THE ETHICS OF SCIENCE AND TECHNOLOGY

Hugh Lacey
Philosophy Department, Swarthmore College, Swarthmore, PA 19081, USA
Departamento de Filosofia, Universidade de São Paulo, São Paulo, Brazil.

Keywords: Science, ethics, values, science as value free, objectivity, impartiality, neutrality, autonomy, scientific ethos, technology, technological progress, agroecology, sustainability, transgenics, scientific methodology, methodological pluralism, research strategy, decontextualized approach, precautionary principle.

Contents

Summary

The tradition of modern science has tended to uphold the ideal of 'science as value free', that ethical values have no essential place at the core moments of scientific practices. Nevertheless, no one doubts that ethics is pertinent to many aspects of these practices, and this is detailed in Section 2 of the chapter. One component of 'science as value free', that settled judgments about scientific knowledge and acceptable theories should be in accord with *impartiality* (that ethical values should play no role in the cognitive appraisal of knowledge claims) is defended as essential to scientific inquiry. It is argued, however, that ethics does play a role at the moment of methodological decision-making; there exist mutually reinforcing relations between adopting particular methodological approaches and holding particular ethical outlooks, and these relations serve to explain many methodological choices. In the light of this, so as to avoid that scientific practices become subordinate to a particular ethical outlook, it is argued that a multiplicity of methodological approaches should be adopted in the worldwide scientific community and that, to facilitate this, a pluralism of ethical outlooks should be represented in that community. Illustrations of many of the arguments made in the chapter are drawn from current controversies about using transgenic crops and foods.

1. Introduction

The modern scientific tradition has fostered two complementary claims about the role of ethics in science. First, science permits no permanent and substantial role for ethics at its core moments, when scientific hypotheses are appraised, their consequences explored, and decisions made about methodology and research priorities. Second, at the moment of technological application of scientific knowledge, when ethical judgments cannot be avoided, no particular ethical outlook is privileged. The parallel claims about technology have also been fostered: ethical judgments have nothing to do with appraisals of technological efficacy; and the value of using technological objects and systems generally does not depend upon holding any particular ethical outlook. Hence, it is said, science and technology are or ought to be 'value free', in particular, free from any deep or permanent entanglement with ethics. In order to grasp 'the ethics of science and technology' adequately, this view must be critically confronted and, thus, close attention given to the ethical judgments that are and should be made by those engaged in scientific and technological practices, and to the impact they and disagreements about them may have.

1.1. Science as Value Free – Free From Deep and Permanent Entanglement with Ethics

There is little disagreement that the idea that science is value free reflects the convictions: first, that there is a fundamental dichotomy between fact and value, between 'is' and 'ought', between the way the world is and the way one might think that it should be, and (in influential interpretations) between the *objectivity* of factual discourse and the *subjectivity* of ethical reflection; and second, that the aim of science is to obtain systematically empirically based knowledge and understanding of the phenomena and states of affairs of the world, and thereby to discover new phenomena and facts. Nevertheless, there is no single generally accepted formulation of the idea and there is wide variation of terminology. Hugh Lacey articulates it as incorporating the following three theses concerning, respectively, the appraisal of scientific knowledge, the conduct of scientific practices and the character of their methodologies, and the consequences of confirmed scientific theories:

1. Scientific knowledge is *impartial*. Ethical values should not be among the criteria for accepting scientific theories and appraising scientific knowledge.
2. Scientific practices are *autonomous*. Ethical values have no proper fundamental role in the practices of gaining and appraising scientific knowledge. The defining features of scientific methodology should be responsive only to the interest of gaining understanding of facts and phenomena, and research priorities should not be determined systematically in the light of particular ethical values. The proper trajectory of scientific developments is determined by its own internal dynamic, free from extraneous (including ethical) interferences.
3. Scientific theories are *neutral*. Ethical value judgments are not among the logical implications of scientific theories (call this *cognitive neutrality*) and, in the context of their practical or technological application, the totality of confirmed theories, in principle, can inform evenhandedly interests fostered by a wide range of competing ethical outlooks (*applied neutrality*) – and so, there is nothing about scientific practices *per se* that is incompatible with their results being used to serve either 'good' or 'bad' ends.

Note that 'science is value free' – understood as constituted by the three theses – does not mean (as we will see in Section 2) 'science has no important ethical dimensions at all'.

1.1.1. Technology as Value Free

The theses of *impartiality* and *neutrality* have clear counterparts regarding the claim that technology is value free: First, the characteristic criterion of appraisal for technological objects and systems is *efficacy*, the factual issue of whether they work as intended or not; and secondly, technology progressively makes it possible to achieve more ends effectively, and its innovations are available to serve the interests of a wide variety of ethical outlooks. Since most technological innovations occur under the sponsorship of corporations or governmental military institutions, it is difficult to state a counterpart of the thesis of autonomy; even so, it has been held that the trajectory of technological development is irresistible – with corporations and the military being only agents that facilitate it – or, that if it is not irresistible, it ought not be resisted normally, regardless of the sponsorship of particular projects, since technological development is essential for resolving the world's major problems (Section 3.3.5).

1.1.2. 'Science as Value Free' as Part of the Ethics of the Conduct of Scientific Practices

'Science is value free' is not a *fact* about scientific practices for, as even its most committed adherents recognize, scientific activity *de facto* does not always accord with the three theses. That is consistent, however, with it being a *value* of the scientific community that scientific practices and results accord with them; and, indeed, it is usually considered to be an *ideal* by members of the scientific community. This is fundamental to the ethics of the conduct of scientific research. It is not paradoxical to affirm that 'science is value free' (being committed to the three theses) is a *value* widely held in the scientific community, and that the conduct of science ought to be appraised in the light of the three ideals.

Similarly, it is not paradoxical to affirm the universal ethical value of the conduct of scientific research that is held to the ideal of science as value free. The scientific community generally supports this affirmation, although currently there are many who deny the ethical value of the pursuit of scientific understanding *per se* – witness the furor in the USA surrounding opposition to the theory of evolution from creationist and intelligent design perspectives by those who subordinate the value of scientific achievements to certain ethical values that they maintain are rooted in their religious beliefs, and the controversy about global warming where there are those who would subordinate acceptable scientific results to what may serve their economic and political interests. Against such opposition, the scientific community generally holds that the universal ethical value of scientific research can be grounded not only on the contribution of scientific knowledge, when applied, to contribute to meeting human needs and expanding the range of human capacities – in ways of value to everyone (*applied neutrality*), but also on the supposed value of knowledge *per se* for any rational person and on the allegation that scientific practices cultivate in their practitioners virtues that are conducive to human flourishing (Section 2.2).

Hence, it draws the conclusion that any rational person should endorse the universal ethical value of scientific research, and that any society, which cares about human well being, should provide the financial and other social conditions necessary for scientific research to be conducted.

1.2. Ethics and Science 'Touch' But Do Not 'Interpenetrate'

Since the 1970s, many arguments have been made that ethical values and judgments play important roles in science, even at such core moments as the appraisal of theories and making methodological decisions. Such criticisms of 'science as value free' have come from many philosophical perspectives, including phenomenology, critical theory, neo-Marxism, postmodernism, feminism and multiculturalism. The literature is too vast and varied to survey here. For the sake of depth of coverage, and in line with the author's primary competence, this chapter will focus (in Section 3) on criticisms that have been developed within the tradition of Anglo-American analytical philosophy. Regardless of what one may make of these criticisms, the idea of science as value free is consistent with ethics playing many roles in connection with the conduct of scientific research. Not only is the very conduct of science reflective of ethical values (Section 1.1.2), but also, as Henri Poincaré, the great French mathematician of the early twentieth century, put it: 'Science and ethics touch but do not interpenetrate'. The touch can be quite pervasive and firm.

2. The 'Touch' of Ethics and Science

In this chapter, only the roles of ethics in science will be discussed. This is not the whole story. Part of what is meant, when it is said that ethics and science do not 'interpenetrate', is that confirmed scientific results do not logically imply any ethical judgments or provide support for any particular ethical outlook (an integral part of *neutrality* – Section 1.1). Not only is it affirmed that science is value free, but also – one might say – ethics is fundamentally 'science free'. Nevertheless, this leaves open some aspects of the 'touch' of science and ethics pertaining to the role of science in ethics. One is that scientific results may be instrumental in drawing *derivative* ethical judgments. For example, ethically grounded support for stem cell research may derive from the belief that its results will be causally efficacious (a belief within the purview of scientific research) for treating hitherto untreatable diseases (a fundamental ethical value). Even when held to be 'value free', as Max Weber pointed out, science may still be 'value relevant'. Another aspect is that there may be scientific studies of ethical values: of their being held, manifested and embodied in persons, institutions and cultures, and of how particular values come to be held and transformed. Much about ethical values and the making of ethical judgments can be *explained* as a result of scientific research in psychology, biology and the social sciences, but their *justification* or rational basis is not in the purview of science. Issues, such as these, will not be discussed in this chapter.

Before addressing any alleged 'penetration' of ethics into science, any essential role for ethical values at the core moments of scientific practices – i.e., the denial that science is value free – several aspects of the 'touch' of ethics on science will be examined.

2.1. Experimental Methods Open to Ethical Appraisal

In the *first* place, specific experimental methods – as distinct from the general features of scientific methodology – are properly open to ethical appraisal. This is consistent with holding that scientific practices have universal ethical value (Section 1.1.2); one does not deny that they have such value by holding that it must be balanced with other universal values of humanity, e.g., protection of fundamental human rights, and at times be subordinated to them. For the sake of balancing the full array of universal values, ethical appraisal, and sometimes restrictions derived from it, is appropriate (and obligatory) when experimental methods involve, e.g., the use of human subjects, or possibly causing gratuitous pain to animal subjects, or harmful effects on the health of researchers and others in the vicinity of a research facility.

Few in the scientific community deny that such ethical appraisal is necessary and, moreover, that the conduct of scientific experiments has sometimes violated ethical norms. This underlies the widespread acceptance that there is a proper role for ethics review committees, especially regarding experiments in medicine and psychology. Nevertheless, the scientific community tends to be wary of ethical criticism, especially that coming from outside the scientific community. It is aware that ethically derived restrictions, if inappropriately intrusive, can retard scientific research or even prevent it being conducted in certain domains; and it fears that the value of gaining scientific knowledge may be under-appreciated (outside of the scientific community) in comparison, e.g., to the prevention of cruelty to animals. This fear is reinforced by the fact that it may see ethical criticism sometimes, not so much as derived from reflection on universal human values, but as a cover for special interests' attempts to co-opt the scientific agenda or to de-value it, or as mischievous, politically or religiously motivated interference with the autonomy of science. (Think of the outcry in the scientific community that greeted President Bush's formation of a task force to develop ethical guidelines for federally supported stem cell research in the USA!) Controversy is inevitable on these issues, e.g., concerning experiments on embryonic stem cells, where the ethical value of gaining knowledge is weighed against that of, e.g., maintaining human life, in a context where there are questions about what constitutes a human life, whether or not *in vitro* generated embryos are actual or potential human beings; and, if they are, does the potential value of therapeutic cloning justify their destruction? Questions such as these are addressed in the rapidly developing field of bioethics.

Accepting ethically derived restrictions on experimental methods does not threaten *impartiality*. Accepting them may prevent scientific knowledge from being obtained in certain areas or, pending the development of alternative methods, lead to delays in carrying out research. It does not imply, however, that ethical judgments function among the criteria for appraising scientific knowledge. It is just that if – for ethical reasons – relevant experimental data cannot be obtained for a particular problem, then no sound scientific judgment may be made.

2.2. The 'Scientific Ethos'

In addition to the controversy about experiments involving human embryonic stem cells, stem cell research has also occasioned another controversy, concerning the fabrication (by a team of South Korean scientists led by Hwang Woo-suk) of results purporting to have developed stem cell lines matched to specific diseases and to have cloned human embryos.

This illustrates a *second* aspect of the 'touch' of ethics and science, *viz.* that the practices of science, especially since they aim for results that accord with *impartiality*, may require that their practitioners have cultivated certain ethical virtues that are reflected in their conduct *qua* scientists. The sociologist of science, Robert Merton, called the cultivation and practice of these virtues, the 'scientific ethos'. Galileo held that they strengthened scientists for "refining [their proposals] in the crucible and weighing them in the assayer's balance". Lists of the virtues typically include: honesty, disinterestedness, humility, courage to follow the evidence wherever it may lead, freely opening one's work publicly to critical scrutiny, forthrightness in responding to the best arguments of others, and recognizing their contributions without giving undue priority to one's own.

Publishing fabricated results, and publicizing them in the popular press before they had been subjected to peer criticism, clashes with the scientific ethos, and undermines the ideal of value free science by subordinating *impartiality* to extraneous values. What extraneous values were motivating the researchers, who fabricated the stem cell results, is not known publicly (at the time of writing this article). It has been speculated that they may include the quest for fame (Nobel prizes, worldwide publicity in the press), wealth (*via* obtaining patents for discoveries from research on stem cells and therapeutic cloning), prestige for national scientific prowess, obtaining funds for research in a highly competitive process, gaining impetus and public enthusiasm for research that the researchers are convinced will lead to cures for serious diseases (for which they were willing to take short-cuts), or just hubris.

2.2.1. The Scientific Ethos and the Public Discourse of Scientific Spokespersons

Societal recognition that the application of scientific knowledge has contributed to meeting human needs and expanding the range of human capacities (Section 1.1.2; cf. Section 4.2), and the expectancy that this will continue, explain the enormous financial (and other) support for scientific research available in the advanced industrial countries. Since the 1980s, e.g., research in molecular biology and biotechnology has been lavishly supported, largely based on the promise that its discoveries would rapidly bring about major advances for treating hitherto untreatable diseases. Prominent scientific spokespersons have put their authority behind this promise, suggesting that highly significant medical discoveries are imminent, just awaiting the next steps of the research programs on the human genome, stem cells and the like. This is widely publicized and it has had important political ramifications. (In the 2004 presidential campaign in USA it was a point of contention between the candidates, and it led to the passing of a referendum to fund stem cell research in California).

The historical record supports the view that scientific advances often lead to socially significant applications. Although this may provide good reason to hope, even expect, that biotechnological and molecular biological advances will lead to advances in medical treatment, nevertheless, it seems clear that the promise of imminent major advances has been grossly over-stated; and scientific spokespersons are hardly acting in accordance with *impartiality* when they make it authoritatively. It is true that normally scientific authority is put behind carefully guarded promises: e.g., 'we *may* be able to develop embryonic stem cell lines to match the DNA of patients suffering from spinal cord injuries'. Unaccompanied by further qualifications about uncertainties and the unlikelihood of medical advances being generated imminently by the research, however, statements like these are rhetorically misleading; apparently intentionally so since, given the public and political contexts in which they are made, they are intended to silence critics and to encourage the public to believe that such results are to be expected soon. This is the context in which Hwang's fabrications could get by without being scrutinized too critically — and, also, in which his offense is magnified (from the perspective of scientific spokespersons), because it may lead to public questioning of the alleged promise of the research projects.

The scientific spokespersons may be 'well intentioned', only aiming to get the funds needed to support what they see as important scientific research; and, no doubt, the over-stated promises have been instrumental in gaining public commitment to funding molecular biological research – the public (and certainly the politicians) are not likely to want to invest huge amounts of money in research projects for which one can only expect long-term and currently uncertain returns. Well intentioned or not, however, making rhetorically misleading statements, and using the authority put behind them to silence critics who lack standard scientific credentials, conflicts with acting out of the scientific ethos. But the public acceptance of the authority of science is linked with the belief that the scientific ethos prevails in the scientific community. (That is why, once his fabrication was exposed, the scientific community for the most part distanced itself from Hwang.) Moreover, it is doubtful that this acceptance could be maintained in face of the claim that has sometimes been made that, in these days of 'big science', the on-going conduct of science depends to some extent on political, entrepreneurial and advertising skills, so that the cultivation of the scientific ethos will have to be balanced with them – perhaps by emphasizing it in the context of engaging in experimental and theoretical research, but allowing the other skills to take over when scientists enter the public arena. The doubts are reinforced when one also takes into account the fact that it has become commonplace for research scientists to obtain patents to their discoveries; then conflict between scientific and business interests – between the logic of *impartial* scientific evaluation and of effective advertising – is hard to avoid.

When science effectively becomes an integral part of business practices, the cultivation of the scientific ethos ceases to be of primary significance, and the appeal of the idea of science as value free may vanish: *autonomy* is no longer defensible; *neutrality* is not aimed for (a corporation wants to sponsor research whose results can be monopolized to further its profits); and, most significantly, *impartiality* may be subordinated to corporate interests or the interest of the scientific community to obtain funds for research, or simply the self-serving interests of individual scientists.

2.3. Ethically Based Motivations for Research and Criticisms of Scientific Practices

Cultivating the scientific ethos does not mean that scientists may not be *motivated* to engage in a particular line of research by their personal, ethical and social values. Sometimes motivation may come simultaneously from cognitive interests and ethical values. A theoretically interesting problem, e.g., may be pursued equally well by adopting any one of a variety of immediate aims with different ethical impact; then, it makes good sense to pursue the cognitive interests in a way that will also have positive ethical impact. E.g., if the molecular structure of viruses may be investigated by focusing on any one of a large number of particular viruses, why not focus investigation on a virus that causes a serious disease, anticipating that the knowledge gained may lead to a remedy? Sometimes motivation may be almost entirely based in considerations of social and ethical significance, when, e.g., a line of research is expected only to provide new details exemplifying well-established principles. Some have maintained that research on genetically engineered crops is of this kind; certainly routine research on drug development usually is, as is that on solid-state physics. However, having such motivation *per se* is no barrier to obtaining results that accord with *impartiality*. On the other hand, since what is of social and ethical value can be controversial, whether the results accord also with *applied neutrality* needs to be scrutinized case by case (Section 3.1.5).

Ethically based motivations, point to a *third* aspect of the 'touch' of ethics on science. Often articulations of 'value free science' (e.g., by Hans Reichenbach and Karl Popper) incorporate the methodological view that there is a separation between the contexts of 'discovery' and 'justification'. In the context of discovery, motivations, the priorities for research, and even the hypotheses entertained for investigation, may be motivated by ethical (political, religious or egoistic) outlooks, provided that they are filtered out in the context of justification, where manifesting the scientific ethos is obligatory, when hypotheses are appraised for their acceptability in accordance with *impartiality*.

Some scientists and philosophers of science deny that there is a sharp contrast between the contexts of discovery and justification. Some of them consider the scientific ethos to be a myth. They hold that the actual historical process of accumulation of scientific knowledge provides no support either for it, or for the discovery/justification dichotomy having much to do (even as idealization) with what scientists actually do and with the judgments they make. On the contrary, they say, ethical values (virtues *and* vices), as well as self-serving aims and disregard of others, penetrate deeply into the whole scientific process, so much so that, where *impartiality* is realized, it should be explained in terms of the dynamics and politics of the scientific community, rather than in terms of the virtuous behavior of individual scientists. Others endorse the importance of the scientific ethos as an ideal but hold that, unless its cultivation takes place in scientific institutions in which a pluralism of ethical outlooks flourish, there is no assurance that its cultivation will always lead to scientific judgments being made in accordance with *impartiality* (Section 3.1.4, Section 4.4).

Pluralism of ethical outlooks within scientific institutions also is pertinent to a *fourth* aspect of the 'touch' of ethics on science, one that has been emphasized in feminist philosophy of science. There may be ethically based criticism of scientific practices and institutions (see also Section 3.1.3). Particular ethical commitments may motivate scrutiny of common scientific practices for 'biases', including those that may be so widely shared throughout the scientific community as to be rendered virtually undetectable; or scrutiny for focus on particular problems at the expense of failure to address ethically significant related problems. Such biases and questionable foci may arise because of institutional policies regarding membership in the scientific community, or from features of science education. The remedy usually proposed, by those who make these criticisms, is the ethical pluralism mentioned above. This ethical pluralism, it will be argued later (Section 4.4) is linked, in mutually reinforcing ways, with a kind of methodological pluralism.

2.4. Ethics and the Application of Scientific Knowledge

A *fifth* aspect of the 'touch' of ethics and science concerns the application of scientific knowledge. Here the 'touch' seems to be most firm, pervasive and impossible to ignore. The first four aspects can often be pushed into the background, because *normally* one may expect that either consensus will reign or that – because of the presumed sound ethical sensibility of most scientists and reliability of review processes created by scientific institutions – ethical differences will not be reflected in the overall outcomes of research. Not so with the ethical issues that arise in connection with technological applications of scientific knowledge. Obviously both the ends of an application and its potential side effects should be evaluated ethically. This inevitably generates controversy, reflecting the variety of competing ethical outlooks that are held in society today, and often with profound political or religious ramifications that – consistent with ethics being 'science free' (beginning of Section 2) – cannot be adjudicated scientifically. Some people also maintain that such controversy reflects the alleged subjectivity of ethical reflection that supposedly contrasts with the objectivity that should mark research activities.

Applications of scientific knowledge may be appraised from the perspective of any ethical outlook. *Applied neutrality* (Section 1.1) maintains that scientific knowledge – taking into account the totality of accepted theories in which it is expressed – may be applied (in principle) evenhandedly across ethical outlooks. That does not mean, however, that any one proposed application would be appraised in the same way from all outlooks. Furthermore, whether or not technological applications are actually developed and implemented to serve the interests of a particular ethical outlook depends on the resources and power of institutions that embody it. This goes well beyond the scientific ethos (Section 2.2) and ethical appraisal of experimental methods (Section 2.1), matters that may be held to be the special concern of the 'autonomous' scientific community itself, which normally do not require *external* ethical review. When dealing with applications there can be no appeal to the autonomy of science. What is applied, and what is not, matters ethically and socially, so that *external* ethical appraisal – i.e., appraisal made by people and institutions, who are not directly involved in scientific research, but who have stakes in the outcome of an application – is both inevitable and desirable.

2.4.1. Ethics-As-Reactive

That ethics and science only 'touch' lies behind a further proposal – call it *ethics-as-reactive* – that, normally, unless the scientific community lapses egregiously from socially recognized ethical standards, external ethical appraisal is appropriate only *after* items of scientific knowledge have been confirmed, only at the end of the research process, only in reaction to the question of how the knowledge may be applied in technological projects. Or, putting it another way, 'neutral' scientific research generates possible applications and, *ceteris paribus*, only then does there arise a legitimate role for external ethical reflection. This proposal tends to accompany the view that scientific research has its own internal trajectory which, if it is not impossible to resist, in the final analysis ought not to be resisted. Normally, the proponents of *ethics-as-reactive* maintain, to question this trajectory from an external ethical viewpoint would be to attempt to impede the freedom of scientific research, to limit the autonomy of science for the sake of imposing ethical (and subjective) values on the conduct of science. Provided that it *comes after* successful scientific research, being *reactive* not proactive to scientific developments, external ethical reflection (with whatever disputes it may bring) will clash neither with the autonomy and progress of science, nor with presuming the general ethical legitimacy and social importance of scientific developments (Section 1.1.2).

Although widely influential, *ethics-as-reactive* is not uncontested. Some people hold, e.g., that the value of a line of research may be challenged on the ground that it is likely to produce results that will be applied in ethically illegitimate ways. Hence they tend to accept the propriety of imposing restrictions on scientific research, or at least of curtailing the financial and other conditions needed to conduct it, in the light of ethically based preoccupations about anticipated applications of its results. Thus, they challenge directly the implication of *ethics-as-reactive* that it is not the responsibility of scientists – *qua* investigators aiming to gain understanding of phenomena and to make novel discoveries – to take into account the ethical significance of potential applications of the results they hope to establish. They, thereby, also challenge the more extreme view that it is in conflict with their responsibilities (though not necessarily their motivations – Section 2.3), *qua* investigators, to do this. The assumption of *neutrality* is crucial to holding the view that how applications are made, and to what ends, lies outside of scientists' power and, therefore, responsibility – the view that scientists, *qua* investigators, as distinct from *qua* citizens – except when engaged in 'applied science', i.e., research directly aiming to inform particular applications – have no responsibility for the applications of the discoveries they make, because their results may in principle (if not always *de facto*) be applied, regardless of their desires, to serve any ethical outlook, for good or for ill.

2.4.2. Precautionary Principle

Often challenges to *ethics-as-reactive* arise from preoccupations about the potential side effects of applications and the risks that they may pose, and they may invoke the *precautionary principle*. This principle, which has been espoused by an increasing number of governments and international organizations in recent years, urges that precautionary approaches be taken towards novel techno-scientific applications in view of their potential risks, so as to permit sufficient time for relevant ecological, social and other studies to be conducted and appraised, before going ahead with implementing them (Section 3.2.3). The precautionary principle has been much criticized by those who hold *ethics-as-reactive* as involved in marshalling parochial ethically based fears about risks in order to *inhibit* autonomous scientific research, which (they claim – Section 1.1.2) has universal ethical value. Thus, they conclude, appealing to the precautionary principle is devoid of both scientific and ethical legitimacy.

The dispute about the precautionary principle raises some important issues. As stated above, the principle concerns implementations of applications, and not the research that underlies their possibility; it urges delay in implementations, not curtailing of research. To its opponents this is just obfuscation. They charge that delaying implementation, pending the thorough empirical review of risks, inevitably also hinders the conduct of the research, either because the corporations or governments who are key funding agencies, may be deterred from investing in the research if they cannot be confident of the rapid implementation of its outcomes – for the sake of profit (corporations) or garnering popular support (governments) – or because research on risks will lead to competition for scarce research funds, or because other priorities may come to the forefront. This charge may be correct. If it is, it raises suspicions about the *autonomy* and *neutrality* of the research in question, for it seems to acknowledge that the research responds to corporate interests, or to what is politically popular. The suspicions are reinforced when one takes note that the anticipated curtailing of research would be caused by the withdrawal of funds from external sponsors, not on the recommendation of those who deploy the precautionary principle.

Proponents of the precautionary principle do urge, however, that research be conducted (and funds be made available for it) on matters – environment and social risks – that, in the projects of their opponents, are under-researched, normally of salience only when their effects are already apparent or imminent, and they have to be reacted to (Section 3.2.3, Section 4.3). Since research funds are scarce, adopting the precautionary principle may indeed bring it about that certain lines of research are curtailed. At the same time, however, other currently under-researched lines will be opened up.

2.4.3. Efficacy and Legitimacy

Disputes about the precautionary principle make clear that when applications are being considered, in addition to the ethical appraisal of their aims and expected benefits and the confirmation of the knowledge that underlies their *efficacy*, the confirmation of knowledge that informs their *legitimacy* is also relevant. The latter includes knowledge about their risks, and the potential benefits and risks of alternative approaches; but, for the most part, research that leads to knowledge relevant to efficacy has little relevance for what needs to be known to support or challenge legitimacy.

Scientists, who engage in research – e.g., in molecular biology or biotechnology, or nuclear physics, or mainstream economics – that produces knowledge that underlies technological efficacy, usually take into account its actual and potential applications and standard risk assessments (Section 3.2.3, Section 4.2.2) But, consistent with *ethics-as-reactive*, they tend to pay little attention to potential risks with social and long-term ecological aspects, except when they cannot be ignored; and so their research on risks is incomplete and, therefore, often inadequate. When they endorse the universal ethical value of scientific research 1.1.2), partly on the ground that it leads to efficacious applications, they are in effect presuming that *normally* these applications are legitimate. It is this presumption – an ethical presumption with impact far beyond the realm of scientific research, and whose rational support (if there is any) remains outside of the purview of science – that explains the fact that, prior to the time when they have to be reacted to (Section 4.2.2), research conducted on risks tends to be inadequate. This ethical assumption is in play at the outset of the research of these scientists, influencing what is and is not subject to investigation, partly shaping the direction of their research (Section 4.3, Section 4.4); it is not just after the research has been completed that ethics comes into play. The fact that this is so adds support to the proponents of the precautionary principle, when they hold that ethical reflection about the legitimacy of potential applications of scientific research, and research needed to produce knowledge to inform them, should not wait until the relevant research has been completed.

2.4.4. Ethical Responsibility of Scientists

This has implications regarding the responsibility of scientists, *qua* investigators. How scientific results are actually applied, once in the public domain, is outside of the power of scientists; and, certainly, scientists cannot be held ethically responsible for applications that could not be anticipated. The critics of *ethics-as-reactive* point out, however, that often it can be clearly anticipated that, *de facto*, results will be applied in ways that serve the interests of those holding some ethical outlooks, but not others; so that, regardless of what may be speculated about in principle, *de facto*, evenhandedness across ethical outlooks cannot be expected in the context of application of these results. It can be anticipated, e.g., when institutions that embody particular ethical outlooks not only provide the material and socio-economic conditions for conducting research and, hence, expect access to (and sometimes monopoly on) novel applications derived from it, but also underlie interests that, when accompanied by adequate power, undermine the realization of competing interests.

The critics contend that the ‘in principle’ attached to ‘evenhanded in application’ in the definition of *applied neutrality* (Section 1.1) is illusory. Since arguments for it dissociate from the fact that the conduct of research must depend on the availability of material and socio-economic conditions, and that these come only at a price, they also dissociate from the fact that to conduct research under certain conditions, (even though its results fully accord with *impartiality*) is, *de facto*, contributing to further the interests nurtured by particular ethical outlooks. And so, the critics contend, scientists are ethically responsible for the implementations of applications of results that are foreseeable when the material and socio-economic conditions, under which their research is conducted, are taken into account.

Meeting that responsibility – as urged by proponents of the precautionary principle – may require curtailing certain lines of research, or conducting research pertinent to the legitimacy of applications as well as to their efficacy. Then, sometimes unavoidable, even irresolvable, tensions may arise in the roles played by scientists, *qua* investigators aiming to gain understanding of phenomena and to make novel discoveries, and *qua* officers or employees of an institution that embodies a particular ethical outlook.

2.4.5. Questioning ‘Autonomy’

The discussion (in Section 2.4.2–Section 2.4.4) may lead to questioning the ideal of *autonomy*. It suggests that external ethical judgments are inevitably are in play, not just after research has been completed, but also in *directing* it, helping to decide which specific questions to pursue. ‘Touch’ – the ‘touch’ of ethics on science – seems too weak a metaphor here. Perhaps it is not ‘penetration’ (but see Section 4), for ethical outlooks have not been held to have anything to do with the core moments of the process of science, where decisions about scientific methodology and theoretical appraisal are made. Maybe ‘grasp’ – the ‘grasp’ of science by ethics! Regardless, the idea of an autonomous research trajectory, impervious to external ethical appraisal, starts to look vulnerable. It remains open, however, to re-articulate *autonomy* by proposing that commitment to the scientific ethos should be complemented by ensuring the representation of a pluralism of ethical outlooks in the scientific community, in such a way as to enable research directions and priorities to emerge out of the attempt to balance the competing claims of the ethically pluralist community.

-
-
-

Bibliography

Altieri, Miguel (1995) *Agroecology: The Scientific Basis of Alternative Agriculture*. Second Edition. Boulder, CO, USA: Westview. [Important example of research conducted under strategies that do not fit into (what is called in the text) ‘the decontextualized approach’, and detailed source of evidence for the productive potential of agroecology.]

COMEST – World Commission on the Ethics of Science and Technology (2005) *The Precautionary Principle*. Paris: UNESCO. [Discussion, with useful example, of different versions of the Precautionary Principle, its history and its political and legal implications.]

Douglas, Heather (2000) Inductive risk and values in science. *Philosophy of Science* **67** (4): 559–579. [Development of ideas in Rudner (1953).]

Forge, John (2008) *The Responsibility of Scientists*. Pittsburgh, USA: University of Pittsburgh Press. [Critical analysis of the ethical responsibility of scientists; presents arguments against what is called ‘ethics-as-reactive’ in the text.]

Kitcher, Philip (1997) *The Lives To Come: The Genetic Revolution and Human Possibilities*. New York, USA: Touchstone. [Rich ethical appraisal, grounded in liberal values, of the application of knowledge gained in genetic research.]

Kitcher, Philip (2001) *Science, Truth and Democracy*. New York, USA: Oxford University Press. [Analysis of the way in which scientific appraisal involves both cognitive and ethical dimensions; speculations on how scientific research might be made responsive to democratic deliberation without undermining its commitment to what in the text is called ‘impartiality’.]

Longino, Helen (1990) *Science as Social Knowledge*. Princeton, NJ, USA: Princeton University Press. [Argues for pluralism in scientific methodology that is linked with a variety of ethical and social values; relevance of feminist values for critique of and for directing scientific research; questions the separation of the criteria of cognitive appraisal from ethical and social values.]

Lacey, Hugh (1999/2004) *Is Science Value Free? Values and Scientific Understanding*, 285 pp. London, UK: Routledge. [Contains a detailed analysis and critique of ‘science as value free’, proposes a systematic account of how science and (ethical) values interact, and elaborates the argument of Section 4 of the text.]

Lacey, Hugh (2005) *Values and Objectivity in Science*, 289 pp. Lanham, MD, USA: Lexington Books. [Elaborates themes in Lacey (1999/2004), and applies the account of the interaction of science and values to current controversies about transgenics and their alternatives such as agroecology.]

Machamer, Peter & Wolters, G. (eds) (2004) *Science, Values and Objectivity*. Pittsburgh, USA: University of Pittsburgh Press. [Collection of high-level articles representing an array of positions on the interaction of science with ethical, social and other values.]

Poincaré, Henri (1920/1958) *The Value of Science*. New York, USA: Dover. [Seminal statement of 'science as value free', which recognizes that this view is compatible with the 'touch' of ethics and science, but not with their 'interpenetration'.]

Putnam, Hilary (2002) *The Fact/Value Dichotomy and other essays*. Cambridge, MA, USA: Harvard University Press. [Challenges the fact/value dichotomy, which often regarded as the foundation of the view, 'science as value free'; argues for the 'entanglement' of facts and values.]

Rouse, Joseph (1987) *Knowledge and Power: Towards a Political Philosophy of Science*. Ithaca, NY, USA: Cornell University Press. [Contains (among other things) an introduction to European philosophical ideas, related to the interaction of science and values, not discussed in this article: e.g., ideas from critical theory (Habermas, Marcuse), phenomenology, Marxism, postmodernism (including Foucault).]

Rudner, Richard (1953) The scientist *qua* scientist makes value judgments. *Philosophy of Science* **20** (1): 1–6. [Seminal argument in favor of the ineliminable interplay of empirical evidence and ethical judgments in the kind of appraisal of hypotheses that, in the text, is called 'endorsement'.]

Santos, Boaventura, de Sousa (2004) (ed.) *Conhecimento Prudente para uma Vida Decente*. São Paulo: Editora Cortez. [Collection of articles representing a range of multicultural and third world perspectives.]

Biographical Sketch

Hugh Lacey is Senior Research Scholar and Scheuer Family Professor Emeritus of Philosophy at Swarthmore College (Pennsylvania, USA) and a frequent Visiting Professor at Universidade de São Paulo (São Paulo, Brazil). He was educated at The University of Melbourne (Australia) - BA (1962), MA (1964), and Indiana University (USA) - PhD in History and Philosophy of Science (1966). His published books include: *Valores e Atividade Cientifica* (1998), *Is Science Value Free? Values and Scientific Understanding* (1999), *Values, Objectivity and Science* (2005) and *A Controversia sobre os Transgênicos: Questões Eticas e Cientificas* (2006).