
INTRODUCTION

Human beings are in the midst of creating a new world through science and technology. But what kind of world we create will not be decided by science and technology alone. It will depend even more significantly on our views, implicit or explicit, about the nature of the good life—about good and bad, right and wrong, and our abilities to enact ideals in the face of limited knowledge and temptations to ease or arrogance.

Virtually all sciences and technologies today have implications for ethics and politics, and ethics and politics themselves increasingly influence science and technology—not just through law, regulation, and policy initiatives, but through public discussions stimulated by the media, public interest organizations, and religious concerns. According to Alan Leshner, CEO of the American Association for the Advancement of Science, the largest interdisciplinary scientific society in the world, a new science-society relationship has emerged in the public realm and within the scientific community. As he wrote in the lead editorial in *Science* (February 11, 2005):

We've been used to having science and technology evaluated primarily on the basis of potential risks and benefits. However, our recent experience suggests that a third, values-related dimension will influence the conduct and support of science in the future.

In response, Leshner called on members of the technoscientific community to engage others in discussing the meaning and usefulness of science, engineering, and technology. But such engagement cannot be a one-way street; it must also stimulate scientists and engineers in self-examinations of the social character of their professions and the proper roles of science and technology in society. Additionally, the non-scientific public would

do well to eschew any easy criticism or naive enthusiasm in the pursuit of informed consideration. Such multipath assessment is precisely what science, technology, and ethics is all about, and the present encyclopedia aims to contribute in the broadest possible way to this on-going process of promotional and critical reflection.

To this end the *Encyclopedia of Science, Technology, and Ethics* has three objectives:

- To provide a snapshot of emerging bodies of work in the co-construction of an ethical, scientific, and technological world;
- To design and build bridges between these not always collaborative efforts;
- To promote further reflection, bringing ethics to bear on science and technology, and science and technology to bear on ethics.

Background: The Encyclopedic Idea

The term “encyclopedia” comes from the Greek, *enkyklios* (general) + *paideia* (education), and thus alludes to the classical conception of *paideia* as character formation that transmits a level of cultural achievement from one generation to the next among the educated few. In this classical form education came to include the liberal arts of logic, grammar, rhetoric, arithmetic, geometry, astronomy, and music. As achievements in these fields accumulated and became more extensive, explicit efforts were naturally undertaken to summarize them. Early examples of such summaries were the *Antiquitates rerum humanarum et divinarum* and *Disciplinae* of Marcus Terentius Varro (116–27 B.C.E.), neither of which survives. The oldest extant work in this tradition is the *Historia naturalis* of Pliny the Elder (23–

79 C.E.). The *Etymologiarum* of Isadore of Seville (560–636) became a work of standard reference that helped transmit classical learning into the Middle Ages. Medieval and Renaissance encyclopedias continued this tradition in, for example, the *Speculum majus* of the thirteenth century Dominican scholar Vincent of Beauvais and the *Encyclopaedia seu orbis disciplinarum tam sacrarum quam prophanarum epistemon* of the sixteenth century German scholar Paul Scalich, the latter being the first to use the term “encyclopedia” in its title.

The work with which the term is most commonly associated, the Enlightenment *Encyclopédie ou Dictionnaire raisonné des sciences, des arts et des métiers* (1751–1772) marked a three-fold change in the encyclopedia idea. First, the French encyclopedia was written to educate the many as well as the few; the aim was to popularize or democratize knowledge. Second, the knowledge summarized in the French encyclopedia included technical craft traditions as well as learned or intellectual knowledge, thus building a bridge between intellectual and workshop traditions of knowing and making. Third, the French encyclopedia proposed not simply to summarize existing cultural achievements but to produce new ones. In the project of the *philosophes* Denis Diderot, Jean d’Alembert, and others, the modern idea of education as going beyond the transmission of previous cultural achievements to produce new cultural formations found one of its paradigmatic cultural expressions.

As the modern project of knowledge production took hold it proceeded by means of disciplinary specialization. In this context the encyclopedic idea also became a kind of counter movement to the creation of more and more specialized knowledge in the physical sciences, the social sciences, the humanities, and the arts. Projects that exemplified efforts at synthesis range from G. W. F. Hegel’s *Encyclopedia of the Philosophical Sciences* (1817) to Otto Neurath, Rudolf Carnap, Charles W. Morris’s *International Encyclopedia of the Unified Sciences* (1938–1969).

It is on all three of these visions that the present *Encyclopedia of Science, Technology, and Ethics (ESTE)* seeks to draw. *ESTE* aims to summarize, in however provisional a manner, emerging bodies of knowledge bearing on the co-construction of an ethical, scientific, and technological world; to promote new collaborative efforts in this interdisciplinary field of thinking and acting; and to stimulate new cross-fertilizations and syntheses between science, technology, and ethics.

The ESTE Idea

Moral teachings and ethical inquiries regarding the creation and use of science and technology have been part of religious and philosophical traditions from the earliest periods. Repeated cautions about over reliance on science and technology occur in the primary texts of many religious traditions (see the Tower of Babel, the myth of Daedalus, and the tales of Chuang Tzu) and in classic Western philosophy (Plato’s *Gorgias*). By contrast, modern European history displays a rejection of the tradition of caution in favor of a commitment to science and technology as the best means to improve the human condition—even as restatements of caution have appeared especially in the Faust story, *Frankenstein*, *Brave New World*, and some popular science fiction.

Since their rise in the sixteenth and seventeenth centuries, science and technology have nevertheless been increasingly involved with a series of ethical and political challenges. During the eighteenth century, the Enlightenment and Romanticism sparred over the ethical character of the scientific view of the world in both epistemological and metaphysical terms. The nineteenth century witnessed the rise of major political reactions against the evils of the Industrial Revolution, reactions that influenced the military and ideological conflicts of the twentieth century. During the last half of the twentieth century whole new fields of ethical reflection emerged to deal with the technoscientific world of nuclear weapons (nuclear ethics), chemical transformation of the environment (environmental ethics), biomedical advances (bioethics), and computers and information technology (computer ethics). Additionally, the ethics of scientific research and of the engineering practice became specialized areas of study.

As the twenty-first century begins, ethical and political challenges have become global in scope and intensified by the terrorist use of technology and science. Science, technology, and ethics interactions thus transcend disciplinary and cultural boundaries—and promise to play ever more prominent roles in human affairs for the foreseeable future. *ESTE* thus aims to integrate more specialized work in the applied ethics of particular technologies, in the professions of engineering and science, and in science and technology policy analyses, to point toward general themes and grapple with contemporary issues, while including articles that provide historico-philosophical background and promote cross-cultural comparative reflection. Had *ESTE* needed a subtitle, it might well have been “Toward Professional, Personal, and Political Responsibility in

the Technoscientific World.” The goal is to help us all practice a more informed seeking of the good in the high-tech, deeply scientific world in which we progressively live.

Building Bridges to Promote Reflection

The field of science, technology, and ethics is not mature. As a result this encyclopedia seeks to exercise as much a creative or formative role as it does a reporting or summary one. *ESTE* is an experiment in synthesis. Although it is clear that advances in science and technology are insufficient in and of themselves to constitute true human progress, previous encyclopedic efforts to survey the ethical challenges involved with both advancing and responding to such advances have focused only on specific areas such as biomedical ethics, computer ethics, or environmental ethics—or provided synthesis at the higher level of ethics in general. The present encyclopedia is the first to attempt a mid-level synthesis of the various specializations of applied ethics as they deal especially with science, technology, engineering, and medicine in order to promote interactive scholarly reflection, practical guidance, informed citizenship, and intelligent consumerism.

To meet these diverse but overlapping purposes *ESTE* coverage aims to include (although not exhaust) four themes: (1) types of science and technology; (2) approaches to ethics; (3) types of science, technology, and ethics interactions; and (4) historical and cultural contexts.

(1) The terms “science” and “technology” are somewhat flexible. In the present context “science” indicates the modern sciences of physics, chemistry, biology, and geology—and their numerous extensions: psychology, nuclear physics, biochemistry, cosmology, and more. “Technology” refers primarily to the modern activities of making and using artifacts, especially in applied science, engineering, medicine, decision-making, and management. The merging of science and technology in science that is highly dependent on advanced engineering instrumentation (cyclotrons, electron microscopes, advanced computers) and major capital

investments, and in technology that is highly dependent on scientific knowledge or theory (designer materials, computers, biotechnology, genetic engineering, etc.) is sometimes referred to as “technoscience.” None of these understandings of science and technology are excluded from *ESTE*, although the encyclopedia has not been able to include everything equally.

(2) Ethics is likewise understood broadly to be concerned with all questions of right and wrong, good and bad, in science, engineering, and technology. Although science provides descriptive knowledge of the world, on its own it is not able to interpret the human meaning of this knowledge, nor to provide full guidance for distinguishing between proper and improper processes in the acquisition of knowledge. Likewise, engineering and technology provide increasingly powerful means, but tell us little about the ends to which they should be dedicated. Ethics, generally speaking, is concerned with identifying proper means and distinguishing good and bad ends. Traditions or schools of ethical reflection and analysis include those of consequentialism, deontology, virtue ethics, natural law, and more.

Adapting a working definition from the *Encyclopedia of Bioethics*, 2nd edition (1995), *ESTE* is concerned with the *multiple moral dimensions—from vision and conduct through decision and policy making at the personal, professional, and governmental levels—of science and technology broadly construed, and employing a diversity of methods in interdisciplinary settings*. This description emphasizes the unity of ethics and politics both within technoscientific communities and in the technoscience-society relationship.

(3) Science, technology, and ethics interactions can take place within technoscientific communities and outside of such communities. Furthermore, interactions outside professional communities may take place at the personal or public levels, thus suggesting the following matrix:

	Professional	Personal	Public
Science	Professional ethics of doing science	Personal interpretations and uses of science by non-scientists	Political and policy issues raised by science in relation to society
Technology	Professional ethics of doing technology, especially engineering and clinical medicine	Personal interpretations and uses of technology by non-engineers and non-physicians	Political and policy issues raised by engineering and technology in relation to society

External (personal and public) issues may further be divided into those that stress the social-political adjustment to accommodate scientific and technological change or questions about how society should promote, support, or regulate science, engineering, and technology. Science policy (both science for policy and policy for science) and technology policy are specialized approaches.

Each of the six matrix boxes further interact: professional ethics of science and engineering can overlap and influence each other; the social impacts of science and technology are sometimes difficult to distinguish; internalist ethics often has implications for external issues and vice versa. *ESTE* aspires to be cognizant of the full spectrum of this complex diversity in possible relationships.

(4) Science, technology, and ethics interactions in these broad senses have, furthermore, been examined from multiple historical and cultural perspectives: The Continental European tradition, for instance, tends to focus more globally on science and technology as a whole, whereas in the Anglo-American tradition the ethics of particular technologies (as in medical ethics or computer ethics), areas of professional practice (engineering ethics, business ethics), or issues (equity, privacy, risk) dominate. In *ESTE* perspectives from different philosophical schools are to be further complemented by those from diverse religious, political, and cultural or linguistic traditions.

Types of Articles

The Editorial Board considered these four themes in writing scope notes for *ESTE*'s more than 670 articles, using the following four-part categorization scheme:

1. Introductions and overviews
 - 1.1 Specialized introductions
 - 1.2 Overviews
2. Concepts, case studies, issues, and persons
 - 2.1 Key concepts
 - 2.1.1 Concepts, Ethical and Political
 - 2.1.2 Concepts, Scientific or Technological
 - 2.2 Case studies
 - 2.3 Issues
 - 2.3.1 Issues, Historical and Social
 - 2.3.2 Issues, Scientific or Technological
 - 2.3.3 Issues, Phenomena
 - 2.4 Persons and narratives

- 2.3.1 Persons and figures, premodern
- 2.3.1 Persons and figures, modern to World War I
- 2.3.2 Persons and figures, post-World War I
3. Sciences, technologies, institutions, and agencies
 - 3.1 Particular sciences and technologies
 - 3.2 Social institutions
 - 3.3 Organizations and agencies
4. Philosophical, religious, and related perspectives
 - 4.1 Philosophical perspectives
 - 4.2 Religious perspectives
 - 4.3 Political and economic perspectives
 - 4.4 Cultural and linguistic perspectives

The Topical Outline presents the full list of articles organized by these categories.

INTRODUCTIONS AND OVERVIEWS. As this categorization framework indicates, there are two types of introductory articles in *ESTE*. One consists of the thirty-three specialized introductions to existing applied ethics fields such as "Agricultural Ethics," "Bioethics," "Computer Ethics," and "Engineering Ethics." The second is a set of more than a dozen Overview entries that serve two kinds of purpose. In the first instance they are stand-alone articles to review a few central concepts such as Science, Technology, and Ethics themselves. In the second they provide introductions to composite articles. In both instances, unlike all other *ESTE* entries, they give internal references to closely related articles.

CONCEPTS, CASE STUDIES, ISSUES, AND PERSONS. The bulk of *ESTE* articles, as is appropriate in an emerging dialogue, deal with concepts, case studies, issues, and persons. In relation to concepts, the distinction between those classified as Ethical and Political in character (such as "Plagiarism" and "Trust") and those classified as Scientific or Technological ("Efficiency" and "Networks") could in many instances be contested. Why is "Aggression" ethical but "Ethology" scientific? Is not "Human Nature" as much ethical as scientific? But the interest here is simply to make a rough distinction between those more closely associated with ethics or politics and those more easily associated with science or technology. Ethics concepts also tend to have a longer history than scientific or technological ones. In each instance, however, articles aim to bring out both ethical and scientific or technological dimensions.

The distinction between Case Studies and Issues is likewise somewhat arbitrary, since along with such clear instances as the “DC-10 Case” and “DDT” are included the “Apollo Program” and the “Asilomar Conference.” But the intuition is that the case studies are modestly more closely tied to historical particulars than are issues. It is also important to note that *ESTE* has avoided attaching the names of persons to cases, at least in article titles, opting instead for more generic descriptors. Since there are an indefinite number of cases, there has also been an attempt to group some kinds of cases together, as in the three entries on “Misconduct in Science.” Among the case studies some are more expansive than others, often reflecting a sense that other material relevant to the case is provided elsewhere, but sometimes just as a result of the accidents or oversights that inevitably find their way into such a large compilation.

The separation of Issues into three types is again not meant to be hard and fast but suggestive. But some issues are more Historical and Social than Scientific or Technological. Then there are some Phenomena that have an issue-like dimension related to science, technology, and ethics. For instance, although the notion of elements is covered in the entry on “Chemistry,” to provide some historical and phenomenological perspective articles are included on what in the European tradition have served as the four traditional elementary phenomena: “Air,” “Earth,” “Fire,” and “Water.”

The classification of Persons and Figures is divided into Premodern, Modern to World War I, and Modern since World War I. The ancient/modern division is quite common. Using World War I as a divide in the modern period recommended itself because of the role the Great War played in stimulating recognition of the destructiveness of modern science and technology, and thus ethical discussion.

SCIENCES, TECHNOLOGIES, INSTITUTIONS, AND AGENCIES. Articles on sciences, technologies, institutions, and agencies are not comprehensive. For instance, although there is an article on “Chemistry” there is none on physics or biology. The reason is that chemistry tends to be an overlooked science when it comes to ethics, whereas physics and biology are dealt with in numerous other articles such as “Nuclear Ethics” and “Bioethics”. At the same time, because of the profound significance of the mathematical discipline of probability and statistics, together with its under-appreciation in ethical and political discussions, this topic has been given a somewhat more extensive treatment. The length of this treatment, which includes introductory technical material, reflects a belief in the importance of

this new form of thinking that demands both attention and comprehension especially in ethical assessment. In like manner, there might have been articles on a host of social institutions as well as organizations and agencies. The goal was simply representation and illustration of the importance that these realities must play in ethical reflection and practical action that engages the world transforming character of science and technology.

PHILOSOPHICAL, RELIGIOUS, AND RELATED PERSPECTIVES. Finally, the four sets of Perspectives articles—Philosophical, Religious, Political–Economic, and Cultural–Linguistic—aim to give *ESTE* a breadth that would otherwise be lacking. Here special efforts have also been made to secure contributors from throughout the world. *ESTE* represents authors from 28 countries, reflecting the growing interest of scholars worldwide in these important issues.

Organization of the Encyclopedia

Entries vary in length from 250 to 5000 words and are arranged alphabetically. In general structure they begin with a statement of how the topic relates to the theme of the encyclopedia, followed by some background of a historical or developmental character. The main body aims to provide an authoritative exposition of its particular theme, concept, case, issue, person, science or technology, or perspective, and to conclude with critical application or comments.

In selective instances entries are composed of more than one article. For example,

RESPONSIBILITY

Responsibility: Overview

Responsibility: Anglo-American Perspectives

Responsibility: German Perspectives

Since any article is going to exclude as well as include, and this kind of composite occurs only occasionally, references to Related Articles at the end of each entry provide another means for broadening a reader’s knowledge. In a synthetic, interdisciplinary encyclopedia like *ESTE* topics invariably have tendrils that reach out into multiple entries.

Bibliographies for each article are another important feature, often complemented by a few Internet Resources. They were prepared by the contributors and verified by a bibliographic editor. Although brief, bibliographies nevertheless serve different purposes from article to article. Seldom are primary sources listed. Some bibliographic items refer readers to sources used or

cited by the contributor with internal reference, for example: (Jones 2000, p. 100). In cases where a bibliographic entry is not explicitly used in the text it is often briefly annotated for significance.

The article bibliographies are supplemented by two appendices: a selective, annotated general bibliography; and selective, annotated list of Internet resources. Written entries are further enhanced with more than 300 graphics that range from tables to photographs.

SPECIAL FEATURES. The main body of alphabetical entries is complemented by eight introductory essays. Given the constructive character of the encyclopedia, these essays present selective but fundamental perspectives on the dialogue among science, technology, and ethics. These range from science and technology studies scholar Sheila Jasanoff's argument for new forms of citizen participation in technoscientific governance to engineer-inventor Ray Kurzweil's argument for the ethical responsibility to promote scientific research and technological development. Historian Ronald Kline compares and contrasts developments in research ethics and engineering ethics, while philosophers Deborah Johnson and Thomas Powers set out a new program for research in ethics and technology that would help bridge the divide Kline observes. Computer science philosopher Helen Nissenbaum argues for new practices in science and engineering that would complement the Johnson-Powers program in scholarship. Mathematician Valerie Miké proposes a new ethical use of scientific evidence in the promotion and utilization of both science and technology. Science, technology, and society scholar Carl Mitcham and philosopher and environmental scientist Robert Frodeman note some ethical challenges associated with the expansion of knowledge, both scientific and technological. Philosopher of science and technology Hans Lenk calls attention to a range of emerging, ethically relevant special features in contemporary technologies themselves.

These introductory essays, which are an unusual feature in an encyclopedia, are especially recommended to readers seeking synthetic perspectives. Although they are necessarily limited in their scope, they point the way toward the kinds of interdisciplinary reflection that is crucial to further enhancement of the science, technology, and ethics dialogue.

The Appendices are another special *ESTE* feature. Along with the "Selective, Annotated General Bibliography on Science, Technology, and Ethics," and the annotated list of "Internet Resources on Science, Technology, and Ethics", there is a "Glossary of Terms"

often found in discussions of science, technology, and ethics, and a "Chronology of Historical Events Related to Science, Technology, and Ethics." Finally, a set of ethics codes from around the world enhances appreciation of the truly transnational character of the science, technology, and ethics interactions at the levels of both theory and practice.

Comments and Qualifications

As will be immediately obvious to any reader, some topics are treated at greater length than others; some articles are more argumentative or polemical than others; and some articles contain more overlaps than others. Across all such variations, however, the goal has been a balance that would provide an index to emerging bodies of work contributing to the co-construction of an ethical, scientific, and technological world, enhance links between not always collaborative efforts, and further theoretical and practical engagements between science, technology, and ethics. Of course, in making such decisions there is never any one perfect way; there is always room for improvement.

With regard to length: Often less well known topics are treated at greater length than more well known. *ESTE* has, for instance, made no effort to replace other more specialized synthetic works such as the *Encyclopedia of Bioethics* (1978, 1996, 2004), the *Encyclopedia of Applied Ethics* (1998) and its offshoots, or the *Encyclopedia of Ethical, Legal, and Policy Issues in Biotechnology* (2000)—although it has tried to pick up many of the themes and issues found in such works and place them in a distinct and broader perspective. Additionally, in some cases contributors simply submitted articles longer than specified, but that were just so good it would have been a mistake to cut them.

With regard to polemics: There has been a serious effort to allow contributors when appropriate to express their views in stimulating, thought-provoking arguments rather than insist on rigid adherence to uniformly balanced reports that could come across as dull or pedantic. At the same time, efforts have also been made to complement arguments in one article with arguments in others.

With regard to overlaps: It has been judged a positive feature when, for instance, similar themes occur in entries on "Acupuncture," "Confucian Perspectives," and "Chinese Perspectives." Similarly, the importance of the idea of social contract for science justifies related treatments in entries on "Social Contract for Science," "Social Contract Theory," "Governance of Science, and Rawls, John."

The fields of economics and statistics presented special challenges. Ethics today cannot be seriously pursued without appreciation for the achievements in these disciplines, which themselves overlap. Contemporary economics is heavily mathematical, involving extensive use of probability and statistics, and it is for the latter an important area of application. Relations between a number of entries related to economics are highlighted in “Economics: Overview,” but a number of approaches were nevertheless slighted. There are two articles each for probability and statistics, with one containing a brief introduction to basic concepts in terms of elementary mathematics. The goal was to include sufficient technical detail and symbolism to serve as a point of entry to further study, but there are many illustrations and adequate narrative text to convey the main concepts to those who may prefer to skip over any unfamiliar mathematics. These technical articles provide useful background for more applied entries based on statistics, such as “Biostatistics,” “Epidemiology,” and “Meta-Analysis,” as well as for the implicit use of statistics in many other articles. They are further complemented by biographical entries on, for example, “Nightingale, Florence” and “Pascal, Blaise.”

Conclusion

In the world of high-intensity science and technology, how does one lead the good life? What is the form of

the just state? Is it sufficient to practice the traditional virtues in traditional ways? To apply received moral principles to new technological opportunities? Or is it not necessary to rediscover ethical and political practice in forms equal to the radical re-founding of knowledge and power that itself has reconstituted modern science and technology? Without in any way suggesting the end of tradition or of scientific and technological progress, *ESTE* seeks to make common cause with all persons of good will who see a need for critical ethical reflection in the midst of the new world we are creating—remembering that questions can be asked in order to seek the good with greater diligence. In a pluralistic world it is, in addition, no mean feat to practice such questioning with a tolerance and pursuit of principled compromise that avoids the failures of relativism or self-righteousness. The aspiration here is to provide common ground for scholars in the various disciplines who would place their work in broader perspectives, students desiring to deepen their knowledge of complex issues, scientists and engineers sharing their expertise with a participating public, and citizens who aspire to make intelligent decisions in the increasingly scientific and technological world in which we all now live.

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