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PAPER

Science, culture and (eco-)ethics

Louis Legendre*

Laboratoire d'Océanographie de Villefranche, BP 28, 06234 Villefranche-sur-Mer Cedex, France

ABOUT THE BOOK: EE Book 16 focuses on achievements and shortcomings of modern marine ecology. It also analyses the crux of all science: human capabilities and limitations of conducting research — of critically perceiving the world in and around us. Louis Legendre further examines the relationships between science and culture and underlines the significance of ethics, especially eco-ethics.

KEY WORDS: Science · Research · Culture · Process · Creativity · Education · Perceptions

'We are learning the fundamental principle that ethics is everything.' E. O. Wilson, *Consilience* (1998)

The German philosopher Immanuel Kant (1724–1804) was the first to use 'culture' (*Kultur*) to mean the whole intellectual aspects of a civilisation, at the end of the 18th century. It was only at the beginning of the 20th century, however, that the word became generally used in that sense[38]. I showed in Chapter II that scientific research, which aims at discovery, is an intellectual activity. It follows that science is among the intellectual aspects of civilisation, and is thus part of culture. Within the context of this book, I therefore define CULTURE** as the whole intellectual aspects of civilisation, including science. In modern, developed societies, it could be argued that science is not only part of culture, but is one of its dominant aspects. However, science and culture are often thought of as distinct, if not opposed, aspects of civilisation in modern societies. Why is that so, and what are the consequences of this view?

Science and Culture

At the end of the 19th and beginning of the 20th century, scientific discoveries created great excitement in the general public. For example, the impressionist school of painting developed from the chromatic theory of light[39]; public lectures on such physical phenomena as electricity attracted large audiences and difficult theories such as evolution (Darwin 1859) and relativity (Einstein 1905) were widely discussed in the press, fashionable circles and philosophical groups. Science was then part of culture. Deep interest of the public in scientific discoveries progressively declined during the course of the 20th century, as a gulf opened between science and culture. Here are three examples:

*Email: legendre@obs-vlfr.fr

**Editorial note: Terms in small capitals are defined in the Glossary

[38] 'Culture' in Kant's sense entered the French language at the beginning of the 19th century in a book by Madame de Staël (1810, *De l'Allemagne*); from *Le grand Robert de la langue française* (1985). The word was later adopted from French into English

[39] The French word 'impressioniste' was created by the art critic L. Leroy, in a paper she published in the newspaper *Charivari* on 25 April 1874, to deride an exhibition of impressionist paintings that included Monet's *Impression, soleil levant*; from *Le grand Robert de la langue française* (1985). Boden (1992, p. 249) discusses the psychological basis of impressionist painting: 'Impressionists focused on patches of light, rather than realistic visual interpretations… Indeed, computational theories (and computer models) of vision suggest that our visual perceptions are constructed on several successive representation levels… What the Impressionists did, in effect, was to remind us of (some of) this, and to suggest what our vision would be like if we could not compute interpretations at the higher levels. The Impressionists were well aware that their artistic style is relevant to visual psychology, which they discussed at some length.'

The theory of plate tectonics (Le Pichon 1968) is as important in explaining Planet Earth as the theory of evolution was for living organisms a century before, but its appearance did not make a deep impression on the general public (for additional details on the theory of plate tectonics, see Ch. IV, Sec. 'Scientific Theories and Observations'). Similarly, the idea of a sudden creation of the Universe twelve billion years ago, called 'the big bang', is not generally known or understood in the public despite its imaginative name. Finally, the last great scientific excitement of the 20th century was probably the landing on the Moon and the first steps of Neil Armstrong there on 21 July 1969, and that was more for its human than scientific aspects; the key to public interest in space exploration is the involvement of human beings. Possible reasons for the progressive widening of the gulf between science and culture will be discussed below.

Let us first examine the present relationships between science and culture at the international level, in national governments and in universities.

On the *international* scene, education, science and culture are considered to be complementary components of civilisation. The *United Nations Educational, Scientific and Cultural Organization* (UNESCO) was created in 1946 as a specialised institution of the *United Nations*. Its main objective is to contribute to peace and security in the world by promoting collaboration among nations through education, science, culture and communication, as will be explained at the beginning of Chapter X.

Within *national* governments, science is seldom associated with culture. According to countries or fashions, scientific research may have its own Ministry or Agency, or be grouped with such government activities as education, technology, industry or even commerce. Alternatively, research may be spread among several ministries, with sometimes a more or less efficient coordination structure, the efficiency of the coordination depending on who actually controls the research monies. That situation may be seen as favouring scientific research, in the short term, because the budgets allocated to culture by most governments are much smaller than those going to research. However, it contributes to pushing science into a ghetto, where it generates little excitement in the public. I showed in Chapter VI that such a situation might jeopardise the long-term public support of research.

The situation of science relative to culture varies widely in *universities* and schools of higher education; examples of the latter include the various Institutes of Technology in the USA, and the Grandes Ecoles in France. At one end of the range, one finds universities or schools that specialise in a single or a small number of subjects, i.e. scientific, non-scientific — arts, languages, literature, etc. — or professional — agriculture, business, engineering, forestry, law, medicine, and so on. At the other end of the range, there are universities that are composed of only two large faculties, i.e. Arts and Sciences at the undergraduate level and Graduate Studies, plus professional schools. In the mid-range, universities may have several scientific and non-scientific faculties and professional schools, on the same campus. There exist a large number of intermediates between these three broad models. Hence, some universities focus on scientific or non-scientific or professional subjects only, whereas others integrate to various degrees scientific and non-scientific subjects.

The previous paragraphs show that there is no agreement in developed societies on the situation of science relative to culture. Science may be seen as a utilitarian activity, completely distinct from culture, e.g. science put into Ministries of Industry or Commerce, or as the complement of other activities that include culture, e.g. science as the complement of education and culture in the UNESCO, or as part of culture, e.g. Faculties of Arts and Sciences in some universities.

The general situation in international organisations, governments and universities reflects the fact that, for most people in modern societies, science and culture are distinct, and even opposed, high-knowledge activities (see Ch. I). Culture is often understood as covering such activities as visual arts, music, literature and philosophy, to the exclusion of science. In many countries, most 'cultured' people would not only easily confess, but even proudly state that they have no understanding of science and no interest in it. In contrast, most researchers that I know have a keen interest in such non-scientific activities as visual arts, music, writing, philosophy or others, and several practice some of these activities non-professionally.

The gulf that opened between science and culture during the 20th century was already wide when Koestler (1964, p. 264) wrote:

> 'The absurd division of our society into "two cultures" produced the paradoxical phenomenon that the average educated person will be reluctant to admit that a work of art is beyond the level of his comprehension, but he will in the same breath and with a certain pride confess his complete ignorance of the principles which make his radio work, the forces which make the stars go round, the factors which determine the heredity of his children, and the location of his own viscera and glands. One of the consequences of this attitude is that he utilizes the products of science and technology in a purely possessive, exploitive manner without comprehension or feeling... Modern man lives isolated in his artificial environment, not because the artificial is evil as such, but because of his lack of comprehension of the forces which make it work — of the principles which relate his gadgets to the forces of nature, to the universal order. It is not central heating which makes his existence "unnatural", but his refusal to take an interest in the principles behind it. By being entirely dependent on science, yet closing his mind to it, he leads the life of an urban barbarian.'

Despite the numerous popular books and magazines as well as radio and television programmes on science and technology, I am afraid that the situation has not really improved since the 1960s (see Ch. VI).

The above '…absurd division of our society into two cultures…' is all the more difficult to understand or accept because the two groups of creators, in science and arts, are actually close to each other. As explained by Koestler (1964, p. 329), on the one hand, '…every scientific discovery gives rise, in the connoisseur, to the experience of beauty, because the solution of the problem creates harmony out of dissonance; and vice-versa, the experience of beauty can occur only if the intellect endorses the validity of the operation—whatever its nature—designed to elicit the experience'. On the other hand,

> '…painters and sculptors, not to mention architects, have always been guided, and often obsessed, by scientific and pseudo-scientific theories—the golden section, the secrets of perspective, Dürer's and Leonardo's "ultimate laws" of proportion, Cézanne's doctrine "everything in nature is modelled on the sphere, the cone and the cylinder"; Braque's substitution of cubes for spheres; the elaborate theorizings of the neo-impressionists; Le Corbusier's modulator theory based on the so-called Fibonacci sequence of numbers—the list could be continued endlessly'. (p.329)

Hence, scientists and artists have much in common, because 'Beauty is a function of truth, truth is a function of beauty. They can be separated by analysis, but in the lived experience of the creative act—and of its re-creative echo in the beholder—they are inseparable as thought is inseparable from emotion' (Koestler 1964, p. 331).

Koestler (1964, p. 265) stressed

> '…one specific factor which is largely responsible for turning science into a bore, and providing the humanist with an excuse for turning his back on it. It is the academic cant, of relatively recent origin, that a self-respecting scientist *must* be a bore, that the more dehydrated the style of his writing, and the more technical the jargon he uses, the more respect he will command.'

This is, of course, one of the factors that contribute to cutting researchers from the public, but I think that the main reasons for the situation described here are deeper. As explained in Chapter VI, they include at least three components. Firstly, there is the way society and even researchers themselves think of scientists: too often scientists are imagined—and/or think of themselves—as very logical, highly trained and cold individuals; in other words, scientists are imagined as dull or even frightening people. Secondly, scientific knowledge is generally seen as an immense and complex body of firmly established and interconnected laws which is almost impossible to penetrate. Thirdly, research is often marketed as a primarily utilitarian activity which is of interest for technologically oriented people, but unbearably boring for non-specialists. This situation is all the more dangerous because most politicians have little or no knowledge of science, whereas addressing the most pressing problems that confront our societies requires some understanding of the processes of Nature (see the next Sec., and Ch. XI).

The situation described above contains the elements of a positive-feedback, downward process, as explained in the remainder of this paragraph. The three factors mentioned above—researchers are imagined as dull or frightening people, scientific knowledge is considered to be almost inaccessible and research is seen as a mostly utilitarian and boring activity—concur to bring about a devastating result: the public and young people withdraw from science. As a response, researchers retreat into more specialisation and isolation, which pushes the public and young people to further withdraw from science, and so forth, in a downward spiral (Fig. 34). This feedback process would explain why the public response to science progressively spiralled down, from general excitement at the end of the 19th and beginning of the 20th century to overall indifference, except for a few scientific fields (see Ch. VI), at the end of the 20th and beginning of the 21st century. I am not sure that the process I describe here actually took place or, if it did, that the process played a significant role in the disaffection for science. I am not sure either which factors initiated the process; it might have been related to the two World Wars (1914–1918 and 1939–1945) or the

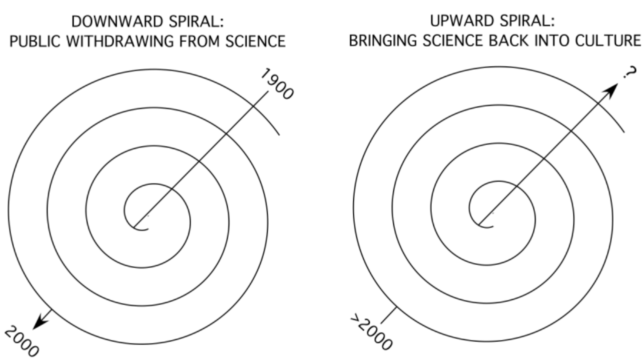

Fig. 34. Left: the public withdrew from science during the 20th century because, progressively, researchers were imagined as dull or frightening people, scientific knowledge was considered almost inaccessible and research was seen as a mostly utilitarian boring activity; this led researchers to retreat into more specialisation and isolation, hence a positive-feedback process and downward spiral. Right: proposed upward spiral toward reintegration of science into culture, by bringing back discovery and creative imagination to the centre of research; this could start a new positive-feedback process, and thus an upward spiral (Original)

intervening Great Depression (1929 to the end of the 1930s). Nevertheless, I am sure that the public and young people increasingly withdraw from science. This must be stopped, and reversed.

Possible solutions to the three problems cited above are discussed in Chapter VI, and there are undoubtedly many other aspects in the relationships between researchers and non-researchers that could be improved. These solutions include: science communicators and researchers themselves must show scientists as true creators; science communication must explain that the body of scientific knowledge, although formidable, is transient, and researchers must behave accordingly; science communication and researchers must avoid focusing exclusively or even primarily on the utilitarian facets of science. In order for this to occur, and thus permanently bridge the present gulf between science and other aspects of culture, researchers must change drastically the way they see and show themselves. Such a new attitude will require, in turn, a change in the training of researchers (see Ch. V), which will result, among other consequences, in attracting to science some of the bright youngsters who presently avoid it. The presence of these new people will contribute to modifying the way science is seen by researchers and society. This will, hopefully, initiate a positive upward feedback process (Fig. 34).

What I proposed in the previous paragraph is to reverse the downward spiral, and start an upward trend. I think that we could decelerate and stop the downward spiral of the 20th century, and initiate an upward spiral in the early 21st century by bringing back discovery (Ch. II) and creative imagination (Ch. III) to the centre of research. I am not sure how my proposal could be put into practice, because those who must reverse the present trend, i.e. the active researchers, are themselves caught in the downward spiral. I believe, however, that resolute, well-planned action by a few people could initiate a movement in the right direction, which may prove overwhelming.

The approach proposed here, if successful, would reintegrate science into culture. This may turn out to be crucial not only for the scientific community, i.e. to attract bright youngsters to scientific careers, and ensure the public funding of research (see Ch. VI), but also for society as a whole, as mentioned in Chapter III (Sec. 'Significance of Creativity') and discussed in the next Section.

Culture and Eco-Ethics

I explained in Chapter III (Sec. 'Significance of Creativity') that the survival of our species might depend on a new approach to the environment — called *eco-ethics* by Prof. Otto Kinne (1997) — to be rooted in science, knowledge and compatibility between Nature and humanity. Interestingly, French Prof. Maurice Fontaine developed independently a parallel proposal for the oceans, which he called *thalassoethics* (Fontaine 1995, 1997b), and US Prof. Edward O. Wilson promoted a similar idea, under the name *environmental ethics* (Wilson 1998), which itself stemmed from *conservation ethic* (Wilson 1984, pp. 119–140). Because the world economy cannot continue to thrive without ethical guidelines, Kinne (2002) extended the concept of eco-ethics to economy, and called the new concept *econ-ethics*.

ETHICS[40] is the philosophical theory of moral; it provides rules of conduct and behaviour. MORAL[41] is the theory of human actions, as subjected to duty and aiming at good. Because ethics takes into account intellectual progress, it can change with time and its rules may differ among cultures. Hence, the rules of conduct based on ethics evolve. This is contrary to the approach of most religions in which the rules of conduct are often immutable, because their basis is dogma. However, there are as many sets of religion-based rules as there are religions, and within a given religion, new interpretations of religious traditions or texts sometimes lead to changes in rules of conduct. As a consequence of the fundamental difference between ethics and religions, the rules of conduct based on ethics sometimes conflict with those from religions. Nonbelievers may be interested in looking at religion-based rules, because religions have influenced and continue to influence cultures, and thus ethics.

According to Wilson (1998, p. 250), ethical precepts are '…principles of the social contract hardened into rules and dictates, the behavioral codes that members of a society fervently wish others to follow and are willing to accept themselves for the common good'. Before focusing on eco-ethics, it is useful to examine one well-known example of successful application of ethics to everyday life: *medical ethics*. 'Medical ethics' is sometimes called 'bioethics', but as explained by Fontaine (1997a), medical ethics is only one component of bioethics.

It is now generally accepted that all steps leading from biomedical research to the treatment of patients must obey rules of medical ethics (Fig. 35, left-hand side). These steps include biomedical research, the interactions between researchers and companies that make and market medical products, e.g. drugs and medical equipment, the use of biomedical discoveries

[40] From the Greek adjective ηθικος (ethikos), which means 'moral'; itself from the noun ηθος (ethos), meaning 'custom'

[41] From the Latin noun *mos* (plural: *mores*), which means 'custom'

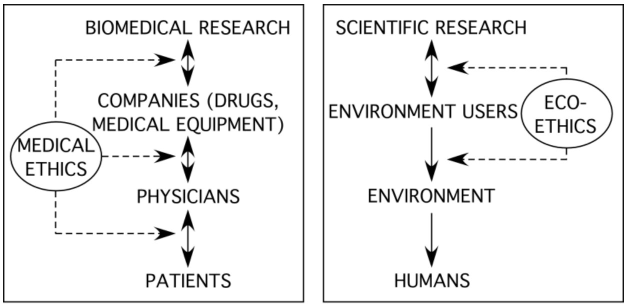

Fig. 35. Roles of medical ethics (left) in controlling the steps from biomedical research to the treatment of patients, and of eco-ethics (right) in the steps from scientific research to humans. Solid arrows identify interactions (double arrows) and unidirectional actions (single arrows). Dashed arrows refer to the role of ethics (Original)

by companies, the interactions between companies and physicians, the use of medical products by physicians and the interactions between physicians and patients. Double arrows in Fig. 35 identify interactions. Examples of unethical practices during interactions include: researchers trying to get funding or employment from companies at the expense of their scientific integrity, or companies trying to convince researchers to doctor their results; companies offering personal advantages to physicians who prescribe their products, or physicians demanding such advantages from companies; physicians behaving unethically with their patients, or patients requesting unethical acts from physicians.

As summarised in the central part of Table 17, the improvement of human health benefits from biomedical discoveries. These reach patients through companies that make medical products, and physicians who use these products or apply some of the discoveries directly. If there were no external control exerted on both companies and physicians, corporate or personal interests could threaten the health of patients. This has been understood for a very long time, as evidenced by the oath embodying the code of medical ethics devised by the Greek physician Hippocrates (from ca. 460 to 377 BC). The Hippocratic Oath was taken by those about to begin medical practice more than two millennia ago, and is still taken in many countries nowadays. In modern societies, establishing rules of medical ethics generally involves discussions among representatives of interested parties (associations of biomedical researchers, companies, physicians, patients, etc.; Table 18), and other specialists (social scientists, philosophers, lawyers, and so on). Involving in the exercise a wide array of people takes advantage of their diversity of expertise and opinions; it also helps in developing consensus in the community. In most countries, rules of medical ethics are embodied in national laws and regulations, and some are part of professional codes. Hence, medical ethics is not a matter of sentiments: its rules are implemented with necessary coercion by governments and professional bodies.

The rules of medical ethics often vary among countries, i.e. among cultures. Medical ethics both prescribes some courses of action, and forbids others. Except for a few extremists who wish total freedom for themselves (often dictated by greed), most biomedical researchers, companies that make medical products and physicians realise that the absence of medical ethics would threaten not only the patients but also

Table 17. Role of medical ethics in improving human health, and possible role of eco-ethics in ensuring human progress and survival

	Human health	Human progress and survival
Knowledge base	Biomedical discoveries	Natural sciences discoveries
Users of knowledge	Companies (drugs, medical equipment, etc.)	Environment users (companies, communities, farmers, etc.)
Actors	Physicians	Environment
Threatened party	Patients	Humans
Controlling the threat	*Medical ethics*	*Eco-ethics*
Representatives of parties	Associations of biomedical researchers, companies, physicians and patients	Scientific, professional and industrial associations, environmentalists and politicians
Other specialists	Social scientists, philosophers, lawyers	Social scientists, philosophers, lawyers
Coercion	National laws and regulations, professional codes	International treaties, national laws, professional codes

Table 18. Parties involved in the improvement of human health, and their representatives for establishing the rules of medical ethics

	Parties	Representatives
Knowledge base	Biomedical researchers	Associations of biomedical researchers
Users of knowledge	Companies (drugs, medical equipment, etc.)	Company associations
Actors	Physicians	Physician associations
Threatened party	Patients	Patient associations

their own professions. I suspect that a similar, realistic reasoning, and not only or primarily idealism, led to the Hippocratic Oath, twenty-four hundred years ago, because the Hippocratics, who devised wonderfully precise rules of medical ethics, were not idealists but followed a materialist philosophy.

Concerning eco-ethics, we know that humans are presently modifying the environment of Planet Earth at an accelerating pace, which threatens the very survival of the human species. Professors Fontaine (1995, 1997b), Kinne (1997, 2003) and Wilson (1998), and the *Eco-Ethics International Union* (EEIU[42]) proposed that ethics provides the approach to face that major treat. Wilson (1998) assigned two major targets to environmental ethics: sustainable development and conservation. He thought that each technological advance in reducing the risk of short-term environmental and economic catastrophe is a prosthesis, which creates a corresponding long-term risk. For him, the first target of environmental ethics must be '…to expand resources and improve the quality of life for as many people as heedless population growth forces upon Earth, and do it with minimal prosthetic dependence' (p. 289). The second target of ethics must be '…preserving the Creation by taking as much of the rest of life with us as possible' (p. 292) in the passage through the present environmental bottleneck.

As far as I know, there is no formal definition of ECO-ETHICS or environmental ethics. I propose to define it as follows: the theory of human actions, as subjected to duty toward Nature — to which humans belong — and aiming at compatibility between Nature and humanity, which provides rules of conduct and behaviour for interacting with the natural environment. It must be remembered that Nature consists of the physical environment and living organisms, including human beings (Ch. II, Sec. 'The Nature of Scientific Discovery'). The definition of eco-ethics stresses the fact that human beings both belong to Nature and often act on the natural environment as if they were not part of Nature. This almost schizophrenic attitude is largely responsible for the problems discussed here. In the remainder of this Section, I will analyse the idea of eco-ethics and discuss how I think it could be implemented.

Fig. 35 compares the roles of medical ethics (left-hand side) in controlling the steps from biomedical research to the treatment of patients (discussed above), and of eco-ethics (right-hand side) in controlling the steps linking scientific research to humans. The steps involved in eco-ethics include scientific research, the interactions between researchers and those who use the environment, the utilisation of scientific discoveries by the environment users, the action of users on the environment and the action of the environment on human beings.

The two sides of Fig. 35 show major differences. On the left (medical ethics), all steps are tightly coupled by interactions (double arrows). In order to remain in operation, such a coupled system must have well-defined rules, which probably explains why medical ethics appeared early in human civilisations. On the right (eco-ethics), only two of the steps are interacting (i.e. double arrow between scientific research and users), whereas the other steps are characterised by unilateral actions (single arrows). Because of the absence of a tight coupling of the various steps that link scientific research to humans when dealing with the environment, the system has been operating until now without ethics rules. Eco-ethics is appearing now because an increasing number of people realise that the build-up of environmental problems is threatening the very survival of our species. I will first discuss the single interaction and the two unidirectional actions on the right-hand side of Fig. 35, before examining the possible role of eco-ethics.

The interaction between researchers and those who use the environment sometimes leads to unethical practices, e.g. researchers trying to get funding or employment from users at the expense of their scientific integrity, or users trying to utilise scientific

[42] The Internet address of the Eco-Ethics International Union is: http://www.eeiu.org. See also the electronic journal *Ethics in Science and Environmental Politics*: http://www.esep.de

discoveries for purposes unacceptable to researchers. Hence, there are rules in many countries or professional associations that govern this interaction. The situation is very different for the two unidirectional actions.

The first unidirectional action is that of users on the environment. Western culture, among others, considers that the natural environment can be used freely for the benefit of human beings, forgetting that humans are themselves part of Nature. However '…the truth is that we never conquered the world, never understood it; we only think we have control' (Wilson 1984, p. 139). Of course, we preserve some parts of the natural environment, which are relatively small, for both future generations and our present enjoyment, e.g. parks, with the feeling that this 'good deed' in favour of Nature allows us to use the remainder of our planet as a supply of resources or a dump for wastes. This attitude did not inflict large-scale or long-lasting damages to the global environment as long as technology was primitive and the human population remained small. This started to change with the beginning of the industrial revolution and the population explosion, about two centuries ago. We now begin to see the consequences of the exponential degradation of the natural environment, caused by the combination of technological developments and rapid population growth. This occurred because of our unidirectional action on the environment: in general, those who exploit the natural environment do not suffer directly from the damages they cause to it. Other people, often far away or in the future, do or will suffer. Hence, the lack of direct, immediate reactions of the environment on those who exploit it explains why there are presently no ethics-based rules of conduct governing this action.

Csikszentmihalyi (1997) proposed the interesting idea that, for human beings, '…the power to create has always been linked to the power of destroy' (p. 320). In other words, '…the main threats to our survival as a species, the very problems we hope creativity will solve, were brought about by yesterday's creative solutions' (p. 318). For example, without improvements in farming and public health, there would not have been the population explosion that is a key factor in the present degradation of the environment. It follows that each discovery '…has a potentially dark side that often reveals itself only when it is too late' (p. 319). This would lead to the law of history that '…the greater the power to change the environment, the greater the chances of producing undesirable as well as desirable results' (p. 319). Hence, '…the future is in our hands; the culture we create will determine our fate' (p. 318).

The second unidirectional action is that of the environment on humans. The functioning of our planet is controlled by a large number of feedbacks, which are governed by natural laws. One relatively recent event that I interpret in term of feedback concerns the 'nuclear winter' (e.g. Turco et al. 1983, Covey et al. 1984, Thompson et al. 1984). It was hypothesized by researchers in the 1980s that, if a major nuclear war occurred, the numerous and immense fireballs caused by exploding nuclear warheads would ignite huge firestorms. Great plumes of smoke, soot and dust would be lifted by their own heating to high altitude, where they would form a belt of particles in the Northern Hemisphere, which might spread worldwide within a few weeks. This thick layer would block out most sunlight for several weeks to months, thus causing surface temperatures to plunge by as much as 10 to 20°C: a nuclear winter. The conditions of semidarkness, killing frost and subfreezing temperature, combined with high doses of radiation from nuclear fallout, would interrupt plant photosynthesis and thus destroy much of the Earth's vegetation and animal life. The extreme cold, high radiation levels and widespread destruction of infrastructures along with food supplies and crops would cause massive death from starvation, exposure and disease, thus reducing the human population to a fraction of its previous numbers. Although different aspects of this catastrophic scenario were disputed by some researchers, the hypothesis received support from Academies of Science throughout the world. The last Secretary-General of the communist party of the Soviet Union wrote:

> 'Scientific research... showed convincingly what human beings faced in the event of a nuclear catastrophe. Eloquent testimony to what might happen was expressed in descriptions of a possible "nuclear winter"... Governments had to renounce approaches involving the use of force, fraught with the danger of the destruction of millions of people, if not the entire human race.'
>
> (Gorbachev 2000, p. 174)

Recognising the ineluctability of nuclear winter as a consequence of large-scale nuclear war was instrumental in bringing to fruition the first Strategic Arms Reduction Treaty (START I), which was signed by President George H. W. Bush and Mikhail Gorbachev in Moscow on 31 July 1991.

By reference to Fig. 35, the release of smoke, soot and dust in the atmosphere as a consequence of nuclear war, and the subsequent deterioration of environmental conditions for humans correspond to the first and second unidirectional actions, respectively. In the second unidirectional action, the Earth's environment would have acted blindly on humans, who would not have had any direct means of countering that action. This example shows that the only way humans can prevent or stop environmental disasters—for humanity—is to modify their own actions on the environment, i.e. change the first unidirectional action, because they do not have any hold on the second one. This is consistent with the view of Wilson (1984, p. 121) that '…the destruction of the natural world in which the [human] brain was assembled over millions of years is a risky step'. In the same vein, Lovelock (2000, p. xx) wrote: 'The health of the Earth is most threatened by the damage we do to natural ecosystems by agriculture, forestry, and to a lesser extent fishing, and the threat is aggravated by the inexorable increase of the greenhouse gases... we are part of the Earth system and cannot survive without its sustenance'.

It is generally difficult for people to see how their actions on the environment (first unidirectional action in Fig. 35) are linked to the reactions of the latter on them (second unidirectional action), because the two types of action often occur on different time scales. Usually, the actions of humans on the environment take place on a much shorter time scale than the reactions of the environment. A striking example, which was discussed in the previous paragraphs, is the long-lasting environmental effect of a nuclear war: nuclear explosions would take place over a few minutes or a few hours, whereas the Earth's environment would be damaged and thus make life difficult or even impossible for humans over centuries and, in some respects, millennia. Even when the actions of humans on the environment are in the long term, e.g. the steadily increasing release of CO_2 in the atmosphere since the beginning of the industrial revolution, more than 200 years ago, most people do not relate their day-to-day activities to the resulting changes in the Earth's environment (i.e. climate change, see Ch. XI, Sec. 'Possible Solutions').

There is also a spatial aspect to the above two unilateral actions. In small systems, those who use the environment are often spatially close to those who would suffer from their abuses. In addition, because spatial and temporal scales are not independent in natural systems, the actions of users on the environment in small systems may be followed rapidly by reactions of the environment on the human community. For example, in a small-lake system, farmers who would release excessive amounts of fertilisers in the watershed, and would thus cause eutrophication of the lake, are physically and socially close, and/or related to, or even among those who use the lake, e.g. for drinking water and recreation. In such a system, there is a potential for spontaneous feedback and the development of community solutions, without the need for resorting to formal rules of eco-ethics. In contrast, in large systems those who use the environment are often far in space, time and/or socially from those who would suffer from their abuses, which can lead to the situation illustrated on the right-hand side of Fig. 35. The resolution of actual or potential problems without resorting to formal rules of eco-ethics in some small systems stresses the need for such rules in larger systems.

Combining the above paragraphs on the two unilateral actions shows that, because the steps that link scientific research to humans are not tightly coupled, on the one hand, there is no immediate incentive for those abusing the natural environment to treat it ethically, and on the other hand, humans generally cannot protect themselves from catastrophic environmental reactions. The catastrophes would be for the humans, not for the environment. In that sense, the idea of 'saving' Planet Earth is mistaken, although generous, because the Earth does not need our protection. As a matter of fact, our planet does not need human beings anymore than it needed the dinosaurs. In other words, what we must 'save' is not the Earth, but ourselves. Fig. 35 shows that the only way humans can avoid catastrophic environmental reactions is to force ethics on the unidirectional action of users on the environment. This could probably be achieved through international actions only, although incorporating rules of eco-ethics in national laws and professional codes could be a first step in the right direction.

The approach to eco-ethics described above is primarily anthropocentric: 'saving ourselves'. It is in line with the opinion of Wilson (1984) that, even if people have an '…innate tendency to focus on life and lifelike processes…' that he called 'biophilia' (p. 1), '…the only way to make a conservation ethic work is to ground it in ultimately selfish reasoning' (p. 131). However, some colleagues rightly pointed out to me that this is a bare minimum. Indeed, there are increasing numbers of people who think that human beings have the moral responsibility to act as stewards of the biosphere, for present and future generations. As a matter of fact, many researchers feel a strong responsibility to the living world in general (e.g. Salk 1983, Wilson 1984, Klein 1992), which provides a complementary basis for developing eco-ethics. I wish to point out that 'saving ourselves' and 'acting as stewards of the biosphere' are, in fact, two sides of the same coin. On the one hand, I think that most people can understand the urgency of saving ourselves, and be convinced to rapidly take steps in that direction. By raising the environmental standards in a way to save ourselves, we would improve the likelihood of survival not only for human beings but also for most other species. On the other hand, a number of people may prefer to base eco-ethics on the idea of a stewardship of the biosphere. By raising the environmental standards in such a way as to save other species than our own, we would improve the likelihood of survival not only for these species but also for ourselves. Hence, the two approaches are complementary, and they would lead to the same rules of eco-ethics. The difficulty lies in finding a way to set the process in motion. Combining the two approaches may be the key to success.

In the same vein, Wilson (1998, pp. 277–278) stressed the facts that humankind has become a geophysical force which rapidly alters the Earth's climate, and the greatest destroyer of life since the Age of Reptiles was abruptly terminated by the impact of a ten-kilometre-wide meteorite on the Earth, 65 million years ago. In addition, we may run out of food and/or water in a few decades because of overpopulation. As a response to the present danger, most people instinctively wish to either re-create our Blue Planet as it was before we changed it, or use technology to get free from the laws of ecology, which are imposed by the natural environment of Earth. These two dreams are, of course, impossible, which leaves only one course of action: environmental ethics. Wilson (1998, p. 287) explained that many people and governments accuse environmentalists of being alarmists, and prefer to save efforts now by making the choice of not taking action. However, if they are wrong and the environmentalists are right, the price to pay will be ruinous. In matters of the environment, as in medicine, a false positive diagnosis is an inconvenience, but a false negative diagnosis can lead to catastrophe. As summarised by Wilson (1998, p. 297), '…we are learning the fundamental principle that ethics is everything'.

The right-hand part of Table 17 summarises how eco-ethics could ensure human progress and survival if the utilisation of discoveries in the natural sciences by the environment users, and their effects on the environment, were subjected to eco-ethics rules of conduct. Such rules already govern the interactions between researchers and some environment users, in a limited number of countries, and there are a few international agreements that regulate the actions of users on the environment, e.g. the Antarctic Treaty, which forbids the exploitation of the Antarctic environment, and the Montreal Protocol, which bans the production of ozone-destructive chlorofluorocarbons. The very existence of such rules shows that eco-ethics is not a wild dream, and indicates what the general rules of eco-ethics could be. By reference to the example of medical ethics, discussed above, it is clear that building eco-ethics will require discussions among representatives of interested parties. These include: scientific, professional and industrial associations, who will represent the researchers and environmental users, respectively; environmentalists, i.e. researchers and activists, who will 'represent' the environment; and politicians (yes!), who will represent the citizens of Planet Earth (Table 19). As in the case of medical ethics, the discussions should also involve other specialists, such as social scientists, philosophers and lawyers. The end result would be rules of eco-ethics, embodied in international treaties, and possibly national laws and professional codes. These rules would be enforced by governments and professional bodies. In some cases, the development of eco-ethics rules at national and professional levels could be steps leading to the necessary international actions. Cairns (2003) provides ten examples of eco-ethics rules that could be implemented internationally.

Eco-ethics appears so important and reasonable that it should have aroused strong interest in the scientific community, intellectual circles and the general public, especially in developed countries where the functioning of society is based on exchange of information. However, relatively few people have actively responded to the idea so far, although their number is growing. How could this be explained, and perhaps reversed?

I think that a major reason explaining the limited involvement of non-scientist intellectuals and the general public in eco-ethics, so far, comes from the wide gulf discussed in the previous Section which exists between researchers and the public, and more generally between science and culture. On the one hand, because of that gulf, the general public and non-scientific intellectuals are not really interested in social ideas originating from natural scientists, or at best they suspect these ideas to be self-serving. On the other hand, because of the same gulf, few researchers in developed countries believe that they could exert significant influence on

Table 19. Parties involved in achieving human progress and survival, and their representatives for establishing rules of eco-ethics (based on Table 18, for medical ethics)

	Parties	Representatives
Knowledge base	Natural sciences researchers	Scientific associations
Users of knowledge	Environment users (companies, communities, farmers, etc.)	Professional and industrial associations
Actors	Environment	Environmentalists
Threatened party	Humans	Politicians

social conduct or behaviour, except perhaps through political lobbying. For example, many scientific societies in the USA have their headquarters in Washington, where they actively meet and/or lobby senior civil servants and politicians. Interestingly, the idea of eco-ethics seems to be slightly more successful in Eastern Europe and some developing countries than in Western Europe or North America. It may be that the gulf between science and culture is not as wide or well-defined in the first group of countries as in more technologically developed countries. Whatever the explanation, the progress of eco-ethics in the latter countries will require very determined actions in the short term.

Some examples show that the international community is capable of action when there is clear evidence that humanity is endangered. I already cited the examples of the first Strategic Arms Reduction Treaty (START I), which largely resulted from the recognition that a large-scale nuclear war would throw the whole Planet into nuclear winter, and the Montreal Protocol, which banned the production of chlorofluorocarbons when it was suspected that their destructive effect on the ozone layer could lead to a life-threatening increase of ultraviolet radiation at the Earth's surface. The purpose of eco-ethics is not only to prevent the occurrence of such catastrophes, but also to avoid coming close to them, because at some point in the future last-minute action may happen too late.

I think that one of the problems of present environmental policy is that environmental researchers and activists both aim at wrong targets. Environmental researchers favour education, in which they advocate a gentle, ethical approach to the environment (e.g. Cairns 2002). However, as shown in the biomedical field, ethics is not a matter of sentiments, and its efficiency depends on the definition and implementation of rules of conduct. The latter sometimes requires coercion. Environmental activists would like to save the Earth[43]. However, as I already explained, the Earth does not need to be saved: it existed more than four billion years without human beings, and if we destroyed the conditions necessary for the existence of complex organisms or societies and consequently disappeared, such conditions would probably be restored quite quickly, say, within a few thousand years. The Earth does not need to be saved by us, but we may need to save ourselves from life-protecting Earth.

I suggest that the community of interested environmental researchers sets as its central objective the definition of eco-ethics rules of conduct. Once this objective is clear, we should approach, as a community, all groups that could become potential partners in establishing these rules (Table 19). It should be clear to all parties involved that no group alone has the expertise to set the rules of eco-ethics. Because of the diversity of interests among partners, actual agreement on rules would not be easy, but it could be successful if the objective of the exercise were clear: preventing catastrophic feedbacks of Earth on humans, resulting from our disruption of major natural equilibria. The idea could be appealing even to those who wish to 'save' the Earth, because their objective — bringing under control our actions on the environment — is the condition for eliminating the danger of catastrophic natural feedbacks on humans.

According to the above proposal, the community of environmental researchers should approach potential partners in other fields of activity with a clear idea of the problem to address and a general agenda for doing it, and it should clearly inform partners that the rules of eco-ethics would be defined collectively by all interested parties, e.g. as is done in the case of medical ethics. This could be a major step in reintegrating science into culture, as discussed in the previous Section. This would be all the easier if researchers showed themselves to their partners as they truly are: imaginative people, who do not think of themselves as possessing the truth and who put the pleasure of discovery before the utilitarian aspects of research.

[43] One example is the main title on the cover page of *Time* magazine of 2 September 2002, referring to the Johannesburg World Summit on Sustainable Development, which took place from 26 August to 4 September 2002. The title was: 'How to Save the Earth'

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GLOSSARY

CULTURE. Whole intellectual aspects of civilisation, including science. *Back to text*

ECO-ETHICS. Theory of human actions, as subjected to duty toward Nature — to which humans belong — and aiming at compatibility between Nature and humanity, which provides rules of conduct and behaviour for interacting with the natural environment. *Back to text*

ETHICS. Philosophical theory of moral, which provides rules of conduct and behaviour. *Back to text*

MORAL. Theory of human actions, as subjected to duty and aiming at good. *Back to text*