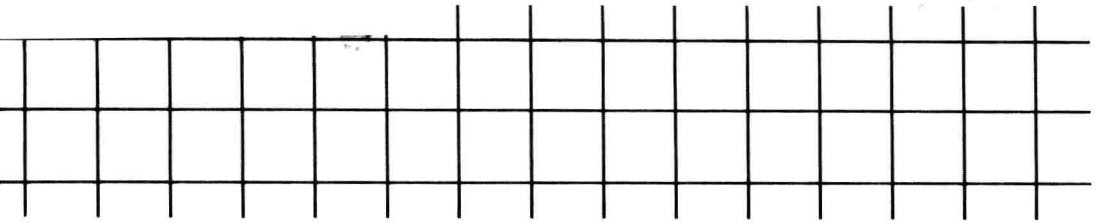
CONTEMPORARY TECHNOLOGY

Innovations, Issues, and Perspectives

LINDA RAE MARKERT



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INTRODUCTION

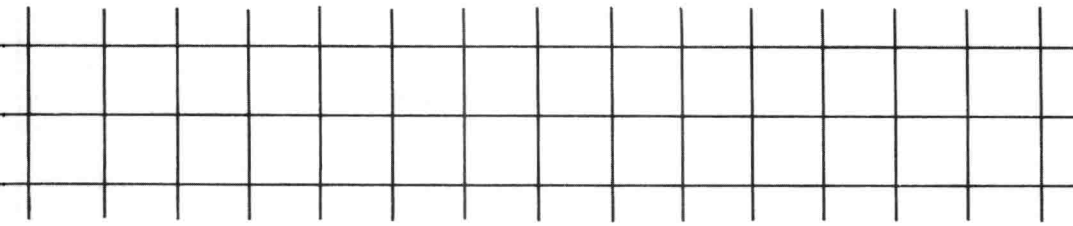
CONTEMPORARY TECHNOLOGY: Innovations, Issues, and Perspectives is written for college and university courses related to technology and society. It is intended to introduce you to the pervasive nature of technological innovations and to increase your awareness of both the promises and the uncertainties associated with the use of technology as a creative human enterprise.

The chapters are organized under three subheadings. Section I, Innovations, contains six chapters that discuss recent developments and breakthroughs in the following technical disciplines: genetic engineering, artificial intelligence, communication, space exploration, medicine, and manufacturing. Section II, Issues, includes four chapters that focus on some of the public controversies associated with significant issues in technology transfer, energy resources, environmental policy, and defense strategy. The final three chapters make up Section III, Perspectives, and address sociological viewpoints regarding our effective use of technology and the projected stability of our "pseudo traditional" social institutions.

CONTEMPORARY TECHNOLOGY presents technical facts and figures in a general way to provide you with an overview of the innovations, issues, and perspectives on the topic of technology. It is impossible, in these few pages, to cover all the bases, investigate all the angles, or delve into all of the topics with the thoroughness desired. This book will prove to be a useful starting point in your study of technology and its impact on society. The text raises issues, pro and con, to be considered in the application or use of technology. The lengthy reference list at the end of each chapter will provide you with suggested readings for further study or research in areas of particular interest.

It is the author's desire that the course or activity for which you are reading CONTEMPORARY TECHNOLOGY will "teach" you to think, analyze, cricitize, and ultimately search out new sources of information. It is also the author's primary objective to motivate you to take an active role and participate in current and future technological ventures.

Linda Rae Markert



About the author . . .

Dr. Linda Rae Markert is well qualified to write CONTEMPORARY TECHNOLOGY. As a professor in the Division of Technology at San Jose State University, she developed and teaches the basic Technology and Civilization course, as well as numerous graphics and professional courses. Her teaching experience coupled with various papers presented to industry and education keep her up to date with the field and a sought after speaker. Dr. Markert's educational degrees include a Bachelor of Science from the State University of New York at Oswego, a Master of Science from Illinois State University at Normal, and a Doctor of Education from the University of the Pacific. Her most recent honor was being named the Outstanding Professor of Industrial Technology by the National Association of Industrial Technology. Working and teaching in San Jose keeps Dr. Markert in touch with high-tech industry and trends in technology.

The Publisher

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OUTLINE FOR CHAPTER 1

Chapter 1

DEVELOPING A TECHNOLOGICAL VOCABULARY

DATELINE

Stockholm, Sweden

For some 13 years, a Swedish business consultant by the name of Ulf af Trolle worked on writing a book. The 250-page manuscript contained his recommendations on strategies Swedish companies could use to solve their economic problems. At this point, it appears that it might take him another 13 years to piece it back together.

A Stockholm daily newspaper, the Aftonbladet, disclosed that Mr. af Trolle shipped the completed manuscript to a copying company shortly after the final draft was finished. It seems an employee at the copy house confused a paper shredder with a copying machine. A few weeks later, the author was informed his manuscript had been sliced into thousands of very thin strips.

Apparently, af Trolle had no backup copy and he decided to hire a number of school-age youngsters to piece the book back together. Mathematicians estimated the project could take years. . . .

INTRODUCTION

What better way to open the first chapter of a book about contemporary technology than to relate a fairly insignificant incident about one person's dependence on a modern by-product of technology. Further, this individual's misfortune may sound highly improbable, possibly a touch absurd and even a bit humorous to most of you who have just started reading this book. At least a few of you must certainly be thinking, who could ever mistake a paper shredder for a copying machine? It is quite conceivable the author of the economics manuscript was forced to wonder the very same thing! After all,

electrostatic copiers have been around for years and most people, that you know, use them without a second thought. Although paper shredders are not quite as common, they obviously bear very little resemblance to an office copying machine.

From a different perspective, this calamitous tale about technology brings to mind another series of questions. Who would believe a writer would deposit his or her *only copy* of a manuscript with a group of strangers? Doesn't it seem odd the author did not have a "back-up" copy of his material? Even if the manuscript had not been prepared on a word processor, a typewritten carbon copy should have been reserved in case of any sort of accident. We are living in a world where computerized information storage and retrieval systems have become the rule rather than the exception.

Many of us have actually become quite accustomed to the idea of record-keeping redundancy in our lifetime. All kinds of personal statistics, credit references, academic records, annual earnings figures, and health reports are stored electronically by any number of agencies around the world. These bits and bytes of what was once considered to be "private" information are transmitted back and forth between and among banks, universities, government offices, and detective agencies in a matter of a few seconds. For a while, it seemed as if the grand advancements in communications technology would result in what literary observers called a "paperless society." To date, not many people seem willing to completely relinquish their right to have a "hard copy" of any document being reviewed. In fact, the advent of computerized information systems coupled with the ever present electrostatic copier has led to a society more "full" of paper as opposed to one that uses "less" of it.

Unlike the distressed author in the opening DATELINE story, most people insist on having multiple copies of everything they write or transcribe for someone else. This oversimplified example of contemporary daily living illustrates the point that technology pervades every business and every individual's life. For this reason, it is no longer possible, if indeed it ever was, to be casual about science and technology. Large and small, banal and impressive, scientific innovations and technological improvements pour out at an increasingly accelerated rate of speed. A great portion of such technological change, modification, and improvement is hardly even noticed these days. Many of us have become numb to novelty unless it is formidable, majestic, or entertaining in its outward appearance.

The types of breakthroughs receiving the greatest amount of media attention and the subsequent interest of the public seem to take place most often under the guise of exotic new "high-tech" industries. Among these disciplines one might list: biotechnology, computers, robotics, artificial intelligence, lunar mining, fiber optics, pharmaceuticals, supersonic transport, lasers, glass ceramics, satellites, space shuttles, and so forth. Behind all the glitter of high-tech, we find a gamut of new, but also unremarkable technologies that cut across a wide range of businesses including: sporting goods, convenience foods, household appliances, tools and gadgets, children's toys (often enjoyed by

adults too!), video games, soft drinks, music, art, and the like. In other words, contemporary science and technological advances range from tiny improvements in devices that we take for granted (e.g., coated frying pans, or the shape of the knobs on the TV set), to heroic leaps forward that have far-reaching impacts on the status of life on the planet (e.g., nuclear weapons, space stations, and artificial organs).

Who among us though has the authority to say that any one of these changes is any more or any less important than any other? That is one of the most rhetorical questions of the era! Technologies that one social group favors are simultaneously abhorred by other groups. Some persons' lives are hanging in the balance of whether or not a medical breakthrough will be made before it's too late. Others believe too much money is already being spent on medical research which only benefits those who can afford it. Some people profess to be anti-technologists, while others are avid supporters of technology. Still more persons find themselves somewhere along this continuum of extremes. Before we go any further, it seems essential that we stop and think about what these central terms imply, or how they can best be defined.

THE NATURE OF SCIENCE AND TECHNOLOGY

Over the past several decades, academic leaders around the world have developed a well-regarded discipline given the label "Science, Technology & Society" (STS). Through curricular proposals, scholarly papers, annual conferences, and hundreds of articles and books, these professionals have garnered a great deal of respect for an area of study that is, in every sense of the word, interdisciplinary. Its principles, theories and objectives pervade the many circles of physical scientists, life scientists, humanists, business analysts, educational specialists, engineers, and industrial technologists. One of the aims of STS research has been to investigate the relationships (both historical and contemporary) between science and technology in an attempt to reveal how the developments in both fields influence the nature of social institutions.

CAN TECHNOLOGY BE DEFINED?

The word "define" is a variant of the Latin term "definire" which translates to mean "to set bounds to." In order to define a word or concept, one must therefore be able to delimit its meaning through the establishment of boundaries. A definition not only explains the true or accepted meaning of a term, but it also delineates what is *not* true about it. In this day and age, technology is one of those words (like engineering) that has been used, overused, and misused to the extent that it almost defies definition! If one has difficulty explaining what technology is *not,* then it must be everything else. By definition, a definition should *exclude* something—it can not include everything. This surely sounds like a quagmire of semantics!

In many cases, the word technology has become so diluted that a secondary modifier is demanded for further clarification. Thus we have expressions such

as: medical technology, military technology, household technology, manufacturing technology, communications technology, computer technology, agricultural technology, industrial technology, and so on. The list continues as a greater number of specialized permutations (ordered arrangement) become evident. From this perspective, technology seems to make reference to the procedures and artifacts that are aligned with a particular discipline. On the other hand, the degree to which the research foundations for each discipline are interrelated makes it hard to say exactly where an exclusive product of technology fits. For example, is a solar-heated grain elevator part of agricultural technology, or, does it belong under the energy technology heading, or, even the manufacturing technology category? Modifiers enable us to focus on a certain discipline, but they do not really define the term technology very effectively.

It has become fashionable to abbreviate the term technology to its shortened "tech" version. There is high-tech, low-tech, and no-tech these days. We also use the prefix "techno" to refer to a host of social conditions such as: technophobia, technostress, technocrat, technotoys, technoworld, technodummies, technowizards, technolifestyle, and you name it. Once again, since we have become conditioned to these modern day expressions, they are implicit in their use. Each of these terms has something to do with either the *level* of technological development or society's *behavioral* or *psychological response* to technology.

Perhaps it is easier to explain the meaning of technology by generating a list of its profile characteristics. Let's try that together. As you review the following inventory, place a check mark next to any features you honestly believe are *not* true about this concept.

1. Technology is a powerful force that improves human productivity.
2. Technology is an extension of human physiological capabilities and biological potential.
3. Technology involves inventing new things and modifying the old ones to make them more efficient.
4. Technology is evident in every culture regardless of its level of sophistication or stage of development.
5. Technology creates new economic opportunities and, at the same time, new social problems.
6. Technology enables humans to exert control over the natural environment.
7. Technology liberates us from demeaning and demanding labor and therefore creates more leisure.
8. Technology has increased the human life span by conquering many debilitating diseases.
9. Technology incorporates human knowledge into physical hardware which will eventually respond to some human need or desire.
10. Technology is applied science.
11. Technology is a process for transforming raw materials into useful goods and services.

12. Technology is man-made.
13. Technology creates uselessness by displacing people and trivializing their work.
14. Technology has made many persons apprehensive about the future.
15. Technology is fundamental to the survival of mankind.
16. Technology is destructive to nature.
17. Technology is making the world increasingly incomprehensible.
18. Technology is future-oriented and therefore progressive.
19. Technology is motivated by a pragmatic (practical) or instrumental interest.
20. Technology utilizes the methods, tools, and skills typically characteristic of the process we call innovation.

Now, if you made a number of check marks in the margin as you scanned through this very partial list of modern technology's features, go back to those items and read them over a second time. While there is definitely a thread of deception to each of these ideas, cogent (convincing) examples can also be cited to validate every one of them. Technology is not a simple word to define. It is used over and over again in this book within a whole series of contextual arrangements. Since the purpose of this chapter is to get you started toward the development of a technological vocabulary (a set of terms and definitions), let us try to reach some sort of agreement. The following simple definition is not any more correct or useful than any other, but it can be used to establish boundaries.

> **Technology** is the cumulative sum of man-made means used to satisfy human needs and desires and to solve specific problems in any given discipline.

IS SCIENCE DIFFERENT FROM TECHNOLOGY?

The terms science and technology are so routinely combined to form a single phrase that some people find it nearly impossible to distinguish between the two. What is scientific is also perceived to be technological and vice versa. It was not always this way. For centuries, people regarded science and technology as distinct fields of study entirely separate from one another. SCIENCE was understood to be the pursuit of knowledge that would enhance human understanding of the natural environment. TECHNOLOGY simply entailed making things and inventing other things that humans could use to control or cope with the natural environment. In other words, early scientists were not often concerned with practical applications of the knowledge they secured and early technologists did not have the need to understand the reasons things worked the way they did.

Therefore, one of the early distinctions between science and technology made reference to the world of "know-what" and "know-why" on the one hand, and the world of "know-how" on the other. Throughout the 20th century, the line

between scientific inquiry and technological application has become quite obscure. In fact, one of the chief characteristics of contemporary technology is that it is based more and more on the scientific knowledge of the nature of things, why materials react in certain ways, and which laws are in force at any given point in the process of development. Some excellent examples of "science-based" technology are found in atomic energy, fiber optics, biotechnology, antibiotics, and microengineering. The traditional language that clearly distinguishes science from technology is beginning to break down.

Contemporary scientists are still motivated by curiosity, but they also recognize the need for the results of their research to be industrially relevant. In this regard, a recent strategy among the scientific community has been an attempt to establish that a close link exists, via technology, between pure science and its application to economic ends. Thus, science is what is, while technology is what can be as a result of science. Stated differently, scientists have been anxious to demonstrate their apparently curiosity-oriented work would, ultimately, lead to critical profit-making technological innovations and business ventures. This book reveals numerous instances where this strategy has been quite successful. In sum, it is difficult to separate science from technology. To simplify the confusion, the following explanation for this term is proposed.

Science is a stream of man-made events involving a mathematical or systematic study of nature which results in a body of knowledge that is practical as well as theoretical.

OVERVIEW OF THE TEXT

The following thirteen chapters are organized under three subheadings. Section I, entitled INNOVATIONS, contains six chapters that discuss and explain recent developments in the following technical fields: genetic engineering, artificial intelligence, communications, space exploration, medicine, and manufacturing. These areas have been selected to illustrate the dynamic interaction between and among seemingly disparate fields of specialization.

Section II, ISSUES, includes four chapters that focus on the dilemmas and controversies that are commonly associated with technological change. The subject areas that have received a significant amount of public attention during recent years are presented here as issues in: technology transfer, energy resources, environmental protection/degradation, and defense strategy.

The final segment of the text is Section III, PERSPECTIVES, and it contains three chapters that address sociological viewpoints regarding the effective utilization of technology and the projected stability of our traditional social institutions.

The format for each chapter is consistent throughout the book. As you found with this first entry, each chapter opens with a DATELINE incident which is in some way pertinent to the subject matter covered. These brief "contemporary historical vignettes" are designed to illustrate that technology marches on throughout the world at all levels of fascination, without the least regard for time. They are meant to show you that a simple glance through today's newspaper or last week's national magazine will reveal some event (major or minor) in technology that is already or will soon be shaping the way we live each day. As you read through each chapter, a reference will be made back to the DATELINE to tie it into the material being discussed.

Technical facts and figures are presented in a general way in this book. Highly respected publications and entire series have been written on each and every topic contained here. This fact alone makes it a challenge to provide a brief "overview" that makes any sense. Informed readers will unquestionably react to this author's method of content coverage by saying something like: "the author left this out;" "the author forgot to mention that important historical fact;" "the author doesn't provide enough examples to back up her ideas;" and so forth. For this very reason, a lengthy reference list of suggested readings for further study is provided at the end of each chapter. Your ongoing perusal of technical subject matter either directly related to your career objectives or indirectly supportive of them is strongly recommended. Several publications to which you might want to consider opening a subscription to in the future include: *Technology Review, Discover, High Technology, Wall Street Journal, Science, The Futurist, Science Digest, Scientific American, OMNI, Harvard Business Review* and *Fortune.* While this list is not exhaustive of the titles available, it is a representative sampling which is highly readable and quite informative for English-speaking individuals. The discussion questions found at the end of each chapter are designed to stimulate further creative thinking about the innovations, issues and/or perspectives presented under each of the major subject headings. It is impossible for any one author or solitary instructor to cover all the bases or investigate all the angles—you must take some personal responsibility for the learning endeavor.

Toward this end, it is essential to recognize the development of a technological vocabulary goes far beyond a rote memorization of terms and their meanings. If the formal study or informal activity for which you are using this book "teaches" you anything, it should teach you how to think, learn, and search out new sources of information. No single reference is ever completely infallible. A technological vocabulary changes and expands on a regular basis. In just a few years, a whole new set of terms will be "on the books" but not included on the following list. This introductory glossary offers brief explanations for many of the terms and phrases listed under the KEY CONCEPTS segment of each chapter. Note that the chapter where the term or phrase will be studied is referenced below.

A GLOSSARY OF TECHNOLOGY TERMS AND CONSTRUCTS

Agrigenetics: [C-2] Research and development efforts in the biotechnology industry that seek to modify various plants and animal species to either make them resistant to natural predators or impregnate them with specific genetic traits.

Agroforestry: [C-10] A technology management strategy that proposes creative farming techniques that combine trees (forest preservation) with other crops or livestock.

Amniocentesis: [C-6] A medical test normally performed during a woman's 16th week of pregnancy to determine if the unborn child has certain birth defects. Amniotic fluid is withdrawn through a thin hollow needle inserted through the abdomen. Fetal cells are then cultured in the laboratory and chromosomes are carefully studied. Results are available in 3-5 weeks. Accuracy of the chromosome results is greater than 99.5%.

Anthropomorphism: [C-3] The act of imparting "lifelike" or human attributes to inanimate objects. It also denotes the ascription of human feelings and emotions to nonhuman beings.

Appropriate Technology (A.T.): [C-8] An intermediate level of technology development vs. one too sophisticated or complex for the problem in question. A.T. is also an attitude regarding an overreliance on high technology. A.T. refers to technology that "fits" the cultural situation for which it is proposed without causing more problems than it solves.

Artificial Intelligence: [C-3] A subfield of computer science that studies the use of computers in the execution of tasks that are normally considered to require higher level cognitive abilities (e.g., perception, learning from mistakes, reasoning, and understanding).

Balloon Therapy: [C-6] Formally referred to as balloon angioplasty. It is a medical procedure which has the potential to replace coronary by-pass surgery for clearing out clogged arteries.

Bar Coding: [C-7] A primary component of automatic identification systems in industry. The bar code industry uses several different code languages or symbologies for which uniform symbol descriptions have been published. Each code is generally made up of binary digits where bars and spaces in different configurations represent numbers, letters or other symbols. The code is scanned and transmitted directly into a computer to identify the part or product.

Bioastronautics: [C-5] Quite simply, the study of life in space. How do living organisms adapt to conditions of weightlessness and then re-adapt to life on earth? What sorts of technological innovations can be envisioned to make this cycle occur more smoothly?

Biological Containment: [C-2] A self-regulating policy used in genetic engineering research. It prescribes (1) the use of bacterial hosts too weak to survive outside the laboratory, and (2) experimentation with microorganisms which can only grow in certain hosts that are predictable. It is a method employed to prevent an accidental "environmental release."

Biological Warfare (BW): [C-11] The use of a living organism, usually a pathogenic (capable of causing disease) microorganism (protozoa. fungus, bacteria, virus), for hostile purposes.

Biomass Energy: [C-9] An alternative energy resource that makes use of organic plant matter and animal waste to create heat energy or useful fuels such as methane gas and ethanol.

Bioprocessing Technology: [C-2] Bioprocesses are systems in which complete living cells or their components, such as enzymes or chloroplasts, are used to effect desired physical or chemical changes. In genetic engineering, bioprocess technology will enable biological methods of production to be adapted for large scale industrial volumes.

Breeder Reactor: [C-9] A nuclear reactor that generates fissionable fuel (plutonium-239) by bombarding appropriate nuclei (uranium-238) with neutrons during the routine operation of the reactor. The doubling time is the length of time it takes to produce twice as many plutonium atoms as fissionable atoms that were present when the reactor started operating. This figure is dependent upon the design of the reactor. A very efficient breeder reactor might have a doubling time of about six years which means it would produce enough fuel to refuel itself and another similar reactor after six years of operation.

"C^3I:" [C-11] Pronounced "see-cubed-eye," a military acronym for Command, Control, Communications, and Intelligence. This is a U.S. Department of Defense research project that envisions the establishment of a powerful computerized network to control the nation's nuclear forces in the absence of human beings.

Cell Fusion: [C-2] Involves the artificial joining of cells to combine the desirable characteristics of different types of cells into one cell. This union is known as a hybridoma.

Cellular Telephone Network: [C-4] Cellular technology uses an advanced network of low power transmission and reception sites that form a group of adjacent cells. These cells are linked by actual telephone lines; signals are switched by a computer and connected directly into the local phone system. The network enables callers to place and receive calls from a mobile unit such as an automobile.

Computer Blacklists: [C-4] Databases containing the names and identification codes for individuals who should not be given credit, an automobile

insurance policy, or whatever due to some legal problem in their past. These are regularly compiled and updated by financial institutions and government agencies, etc. This form of electronic record keeping has caused many persons to question their rights to privacy.

Computer Integrated Manufacturing (CIM): [C-7] The umbrella acronym (pronounced "sim") for a host of automation technologies in the manufacturing environment. It does not refer to *one* specific technology, but to the integrated use of computers in *all* sections of enterprise, from the planning of production, through the design and manufacture of a product, up to the assurance of good quality.

Content Analysis: [C-14] A forecasting technique where reviewers keep a close track of events as they happen in order to make an accurate projection of major trends 1-2 years down the line. Content analysis often makes use of daily newspapers as its primary source of reference material. It had its roots among military strategists during World War II.

Creationism: [C-13] A theological doctrine that ascribes the origin of all matter and living forms as they now exist to distinct acts of creation by God. Creationists generally refute theories of evolution which hold that mankind evolved biologically from a less sophisticated species.

Cybernetics: [C-3] A term often used to label computer science curricula. It is the theoretical study of control processes in electronic, mathematical, and biological systems. It is uniquely descriptive of the mathematical analysis of the flow of information through these systems.

DARPA: [C-3] Acronym for Defense Advanced Research Projects Agency. It was established by the U.S. Department of Defense in the late 1950s. It regularly funds research projects in high tech fields, most notably that of artificial intelligence at the present time.

Decoys & Chaff: [C-11] Terms used to describe penetration aids that are included in the deployment of nuclear missiles. Decoys are dummy warheads which look like the real thing but carry no explosive power. Chaff consists of thin, confetti-like metallic strips that are released to confuse the opponent's radar system.

Delphi Study: [C-14] A forecasting strategy whereby a group of pre-selected "experts" engage in an anonymous exchange of opinions through an intermediary who controls the feedback of ideas in sequential rounds of interchange. There is a tendency, over time, toward a converging consensus among the group members.

Demand Lag: [C-8] Related to the rate of diffusion of technologies being transferred. After the technology is first introduced into the innovating country's domestic markets, how long does it take for it to gain acceptance in foreign markets?

Diagnosis Related Groups (DRG): [C-6] Written into federal law in the early 1980s as the funding mechanism of Medicare. Adopted as a payment scheme, DRGs work this way: After a patient has been diagnosed, the hospital receives a fixed fee reflecting an average cost of curing that condition. If the patient is worse than average, the hospital must pay any cost beyond the DRG allowance. If the patient is better than average, the hospital keeps any money left over.

Direct Broadcast Satellites (DBS): [C-4] These satellites can broadcast a television signal directly to small antennas at home or work. The signal can carry multiplexed digital information which characterizes its teletext potential. Teletext refers to computerized information and entertainment systems that use a normal television signal to distribute the data to television sets or monitors.

Durational Expectancy: [C-12] A concept introduced by Alvin Toffler in his *Future Shock*. It refers to a culturally-based attitude or expectation regarding how long things are usually supposed to last. When these expectancies are disrupted, people are forced to cope with unplanned changes.

E. Coli: [C-2] An abbreviation for the single-celled bacterium called Escherichia coli that is commonly found in the human intestinal tract. It is used in recombinant DNA research because of the ease with which it can be engineered. E. coli bacteria reproduce themselves every 25 minutes even after their genetic code has been altered via splicing.

Electronic Cottage: [C-4] A term that was first coined by Alvin Toffler in his publication *The Third Wave*. It refers to a social phenomenon where people spend more time working in their homes instead of going out to the office or the factory. It has given rise to a new form of working labeled "telecommuting" where persons can work at home on personal computers that are connected via telecommunications equipment to the corporate office.

Electrophoresis: [C-5] A space age manufacturing technique that enables materials to be separated in solution by subjecting them to an electrical field inside a restrictive chamber. The Z-gravity environment in space accelerates and improves the process by allowing the mixture to flow continuously.

Environmental Analysis: [C-10] The process of conducting a comprehensive study and review of a broad range of environmental features such as topography, hydrology, geology, and cultural status for a specified land area. The results of this study can aid a developer in selecting an appropriate site to purchase and develop while using a plan that is environmentally sound.

Environmental Release: [C-2] As a generic concept, this refers to the accidental or deliberate release of a contained substance into the natural ecosystem (air, land, water). It represents a central point of debate in genetic engineering experiments where genetically altered organisms are allowed to be tested outside the laboratory.