Global Bioethics
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/rgbe20

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Published online: 03 Jun 2014.

To cite this article: Mario Carmelo Cirillo (2014) Science and environmental stewardship, Global Bioethics, 25:2, 114-124, DOI: 10.1080/11287462.2014.922317
To link to this article: http://dx.doi.org/10.1080/11287462.2014.922317

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Science and environmental stewardship

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People’s vision of world phenomena is still based on the traditional mechanistic concept, which implies that process outcomes can be fully predicted and controlled. The new scientific concept that our world is characterized by complex, self-organizing processes, is so far acknowledged by few insiders. Mass media, advertising companies and information programmes tend to emphasize the success of technology (born at the end of the eighteenth century in the context of the old scientific vision), which significantly contributes to support and spread that mechanistic concept. This situation heavily impacts the management of the environment both in terms of its technical–scientific approach (where a mechanistic idea that does not integrate disciplinary knowledge continues to prevail) and in terms of its stewardship (i.e. an ethically responsible line of conduct). Instead of being solved, environmental problems are frequently shifted through time and space, and eventually magnified. Moreover, among the technicians involved in environmental assessments, as well as decision-makers and the general public, the connections regarding technical–scientific issues, ethical values and policy decisions are often not adequately considered. It’s time for a public debate on an alternative vision of real-world phenomena (according to a new scientific concept) and on its actual implications. The hope is that a valid dialogue between existing polarized views on science, technology and the environment may lead to more positive collaboration between science and environmental stewardship, where every single citizen feels committed.

Keywords: environment; science; technology; society; democracy; population; stewardship

Introduction

This paper focuses on environment, science, technology, society and their mutual relationship, also from a historical perspective.

Technology is “the application of scientific knowledge for practical purposes” (http://oxforddictionaries.com). More precisely, technology is the application of science for the study, design and implementation of material, machinery and processes used in the conversion of a raw material in industry, or for public and private service.

Science is a system of knowledge gained by making use of scientific method. In the Western world, scientific knowledge is expected to be strictly controlled, and therefore to be traceable and verifiable. Some may say, more appropriately, falsifiable; an aphorism attributed to Einstein states: “No amount of experimentation can ever prove me right; a single experiment can prove me wrong.”

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Global Bioethics, 2014
Modern science … is an intellectual construction:
based on a very particular form of observation: the quantifiable aspect of reality;
generally justified by experimentation…;
confident in the results of mathematical rationality … (Panikkar, 2005, p. 28)
Science is not fixed in its contents. It is ever open to change its paradigm, but it always requires proofs – within parameters it recognizes. There are no dogmas of content, but only of method and working hypotheses. Science is open to dialogue expressed in its language, called “rational language” – that it is believed to be universal…
Ultimately, the great value of science as a heuristic method is its flexibility: it knows its limits, it is fallible, provisional. Science, as scientific activity (not technical–scientific institution), has no vested interests. It is not afraid to shock or disorient those who place hopes in already outdated hypotheses. (Panikkar, 2005, p. 36)

Environmental issues: a historical outline
Since the Industrial Revolution (and with a sharp acceleration since the end of the Second World War), many countries have embarked on so-called modernization, a series of processes, with different timing, historical dynamics and geographical distribution. Some of these processes are the production, distribution and use of various forms of energy, mobility of people and goods, production of goods, land use, waste and water management. All these processes have progressively expanded their footprints over spatial areas extending far beyond the territories delimited by city, province or state boundaries. As these processes expand and intensify, the magnitude of their environmental impacts also increases. For example, air pollution, due to the emission into the atmosphere of pollutants from heating, transport, industry and agriculture, may involve cross-regional areas, cross-borders and even an entire hemisphere (UNECE, 2010). Urban areas, characterized by high population density and greater environmental pressure, now suffer from an increasing poverty of common goods such as clean air, pure water, green land and biodiversity, which were formerly considered available in unlimited quantities and consequently were of little or no economic value. Due to the increasing number of urban dwellers, cities are where the largest impacts occur. Further processes of urbanization and infrastructure building unload their pressure on territories where fragility has been increasing over decades and centuries.
In the face of increasingly diversified demands on mobility, work and lifestyle, space scarcity becomes a determining factor, making it more and more difficult to govern the territories where traditional sectors – transport, productive activities, agriculture, housing, etc. – are considered mutually independent. Nowadays they are highly integrated and interacting. It is therefore not possible to improve one sector without taking into account what happens in others.
Increasing awareness of environmental issues, favoured by the above-mentioned processes, has highlighted how many different human activities take place simultaneously in the environment, and therefore environmental protection must be taken into account in all these activities.
This double movement: (a) from relative independence to growing interdependence in various human activities and (b) from a lack of consideration of environmental assets (which were deemed to be available in unlimited quantities) to growing awareness of the environment deterioration, has led to the acknowledgement of the interconnection between environmental protection and the multiple instances of land use and management. Clearly, both elements are two sides of the same coin. The issue is how to govern the environment and its resources, while contending with the limits of the sectorial approach still in force, that is, the traditional division of the departments of public administration in Transport, Industry, Agriculture, etc.
Science and environment

Environmental protection cannot be separated from a knowledge of physical and bio-geochemical processes. These processes, in various ways, are affected by anthropogenic activities that require the use of environmental resources and produce pollution and degradation.

Any productive activity is associated with pollutant emissions, their dispersion and transformation in the environment, and possible accumulation and ultimate impact. Analysis of each of these steps involves multiple scientific knowledge: chemistry and physics, hydrology, geology and soil science, biology, to name just a few. Engineering knowledge is also needed to properly individuate the emissions from various sources in terms of quality and quantity. Medical knowledge to analyse the impact on health. Psychological and social competence to evaluate aspects related to the perception of risk, well-being and quality of life. Management, administrative and planning knowledge are essential to successfully carry out the procedures of protection and restoration. Therefore, environmental protection is a multi-disciplinary activity.

Moreover, in the study of the environment an interdisciplinary approach is necessary in order to identify relationships and connections between the various disciplines.

In addition, the continuous interaction of a huge number of physical, chemical and biological processes, as well as technological, economic and social ones, causes the whole to differ from the simple sum of its parts. This is truly a leap in quality that challenges the reductionist approach and leads to a new vision. Warning signs of this change may be detected between the end of the nineteenth century and the first decades of the twentieth: the discovery of Henri Poincaré’s deterministic chaos (which showed that even the motion of three interacting celestial bodies can occur in a chaotic manner), and the formidable insights of relativity and quantum mechanics (see, e.g. Capra, 1975; Galison, 2003; Zukav, 2009). However, it was only from the 1960s that a true Copernican revolution took place: from a mechanistic idea to an organicistic image, from a reductionist approach to the management of complexity and “emergent properties”, according to which the whole is different from the sum of its parts. Then came an unexpected discovery that simple systems could have chaotic behaviour, and very complicated systems (from which it would have been reasonable to expect only chaotic dynamics) instead behave quite simply:

… it is undeniable that our universe is not a chaos, we can discern beings, objects, things that we can identify with many words. (Thom, 1980, p. 3)

The fields of inquiry that have allowed the birth of this new concept are some areas of physics – the non-linear dynamic systems and applications in meteorology (Lorenz, 2005); the dissipative structures in thermodynamics (Kondepudi & Prigogine, 1998), together with modern biology (US National Academy of Sciences, 2009).

The application of the new point of view for the study of social and economic systems started from the work of Jay Forrester at MIT (Massachusetts Institute of Technology) at the end of the 1960s (Forrester, 1969). His approach, named System Dynamics, was aimed at understanding the behaviour of complex systems over time. In April 1968, Aurelio Peccei, together with some scientists, politicians and intellectuals, founded the Club of Rome whose aim was a reflection on the limits of economic growth connected with the finitude of natural resources and the environmental impacts of human activities. The Club of Rome commissioned MIT to produce the report Limits to Growth (Meadows, Meadows, Randers, & Behrens, 1972), where System Dynamics was used to investigate five major trends of global concern: accelerating industrialization, rapid population growth, widespread malnutrition, depletion of non-renewable resources and a deteriorating environment. The report gave rise to a widespread debate.
More recent contributions to the study and/or modelling of social–economic–environmental metabolism include Bardi (2011), Hall and Klitgard (2012), Sertorio (2013) and Roddier (2012).

From the beginning of the 1960s and 1970s a science of complexity was developed:

Like thousands before us, we are trying to come to grips with “emergent phenomena” – collective behaviour of a system that somehow transcends its components. Because it transcends them, it can’t be “in” the components – so where is it? Tricky. (Cohen & Stewart, 1994, p. 4)

One of the most surprising findings is that the collective behaviour of a system can somehow transcend that of its components. Transdisciplinarity considers the emerging phenomena related to the collective behaviour of a system; this goes beyond that of its components, and transdisciplinarity has to focus its analysis not only on the constitutive properties of the elements of a system, but also on the relationships and the interactions between its different components.

For a long time, something qualified as “complex” meant something difficult to understand or to realize. [...] It is only recently that complexity ceased to be a justification for lack of explanation, and is becoming an object of study in itself, a matter of systematic research. This change of status is significant and constitutes an important event in the recent history of the natural sciences, biology in the first place, but also physics and other disciplines. (Fogelman, 1991, quoted in Cini, 2006, p.76)

What do we mean when we say that the “environment is a complex system”? It means that it is wrong to think that we can predict climate evolution in the same manner with which we plan the trajectory of a bullet: complex systems are characterized by non-linearity and recursivity.

Transdisciplinarity complements disciplinary approaches. It occasions the emergence of new data and new interactions from out of the encounter between disciplines. It offers us a new vision of nature and reality. Transdisciplinarity does not strive for mastery of several disciplines but aims to open all disciplines to that which they share and to that which lies beyond them. (Lima de Freitas, Edgar Morin, & Basarab Nicolescu, The Charter of Transdisciplinarity, Article 3, 1994, http://ciret-transdisciplinarity.org/chart.php#en)

Therefore, analysis of the environment requires a transdisciplinary approach; the most advanced scientific concepts seem to confirm that. Quantum mechanics, the theory of relativity, the thermodynamics of systems far from equilibrium (dissipative structures) and system biology (interactomics) show that the structure of reality in which we are embedded is determined by the relationship between the constituent entities. This relationship allows collective behaviour to transcend that of the individual components (emergent properties).

Yet a mechanistic approach continues to prevail, not only in the current mentality of people of average education but also (in my experience) in the technical–scientific context. What do I mean by “mechanistic approach”?

The mechanistic approach
The mechanistic approach has its source in a worldview where causality and predictability allow full intelligibility of nature and consequently its control and its domain. The archetype of this concept can be traced back to Galileo Galilei:

Philosophy is written in this grand book which stands continually open before our eyes (I mean the universe), but it cannot be understood unless one first learns to comprehend the language and reads the characters in which it is written. It is written in the language of mathematics, and its characters are triangles,
circles and other geometrical figures, without which it is humanly impossible to understand a single word; without these one is wandering in a dark labyrinth. (Galileo Galilei, *Il Saggiatore*, 1623)

Classical mechanics, as it developed from Galileo to Newton and to Laplace, was characterized by resounding success in describing, and then predicting, not only the motions of planets in the universe, but also of bodies on the ground. Which vision of nature is implied in a survey done with the tools of classical mechanics? It is a world of reversible phenomena, in which temporality is an illusion, laws are eternal, the characteristics of all parts of the system are immutable and the parts carry forever the consequences of their initial state.

Science has initiated a fruitful dialogue with nature, but the outcome of this dialogue has been the most surprising. It revealed to man a dead and passive nature, a nature that behaves like an automaton, that, once programmed, eternally follows the rules written on its program. In this sense the dialogue with nature separated man from nature, rather than setting him more closely to it. One of the greatest achievements of human reason has become a sad truth. The science was seen as something that disenchants everything it touches. (Prigogine & Stengers, 1981, p. 8)

**The new scientific approach**

The new approach argues that reversibility and determinism apply only to simple, limited cases, while irreversibility and uncertainty are the rules and the sources of many processes in the spontaneous organization of matter. The world is far from a state of equilibrium, and moves *from the repetitive and universal towards the specific and unique*. In conditions far from equilibrium, matter begins to perceive differences in the outside world; it may react to small causes with great effects, and may find itself before a bifurcation. A small fluctuation may give rise to a new evolution that will drastically change the overall behaviour of the macroscopic system. *Non-linearity* is often responsible for counterintuitive behaviour.

Other peculiar aspects of the new scientific concept are *recursivity* and *self-organization*. A procedure is recursive when it is formulated with an explicit reference to itself. Recursivity, in other words self-reference, is the origin of “strange circles” or, as Hofstadter (1979) defines them, “strange loops”: neither vicious nor virtuous, neither true nor false – undecidable. Consider the phrase “this sentence is false”: it is a phrase that says something about itself, and therefore it is self-referential or, if you prefer, recursive. Well, this sentence brutally violates the usual assumption that wants statements to be either true or false: if you think that is true, it changes its meaning and forces us to think that it is false, and vice versa.

Recursivity and undecidability are thus connected, and it is this connection that allowed Kurt Gödel in 1931 to enunciate the famous theorem of incompleteness which states that *all axiomatizations of arithmetic contain undecidable propositions*; this was a radical change in a context that was trying to make math’s axiomatization the foundation of the whole structure of science! From the point of view of the vision of reality and the human capacity to know this reality, Gödel’s theorem has a range comparable to relativity and to quantum mechanics, the two great scientific theories developed at the turn of the nineteenth and twentieth centuries that radically changed the *weltanschauung*, based until then on Newtonian mechanics.

Closely connected with the property of self-reference is that of self-organization. Indeed, the former is a necessary condition if a system has to play its basic structural and functional organization.

… diversely from the programs of a machine, the DNA’s program needs the results of its reading and execution to be read and executed, according to a recursive loop which is typical of all self-organizers’ systems. (Cini, 2006, p. 84)
Many processes in the environment (e.g., the dynamics of the global climate), the dynamics of the market, and many biological and social dynamics—all self-organized systems—are characterized by the presence of “strange loops”. We should reflect on the persistent mechanistic tendency to consider forecasts on such systems infallible.

Self-reference was used by Gödel to undermine from within the building of formal systems, starting with arithmetic. Self-reference appears for the first time in the language when the reflexive pronoun “ātman”, which is valid for all people, singular and plural, introduced itself as an entity, a noun, which is usually translated as “self”. This change occurred in the Veda… Since then, the thought of India revolves around this word… India begins and ends with something that only at the beginning of the twentieth century (by means of an unexpected path of the logic) has become central in the West… (Calasso, 2010, pp. 160–161)

… even quantum mechanics does not in any way correspond to current life, while Newtonian physics has become the very model of common sense. (Calasso, 2010, p. 450)

How often is this new scientific approach taught to students? How much is this new scientific concept part of the cultural background and mentality of the average citizen?

**Technology and the mechanistic approach**

Technology, as we conceive it today, began at the end of the eighteenth century, with a marked acceleration in the second half of the nineteenth century, when the Newtonian mechanistic concept became the scientific reference model for all the other disciplines.

According to Boltzmann’s results on statistical mechanics, thermodynamics—which is the other side to the science of the nineteenth century and which, because of its Second Principle, stands in conflict with the eternal and reversible laws of Newtonian mechanics—may also be traced back to this vision. These results, linking the microstates of a fluid described from a Newtonian perspective with the macrostates described by their thermodynamic functions (see, e.g., Prigogine & Stengers, 1981), seem to confirm the mechanistic concept and a reductionist approach.

The most significant symbol of technology is still today the machine, that is, an instrument, apparatus or device consisting of a variable number of parts joined together in a cinematic relationship, and used both for the processing or transmission of energy and for the fulfilment of certain operations.

In my opinion, the popular image of technology is still based on the mechanistic idea of reality. Even in environmental management—which often requires the application of technology—the mechanistic approach seems to prevail. The consequence is that interaction of air, water, soil and biota, and their synergic and cumulative effects are often overlooked. It seems to me that this is the scientific concept taught in many schools and propagated worldwide by the media.

Accordingly, environmental evaluations and assessment studies are carried out through a reduction of complexity into separate topics, with inevitably negative implications on a practical level. The environment is not the simple juxtaposition of air, water, soil and biota, and neglecting their complex interrelationships may create unexpected and often negative side effects on local, regional or global levels. A few examples:

- To increase cotton production in an arid region of Uzbekistan two rivers leading into the Aral Lake in Central Asia were diverted. This caused the drying up of the lake, and its surface has been reduced by 75% since 1960, with consequent and severe damage to the environment of the surrounding region and its economy.
- The Aswan Dam in Egypt (completed in 1970) protected the region from floods and droughts, increased agricultural and electricity production, and improved navigation.

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However, it contributed to many unintended side effects: the decrease in strength of the Nile allowed salt water from the Mediterranean to move inland; downstream, to compensate for reduced silt intake, farmers have been prompted to use more fertilizers and pesticides; since the water downstream from the dam now flows more slowly, there is greater growth of phytoplankton and consequently the water used for drinking has to be treated with greater amounts of chlorine; the stagnant water is a habitat for mosquitoes and snails carrying the parasite bilharzia.

- “On 13 October 1908, Fritz Haber filed his patent on the ‘synthesis of ammonia from its elements’ for which he was later awarded the 1918 Nobel Prize in Chemistry. A hundred years on we live in a world transformed by and highly dependent upon Haber-Bosch nitrogen” (Erisman, Sutton, Galloway, Klimont, & Winiwarter, 2008, p. 636).
  “It was ... the first serious human attempt at geoengineering the planet to bring about a desired goal. The scale of its success outstripped the imaginings of its instigators. So did the scale of its unintended consequences” (The Economist, 2011, p. 74).

Other well-known examples of unintended negative side effects are: global climate change caused by the emission of greenhouse gases caused by the use of oil, coal and natural gas to produce energy; the ozone hole caused by substances (no longer produced thanks to the Montreal Protocol) that destroy the “good” stratospheric ozone; not forgetting accidental events such as the oil spill in the Gulf of Mexico in 2010 following an explosion or the accident at the Fukushima nuclear plant in Japan in 2011 following the earthquake and tsunami.

If we want to be consistent with the new scientific vision, the Environmental Impact Assessment (EIA) of infrastructures and industrial plants, and the Strategic Environmental Assessment (SEA) of plans and programmes should not to be considered the juxtaposition of sectorial analyses, but a transdisciplinary procedure; the dynamics of one sector cannot be separated from the others and different expertise must be integrated.

**Technology and democracy**

As it has been pointed out in several papers since the 1960s (see, e.g. Funtowicz & Ravetz, 1991; Weinberg, 1972; White, 1967), to correctly apply scientific knowledge and its tools for environmental stewardship, ethical values, stakeholders and decisions must be considered. We are in the territory of so-called “post-normal science”, in a field where scientific aspects are inter-related to “trans-scientific” ones. I do not enter here into the vast debate that since the last decades of the twentieth century has flourished around words such as trans-science and post-normal science (just type these keywords into any search engine on the Internet for confirmation). The point is that such a debate is mostly confined to specialists, research workers and academics of the field, while it is absent or rare among technicians, decision-makers and the laity.

Today, values, interests and decisions are managed in a growing number of countries within so-called “democratic systems”. Without entering into the difficult question of the pros and cons of democracy (e.g. Dunn, 2005; Lukacs, 2005; Panikkar, 2000), I would like to quote here some thoughts about the relationship between technology and democracy:

Nowadays democracy has been effectively replaced by technocracy, which is the application of technology, and not the technique, the art and the ability to produce things for our well-being, pleasure and comfort. I want to stress that the term technique is akin to “tissue” and also “manual art”, in the sense of “touching”, as well as to the place where we put the “head”, without mentioning the Indo-European root “tekt”, from which “shape” and “give birth” originate.
Technocracy is, instead, the power of the machine, resulting in the dominance of the structure, and in order to operate it demands a mechanical and mechanized vision of reality. …

In this situation the individual, foundation of democracy, is subordinated to the specialized (i.e. partial) knowledge relating to only a part of human being, but not the whole. On the other hand, this individual, if he is really sincere, must admit that he knows almost nothing about what concerns atomic energy, economics, chemistry, coal and many other things. So how can we give responsibly our vote on matters that require years of study and are of extraordinary complexity? How can we form our opinion, albeit rough, and then vote accordingly?

I repeat: technocracy has replaced democracy. (Panikkar, 2000, pp. 35–37)

These statements are, if possible, even more urgent and pressing in the first decades of the third millennium: debates on the future of our planet are literally submerged by scientific and technological issues.

The demographic dimension

Another aspect that cannot be overlooked when tackling environmental issues is demography.

From the first appearance of human beings (at least 2,500,000 years ago) until 1400 BC, the world population did not exceed 100 million. Civilizations such as those of ancient Egypt, Mesopotamia and the Indus Valley developed in a world with fewer than 100 million people. It took about 1400 years for the world population to double, and until the birth of Christ the human population probably did not exceed 200 million. The Iliad and The Odyssey, the Psalms, the Vedas and the Upanishads, Ionic lyric poetry and Attic tragedy, Plato’s dialogues and Aristotle’s metaphysics, the poetry of Horace and Virgil, the thoughts of Buddha and Confucius developed in a world with fewer than 200 million people (less than the population of France, Germany and Italy put together!).

A further doubling of the world population occurred over the subsequent 1200 years, with the flourishing of Latin and Byzantine Christian civilization and Islam. We could say that the foundations of our culture and civilization were laid in a world with fewer than 400 million people.

Between 1200 and 1700 – a period of 500 years – world population rose from 400 million to 800 million; 130 years later there were more than 1 billion people on Earth.

Over 2 billion in 1930, only 100 years later, and 7 billion in 2011, only 80 years later!

A world of 7 billion people is radically different from a world with 200 or 400 million. It is hard to visualize such a gigantic number: 7 billion, a number equal to 35 times 200 million! We are in the Anthropocene, the era in which man is the main force that shapes planet Earth, due to its enormous population and formidable technological capabilities (Crutzen & Stoermer, 2000).

Paradoxically, we continue to teach our children to relate to a world with around 200 or 400 million people in it, a world that is “empty” and “unlimited”, that no longer exists, a world with a population 20–30 times lower than today: a real cultural bias (Douglas, 1982). Much that is still taught in universities and practised considers air, water and land as unlimited resources: it is the “economy of the cowboy”, of unexplored regions and open spaces, that characterized the European colonialism of the modern age and the epic of the American Far West. This type of economy sees great opportunities in the exploitation of the natural gas and oil of the North Pole, which is now possible thanks to the melting of Arctic ice – a staggering alteration that dramatically illustrates the changes taking place on our planet due to global warming (cf., e.g. The Economist, 2012). The same economy advertises monumental SUVs (sport utility vehicles) in unlimited natural spaces (when we are trapped in the daily city traffic) and continues to consume the territory, with dramatic consequences in terms of floods and landslides.

We need to change our categories, paradigms and mentality: we need new visions, cultures and beliefs, if we are to get ahead in this “full” world.
Conclusions

In my opinion there is a mismatch between: (a) the traditional vision of reality centred on the Newtonian mechanistic approach that is still strong and (b) the new vision of reality emerging from the latest scientific findings. In this paper, I have tried to explore the implications of both concepts in the context of environmental issues, emphasizing how often the traditional mechanistic model still prevails, even among technicians, experts and practitioners. The understanding of technology and environmental management continues to be mainly based on the assumption that it is possible to fully know and control nature, and trusts in the absolute power and capability of technology. Without trying to be exhaustive or definitive, I have also argued that with regard to environmental issues, more advanced scientific concepts disagree with the traditional mechanistic approach which is responsible for strong distortions.

It is relevant to note that a similar situation may be seen in the fields of economics and finance: a growing number of insiders affirm that current economic crises are not cyclical, but instead indicate a change in the system; to govern this transition, new approaches and instruments are necessary (see, e.g. Jackson, 2009). Economic crisis and ecological crisis are two sides of the same coin; the critical point is that the world’s economy and finances still operate prevalently without any respect for the environment, and often against it.

With a growing number of voices invoking new concepts and tools (since traditional ones seem inadequate to manage the complexity of the present situation), the mechanistic concept is still the most popular, schools continue to favour this vision and the media also. The triumph of technology – whose roots are firmly fixed in the mechanistic approach – and its pervasiveness do not help to bring into question the mechanistic concept. There is no doubt that this approach has been extraordinarily successful in spreading knowledge and as a means for shaping reality and using natural resources. We continue to mistake it for scientific progress – instead it is technological progress – and the most advanced concepts are still the heritage of a minority. Even in environmental management, the mechanistic approach seems to prevail, despite the growing number of voices warning against an idea that feeds on extreme confidence in the abilities of science and technology:

I personally doubt that disastrous ecological backlash can be avoided simply by applying more science and more technology to our problems. (White, 1967, p. 1206)

… there are reasons which lead to doubt that science, at least in some classes of problems created by itself, is currently under such conditions as to make reliable predictions and assessments, useful in the short term to establish technology policies aimed at greater rationality, locally and globally. (Gallino, 2007, p. 168)

Yet this naive confidence in the capabilities of science and technology is still expressed by technicians, researchers, professionals and other experts. The fact is that schools continue to teach the Newtonian view of the world, ignoring or only skimming over more modern concepts (except in specialized university courses where the emphasis is on technicalities and not on their cultural implications). This does not help, in fact it hinders the development of a culture that could be more attentive to complexity and less prone to false and trivial mechanistic visions of reality. If our children do not “internalize” these modern concepts, they will continue to believe in the old vision. To make young people internalize new visions, they need to be fully understood and accepted by schools and the teaching profession. There is much work to be done …

To conclude, it would seem to me that we need to encourage a change in the idea we have of science and technology, progressing from a magical, infantile concept of the omnipotence of science and technology to a more adult concept that knows its own limitations, as well as its potential – both the positive and negative.
It is necessary to encourage discussion among experts and practitioners of science and technology, as well as among policymakers and people in general. Debate on the visions and roles of science and technology must not remain confined to elitist groups, but must become a broader process, with the aim of promoting a more adult vision. Despite the Darwinian revolution, which returned man to nature as the product of natural selection, there is still much reluctance to accepting our true place in nature “… we are not, in our hearts, part of the natural process. We are superior to nature, contemptuous of it, willing to use it for our slightest whim” (White, 1967, p. 1206).

It is definitely time to change this vision, we need a new vision, one that recognizes the absolute novelty and uniqueness of our current situation, and the journey undertaken, in order to seize this great opportunity and complete the transition: the double trap that we must avoid is, on the one hand, the illusion that we can take refuge in categories of the past, unfit for the present and much less for the future, and, on the other, looking to the future with attitudes ranging from fear to cynicism. We need a vision that seeks responsibly to take the place of the current one, well aware in the process that results are not guaranteed but depend upon each and every one of us.

Acknowledgements

This paper originated from a speech that I was invited to deliver at the 11th Convention on Environment, Youth, Research in Rome, Assisi and Perugia on 21–24 June 2011. I would like to thank Gianluigi De Gennaro for inviting me to the Convention and giving me the opportunity to go deeper into issues that are vital for my job. A special thank you to Anna Chiesura, Felicity Chugg, Guglielma Gareri-Goldenberg, Letizia Maita and Anna Laura Saso for revising the text and for their stimulating comments and suggestions.

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