relationships', and certainly in the practice of science.
6. In talking about the nature of modern scientific abstractions and the 'fallacy of misplaced concreteness', Whitehead observes the following elaboration of Locke's thinking: "The primary qualities are the essential qualities of substances whose spacio-temporal relationships constitute nature. The orderliness of these relationships constitutes the order of nature. The occurrences in nature are in some way apprehended by minds, which are associated with living bodies. Primarily, the mental apprehension is aroused by the occurrences in certain parts of the correlated body, the occurrence in the brain, for instance. But the mind in apprehending also experiences sensations which, properly speaking, are qualities of the mind alone. These sensations are projected by the mind so as to clothe appropriate bodies in nature. Thus the bodies are perceived as with qualities which in reality do not belong to them, qualities which are purely offsprings of the mind. Thus nature gets credit which should in truth be reserved for ourselves: the rose for its scent: the nightingale for his song: and the sun for his radiance ... Nature is a dull affair, soundless, scentless, colourless; merely the hurrying of material, endlessly, meaninglessly". See A. N. Whitehead 1926: 68-69. One point to be noted here is that in the attempt to reduce bias and error to the minimum, scientific research tries to do just this - to identity what is the product of the mind that is being projected onto the object of study, and to eliminate it systematically from that study so as to get to the most truthful account of the phenomena. Going on to evaluate the status of such a system of seventeenth century concepts for organising scientific research, Whitehead states: "It has held its own as the guiding principle of scientific studies ever since.

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It is still reigning. Every university in the world organises itself in accordance with it. No alternative system of organising the pursuit of scientific truth has been suggested. It is not only reigning, but it is without rival". (Cf. A. N. Whitehead 1926: 68-69.) Although this was written in 1926, the selected passages of contemporary scientists that make up this section would seem to support Whitehead's evaluation of the scientific project. Finally, Whitehead makes the following evaluation of this scientific scheme of thought, and which is the point being made here to the question of why anyone would choose to take the step of reduction described by Polanyi (1964:25-26): "And yet - it is quite unbelievable. This conception of the universe is surely framed in terms of high abstractions, and the paradox only arises because we have mistaken our abstractions for concrete realities". (Cf. A. N. Whitehead 1926: 68-69.) Such a mistake Whitehead calls the 'fallacy of misplaced concreteness'.

7. While Polanyi may not hold the view, a further proposition is often adopted that not only is science the truer of the two alternatives he mentioned, but it is the truer of any alternative scheme of thought in specific and vital ways.
8. As will be seen, the position is not only the province of everyday working researchers, but is held by some of the most renowned scientists and writers of our day.
9. This and the next quote are taken from J. Casti 1991: 28-29.
10. The basis of the mechanical world view is just this point.
11. Some disagree that it is as open as scientists would claim, and certainly one must have the opportunity and resources to gain the requisite education to be admitted into normal science.
12. There is in the sociology of science a movement to portray science as one institution among many other institutions in society, and hence not unique in any substantial aspect. This is not necessarily a position well received by the community of scientists, although the description of the origins or workings of an institution does not thereby negate what that institution does or accomplishes. Robert Merton states: "It is true that, logically, to establish the empirical genesis of beliefs and values [made legitimate by institutions of society] is not to deny their validity, but this is often the psychological effect on the naive mind". See R. K. Merton 1962: 26-27. Merton goes on to state: "Most institutions demand unqualified faith [in their institutionalised symbols and values]; but the institution of science makes skepticism a virtue. Every institution involves, in this sense, a sacred area, which is resistant to profane examination in terms of scientific observation and logic. But ... the scientific investigator does not conduct himself in the prescribed uncritical and ritualistic fashion. He does not preserve the cleavage ... between that which requires uncritical respect [the sacred] and that which can be objectively analysed [the profane]". (Cf. R. K. Merton 1962: 26-27.) Merton notes that the "institution of science itself involves emotional adherence to certain values". (Cf. R. K. Merton 1962: 26-27.)
13. As suggested in the first chapter, and which this thesis takes as a starting point, it is not that the method of empirical science is a rational method, and hence worthy of being followed and believed, but that so ingrained has become the method of science - ingrained by its repeated success - that in the West's intellectual inheritance rationality is that to which science attains. Scientific rationality has become rationality such that non-scientific claims are in some sense to be considered not fully rational.
14. See D. Halliday and R. Resnick 1974: 60-61.
15. Science sees, as it were, with its calculations, so that if calculations are impossible then

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researchers not only shelve the problem, they may also simply ignore it or make claims to the effect that it is unreal - a phantom or a conceit.

16. See E. T. Bell 1965: 109-111;122-124; 270.
17. See J. H. Holland, K. J. Holyoak, R. E. Nisbett, and P. R. Thagard 1986: 329-331.
18. See J. Casti 1991: 393-400, about the ontology of scientific laws. See also R. Bradley and N. Swartz 1979: 6; 84-85; 157, on possible worlds thinking about the abstract reality of propositions. For comments about Popper's 'third world' conjecture see A. Murphy 1979:128-149.
19. See J. Bronowski 1973: 221-236; 321-351.
20. For comments about the aesthetics of scientific discovery see J. Bronowski 1961: 13-32, M. Polanyi 1964: 11; 32-33, and A. N. Whitehead 1926: 243-244. For remarks about scientific intuition see J. Casti 1991: 400.
21. See J. H. Holland, K. J. Holyoak, R. E. Nisbett, and P. R. Thagard 1986: 329-331.
22. In other words, to be simple enough to explain and predict a "fantastic variety of phenomena", as quoted earlier in D. Halliday and R. Resnick 1974: 60-61.
23. See E. T. Bell 1965: 154-155.
24. In the later part of the 20th century there are sophisticated computer techniques that permit scientists to analyse complex systems that were previously discounted from the province of profitable scientific work because there was no way to handle them in terms of then existing methods of scientific rationality. Scientists now have a handle on measuring and analysing phenomena that involve systems of interaction much more complex than could be treated in past generations of scientific research. See J. Casti 1991: 61-67; 399, and D. R. Hofstadter 1979: 15-24 on complexity and the limits of proof and calculation. See also P. Cilliers 1998.
25. See A. N. Whitehead 1926: 66-70.
26. This and the next quote are taken from S. Weinberg 1994: 25; 27.
27. See S. J. Gould 1994: 69.
28. Religion here is probably particularly suspect on these grounds. See A. Khursheed 1995: 19-20; 67-81; 136-142 on the battle between science and religion.
29. Cartesian knowledge is just this sort of clear evident knowledge (sought by Descartes). See B. Williams 1978: 102-129, and F. Capra 1983: 42-43.
30. Charles Taylor discusses naturalistic reason and foundationalist modes of thought. (Cf. C. Taylor 1993: 208-231.) Alfred North Whitehead writes: "But the very groundwork of a fruitful methodology is to start from those clear postulates which must be held to be ultimate so far as concerns the occasion in question". See A. N. Whitehead 1926: 183.
31. See A. N. Whitehead 1926: 3.
32. See J. Monod 1972:110.
33. See R. Dawkins 1986: ix-x.
34. Part of what makes it random is that as a system there cannot be in principle a complete description of its configurations, and so no way exists for predictive science to grasp in anticipation the consequences of a prior state upon a latter. See J. Bronowski 1973: 390-400.
35. In a slightly different tone, in commenting about the mainstream of scientific thought, Whitehead states: "Its general success made it impervious to criticism, then and since. The world of science has always remained satisfied with its peculiar abstractions. They work and

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that is sufficient for it". See A. N. Whitehead 1926: 83. To which must be added, science often seems to claim that they work uniquely well, solely capable of sufficient explanation of man and his world.

36. In other words, the mechanistic theory of nature. See A. N. Whitehead 1926: 63.
37. See J-M. Lehn 1996: 103.
38. All of the previous passages speak to their author's conviction about the grandeur that is the institution of modern science and its project of discovery - a conviction, they would doubtless hold, that has been shown worthy of complete acceptance many times over by the edifice of science itself. Even in fields outside the tradition of modern empirical science can be found the same strident tone, as is portrayed in the following interpretation of some of Marx's thinking on ideology (from J. B. Thompson 1990: 37.): "*Assumption 1c*: the theoretical doctrines and activities which constitute ideology can be explained by means of, and should be replaced by, the scientific study of society and history. They can be explained by means of such a science in the sense that they can be shown to be the product of particular social and historical circumstances ... They should be replaced by such a science in the sense that, having been shown to be dependent on circumstances of which they were unaware, and having thereby undermined their claim to autonomy, these theoretical doctrines and activities lose their credibility and give way to a successor discipline the positive science of the social-historical world".
39. This and the next quote are taken from S. Weinberg 1994: 27.
40. When Weinberg speaks of the culture of our times he is not limiting his thought to a particular national culture. His earlier quoted passage speaks of science as moving from the understanding of a handful of Europeans to the civilised world - by which he may well mean modern technological society influenced by scientific rationality and the naturalistic stance. From here it is a short step to "everyone's intellectual heritage" (or thinking humanity). His argument therefore is about generic culture as it were, and not only a particular national form. This is also the gist of the idea by Jean-Marie Lehn when he states "... it is the fate of mankind to pursue the quest for knowledge" (Cf. J-M. Lehn 1996: 103.) Here Lehn means scientific knowledge true for all people. Scientists evidently see their work and the institution to which they belong to be as universally valid as are the laws they discover and use.
41. A communal and universal method is part of what scientific objectivity entails. However, this is directly applicable to empirical science. There is as well a sense of objectivity related to what sort of existence these laws have. This relates equally to the objective status of ideas.
42. Works by Bronowski and Whitehead discuss the relations between these various ages. See J. Bronowski 1973, and A. N. Whitehead 1926.
43. See C. Taylor 1985a: 164-186.
44. If so, and given that science, in Kahane's own terms, proceeds 'generation after generation' to create results beyond the province of any one person, then it seems to be the case that the only way to make empirical or scientific sense is from within a tradition that views the world through the heritage of certain abstractions which by definition exclude some of experience. Every empirical theory is dependent on the tradition of science out of which it comes and without which no one person (be he a "Galileo, Newton, and Einstein all rolled into one") could know anything of scientific importance. See A. Macintyre 1977: 453-472 for an

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argument supporting the tradition of science as a prerequisite for any intelligible theory.

45. Commitment to the epistemic imperative may be said to be the primary scientific commitment, out of which all method is derived. See J. Mouton 1996: 131.
46. "No absolute statement is allowed to be out of reach of the test, that its consequence must conform to the facts of nature". See J. Bronowski 1961: 56. Popper's notion of falsifiablity of theories, so that the agreed theory is the one left standing after all others have been shown false (though it too may some day be falsified), must be mentioned here. Method is not some straight-forward application of clear procedures. This was mentioned earlier in the chapter. But even should Popper's notion of truth in theory be adequate to what happens in science this does not seem to detract from the marching confidence of science in its method or in the truth of its results. Scientists apparently see in their work more than theories not yet proven false. They possess real positive content, both in process and in results. See J. Mouton 1996: 13-16.
47. See J. Mouton 1996: 28-34; 121-124.
48. It is not the case however that science only attempts to make sense of a given world that is the focus of study, for that given world is in part, and perhaps largely, a world of observation, itself formed by the method of approach assumed in empirical science. One may talk of the observable world as if it is there to be seen, but it is as well the invention and province of those very abstractions without which neither empirical observation nor scientific sense could be made.
49. See J. Mouton 1996: 107-113.
50. Merton speaks of disinterestedness as trustworthiness. See R. K. Merton 1968: 612-614.
51. See J. Mouton 1996: 119-124.
52. This is Kahane's position when he says to disbelieve the confirmed knowledge of science is folly. See H. Kahane 1995: 30-31.
53. See J. Bronowski 1961: 56.
54. Marvin Minsky speaks of the assumptions made by opponents of the logic of science who propose some vital spark that makes up human consciousness. Human consciousness is in his terms the result of the interaction of many flexible parts working together in the brain. See M. Minsky 1994: 90. In the opposite camp, Marx, for instance (or at least in interpretation), has made the creation of a positive science of society part of the working out of history, and a means of dealing with ideology. Thus, scientific knowledge and the reliability of the institution of science can be used to make decisions about actual states of affairs in society. See J. Thompson 1990: 36-37.
55. For example, Polanyi (1948:8), quoting N. I. Bukharin writes: "... the distinction between pure and applied science, made in capitalist countries, was due to the inner conflict of this type of society, which deprived scientists of the consciousness of their social functions, thus creating in them the illusion of pure science". Bukharin also states: "Marxism-Leninism denies the intrinsic creative powers of thought. Any claim to independence by scientists, scholars or artists must then appear as a plea for self-indulgence. A dedication to the pursuit of science, wherever it may lead, becomes disloyalty to the power responsible for the public welfare. Since this power regards itself as the embodiment of historic destiny and as the dispenser of history's promises to mankind it can acknowledge no superior claims to the standards of truth ..." (Cf. M. Polanyi 1946:17.) Merton makes the comment that such

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positions tend to confuse "two distinct issues: first, the cultural content of any given nation or society may predispose scientists to focus on certain problems, to be sensitive to some and not other problems on the frontiers of science ... But this is basically different from the second issue: the criteria of validity of claims to scientific knowledge are not matters of national taste or culture. Sooner or later, competing claims to validity are settled by the universalistic facts of nature which are consonant with one and not another theory". See R. K. Merton 1968: 608. If this is Merton's own view then he is a direct inheritor of the scientific mentality. (For a reference to the 'full scientific mentality' see A. N. Whitehead 1926: 6.) In a similar line of thought, Bronowski points out how the anatomical work of Blumenbach, while never designed by him to support racist notions, was added onto and was in time officially sanctioned by the German National Socialists as the true scientific genetic testimony supporting Aryan superiority. See J. Bronowski 1973: 367.

56. Namely, R. K. Merton 1962: 16-28, R. K. Merton 1968: 605-615, and M. Gibbons 1985: 2-20. I reference them here at the beginning so as to avoid a long stream of notes. I have borrowed heavily form both authors, using from these articles many notions, numerous terms, and some phrases. In a sense the following accounts are a kind of embellished summary of their own arguments. Additional ideas here come from R. K. Merton, The Third Daniel Coit Gilman Lecture delivered at the Johns Hopkins University School of Medicine, September 25, 1962.
57. See R. K. Merton 1968: 614, and M. Gibbons 1985: 12-13.
58. When Galileo made a respectable telescope he showed it to the Venetian Senators, who, when using it, could see an incoming trading vessel 2 hours prior to docking - valuable information in those days. See J. Bronowski 1973: 200-204.
59. See C. C. Gillispie 1960: 74-82, R. K. Merton 1968: 614, and M. Gibbons 1985: 12.
60. See R. K. Merton 1962: 22-25, and R. K. Merton 1968: 604-605.
61. R. K. Merton 1962: 21-22.
62. See M. Polanyi 1964: 42-50.
63. It is abstract in the sense that individual scientists subscribe to a general will which the tradition and institutions of science take as postulates, becoming the common property of all who would will to be scientists. For a discussion of the operation of a general will in matters of scientific authority see M. Polanyi 1964: 63-65.
64. The term comes from M. Gibbons 1985: 12. Merton uses the idea at length. See R. K. Merton 1962: 23-24.
65. These terms are directly from Merton. In other words, science as an institution defines knowledge communally based on fundamental methodological grounds. The mores of science come out of its method and are made legitimate and transmissible only in an institutional context responsible for the maintenance of those same mores, now institutional norms. See R. K. Merton 1968: 607.
66. For further observations about this see J. Bronowski 1961: 59-79.
67. In addition, this attitude also helps to ensure the continued existence of science by thwarting any incursion by institutions of society outside the concern of scientific knowledge.
68. This is as well an expression of the norm of organised skepticism - that no scientific opinion can be voiced on matters about which no empirical knowledge is available. See R. K. Merton 1962: 26-28, and R. K. Merton 1968: 614-615.

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69. See J. Bruner 1971: 35-38. This position is clearly countered by opinions such as Dawkins' and Monod's. See J. Monod 1972:110 and R. Dawkins 1986: ix-x.
70. See R. K. Merton 1962: 23-24, and R. K Merton 1968: 614 on the demonstration of the power of technology.
71. See J-M. Lehn 1996: 103.
72. Polanyi holds that a society's commitment to truth is the first condition for scientific support. See M. Polanyi 1964: 19; 73.
73. Even as late as the 1930's quantum and nuclear physics were the province of dedicated groups of people at universities whose work was known and shared on a relatively intimate scale. See R. Jungk 1956: 21-36.
74. Gibbons is the core work from which this and the following account is derived. As with Merton, his notions, terms, and phrases have been adopted here. See M. Gibbons 1985: 2-20.
75. See P. F. Drucker 1993: 7; 165-173.
76. While individual specialist researchers may remain committed to the work of valid experimental results, the choice of research and the reasons behind that choice are invested with the providers of funds who hold the power to determine which likely research outcomes to support.
77. See P. F. Drucker 1993: 17-24 for an account of the new definition of knowledge.
78. This general attitude of the separation of fact and value, the distancing of means from ends, has become a widely adopted assumption in the working of Western society, particularly in its intellectual tradition and qualifies all professions, not just science. See M. Gibbons 1985: 11-12.
79. This particular distinction between tools and ends, as noted earlier, comes out of the seventeenth century analysis of mind and body, and its consequences for the way knowledge is conceived and characterized. One of the historically important changes in the conception of knowledge (and which signalled an end to the thought of the Middle Ages) was the coming to the fore of its use for utility and control. This opened the door for the conception of craft experience as valid technical know-how (later to become technology), which in turn paved the way to the creation of specialist professions each with their unique set of knowledges and methodological approach. See P. F. Drucker 1993: 41-55 for an account of this change in the European conception of the status of knowledge.
80. Whitehead states: "The greatest invention of the nineteenth century was the invention of the method of invention". See A. N. Whitehead 1926: 120-121.
81. The industrial revolution was in part begun on the Enlightenment notion that the good life is more than material well being, but it must be founded on material well-being. See J. Bronowski 1973: 279.
82. Also important here is the still recent creation of deep and powerful theories of nature - nuclear and quantum mechanics, genetics, and molecular biology - which provided the base for rapid discovery of the practical. See A. N. Whitehead 1926: 119-141, and W. Dunn 1994: 54.
83. They share the same method and have a common inheritance of the mechanical world view. See M. Gibbons 1985: 15-16. The following argument is based on Gibbons. See M. Gibbons 1985: 15.

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84. See F. Ferré 1995: 30-53 for a discussion on practical and theoretical intelligence. Also, the ends are chosen by us, they are not givens of nature. Value is therefore a construct of the mind, and is part of the way right and wrong are invented. See J. L. Mackie 1977.
85. See M. Gibbons 1985:16. Competitive advantage for a nation means that it can compete in world trade. In the case of specialisations, one discipline is advantaged over another and thus has a greater chance for survival. Darwinian competition of the fittest thus comes to the fore. See Z. Bauman 1992: 48-53 for an analysis of society based on consumer desire.
86. See M. Gibbons 1985: 15. In this respect kindness, say, or love, is not a commodity as such (though acts of kindness or love could perhaps be made into commodities). Nor is knowledge as such a commodity, but certain forms of knowledge that can be equated with some object or information of value.
87. They are however employed as knowledge workers. See P. F. Drucker 1993: 75-77. It is worth noting that while the institutional side of research may be devoted to commodity exchange, researchers are still trained in the ethos of methodological purity, and they still seek interesting and rewarding research problems to investigate. Scientific freedom here means the freedom to pursue research goals (based on a particular research team's own judgment of a problem) secured through the exchange of beneficial societal results in return for specialist funding and resources. In another sense, a dedication to the creation of results that can serve as commodities could also lead to cynicism, or to an amoral approach to scientific work, as might occur in military research. See R. Jungk 1956: 276-277.
88. See M. Gibbons 1985: 17.
89. See M. Gibbons 1985: 17-18.
90. See W. Dunn 1994: 43-50 for an account of the rise of professional policy analysis.
91. For a definition of policy analysis, and hence a characterisation of the realm of expert knowledge, see W. Dunn 1994: 61.
92. See M. Gibbons 1985: 8.
93. See M. Gibbons 1985: 9.
94. See A. N. Whitehead 1926: 120-122.
95. This position is revealed in Jean-Marie Lehn's statement about the need for more sophisticated knowledge to solve the problems mankind faces. J-M. Lehn 1996: 103.
96. See W. Dunn 1994: 6-10; 61-80; 90-99; 126-129; 138-147 for detailed accounts of complex policy contexts.
97. See W. Dunn 1994: 52. See also P. F. Drucker 1993: 75-77 where he uses the term 'knowledge worker'.
98. Dunn suggests that the scarcity of useful information is the result of competitive practices among institutions that produce knowledge. Such institutions tend to view the research they produce or gather as a private good for increasing their advantage in a society where knowledge is considered a commodity, its trade necessary for continued existence and the increase in power, wealth, or influence. In addition, if science is now involved in the fabrication of phenomena, then both science and technology share the same method and may be produced in the same system of institutionalised research. However, technology as invention has long worked in the realm of property and trade rights, with a contemporary focus on intellectual property as knowledge and information as the main resource of a post industrial or post capitalist society. The assumption in technology then that the goods

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produced by inventors and industry are private property is thereby carried over to science research as fabrication - a result contrary to the scientific tradition of knowledge as communal property whose use is not to be decided by the scientist. With the rise of contemporary science, research is done in institutions with an eye to ownership and material advantage within a competitive information market. Dunn's point is that by taking knowledge to be a private good, then in public arenas that require the best possible information for intelligent action decisions will be compromised with possible serious consequences - this apart from possible vested interest in so called scientific research when taken to be a matter of private property. See W. Dunn 1994: 52, and P. F. Drucker 1993: 167-175.

99. See W. Dunn 1994: 53-54. Dunn's account of technocratic guidance and technocratic counsel comes out of a larger scheme of thought for complex decision-making which he calls 'critical multiplism'. This involves the use of 'inductive plausibility', not certainty, in any production or evaluation of knowledge, and which includes the need to synthesise rival theories, perspectives, or hypotheses within the context of problems as actually experienced by decision-makers and the public. Dunn claims it is a method to make less likely the commission of avoidable errors arising from the limited perspective of an individual expert (through multiple operationism, multimethod research, multiple analytic synthesis, multivariate analysis, and multiple perspective analysis). In some sense it is an attempt to connect explanatory research analysis with pragmatic problem solving. See W. Dunn 1994: 6-10; 140-147.

100. Ezrahi, Y., Utopian and pragmatic rationalism: the political context of scientific advice, *Minerva*, 18(1), 111-131 (1980). See for example A. Rip1984.

101. Dunn divides the types of approach to decisions about problems into 'well structured', 'moderately structured', and 'ill structured'. Of the ill structured type (which is believed to constitute many of the most important policy problems related to strategic decisions) Dunn writes: "The prototype of the ill structured problem is the completely intransitive decision problem, that is, one where it is impossible to select a single policy alternative that is preferred to all others". See W. Dunn 1994: 146.

102. A somewhat similar account is provided by Dunn in his discussion of schema for making rational decisions (such as the rational comprehensive theory, the disjointed incremental theory, and bounded rationality). In contrast to the standard approaches, 'erotetic rationality' refers to situations where one does not know the relation between "policies, policy outcomes, and values in terms of which such outcomes should be assessed". It includes as well the idea of "usable ignorance" and the interrogation of a situation in its context, not the knowledge of certainties in the absolute, context free sense. There are clear connections here with Ezrahi's pragmatic rationalism. See W. Dunn 1994: 275-282. However, Dunn does not seem to support the notion, as does Ezrahi, of the myth of scientific certainty (in the sense of secure and reliable knowledge). Pragmatic rationalism tends to reject the notion that hard facts exist, and that the canons of professional research mean that consensual knowledge is available in the form of expert knowledge.

103. See M. Gibbons 1985: 20.

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Chapter three notes

1. This is a consistent theme in the area of holistic or ecological thought, as well as in systems theory and recent studies in chaos. It is as well an ancient intuition about the way all things are interconnected. See, for example, I. Stewart 1989, E. Jantsch 1979, F. Capra 1983: 15-29; 285-332, I. Prigogine and I. Stengers 1984: 79-102, A. N. Whitehead 1926: 90; 129-134.
2. See the thesis Introduction, page 4.
3. See M. Minsky 1994: 86-91.
4. This idea is taken from C. Taylor 1993: 208.
5. See M. Minsky 1994: 90.
6. See for example C. Taylor 1985a: 117-138, A. N. Whitehead 1926: 3-7, and J. Bronowski 1973: 91-154; 321-352.
7. Kepler's laws is one example since they only describe the behaviour of planets as they orbit the sun. The provide no explanation about how it is they behave this way. Various accounts human experience are also often considered as phenomenological - descriptive but not explanatory. See I. Prigogine and I. Stengers 1984: 57-77.
8. The argument against this procedure is that it often explains away, not explains. See A. N. Whitehead 1926: 20-24; 66-70, and I. Prigogine and I. Stengers 1984: 34-37.
9. Hence Kahane's position quoted in chapter one, about the irrationality of discounting science.
10. See A. N. Whitehead 1926: 69, and C. Taylor 1993: 213-235.
11. The ideas that will be developed are at best my interpretation of the interpretation of some of those knowledgeable in the field.
12. This section will largely based on the works of C. Taylor 1993, C. Taylor 1985a, C. Taylor 1985b.
13. This section is indebted to the works of I. Stewart 1989, E. Jantsch 1979, I. Prigogine and I. Stengers 1984, F. Capra 1983, and C. C. Gillispie 1960.
14 See J. Mouton 1996: 28-34.
15 See I. Prigogine and I. Stengers 1984: 213. Steven Weinberg seems to hold just this sort of view of a science free of the clutches of time. See S. Weinberg 1994: 22-27.
16. See A. N. Whitehead 1926: 83.
17. See I. Prigogine and I. Stengers 1984: 217-220; 229.
18. See J. Bronowski 1973: 259-290.
19. In a sense it is not unlike the times of Eratosthenes, as discussed in chapter one, who used shadows cast by the sun to calculate the size of the earth and so changed a conception of the world. For contemporary science light and shadow is as well the beginning to new conceptions of human knowledge.
20. See C. C. Gillispie 1960: 406-492.
21. The value is now bettered to 1 650 763, 73 wavelengths of the orange red light of krypton-86. (Cf. D. Halliday and R. Resnic 1974: 718-720.)
22. In the words of Maxwell: "Light consist in the transverse undulations of the same medium which is the cause of electric and magnetic phenomena". (Cf. C. C. Gillispie 1960: 473.) Gillispie goes on to mention that this is no statement about the form of equations or inferences about data, but a statement about the makeup of the physical world. Again from Gillispie quoting Maxwell himself: "The theory I propose may therefore be called a theory

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of the Electromagnetic Field, because it has to do with the space in the neighbourhood of the electric or magnetic bodies, and it may be called a Dynamical theory because it assumes that in that space there is matter in motion, by which the observed electromagnetic phenomena are produced". (Cf. C. C. Gillispie 1960: 474.) Gillispie observes that Maxwell nowhere abandons the principle of mechanism. The phenomena as Maxwell's theory describes are "expressions of motions of some kind, causally interrelated and communicated by forces". (Cf. C. C. Gillispie 1960: 474.)

23. For various characterizations of the aether see C. C. Gillispie 1960: 129-131; 490-492; 507-510.
24. See D. Halliday and R. Resnic 1974: 655.
25. Scientist in the 1950's offered as an explanation for their participation in the construction of the thermonuclear bomb, after their very negative experiences of the creation of the first atomic bombs during the second world war, the fact that the project was 'technically sweet'. (Cf. R. Jungk 1956: 266.)
26. See I. Prigogine and I. Stengers 1984: 213-218.
27. See C. C. Gillispie 1960: 474.
28. See J. Bronowski 1973: 241-258.
29. As a consequence of the constant speed of light, time is said to dilate as an observer approaches its limiting value (mass, length, and colour also change). See I. Prigogine and I. Stengers 1984: 213-217, J. Bronowski 1973: 241-258, G. Gamow 1962: 117-132, and H. Bondi 1964.
30. It is worth noting that Einstein, though establishing relativity theory, presumed the universe to be time independent. In other words, time was not a necessary condition for the relativity equations to apply. Einstein saw no need to posit an evolving universe in which time stands as an irreversible quantity (his equations run well with respect to any chosen passage of time), only one in which consideration must be given to the observer's status in order to make determinations of relations among scientific constructs. He therefore still hoped to provide a complete description of nature. See I. Prigogine and I. Stengers 1984: 229-232.
31. Even though the theories imply certain different conceptions of space and matter, scientists take relativity and quantum mechanics as extensions of Newtonian physics and so not contradictory to it. (Cf. H. Bondi 1964: 1-2, and D. Halliday and R. Resnick 1974: 60-61.) Their faith in the unity of nature guarantees this. Still, the new concepts involve modes of thought that are movements away from a strongly mechanistic stance. However, the intent of contemporary science with respect to the natural world has not changed: to hold and control, to manipulate and design, to fabricate, and so to comprehend.
32. It is worth noting that Planck was forced to develop the idea of the quantum in an attempt to give a mechanical explanation of how thermal equilibrium is achieved in matter energy interactions. See I. Prigogine and I. Stengers 1984: 219.
33. See J. Bronowski 1973: 321-378, and I. Prigogine and I. Stengers 1984: 224-225. However, this is not an abandonment of mechanism - as the name quantum mechanics suggest.
34. See J. Bronowski 1973: 340; 364.
35. Quantum mechanics however is an intensely abstract mathematical theory. Science has always been mathematical, but at the level of the quantum, far removed from everyday sense experience, scientists must become thoroughly mathematical in the attempt to

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maintain the tradition of precise descriptive content to scientific theory. See for example I. Prigogine and I. Stengers 1984: 220-222.

36. See I. Prigogine and I. Stengers 1984: 220.
37. The mathematics of operators is not isomorphic with the mathematics of macro scale phenomena - calculus, differential equations etc. See I. Prigogine and I. Stengers 1984: 222.
38. See J. Bronowski 1974: 358; 364-367, and I. Prigogine and I. Stengers 1984: 222-226.
39. See J. Bronowski 1974: 365.
40. See J. Bronowski 1974: 353-356.
41. See I. Prigogine and I. Stengers 1984: 225.
42. See J. Bronowski 1973: 364.
43. There exist different possible languages of descriptive content, none more fundamental than the other, and so the world can only be got at by our conceptualizations of it. The idea of facts then must adopt a notion that admits of a plurality of valid 'notifications' - replace 'fact' with 'facts'. However, science still definitely deals in empirical determinations of what is and is not the case, and so far as valid and repeatable experiments are concerned the notion of fact is under no threat from developments of quantum mechanics.
44. Quantum mechanics is still mechanics, relativity the dynamics of space. For example, there exists what has been called 'cookbook quantum mechanics'. See J. Gribbin 1984: 123-152. This is mechanics for everyday use. It does not require a searching interpretation of the kinds of human knowledge implied by quantum theory. Once a working theory has been posited - even if there are deep level alternate interpretations - the physics works itself out. We can very well and accurately predict quantum effects. We build computer chips, lasers, nuclear probes, etc. that work according to design. There is nothing fuzzy about it. The mechanics is deterministic in a very well defined, probabilistic sense such that effects can be fixed to a very fine degree. We can therefore fabricate the phenomena or build the technology we want. In addition both relativity theory (as developed by Einstein) and quantum mechanics adopt the principle of a time independent universe (There are other time dependent interpretations that are now used to describe an irreversible evolution of the universe. See I. Prigogine and I. Stengers 1984: 226-232. In other words, the theoretical equations used to describe relativistic or quantum effects employ time as a reversible quantity. The equations can run in either direction, and so effects over time in theory can be reversed (although in quantum mechanics once an observation has been made then a particular quantum state is thereby decided which cannot be revoked). This aspect connects both theories to the historical project of science. Despite the nuances of perspective and observation implied by them, they adopt deep level classical assumptions about a knowable and determinable universe.
45. These are otherwise known as open systems - those having non-linear feedbacks. The following treatment is indebted to the works of I. Stewart 1989, E. Jantsch 1979, I. Prigogine and I. Stengers 1984, and F. Capra 1983.
46. Irreversibility is the noise of human ignorance, not the voice of nature speaking. There is a long, contentious history to this notion of entropy, too complex to enter into here. I. Prigogine and I. Stengers 1984 treat it at length.
47. In the standard interpretation, thermodynamics as the science of complex systems where "the only specific feature of complex systems is that our knowledge of them is limited and that our uncertainty increases with time. Instead of recognizing in irreversibility something

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that links nature to the observer, the scientist is compelled to admit that nature merely mirrors his ignorance". See I. Prigogine and I. Stengers 1984: 238-239.

48. Time and natural selection are statistical concepts - a single organism cannot evolve, a universe of one entity experiences no time.
49. See I. Prigogine and I. Stengers 1984: 247-249, 261-264.
50. All reversible processes can be treated by the general abstractions of the standard thermodynamic interpretation. This is one reason why it is often taken to be the archetype of modern scientific theory. The success of the theory may well have contributed to the blind spot created towards irreversible processes as being anything but phenomenally real. The general theory simply was true of the world and no observation could counter it. If any did, they would be interpreted away as having no effect in reality. However, irreversibility cannot be deduced from general thermodynamics for it is not a universal phenomena - that too is why irreversible systems were questioned. To get at irreversibility we must select a less general conception for molecular dynamics - it is impossible to know individual particles and individual trajectories at the microscopic, quantum level. There is no one thermodynamic law that decides all. In the case of reversible processes, a universal theory applies. For the irreversible, embodying the novel and unpredictable, while abstract notions may apply only particular considerations can serve to get a grasp of the process. There are two levels of thermodynamic reality. Systems at equilibrium will show up general reversible characteristics. Those at far from equilibrium will diverge to some other state not recoverable or repeatable, hence, particular and in that sense random. See I. Prigogine and I. Stengers 1984: 233-256.
51. Creativity then is part of the very characterization of irreversibility.
52. This turns out to be true not only for systems in which quantum matter is active, but in other complex systems that involve any type of non-linear feed back.
53. This is worked out in chapters eight and nine in I. Prigogine and I. Stengers 1984.
54. See I. Prigogine and I. Stengers 1984: 300.
55. Fritjof Capra works out this idea in *The turning point* 1983.
56. See E. Jantsch 1980: 6.
57. See F. Capra 1983: 294.
58. See E. Jantsch 1980: 6.
59. See E. Jantsch 1980: 6.
60. See E. Jantsch 1980: 6.
61. See E. Jantsch 1980: 7.
62. See F. Capra 1983: 285-332.
63. However, it is not the case that only organic patterns obtain. Both mechanical and organic models are required to make sense of things.
64. See E. Jantsch 1980: 9.
65. See S. J. Gould 1994: 64.
66. See E. Jantsch 1980: 7.
67. These levels are cells, tissues, organs, organ systems, organisms, systems of organisms. As F. Capra notes: "The multileveled structure of living organisms is a visible manifestation of the underlying process of self organisation". (Cf. F. Capra 1983: 303.)
68. See F. Capra 1983: 304, and E. Jantsch 1980: 16.
69. See F. Capra 1983: 321-322.
70. See E. Jantsch 1980: 14.

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71. E. Jantsch speaks of three types of mind or mentation: organismic, reflexive, and self-reflexive. See E. Jantsch 1980: 162.
72. See chapter nine in both E. Jantsch 1980, and F. Capra 1983.
73. See F. Capra 1983: 327, and E. Jantsch 1980: 165-168.
74. See chapter 9 in E. Jantsch 1980.
75. See chapter 9 in E. Jantsch 1980.
76. See E. Jantsch 1980: 171.
77. See E. Jantsch 1980: 169-179.
78. See E. Jantsch 1980: 172.
79. Since the sociocultural world is organised by the same process of evolutionary interaction out of which developed biological systems - which is not at all to say that the sociocultural is therefore biologically or materially determined - then part of understanding the processes that obtain in such a world (such as the interrelations between science, society, and technology) require an appreciation of the way complex systems self-organize and evolve. Making sense of social systems requires "an understanding of phenomena such as self-organisation and self-regulation, coherent behaviour over time with structural change, individuality, communication with the environment and symbiosis, morphogenesis and space- and time-binding in evolution". See E. Jantsch 1980: 6.
80. Sociocultural evolution has moved beyond that which obtains strictly within systems not open to levels of self-reflexion - systems that have taken millions of years to evolve through dynamic but stable levels. The incomparably faster rates of evolution (because of symbolic communication) that appear in sociocultural systems incorporating individual self-reflexive minds come to take priority. But they in turn show up more quickly and decisively their own weaknesses, such as the potential for war, hatred, and destruction, which are not found in the lesser complex systems (whose processes, while never rigid, has had millions of years to evolve stable forms). See F. Capra 1983: 303-314.
81. See M. Minsky 1994: 88.
82. See M. Minsky 1994: 89.
83. This is consistent with the systems notion of a multileveled reality.
84. Epistemologies other than those of an empirical science become suspect thereby, and are typically accused of circular reasoning - that they simply posit as real what they want to show, and then develop some method to establish their view of the world. Marvin Minsky takes just this sort of stance. For example he writes: "Many scholars from a variety of disciplines firmly maintain that machines will never have thoughts like ours, because no matter how we build them, they will always lack some vital ingredient. These thinkers refer to this missing essence by various names: sentience, consciousness, spirit or soul. Philosophers write entire books to prove that because of this deficiency, machines can never feel or understand the kinds of things people do. Yet every proof in each of those books if flawed by assuming that, in one way or another, what it purports to prove - the existence of some magical spark that has no detectable properties". See M. Minsky 1994: 90. In the same passage Minsky does go on to state his frustration with such views, but more so because of the assumption that thought misses some one 'spark' in machine design, whereas for him there are dozens of missing ingredients which at this time make it impossible to construct machines that think like humans. Of course if (or once) these missing ingredients are reasoned out and designed into the machines then there is no reason to believe that machines could not think.

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85. First, mechanistic and naturalistic assumptions remain very much the daily faire of research in the sciences of man, and in many areas still in the natural sciences. Classical science and its various abstractions are in no wise abandoned by the rise of relativity and quantum mechanics (both are still science, and mechanics, after all). Second, nearly all contemporary science, including the sciences of man and systems thinking, not only adopts the proviso that what something *is* is decided by how it is known - decided by the choice of experiment or shaped by the patterns of consciousness in an evolutionary brain - but that the methods of science (now expanded by contemporary developments) still remain adequate to give an explanatory account of the world - where 'giving an account' means being able to provide a causal description of underlying mechanisms in terms of which observed phenomena can be explained. Indeed, the success of relativity and quantum mechanics supports this contention. Hence, procedural or empirical reason dominate, in concert with two conditions: that any hypothesis held as scientific must also be liable to refutation according to the norms of valid scientific research and theory construction, and that any scientific explanation must reach beyond any phenomenal account down to the level of inner mechanical workings. Even if not the 'original' scientific ontology, then an adjusted image of the real serves the needs of scientific reason to acquire secure and reliable knowledge of the universe. As concerns knowledge of the world, including the sciences of man, empirical science remains the intellectually respectable account.

86. This included systems thinking since it is based on good empirical science. While it posits different levels of reality each requiring specific modes of description, systems science does not abandon the requirements for scientific knowledge - it only extends the realm of science by pointing out phenomena not previously considered as real and hence capable of explanation.

87. Other interpretive frameworks are developed by scholars such as P. Ricoeur 1981, H-G Gadamer 1975, J. Habermas 1987, K-O Apel 1984, M. Horkheimer 1974, and C. Geertz 1973. The notion of man as a self-interpreting creature as developed here is indebted to the works of Charles Taylor (specifically, C. Taylor 1985a, C. Taylor 1985b, and C. Taylor 1993. In addition, Martha Nussbaum's commentary on Charles Taylor: Explanation and Practical Reason (1993), John Thompson's *Ideology and modern culture* (1990), and Alisdair Macintyre's article Epistemological Crisis, Dramatic Narrative and the Philosophy of Science (1977) have been used in developing the general stance of this section.

88. This applies to the topic of holistic modes of thinking since a main stumbling block to any conception of holistic principles is that in Western intellectual culture the naturalistic stance simply commands attention. Alternatives are either suspect or have no impact. The ontology of the machine is taken without option because no other option is seen, or, if seen, is discounted.

89. The ideas in this and the previous paragraph come from M. Nussbaum 1993: 232-235.

90. Much effort is thereby placed on research formulation and design that can be repeated and publicly communicated in clear-cut terms (e.g. defining concepts, constructing hypotheses, choosing units of analysis, operationalization, establishing sampling procedures, methods of data collection, control of errors and insuring reliability, quantitative and qualitative analysis, etc.). A conscious and clear-cut decision procedure is required as the researcher investigates some characteristic or property of the social world. Evidence is built up in support of conclusions about some aspect of that society or the behaviour of its inhabitants. The whole research path is planned and conceived in such a way as to enable the

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researcher to work step by step through whatever actions are required to establish valid knowledge claims. All results are open to inter-subjective analysis, while performance criteria are set out so to ensure the acceptance of research within the circle of science.

91. Indeed, the positions it supports can even go so far as to bring into question the importance of understanding such things as values and human commitments, about which no secure and reliable knowledge can be had. They become mere psychological states of emotion.

92. See C. Taylor 1993: 212.

93. See C. Taylor 1985a: 189. Regarding the tendency to dismiss such a view from the point of view of mechanical explanation, Taylor goes on to state: "The assumption underlying this dismissive attitude must be that the significance feature is a misleading surface appearance, like the movement of the sun or perhaps a purely phenomenal one, like phenomenal colour or felt heat, to be set aside in any rigorous characterization of the events to be explained. But this is, of course, mad. There is all the difference in the world between a creature with and one without the significance feature. Once we look to feelings, emotions, or actions which are defined in terms of them, or of moral categories, aesthetic categories, and so on, like 'saving one's honour' or 'telling the truth', we run out of machine analogies to be bemused by". (Cf. C. Taylor 1985a: 200.) Later Taylor notes the following: "For the crucial difference between men and machines is not consciousness, but rather the significance feature. In other words, when we say that the significance feature is essential to our self-understanding as agents, we are not saying that it is inseparable from our representations in an inner medium, whose deliverances are as dispensable to an explanation of behaviour as our perceptions of the sun in the sky are to account of the solar system. We are rather saying that once we understand ourselves as agents, rather than, say as physical objects on all fours with others, including inanimate ones, we understand ourselves as beings of whom the significance feature is an essential character, as beings such that it is essential to what has to be explained, if we want to explain their behaviour." (Cf. C Taylor 1985a: 201-202.)

94. See C. Taylor 1985a: 189.

95. For example, in the attempt to make sense of some state of emotion, to partly clarify what significance it has for us, then our experience of that emotion will change, and so too then its range of significance. "An emotion clarified is in some way an emotion transformed". See C. Taylor 1985a: 191.

96. These ideas are worked out in detail in C. Taylor 1985a: 97-112. Actions can be accounted for by the firings of the nerves in the cortex. These aim and direct the motions of limbs or combine to create conscious awareness through some sort of feed-back mechanism involving the five perceptual faculties and a highly evolved central nervous system. On this account, to make sense of what it is to be human involves a rational reconstruction in thought via a material-mechanical explanation. Humans are objects like others in the universe. To make sense of them requires that surface features and appearances be dismissed in favour of absolute mechanical descriptions and explanations - the hidden mechanical architecture of human consciousness. Just like machines and computers, the human brain is not an object of original purpose. Human life is instrumental and is to be planned. Hence, evolutionary theory and a mechanical and material explanation of human consciousness by brain function can account for the distinctly human ability to plan and act in an objective world and neutral universe using instrumental reason. As a result of the way the brain has evolved, man is a free being, able thereby to select and accomplish his own

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chosen ends or natural desires in a world of neutral resources that he can control, manipulate, or fabricate as he will according to his needs.

97. See C. Taylor 1985a: 102, 104-105. This idea is not unlike that of a kind of moral intuition. As such it is open to much criticism from the point of view of the requirement of a moral code for the right conduct of human affairs. Taylor's notion of 'strong evaluation' is among his more contested ideas.
98. Taylor 104-105,108-110.
99. See C. Taylor 1985a: 112-114.
100. Such, for instance, is the point of the naturalistic accounts Polanyi described, as discussed in chapter two.
101. See C. Taylor 1985a: 165-166.
102. John Casti sets out a list of causal and non-causal explanations, and types of predictions. See J. Casti 1991: 37-44. Of course, the history of the natural and human sciences does point to situations where *some* understandings of the everyday are shown to be mistaken - where self-understanding does not hold up to the knowledge gained in empirical and inter-subjective scientific accounts. However, the success of the epistemic imperative and the goal of methodological purity can often support the added conclusion that ordinary accounts really have no explanatory force; that the project of science, if systematically and doggedly pursued, will provide a satisfactory mechanical explanation of all phenomenological descriptions. There is no conflict between mechanical and significance accounts because all significance accounts can in principle be reduced to a more fundamental level of explanatory cause. See C. Taylor 1985a: 167-169. Keeping up with appearances may be practically useful, but as regards the world as an objective process then humans are explainable in terms of neurology and physiology, evolution, chemistry, and physics.
103. See C. Taylor 1985a: 170-171
104. Charles Taylor holds there are convincing arguments demonstrating "... that the vocabularies we need to explain human thought, action, and feeling, or to explicate, analyse, and justify ourselves or each other, or to deliberate on what to do, all inescapably rely on [original significance]. Or to put it negatively, that the attempt to separate out a language of neutral description, which combined with commitments or pro/con attitudes might recapture and make sense of our actual explanations, analysis, deliberation, etc., leads to failure and will always lead to failure. It [arguments that counter thorough-going naturalistic accounts] tries to show us that in all lucidity we cannot understand ourselves, or each other, cannot make sense of our lives or determine what to do, without accepting a richer ontology than naturalism allows". See C. Taylor 1993: 212.
105. Taylor argues that in general it cannot be that the entire range of experience based on self-understanding can be overturned by a mechanistic account. While some accounts will be accurately discarded as fantasy, some of the experiences and some of the logic of self-description must be upheld, even if a completely mechanistic account were possible. The point here is not that the naturalistic account is wrong. The logic of mechanical action has explanatory value. But any theory rich enough to make sense of human action must be able to explain a people's self-understanding - not the particular details but minimally the main categories that people make in a culture or field of meaning by which they come to understand themselves. These, and the fact that man's life is cultural, must be preserved, not explained away, in a mechanistic theory. They cannot be merely dismissed as wrong

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since to do so is to dismiss our entire history of self-understanding. Instead, a mechanistic explanation must work to provide a basis for real phenomenal experience as constituted in self-understanding - the thoughts, feelings, actions, that we experience as we do in the cultures of meaning that we create. See C. Taylor 1985a: 178-181; 185-186. It will do no good to explain them away since they do exist. They cannot be seen as experiences that can be shown to be but phantoms and so have no inescapable claim to our humanity. Their existence is substantively real. To discard them is to fall into confusion about ourselves, and where to claim them as fantasy is to show up ourselves inescapably as less than we are. Such goals, meanings, purposes that have this status of inescapable commitment, such that to cease attending to them is to deny something of what we are and is to fall into confusion about who we are, Taylor calls 'strong evaluation'. They are to be clearly distinguished from the various wants and desires that, whether they come or go, imply nothing about who we are. See C. Taylor 1993: 210.

106. See C. Taylor 1993: 209.
107. See C. Taylor 1985a: 220-227.
108. See C. Taylor 1985a: 227-234.
109. See C. Taylor 1985a: 222-223.
110. See C. Taylor 1985a: 230-231.
111. See Johann Mouton's treatment of valid social scientific research in J. Mouton 1996: 109.
112. The coherence theory of truth is discussed in J. Botha 1997. Agents of self-understanding are not objects 'out there', available in clear and distinct terms to some discursive analysis. As such we cannot say definitively what is and is not the case with regard to them as beings of original purpose and meaning. This is so because if some aspect of self-understanding is made more clear via interpretive expression, then reflexive awareness allows that this very interpretation affect and transform that which is being interpreted. The coherence of meaning involved in being able to say a particular articulation is a gain in understanding is not a coherent expression of a whole field of meaning. The whole field is never fully explicit, and its meaning relations for persons whom expression and realization are as one can change as language is used to offer some coherent account. Rational explanation then is an obtaining to a more coherent account of some human practice in terms of purpose and meaning for people who are creatures of self-interpretation, and whose world is made more real in some way. Arguments about some or another interpretation being a gain in self-understanding rest on an ability to be as coherent as one can be about the various contributing aspects to the field of meaning being expressed or realized.
113. Taylor's position is that argument as moral deliberation thereby serves to make more clear what was nebulous before, to rework a confusion that fostered some error in judgment, or to trace out how some aspect of a position is perhaps based on the appeal to exceptions, and which can be shown up as inferior upon the articulation of some other more coherent articulation. While from the naturalistic stance such reasoning may appear halting and vague, ending in dissimulation, the point is not to provide indisputable evidence for the adjudication of rival positions. The field of meaning relations for practical reason in which occurs argumentation about human significance is inexplicit in its symbolic forms. It is open to various reinterpretations that express or reveal something which can act upon a person's moral self-understanding, transforming it in turn. Argumentation is not an attempt to solve the dilemma by presenting the valid argument among rivals by appeal to irreducible fact. The attempt is to offer (then adjust and reexpress) some coherent account that attempts to

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come to terms with a moral problem, making it thereby more lucid, so that errors or gains in understanding can be marked out, and so achieve some type of moral self-clarification. See C. Taylor 1993: 209-210.

114. See E. Jantsch 1980: 177.

115. The tendency, however, in Western intellectual culture (and so too the institution of science) is to represent the mind and the world in terms abstract and separable, and which can lead to concepts that divide out responsibility for human practice from the 'objective' ideas and designs that are used in strategic planning, control, and manipulation. Such divisions are a hallmark of instrumental reason. Human significance can thereby be lost or misplaced in the knowledge structures such reason builds up. The emphasis on naturalistic reasoning and the world view of the machine has tended to narrow down to a single view human efforts at understanding nature and to a single approach right and rational methods of attaining knowledge of it. Ideas become fixed and abstract. The rich and particular connections open to self-reflexive thought become truncated and universalized. Similar processes happen in broader society where institutions become overly rigid such that difference or novelty are taken as threats. Absolute views of the nature of things can become dogmas not open to further renewal; knowledge of states of affairs are taken to be factual and free of prior commitment, whereas they are open to judgment and interpretation. Values are taken as only psychological preferences, and not a high-water mark of the evolution of consciousness. Out of such thinking can be made pronounced distinctions between means to knowledge and the ends of human action, where either certainty as to ends permits the use of any means for their accomplishment, or the assumption that secure and reliable knowledge is scientific knowledge and so renders human intents somehow less real. In general, such conditions of thought are counter to the inter-connectedness of evolutionary trends. The use of mechanical images and material principles as sufficient to explain the world based on only a crystallization (or an 'equilibration') of what are highly dynamic, interrelated, and historical levels of reality where patterns of interaction are as real as are its constituents, and where history cannot be ignored. See E. Jantsch 1980: 177-179.

116. See E. Jantsch 1980: 236.

117. See E. Jantsch 1980: 236-238 for a discussion on these three aspects

118. "Here, I should like to merely indicate that this implies that it is no longer whole structural platforms, whole civilizations, societal systems, art and life styles that may jump to a new structure. A pluralism emerges in which many dynamic structures penetrate each other at the same level. In such a pluralism there is no longer the familiar evolution in big step functions. Change, increasing in an absolute measure, occurs not only vertically, in historical time, but horizontally, in a multitude of simultaneous processes, none of which necessarily has to assume destructive dimensions. The reality of the human world becomes dissolved into many realities, its evolution into a multitude of horizontally linked evolutions" (Cf. E. Jantsch 1980: 256). In the same passage Jantsch goes on to state: "I believe the future will be determined by two factors, besides others. One concerns the progressive weakening of control hierarchies with respect to human systems as well as the accompanying abandonment of the idea of a single, monolithic cultural guiding image. The other factor concerns the strengthening of the autonomy - that is to say, of the consciousness - of the subsystems"(Cf. E. Jantsch 1980: 256.)

119. Evolution involves action along the avenue of the unexpected. It is a process that is

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dynamic, interconnected, never to be completed, never able to be fully anticipated. From a systems view, by adopting in a single minded way the goal of methodological purity, and by distancing itself from the challenge of making sense of the realm of values and ethical action in society (except to explain them away as aspects of inert matter in complex motion), the project of science tends to cut itself off from the human creative response to living systems. In such a view, it is a mistake to see values as the play of pro- or con- emotional states, or as behaviours in response to the environment that can be explained as some complex firing of the cortex. It is a mistake because such accounts see values from the disengaged perspective - a standing back in observation. However, it is not possible to understand the process of human evolution without also doing, creating, becoming - without living in an active historical present and taking responsibility for creating some future world out of it. Human experience of history and the anticipation of the future forms a cyclic dance at the cusp of an active, evolving present. In systems thinking, knowledge from a disengaged stance is but part of this process of taking responsibility for planning and acting with evolution, now sociocultural and trans-personal. To the extent that science is taken as a disengaged institution, or one only providing knowledge capital for the provision of industrial wealth in some kind of social exchange, then it will fail to act with evolution in creating an open future out of an active present.

120. See E. Jantsch 1980: 243-250.
121. These ideas come out of the discussion in E. Jantsch 1980: 263-274.
122. See E. Jantsch 1980: 265.
123. This table has been taken from E. Jantsch 1980: 268.
124. See E. Jantsch 1980: 272.
125. In the systems view evolution involves a dynamic interaction among many levels, is never completed, never to be fully expressed or made final. If so then the notion of 'problem solving' in the realm of ethical action and planning must be suspect. "Problem solving presupposes the existence of an unambiguous answer in the quest for the good and right. But such an answer is possible only at one specific level of a multilevel reality. In the dynamics of dissipative biological, sociobiological, and sociocultural processes, however, there are no problems which may be solved once and for all. There is only a dynamic, evolving problematique". (See E. Jantsch 1980: 273.) The institution of science is heavily invested in providing solutions to problems. But often these are conceived in terms separate and distinct. The levels of interaction between science and society can be overlooked or even denied. In such a systems view, since there is no final end state forever to be labelled good and right, then the point of action is to live out the present in a way as good and as right as can be.
126. As was the case in the earlier treatment of the significance account, this section in highly indebted to the works of Charles Taylor, John Thompson, and Alisdair Macintyre. Refer to note 91 for the works consulted.
127. Johann Mouton's book is a good example of how such research might be conducted. See J. Mouton 1996.
128. See J. B. Thompson 1990: 20.
129. See J. B. Thompson 1990: 275.
130. See C. Taylor 1985b: 24-28.
131. This deals with the science of hermeneutics and the hermeneutical circle, topics too complicated to enter into here. John Thompson refers to it as the hermeneutical arc. See J.

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B. Thompson 1990. There is then no interpretation of self and world that can claim complete coherence with all fields of meaning (See C. Taylor 1985b: 18.)

132. From the naturalistic stance these cannot but appear as shifting and inferior to the knowledge claims of empirical social science. But it is an equivocation to take the norm of certainly posited in modes of though adopted in the empirical social sciences and apply them to accounts based on interpretation. There is uncertainty in interpretation, but it is not the sort that is the negation of the certainty had in empirical social science. Using Taylor's terms, it is the uncertainty coming from the way in which the human world is partly constituted by self-interpretation - where self-understanding changes the self that is being understood - and so the 'objects' in a interpretive account are wholly unlike those that obtain when social scientific abstractions are used to reconstruct experience in (instrumentally) rational forms. It is not uncertainty at all, but the given and unavoidable character of what it means to make sense of social creatures partly constituted by self-understanding. See C. Taylor 1985b: 26.
133. See C. Taylor 1985b: 61-115.
134. The ideas as presented in these paragraphs is a very brief encapsulation of the discussion in C. Taylor 1985b: 91-115.
135. See A. Macintyre 1977, for a description of the way theory must always come out of a historical and cultural practice.
136. This whole notion of symbolic forms and cultural phenomena in structured social contexts is developed by John Thompson 1990, from which this account is taken. For example, Thompson describes culture as "the pattern of meanings embodied in symbolic forms, including actions, utterances and meaningful objects of various kinds, by virtue of which individuals communicate with one another and share their experiences, conceptions and beliefs". (Cf. J. B. Thompson 1990: 132.)
137. 'Meaning in the service of power' is the term Thompson uses to describe the ways in which symbolic forms may be used ideologically, i.e. to create and sustain asymmetrical relations of domination in structured social contexts. The analysis of such a use of meaning as conveyed by symbolic forms is the subject of an in depth study - called depth hermeneutics - occurring in three phases, namely, a social-historical analysis, a formal or discursive analysis, and the reinterpretation of what was part of the pre-interpreted domain of human life. See J. Thompson 1990: 272-302.
138. This is quite foreign to the sort of thinking that goes on in empirically based social scientific research. For instance, a values study is to be conducted - an investigation of various attitudes, beliefs, and opinions people have in a range of social issues and fields of interest. Questions are asked and answers are collected in the form of tick marks, scaled responses, choice of options, and brief responses. The questions are arguably about goals people have, and about their stance on a variety of issues. Much argumentation goes into formulating the questions so to eliminate bias at the start of the research. "What does this question really say?" "Are we assuming too much when we pose the question like this?" "How does this personal goal relate to its analogue in that social context?" After much careful consideration questions are chosen, their language of expression precisely worded. There is a residue of uncertainty about what meanings are the questions going to convey when in the hands of the target population. This introduces some errors of ambiguity into the research, but at the level of values this cannot be avoided. In any event, researchers can learn from this effort and improve the next time so as to achieve results within an

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acceptable tolerance of error. As a result of such careful spade work the responses can be taken as reliable indicators of a person's goals and positions (together with all the other techniques of valid data collection). What do they tell us? To find out researchers perform a set of statistical analyses, various regressions and validations, and in the end are found (or not) a set of significant correlations between response x and response y, between positions with regard to A and those with respect to B, or C. Conclusions then are of the form: "Those who score high on 'value z' tend to support 'position 3' as well" or "There is a negative correlation between those who subscribe to 'act B' and the adoption of 'position F'". In such analyses, there is an unresolvable disc of intersubjective uncertainly at the level of "how do we pose meaningful questions about values", but at the level of statistics the logic of correlations permits valid conclusions. There may be some debate about what the correlations mean, but not that the correlations exist. In this type of research values *per se* are not to be treated, only peoples responses to questions about values.

139. See C. Taylor 1985b: 37.

140. If intersubjective meanings make up social practice, then common meanings are the reference points in terms of which social life is meaningful in particular ways for people in a social-cultural time and place. A person's own life is meaningful in certain ways that he or she understands, appreciates, and values, and which as well makes up part that person's self-understanding. The 'own meaning' for society is a society's common meaning. It is a meaning communally sustained, a type of collective act or practice that underlies the ability of people to make sense of themselves and others as beings-in-society, holding value, and partly constituted by the self-understanding of that social existence. Intersubjective meanings give a common language of expression so to talk about social reality as constitutive of social practice. Common meanings provide the points of reference for significant common actions, celebrations, and feelings in terms of which a people can make sense of who they are (See C. Taylor 1985b: 40.) It is not a matter of many individuals sharing their own beliefs, like a happy circumstance that all agree. Common meaning is an original reference point - though not in the sense of never to be questioned. It is the starting point for meaningful community life - meanings in terms of which people can agree or disagree, argue or accept, and realize what is important or valuable. The whole notion of 'common meanings' comes from C. Taylor 1985b: 39.

141. According to Taylor, intersubjective meanings "... fall through the net of mainstream social science. They can find no place in its categories. For they are not simply a convergence of a set of subjective reactions, but part of the common world. What the ontology of mainstream social science lacks is a notion of meaning as not simply for an individual subject; of a subject who can be a 'we' as well as an 'I'. The exclusion of this possibility, of the communal, comes once again from the baleful influence of the epistemological tradition for which all knowledge has to be reconstructed from the impressions imprinted on the individual subject. But if we free ourselves from the hold of these prejudices this seems a wildly implausible view about the development of human consciousness; we are aware of the world through a 'we' before we are through an 'I'. Hence we need the distinction between what is just shared in the sense that each of us has it in our individual worlds, and that which is had in the common world. But the very idea of something which is in the common world in contradistinction to what is in all the individual worlds is totally opaque to empiricist epistemology. Hence it finds no place in mainstream social science. (Cf. C. Taylor 1985b: 40)

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Chapter four notes

1. See S. Weinberg 1994: 22-27.
2. See J. Bruner 1971: 24-25.
3. See J. Bruner 1971: 25.
4. See J. Bruner 1971: 26.
5. See J. Burner 1971: 25-26.
6. See J. Bronowski 1973: 37-40.
7. See J. Bronowski 1973: 404.
8. See J. Bronowski 1973: 416.
9. See W. H. Calvin 1994: 3.
10. See W. H. Calvin 1994: 79.
11. See W. H. Calvin 1994: 79.
12. See W. H. Calvin 1994: 80.
13. See W. H. Calvin 1994: 83.
14. See W. H. Calvin 1994: 84.
15. See F. Ferré 1995: 30-33.
16. See F. Ferré 1995: 33-34.
17. See F. Ferré 1995: 36.
18. See F. Ferré 1995: 27.
19. See F. Ferré 1995: 37.
20. See F. Ferré 1995: 38-39.
21. See F. Ferré 1995: 41-48
22. See F. Ferré 1995: 40.
23. See P. F. Drucker 1993:17-29.
24. See F. Dunn 1994: 266-324 for an extensive discussion on the modes of rational decision-making in policy formulation.
25. See F. Ferré 1995: 40.
26. See F. Ferré 1995: 26.
27. See F. Ferré 1995: 25-26.
28. Taylor's ideas on this were discussed at length in chapter three. They will be used as well in this chapter as one approach, among many.
29. See J. Bruner 1971: 25.
30. See J. B. Thompson 1990: 135-146.
31. See C. Taylor 1985a: 164-189, 201-205.
32. See A. N. Whitehead 1926: 64.
33. See J. B. Thompson1990: 137-145.
34. See J. B. Thompson 1990: 5-11, 56-67, and 291-294.
35. See J. B. Thompson 1990: 122-162.
36. See C. Taylor 1985a: 45-76.
37. See for example Taylor's discussion in C. Taylor 1985a: 97-114.
38. John Thompson provides an analysis of symbolic forms in structured social contexts, which are involved as well in the analysis of cultural phenomena, and hence from a social and historical perspective. While Thompson's is an attempt to make sense of mass-mediated symbolic forms as an essential characteristic of modern society, including the possible place of ideological meanings, his work can as well be used to trace out many additional

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aspects of technology, especially when it is taken as part of a cultural analysis. See J. B. Thompson 1990: 122-162; 272-302.

39. In the first, analysis may attempt to establish a universal theoretical framework for technology, intersubjectively available, hence, objectively real. Technology can then be analyzed in conceptual terms applicable to all social practice (such as implemented intelligence). The proper study of technology would then concern in part the ways by which such common principles operate in the particular case. In so doing there can be given an explanation of how it is technology has been adopted in this or that particular form in a specific society. The second option is to recognize and accept that when faced with societies operating from different norms and assumptions, each possessing a unique historical and cultural practice, then all cross-cultural judgments about the place of technology must be suspended. What can be attempted is to make sense of technology in this society or with regard to that cultural practice, but using terms to which its own adherents subscribe. It must be described from within, as it were, not by recourse to concepts and categories foreign to it.
40. This was referred to at the end of chapter two, particularly Michael Gibbon's comments about the fact that scientific knowledge cannot be considered solely as a good. Such arguments based on interpretation do not mean of course that questions of ethics and values in the use of technology are not, or cannot be, posed in terms of intelligence and instrumental rationality. There is a long tradition of thought and debate in the Western intellectual tradition on matters regarding practical reasoning and moral deliberation. Much of this transpires from within the naturalistic stance, where terms of reference concern various conceptions of mean-ends analysis and utilitarian calculations, strategic action, the search for universal principles of moral right, and more recently the character of human evolution.
41. Such, for instance, is the case in the way the emergence of intelligence is portrayed, and its characteristics described. The metaphor of the machine has served here as a powerful guiding image of human intelligence.
42. Even this Masters programme grants degrees only by a student studying from within one of the established and participating disciplines.
43. Jerome Bruner supports this idea, maintaining that besides the study of human problems and their solution, students need to approach techniques of learning and discovery as it is done in the various sciences. See J. Bruner 1971.
44. See P. F. Drucker 1973: 17-29.
45. Here applies Gibbon's notion of research as being primarily a matter of a system of trade in a society of exchange relations. This was discussed in chapter two.
46. Quoted in SAIDE 1997:5.
47. See C. Malcolm 1998: 10-11.
48. See Curriculum 2005 Specific Outcomes 1997: 4.
49. Oftentimes there are three approaches to learning in this context - multi-disciplinary, inter-disciplinary, and trans-disciplinary. Curriculum 2005 is probably most similar to an inter-disciplinary approach since it seeks to relate all the disciplines in a common way through like competencies. However, each learning area may adopt, at least implicitly, a different approach to achieving outcomes within its own area. Of course, the sixty-six specific outcomes are to be accomplished through integrated learning programmes, not through the study of eight learning areas one at a time.

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50. See SAIDE 1997: 4-9.
51. See C. Malcolm 1998: 43-45.
52. See SAIDE 1997: 5.
53. See Curriculum 2005 Specific Outcomes 1997: 8.
54. See North West Province In-service Capacity Building Project 1999: 8.
55. It is worth noting that the competencies in a sense are just another way of talking about intelligence - practical and theoretical. In the classroom, outcomes and competencies are meant to be taken as integral to the act of learning. In other words, the teacher is to devise an environment and an approach that establishes a relation between content in the learning areas, methods of learning, the choice of outcomes, the combining of competencies, and the manner of assessment.
56. See SAIDE 1997: 12.
57. See SAIDE 1997: 12.
58. See C. Malcolm 1998: 45-49, and Curriculum 2005 Specific Outcomes 1997: 14-15.
59. The phrase 'being culturally sensitive' may suggest this view, since there is no mention of any form of evaluative effort here. But part of the point to the previous chapter was to map out a way of thinking in not necessarily Western terms that allow for rational coss-cultural evaluations without being ethnocentric. Of course, the curriculum is open to interpretation and, while these various comments are in no way an in depth study of the curriculum documents, they are at least suggestive of such characteristics.
60. This integration may be done in principle via multi-disciplinary studies, inter-disciplinary studies, or trans-disciplinary studies. As noted earlier, the new curriculum seems to place emphasis on inter-disciplinary approaches. See North West Province In-service Capacity Building Project 1999: 32.
61. See Curriculum 2005 Specific Outcomes 1997: 3-6.
62. See Curriculum 2005 Specific Outcomes 1997: 84.
63. See Curriculum 2005 Specific Outcomes 1997: 84.
64. See Curriculum 2005 Specific Outcomes 1997: 84.
65. See Curriculum 2005 Specific Outcomes 1997: 84.
66. See F. Dunn 1994.
67. See Curriculum 2005 Specific Outcomes 1997: 88-95.
68. See Curriculum 2005 Specific Outcomes 1997:103-106.
69. See Curriculum 2005 Specific Outcomes 1997:103-104.
70. The learning areas are language and communication, human and social sciences, technology, mathematics, natural sciences, art and culture, economic and management sciences, and life orientation.
71. See Curriculum 2005 Specific Outcomes 1997: 32.
72. It is interesting to look at how the writers of the specific outcomes for natural science attack this issue - they do so from within the scientific tradition, showing how one theory is gradually adopted over time, and a new one comes on board. In this sense is scientific knowledge presented as changing and contested. See Curriculum 2005 Specific Outcomes 1997:156-158.
73. There are, however, good reasons for this. It must first be recognized that there is a serious attempt in the curriculum to create a different approach to learning that, while reliant on disciplinary knowledge, is not solely dependent on it. In this way a break with the past is a focus of curriculum design. As noted in an earlier section in this chapter, the curriculum is

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intended in part to break past habits of training that fail to fit the needs of the contemporary workplace, and which long served to educate a workforce that could participate in the economy in only a very restricted sense. It is intended as well to help redress past education practice as such, and to reorientate social structures that were built up in service to imposed racial or ethnic norms. It must also be recognized that disciplinary knowledge and the character of scientific know-how are believed to provide the basis for a sound economy based on industry, information, and a well trained, employable work force. This in turn requires strategic and rational decision-making, and the attainment to certain performance criteria in human action and planning. In addition, nearly all educated persons in South Africa, including teachers, have degrees in specialized disciplines. The universities that train them are the inheritors of a long tradition of scholarship indebted to disciplinary instruction, and the continuation of specialist research. Given such a workforce for education, and the long standing and immensely successful, secure, and reliable practice of disciplinary knowledge and know-how, then any school system must work well and thoroughly within this tradition and history. It is simply not practicable to create a system of education that does not use the disciplinary knowledge within which its teaching workforce is trained. Neither is it possible to ignore the fact that millions of people in South Africa are without work - with science, technology, information, and industry seen as crucial to any successful modern and globally competitive economy.

74. In part this may even be encouraged since in some respects, as evidenced by the previous analysis of the technology learning area, the specific curriculum outcomes tend to support such a view of knowledge, action, theory, rational action, etc. as obtain in the world view of the machine and the naturalistic stance.
75. See Curriculum 2005 Specific Outcomes 1997: 105.
76. See Curriculum 2005 Specific Outcomes 1997: 84.
77. See J. B. Thompson 1990: 277-294.
78. In this respect the technological process need not be seen as existing only within a world of irreducible fact (or from its 'back opposite' view of value and cultural relativity), but, for example, from Taylor's idea of intersubjective meanings, as developed in chapter three.
79. There is reference to communication in the critical outcomes, but this includes areas not subsumed under the language, literacy and communication learning area.
80. In a sense this is to be expected, since the critical outcomes are a kind of broad guiding image for education practice.
81. This does not conflict with the comment earlier that the curriculum supports an interdisciplinary approach. That was with reference to the way the learning areas are to focus on developing skills and competencies. Here the issues is how to regard the world as a set of systems.
82. In one sense the account based on significance is part of the migration from empirically based human and social sciences, the over emphasis on which tended to make them the only respectable approach to knowledge. In addition, it is a common complaint of education systems that they are resistant to the developments in knowledge that are contemporary with them. In other words, the sciences they teach are all well established, no longer part of the growing cusp of scientific discovery, and in that sense outdated - though not invalid as knowledge.

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Conclusion notes

1. See J. Bronowski 1973: 356.
2. See J. Bronowski 1973: 356.

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