Chapter 10
Technology and Ecology

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Anticipating a shift in our collective worldview the holistic philosopher Lewis Mumford, in *Technics and Civilization,* advocated a new culture in which, rather than simply shaping our lives, a new form of humanistic technology immersed in the social milieu would become an evolutionary instrument enabling a better quality of life by actively enhancing our environmental setting. Mumford believed that what distinguished humanity from other species, was not primarily our use of tools, but our use of language. Widespread electrification and mass communication, in better connecting us, would allow us to share our, "wishes, habits, ideas, and goals", and so build "a better world for all".[1] Technology was one part of technics but for Mumford for it to be durable, effective, and efficient it had also to be fused with human spirit and creativity. Later Thomas Kuhn in *The Structure of Scientific Revolutions* challenged the prevailing view of progress in science as a continuous accumulation of accepted facts and theories, arguing that often advances in science have been more sporadic in nature. Asking new questions of old realities, he said, had led to game-changing periods of ascendant transformation. Rather than accepting the unwavering logic of constant growth, Kuhn's concept of paradigm shift[2] offers the tantalising prospect of advancement through discontinuous revolutionary breaks with our earlier thoughts, beliefs, values, and experiences. Both concepts sanction a transition towards an ecological view[3] of the world that is achievable, and provoke the prospect of realising a different world through a radical redefinition of the faltering relationship between society, technology, and nature.

The mechanistic worldview that has determined nature as a machine composed of related but discrete components helps to support the commonly held idea that humans are at the pinnacle of creation, the source of all value, the measure of all things. In offering resistance to this way of thinking and rejecting the assumption of human self-importance in the larger scheme of things, physicist Fritjof Capra has argued that our society is now embarking on a fundamental shift towards a more ecological, holistic, organic, or systemic view of the world.[4] This chapter identifies threads of the mechanical and ecological paradigms and describes some characteristics that seem to signal a shift from one to the other giving emphasis to the importance of aligning future technological developments with ecological values and the practice of sustainability.

Constant Craving and Ecological Limits

Developments in science and technology have without question driven our evolutionary progress and helped shape our modern lives. Advancements in scientific knowledge and technological skills and expertise have been beneficial in helping improve health, raise standards of living, and enhance global communications. Nevertheless, when viewed through

[1] Mumford 1934.

[2] Kuhn 1962.

[3] The word *ecology*, coined by the German biologist and philosopher Ernst Haeckel (initially as *oecology*) in 1866 derives from the Greek *oikos*, referring originally to the family household and its daily operations and maintenance. Haeckel described ecology as the study of the relationships between living things and the environment in which they live. Today this definition has been expanded to refer to the larger cosmic household here upon Earth. Cited in Worster,1985. See also Dobson 1995.

[4] Capra 1986.

a critical lens, such progress has been achieved at considerable environmental and human cost.[5]

Contemporary discourse within the sustainability agenda upholds the belief that social and environmental problems arise largely from seeing ourselves as separate from nature. The *mechanistic* (or *reductionist*) paradigm has roots within the European scientific revolution influenced by Copernicus, Kepler, Newton, and Galileo, and has dominated our culture for several hundreds of years, having shaped Western society and significantly influenced the rest of the world. While a mechanistic view of the world has underpinned enormous changes impacting on all aspects of modern life and brought many benefits, relatively recent discourse around the sustainability agenda has brought into question long held assumptions with respect to aspects of economic growth, along with previously entrenched ideas and values (e.g. nature exists to serve humanity). Sustainability involves a move from a current condition of unsustainable activity towards a process of improvement and increased quality. Essentially the term is used to indicate a change of attitude prioritizing ways of life that are in balance with the current renewable resources of the ecosystem and the biosphere. Although we are unclear about how much damage has already been inflicted on the biosphere the thesis proposes a precautionary approach as a practical way forward. In the face of inherent uncertainty, risk is deemed inappropriate, since failure to maintain a viable biosphere will be catastrophic and irreversible. The widespread interest in theories, ethics, and practice concerning sustainability indicates an increasing concern around the adverse impacts that conventional models of development have had on the environment, in both the developed and undeveloped parts of the world.[6]

Capra argues that the major problems of our time require a radical shift in our perceptions, our thinking and our values as radical as the Copernican revolution; one which is underpinned by a new perspective pre-figuring an integrated network of all living and nonliving parts. With echoes of the medieval cosmology depicted in the Great Chain of Being, actions in any one part this network affect the equilibrium of the whole. In support of his assessment that a mechanistic paradigm is now giving way to an ecological one, Capra sees the convergence of a number of theoretical/conceptual positions (ecology, feminism, community politics, environmental economics, consciousness raising) which to varying degrees augment an ecological view and support different groups working on a variety of causes with common elements, increasingly being brought together in collective action. James Lovelock's Gaia hypothesis, for example, presents the Earth as a self-regulating system within which conditions suitable for life are maintained by feedback processes involving both living things and the non-living part of the planet.[7] But rapid growth in populations, economies, and cities since the industrial revolution has placed the system under huge stress. Richard Douthwaite in *The Growth Illusion* (1992) asked how it is that we could have progressed along the path of economic growth, technical innovation and increasing efficiency for so long and yet end up with massive unemployment, widespread poverty and the fear of economic and ecological collapse. His answer is that "economic growth has enriched the few, impoverished the many, and endangered the planet".[8] He argues that as economic growth continues it takes more and more resources to achieve additional increments of growth. The whole process, in effect, becomes progressively more inefficient.

[5] Barbour 1991.
[6] Grierson 2003.
[7] Lovelock 1979.
[8] Douthwaite 1992.

The last fifty years has been marked by an intensification of concern about pollution and an awareness that environmental problems arise within the context of a complex interrelationship between humans, their resource base, and the social and physical environments.[9] Consequentially questions about the objectives and strategies of conventional growth policies have been brought to the forefront of public debate. In 1972 *The Limits to Growth* report by the Club of Rome (the name given to an "invisible college" of scientists, researchers, industrialists who conducted the research), described the results of a complex computer model, which they argued outlined the "predicament of mankind". In neo-Malthusian fashion the report indicated that if the then current growth trends in world population, industrialisation, pollution, food production, and resource use continued, the planet's carrying capacity would be exceeded within a hundred years, bringing about a disastrous "overshoot and collapse", ultimately leading to "eco-catastrophe", famines, and wars. The fundamental problem according to the *Limits* thesis is that global growth in resource use, industrial output, population and pollution is exponential. The report explained that, "A quantity exhibits *exponential* growth when it increases by a constant percentage of the whole in a constant time period".[10] This kind of growth displays a gentle and gradual curve for a long time but then rapidly shoots up in a very short period. Translated to the arena of industrial production, resource depletion, and pollution, what seems an innocuous rate of use and waste disposal can quickly result in dangerously low levels of available resources and dangerously high levels of pollution. The theory, in applying thermodynamic laws to economics, argues that all production that uses material and energy eventually transforms them into a more random, chaotic, or disordered, state.

Inspired by nineteenth-century liberal philosopher John Stuart Mill, who proposed the idea of the "stationary state" as a counterpoint to the relentless selfish and competitive drives at the heart of capitalism,[11] Herman Daly suggests that there is a limit to the use we can make of scarce resources when exponential extraction leads to sudden exhaustion. Waste, he says, is an inevitable by-product of the extraction and use of resources. For Daly, "living in intimate contact with garbage and noxious wastes is a by-product of growth."[12] He sees environmental degradation as a disease induced by economic "doctors" who have tried to treat the basic sickness of unlimited wants by prescribing unlimited production.

Economic growth in the conventional sense is ultimately more of a problem than a solution because it damages the environment and leads to social injustice. While it may be anathema to many to abandon our constant craving for material wealth and redefine our notion of growth, modern environmentalists recognise the necessity of an ecological society based on a comprehensive set of sustainable policy objectives that cover all aspects of our lives; economic, social, cultural, political, technological and environmental. Such a society, if it can be constructed at all, will acknowledge that there are ecological limits to material growth.

Imperceptible Changes and the Illusion of Free Will

> *Changes from one kind of civilisation to another do not happen often in history: the invention of agriculture, the rise and fall of conquest states…and the coming of*

[9] Turner 1988.
[10] Meadows et al 1972.
[11] Daly 1977.
[12] Daly 1991.

> *industrialism. An earlier generation may have been justified in discounting any further such radical changes. We cannot. Most trends of the past are simply not sustainable.*[13]

The dramatic changes of thinking that took place in the field of atomic and subatomic physics at the beginning of the twentieth century led Kuhn, in 1962, to define the idea of a scientific *paradigm* as, "a constellation of achievements – concepts, values, techniques, etc. – shared by a scientific community and used by that community to define legitimate problems and solutions."[14] Kuhn argued that a paradigm gains its status because it is more successful than a competitor at solving some problems that have been recognised as acute, and that changes in world views occur in sporadic, progressive spaces, which he called *paradigm shifts*. The nature of these transitional periods is such that it is not always possible to accurately trace the rise and fall of new ideas as their beginnings may be barely perceptible and they might end unnoticed. Kuhn also displays a sense in which paradigms not only belong to a scientific community but also apply to wider society and its relationship to nature. Although some question his analysis, suggesting that the shift from classical to quantum theories in the twentieth century failed to display all the characteristics he suggests, the notion of paradigms is useful in allowing us to theorize on how societal and environmental change may occur.

The underlying causes of the modern environmental crisis in its widest sense lie in the revolutions of science, religion and economics in the early modern age, which helped to lay down the foundations of the dominant Western worldview, and shaped institutions such as the systems of capitalism and state socialism. From the middle of the sixteenth century to the end of the seventeenth, early modernism and the principles of classical science established ways of thinking about the world and our position in it, which were vastly different from the medieval cosmologies and pre-modern notions that had preceded them. Seeing ourselves as separate from nature follows ideas of Rene Descartes, who saw science as rendering us the "masters and possessors of nature"[15], and in particular, Francis Bacon who saw it's potential in "enlarging the bounds of Human Empire".[16] Although now refuted, classical science held that the machine of nature is composed of discrete components. Its fundamental particles, like atoms, electrons, and quarks are solid bodies in empty space. We, as observers of nature (subjects) were separate from it (the object) so we could be "objective", impersonal, or detached about it. The widespread acceptance of this view, which led to the belief that we humans are at the highpoint of creation, became deeply embedded in our culture and consciousness. The historical roots of this perspective coincide with the beginnings of industrial capitalism. The science associated with this period is characterized as being primarily concerned with achieving material progress and was imbued with values identified with liberalism and the French Revolution. From ancient times the main goal of science has been gaining wisdom and understanding while remaining in harmony with nature. However in the Western world, since Bacon, the goal of science has tended to be patriarchal and has largely involved the pursuit of knowledge in order to control and exploit nature. Dualism, as between mind and matter, championed by Descartes, sets the paradigm for understanding most of Western culture. Descartes doubted everything until he reached a definite conclusion in his famous dictum *Cogito ergo sum*.[17] He deduced from this that since thought was the essence of nature, mind and matter were separate and distinct entities. The material world was a machine without life or spirit. The natural world functioned in accordance with

[13] Goerner 1999, 32.
[14] Kuhn cited in Capra 1986, 3.
[15] Descartes 1637, Part VI.
[16] Bacon 1626.
[17] Descartes 1637, Part I.

mechanical laws and nature could be explained in terms of the mechanistic movement of the parts. Even human beings belonged to a category of machine in which the human body was seen as a container activated by a soul that was connected to the body via the pineal gland in the brain. Thanks to Cartesian dualism the mechanical view of nature became the dominant view of "classical science". Isaac Newton derived a mathematical formulation that undertook Descartes' work and completed the mechanistic world-view. For Newton, God had set the whole universe in motion and it has continued to run ever since like a machine governed by immutable laws. Such a view is essentially deterministic and fatalistic. It says that given sufficient knowledge of nature's laws we could have predicted the present. The future is already cast, and free will is an illusion.

Capra suggests that the mechanistic paradigm is now receding because, as a model, it has a number of entrenched ideas and values that have recently been brought into question, namely:

- the view of the Universe as a mechanical system composed of elementary building blocks;
- the view of the human body as a machine;
- the view of life in society as a competitive struggle for existence;
- the belief in unlimited material progress to be achieved through economic and technological growth;
- the belief that a society in which the female is subsumed under the male follows a basic law of nature.[18]

Against the Plague Wind

In *A Green History of the World* Clive Ponting relates many examples where human societies have failed to achieve a sustainable balance between their own material demands and the environment's well-being. He describes the Sumerian empire as the first literate society on Earth to succumb to self-inflicted ecological collapse. The technical innovation of irrigation, which had been invented around 5500 B.C., eventually brought Sumeria to its nemesis. Irrigation increased crop yields substantially but it also increased the salt content and the ability of the soil to retain water. The rapid population growth, which resulted from increased crop production, meant that the land could not be left to lie fallow in order to recover. Crop yields remained high for a time, but collapsed abruptly in 2400 B.C. The food shortfall made it difficult for the empire to support its army and Sumeria was conquered within a few decades. The rise and fall of Sumeria illustrates a tendency that has shown itself time and again in the history of human society: a given technological development increases humanity's ability to extract a higher level of comfort from the natural world, but it does so at the cost of greater environmental damage. Ponting points out that damage to the environment was usually one among a number of factors, which caused these societies to come apart, and in such cases, "the decline and eventual collapse were usually prolonged…and generations living through this process would probably not have been aware that their society was facing long term decline".[19]

Classical science asserted that the world operated according to consistent physical laws, which could be discovered through reason and experiment and applied to practical effect. To a rising class of European modern capitalists during the sixteenth to eighteenth centuries, better knowledge resulted in better machines, which lowered production costs, attracting

[18] Capra 1996.

[19] Ponting 1991, 401.

more and more people into the system, and accumulating the capital needed to develop better production methods and machinery. By the late eighteenth century the pursuit of technological advantage in Britain had culminated in the industrial steam engine, a machine, which would power the Industrial Revolution through the next hundred years. During the nineteenth century advances in technology raised the standard of human welfare across Europe but inflicted greater environmental damage as forests were systematically destroyed. Eventually, because wood was becoming a scarce resource, it was replaced by coal as the primary source of fuel. For centuries humans had limited the burning of coal, because as a source of fuel it was inefficient, messy and difficult to extract from the ground. Dwindling wood stocks and technological breakthroughs in the 1840s enabled coal to be converted into heat much more efficiently and the industry grew rapidly. But the environmental trade-off for coal was worse than it was for the steam engine. As "progress" became the key word of nineteenth century philosophy and politics, massive increases in production and efficiency were accompanied by blackened skies, putrid rivers, and other side effects leading to William Blake's passionate assault on the "dark Satanic Mills" of industrial England.[20]

The ideas, beliefs and values held within *sustainability* (as the pursuit of an ecologically benign culture) are historically derived from a diverse range of philosophical and ideological sources. Some have likened the modern surge in ecological awareness to the growth of religious sects in the seventeenth century – the Shakers, Quakers, Diggers, Ranters, Pilgrims, Fifth Monarchists, and Levellers. Their fiercely independent spirit of egalitarian politics, their love of the Earth, their decentralist tradition, and their passionate spiritual commitment certainly number them among a long line of antecedents of an ecological world-view. Within the eighteenth and nineteenth century Romanticism expressed by Thomas Carlyle; John Ruskin; and the Romantic poets, Blake; Wordsworth; Coleridge; and Byron we can identify a revolt against capitalism and the utilitarian, materialistic values of the time. They shared concern for the increasing effects of industrialisation and urbanisation on the landscape alongside a desire to hold on to traditional values and beliefs in the face of tumultuous change. Perhaps the foundation of an ecological sensibility is most clearly reflected in Ruskin who in 1859 lectured Bradford manufacturers on the potential total disfigurement of the English countryside by spreading industrialisation and later carried out practical experiments in combating pollution. Ruskin called for a renewal of moral and spiritual values in society. In *The Storm Cloud of the Nineteenth Century* he noted that climatic deterioration and pollution were creating a new form of cloud, a "loathsome mass of sultry and foul fog, like smoke…a plague wind".[21] Apparently referring to the pollution from the blast furnaces at Barrow-in-Furness, what seemed to concern him most was the symbolic nature of the cloud as the material expression of moral decline instigated by industry and commerce.

Shifting Paradigms

Neil Armstrong's "small step" from Apollo 11's *Eagle* landing craft onto the Moon's surface in 1969 (the climax of a massive, politically driven, scientific and technological *coup de grâce)* served to embody an anthropocentric spirit inherent in the Baconian creed. But his "giant leap for mankind" also served as inspiration for an evolutionary stewardship approach that saw in an emancipated humanity the expression of a natural evolution rendered self-conscious.[22] Some of the younger generation, raised on the exhilaration and hopefulness of

[20] Blake 1808.
[21] Cited in Cosgrove 1984, 251
[22] Bookchin 1990.

space exploration and science fiction, turned their attention away from a technological future back towards Earth to confront life in all its organic richness, diversity, and creativity. In the United States campus riots and civil rights demonstrations led to the "summer of love" and onto a farm in Woodstock, where half a million turned up to "tune in and drop out" and "go with the flow" in the physical and spiritual footsteps of the beat authors and poets like Jack Kerouac and Alan Ginsberg. For many the challenge wasn't any longer technological but rather philosophical. It was really about how to get "back to nature".

A rejection of the assumption of human self-importance in the larger scheme of things has a long history that can be traced back through the wilderness/environmental/land ethics of Henri David Thoreau[23], John Muir[24] and Aldo Leopold[25], to the fraternal teaching of Saint Francis of Assisi (the "patron saint of ecology"), and further into the past within medieval and Renaissance cosmologies, with their images of the world that were holistic, organic, ecological, and spiritual. The medieval organic metaphor of nature also derived from a human experience in which the Earth was perceived as a living body wherein the circulation of water through the rivers and seas was comparable to the circulation of blood; the circulation of air through wind was the breath of the planet; volcanoes and geysers were seen as corresponding to the Earth's digestive system. And there were a number of Renaissance organic philosophies based on the idea that all parts of the cosmos were unified in mutual interdependence, in which everything was saturated with life, and it was impossible to distinguish between living and non-living things. Earth was a living being among humans. Even although she could also be unpredictable, wild, passionate, and dangerous, "Mother Earth" nourished and nurtured us, and so should command respect and reverence.

The organic view and the medieval cosmology stemmed from the Great Chain of Being, which had originated with the Greeks and had been transmitted to medieval writers who adapted it to their own cosmology. The Great Chain is a designed hierarchy in nature in which all matter, from rocks to angels, is in possession of a soul, and all earthly species of organic life have their appointed place on the chain, from the insects above the rock to the humans below the angels. All were joined together in a fixed hierarchy, and were interdependent. The metaphor and related ideas, which continued to influence essential assumptions framing scientific theories into the eighteenth century, placed people and nature in a mutual relationship in which each link in the chain was vital for the continued existence of the whole chain. The elimination of one link would dissolve the whole cosmic order and render the world muddled and disjointed.

The idea of a coherent cosmic order based on continuity and gradation was tied to the notion of "plenitude", or "abundance", which held that the world is filled with diverse living things such that all species that could theoretically exist do in fact exist. Fullness stemmed from a hypothetically infinite process of reproduction. The diversity of living organisms was deemed to be so great and the numbers so abundant that some feared that a single species could multiply indefinitely and eventually cover the entire Earth. This view led Malthus (in 1798) to posit that humans could theoretically fill not only Earth, but all planets in our solar system if population growth was not held in check by wars, famines, disease, and poverty, and by competition between and within species.[26]

[23] Thoreau 1854.
[24] Muir 1901.
[25] Leopold 1949.
[26] Malthus 1778.

Many today advocate a sustainable society, not because they think it would be a better place to live, but because they believe they occupy a scientifically and sociologically legitimate position. Environmental sociology offers a critique aimed at the lack of human-environmental focus in classical sociology, and has led to a new perspective that takes account of interrelationships between environment and society, environmental variables, and feedback loops from ecosystems. The New Environmental Paradigm (NEP) acknowledges that the biosphere can impose constraints on human activity.[27] It follows the post-modern ecological view of science borrowed from a number of writers in the first half of the twentieth century, including Alfred North Whitehead, Henri Bergson, and Lewis Mumford. The view draws on the work of Michael Faraday (particularly in the sense that his *electromagnetic field* refuted the Newtonian idea that all entities were separate and governed by fundamental mechanical laws determined by God), Albert Einstein (whose *relativity theory* offered an interconnected view of the Universe), *evolutionary theory* in biology, and in *quantum theory* within subatomic physics. Lovelock's *Gaia hypothesis*, relating aspects of Greek and Medieval cosmologies, the organic metaphor, and new physics, refers to the Earth as a self-regulating organic system, striving toward a steady-state condition favourable for the maintenance of life, while being capable of responding to changing needs for human sustenance.[28] The concept sees the Earth as a self-regulating system which is impacted upon by humans but cannot be controlled by them and in which conditions suitable for life are maintained by feedback processes involving both living things and the non-living part of the planet. According to the hypothesis, the self-regulating organic system is striving toward a steady state condition favourable for the maintenance of life, while being capable of responding to changing needs for human sustenance. In seeking homeostasis this complex system can adjust, within certain limits, to large-scale human technological interventions. But the current pattern of urbanisation, resulting as it does in energy-intensive, highly-pollutant, forms of human settlement represents interventions which are spiralling out of control, causing levels of environmental degradation and social disruptions that threaten the planet's equilibrium.

We now have irrefutable scientific evidence that our activities are harming the biosphere and human life in alarming ways that may soon become irreversible. Advances in satellite technology have provided environmental data giving us crucial insights into changing geological patterns, rising sea levels, and the depletion of the ozone layer. What the evidence points toward is global environmental problems on an unprecedented scale; rapid depletion of natural resources, energy and materials, atmospheric pollution, climate change, deforestation, and dramatic loss of biodiversity. The more we investigate these problems the more we come to realise that they are interconnected and interdependent. Scarcities of resources and environmental degradation combine with rapidly expanding populations leading to the breakdown of communities, collapsing infrastructures in cities, and to ethnic and tribal violence. Stabilising the world population growth rate will only become possible when poverty is reduced throughout the world. The mass extinction of animal and plant species will go on as long as the developing world is burdened by huge debts. Environmentalists now describe these problems as different facets of a single crisis deriving from an out dated worldview that is no longer adequate for dealing with an overpopulated, hyper-consuming, globally connected world. Many advocate that it is the dominant attitude towards nature and the environment in Western society underpinned by a long-standing and far-reaching mechanistic paradigm that needs to change.

[27] Catton and Dunlap 1978.
[28] Lovelock 1979.

When Capra describes how the major problems of our times require a radical shift in our perceptions, our thinking and our values, he generalises Kuhn's definition of a scientific paradigm to that of a social paradigm. Capra's analysis of cultural transformations defines, a set of beliefs and practices shared by a community, which forms a particular vision of reality and a basis for the way the community organises itself.[29] Towards the end of the Second World War, Mumford foresaw not only the imperative for change but signs that we were beginning to embrace a new humanistic vision for an emerging global culture:

> *An age of expansion is giving place to an age of equilibrium. The achievement of this equilibrium is the task of the next few centuries…The theme for the new period will be neither arms and the man: nor machines and the man: its theme will be the resurgence of life, the displacement of the mechanical by the organic, and the re-establishment of the person as the ultimate term of all human effort. Cultivation, humanization, co-operation, symbiosis; these are the watchwords of the new world-enveloping culture. Every department of life will record this change: it will affect the task of education and the procedures of science no less than the organization of industrial enterprises; the planning of cities; the development of regions; the interchange of world resources*.[30]

Throughout the twentieth century the displacement of the mechanical by the organic has taken a variety of forms and moved at different speeds in disparate fields. It has involved revolutions, reactions and complex oscillations but primarily the basic tension was always between the parts (the mechanistic, reductionist, or atomistic) and the whole (the holistic, ecological or systemic). In dealing with our growing environmental and social problems however, the deterministic and mechanical view of the world, continues to promote a specialised instrumental approach, which relies heavily on scientific method and technological know-how. When associated with the relentless pursuit of material progress, based on a no-limits mentality, we appear blind to the fact that beyond a certain threshold (carrying capacity) we will inevitably deplete the world's natural resources and overburden the biosphere with waste products incapable of being absorbed by Gaia's self-balancing system. In effect we undermine the Earth's equilibrium-seeking mechanisms. When confronted with the evidence of ecological overreach and collapse, the default response is generally (and unsurprisingly) reductionist; limited to strategies of policy reform geared to the technological solution – we continue to emphasise technological means for solving problems which are essentially ecological in origin. This almost universal and implicit assumption that all of our modern problems (rapid population growth, pollution, the threat of nuclear conflict) have a technical solution is contested. In *The Tragedy of the Commons* Hardin defines a "technological solution" as one that requires "a change only in the techniques of the natural sciences, demanding little or nothing in the way of changes in human values or ideas or morality."[31] If technological answers to problems associated with growth are inadequate, then it follows that more profound social, cultural, political, economic and environmental transformations will be essential to "building a better world for all", and in redefining the notion of progress. For Hardin such changes will require the recognition of the necessity of "mutual coercion" in social arrangements (e.g. pollution taxes) and a careful rethinking of the meaning of "freedom". He points to the legislation against robbery as an example of society becoming more, not less, free through mutually agreed laws. Quoting Hegel, Hardin reminds us that, "Freedom is the recognition of necessity".

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[29] Capra 1996.

[30] Mumford 1944, 598-99.

[31] Hardin 1968, 1245.

Technology, the Cause and the Cure

According to Barry Commoner pollution is an unintended by-product of the drive to increase profit by introducing technologies that increase productivity, and is intensified by the displacement of older techniques by new, ecologically faulty, but more profitable technologies.[32] In this causal relationship between pollution, economy, and modern technology, the cost of environmental degradation is borne, not by the producer, but by society as a whole. Polluters are therefore being subsidised by society. It is the kind of relationship that must be redefined in the midst of an ecological crisis. During recent decades the increasingly popular notion of sustainable development has been propelled to the forefront of our thinking, and our policy debates, because it promises to respond to an irreconcilable contradiction between growth and limit agendas, and the conflicting territorial challenges posed by society, technology, and nature. Sustainable development "is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."[33] It contains within it two key concepts:

- the concept of "needs", in particular the essential needs of the world's poor, to which overriding priority should be given; and
- the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs.[34]

The urgency of the conflict steers an essential movement toward sustainability wherein the principle tension is between those who believe that technology can resolve all of our problems and those who know that it cannot. Theoretically at least it is conceivable that with sufficient investment in basic needs and infrastructure, communities in the developing world can provide the food, water, farmlands and industry needed to raise themselves above absolute poverty, with stable levels of population, and sustainable levels of energy and resource use resulting in better living standards for all. Achieving this will require us to carry out as many experiments and look to as many alternatives as possible. And perhaps it is just possible that, through careful research, innovation, and evaluation, we can develop sustainable technologies, and employ these productively at a reduced cost to the ecosystem, within our resource availability, while still maintaining our environmental and cultural integrity. But neither those who write-off science as a possible contributor to human well-being and environmental stability nor those who believe that technology will solve all of our human ills and rid us of all our environmental problems, can ever be more than half right.[35] Technology is both the cause and the cure of what ails us. Human strategy and planning is what gives it its stimulus and defines its limits. But the modern world, with its rapid growth in population, its pursuit of material wealth via increasing rates of resource consumption, and its rapid shift from rural to urban life via the process of urbanisation, lacks strategies to preserve, protect, and maintain an ecological equilibrium that could lead to a better world for all. Technological solutions, no matter how clever, cannot facilitate infinite growth in a finite system. Our technological expertise has, thus far, merely shifted the problem around often at the expense of more energy and resource use, and therefore more pollution. How such expertise in the future might be allied with a human spirit and creativity that will embrace an ecological view of the world could determine how our, "wishes, habits, ideas, and goals" are

[32] Commoner 1971.
[33] World Commission on Environment and Development 1987, 43.
[34] World Commission on Environment and Development 1987.
[35] Thayer 1994

not only communicated, but implemented. Better knowledge and better machines may well lead to technological advantage but, if we fail to acknowledge that many of our modern problems are ecological in origin; that technological responses must incorporate changes in human value and morality signalling a shift away from unlimited production and consumption towards a redefined relationship between society, technology and nature, sadly not to a better world for all.

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