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ABSTRACT

This student guide was designed to be used with senior high school level classes as a supplement to existing programs in the areas of science and social studies. Each of the 12 chapters included in the guide may be used independently or may be combined into a separate course on the relationships between science, technology, and society. The separate chapters deal with: (1) technology; (2) decision making in a high-tech world; (3) genetic engineering; (4) artificial intelligence; (5) nuclear energy; (6) acid precipitation; (7) hazardous wastes in the environment; (8) food and agriculture; (9) organ transplantation; (10) transportation; (11) robotics; and (12) technology and decision-making. Each chapter of the student guide contains independent reading assignments, discussion questions, activities, and simulations. (TW)

DECISIONS FOR TODAY AND TOMORROW:
ISSUES IN SCIENCE-TECHNOLOGY-SOCIETY

A Multidisciplinary Approach to
Problem-Solving and Critical-Thinking

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Louis A. Iozzi

Peter J. Bastardo

PREFACE

We live in an exciting, rapidly changing, and challenging world - a world highly dependent upon science and technology. Because our world is changing so rapidly we sometimes fail to recognize that much of what we today take for granted as common, everyday occurrences existed only in the imaginations of people just a few short years ago. Advances in science and technology have brought many dreams to fruition. Long before you become a senior citizen, much of today's "science-fiction" will, in fact, become reality. Recall just a few accomplishments which not too long ago were viewed as idle dreams:

- New biomedical advances have made it possible to replace defective hearts, kidneys and other organs.
- The first air flight at Kitty Hawk lasted only few seconds. Now, a little over half a century later, space crafts travel thousands of miles and hour to explore distant planets.
- Nuclear technology - of interest a few short years ago because of its destructive potential - could provide humankind with almost limitless supplies of energy for peace-time needs.
- Computer technology has made it possible to solve in second problems which only a decade ago would require human lifetimes.
- Science and technology have brought us to the brink of controlling weather - even earthquakes - and other natural phenomena.

Moreover, the changes which we have been experiencing and to which we have beome accustomed are occurring at an increasingly rapid rate. Changes, most futurists forecast, will continue and, in fact, even accelerate as we move into the 21st Century and beyond. But, as Barry Commoner has stated, "There is no such thing as a free lunch." These great advances will not be achieved without a high price. We are now beginning to experience the adverse effects of our great achievements:

- Our world's natural resources are being rapidly depleted.
- Our planet's water and air are no longer pure and clean.
- Thousands of plants and animal species are threatened with extinction.
- Nearly half the world's population suffers from malnutrition.

Because science and technology have given us tremendous power, we are now confronted with awesome responsibilities to use that power and ability wisely, to make equitable decisions and tradeoffs, and to make valid and just choices when there are no absolute "right" alternatives.

You will soon become one of society's decision-makers. Will you be able to improve upon the decision-making of the past? Will you have acquired the skills and abilities to deal with complex problems and to make effective and equitable long range decisions to create a better world?

This book has been prepared to help you function more effectively in a rapidly changing world. It is our hope that the contents and activities in this volume will help to prepare you to live life to the fullest, in balance with Earth's resources and environmental limits, and to meet the challenges of tomorrow's world.

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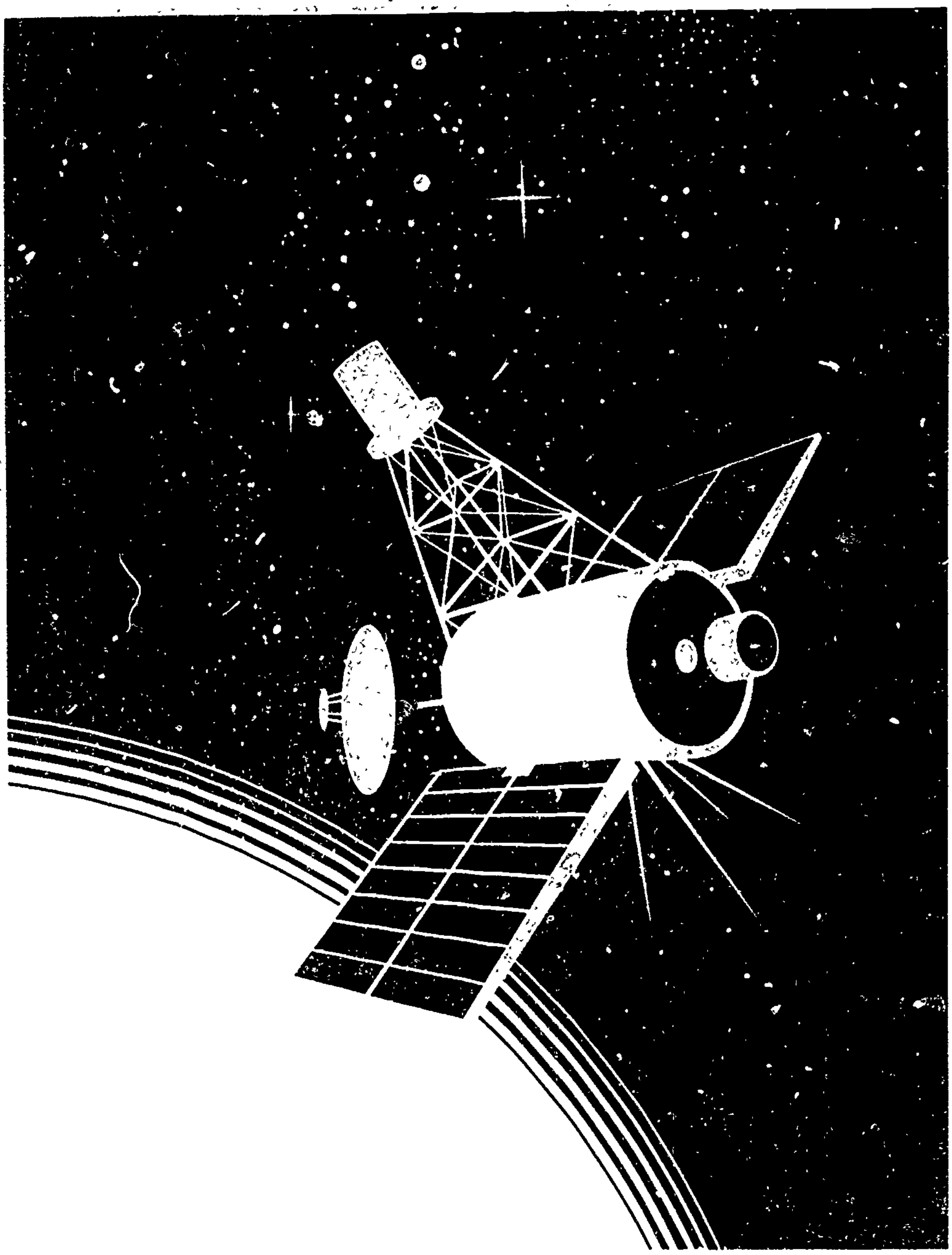
Chapter I



Technology

What Is Technology?
- Introduction -

From the earliest times when humans fashioned their first tools, how they lived and the world they lived in changed in many different ways. Tools extended human power and offered new opportunities and techniques for survival. The development of farming tools and agricultural knowledge, for example, made it possible for the once migratory hunters to establish permanent settlements. Groups of small roving bands now became farming communities. An agricultural way of life brought out new types and styles of social organizations, shelters, foods, eating habits, and clothing. It required new forms of knowledge such as weights and measures for the purposes of barter and engineering to build irrigation systems. The land of forests and plains became transformed into checkerboards of planted rows, interlaced with canals carrying water. The earth's environment thus took on new characteristics with the development of new techniques, tools, and machines.

Throughout our history the development of new and more sophisticated technologies has had a major impact on the lives of humans. Without these advances, we humans might not exist today as a species, and if we did, we would be relatively powerless, few in number, and of little significance on planet Earth. But because of dramatic advances in science and technology over the centuries, we have become - for better or worse -the rulers of planet Earth. But, if we are to continue to exist - even grow and flourish further - we must take care to use our powers responsibly and wisely.

Although technology has been an integral part of human existence since its beginning, we tend to think of our modern times as the "age of technology". Is this true, or have there been many "ages of technology" in history? Consider the following questions.

What does the "age of technology" mean?

Does technology today differ very much from technology of the past?

Since we tend to think of modern times as the "age of technology" is it because:

- *we now use so many products made by machine?*
- *of the increased numbers of new inventions?*
- *machines have drastically changed the way we live and work?*
- *changes are taking place too rapidly?*
- *we have acquired more powerful tools?*

One way we can examine the meaning of technology and its interrelationship with our lives is to look at some of the recent technological innovations that have emerged during the past century. Conducting a "Technology Inventory" is an effective way of charting changes and effects.

A Technology Inventory
- Part A: Mass Production -

In this activity, you will first examine how one technology - Mass Production - has affected or changed different areas of human activity. You will also consider the types of resources required by the technology as well as the changes it has created. Some of the effects or consequences are immediately obvious, while others are not so obvious. A good way to approach this activity is to ask yourself, "What would life be like if this technology had not been developed?" After completing the inventory for mass production, you will then have an opportunity to complete an inventory for another technology.

Procedure

A copy of the chart "Technology Inventory" (Handout 1) will be provided by your teacher.

There are three rows of boxes on the chart. The first row is for the category "Changes", the next is for the category "Resource Requirements", and the third is entitled "Consequences". Each box in each row is also labeled.

The information for the first row of boxes under the category "Changes" (such as Individual, Community, Business, Government) has been provided below under "Getting Started . .".

Read the article "Information About Mass Production" and complete the inventory.

New Technology: Mass Production

Consider the "new technology" of mass production. One of the questions we need to answer is, "How has mass production affected or changed the individual, community, business, and government?" You might list the following in the appropriate boxes:

Individual effects might include the following:

Work on assembly line is repetitive.

Work schedule is heavily regulated.

People pay less for mass-produced products.

More people enjoy labor-saving products.

Community effects might include the following:

Large factories replace small craft shops.

Industrial towns and cities are built.

People move from farms into industrial towns.

Business effects might include

greater efficiency,

need for large investments to build factories and purchase machinery,

rise of large corporations, and

standard product lines.

Government effects might include the following:

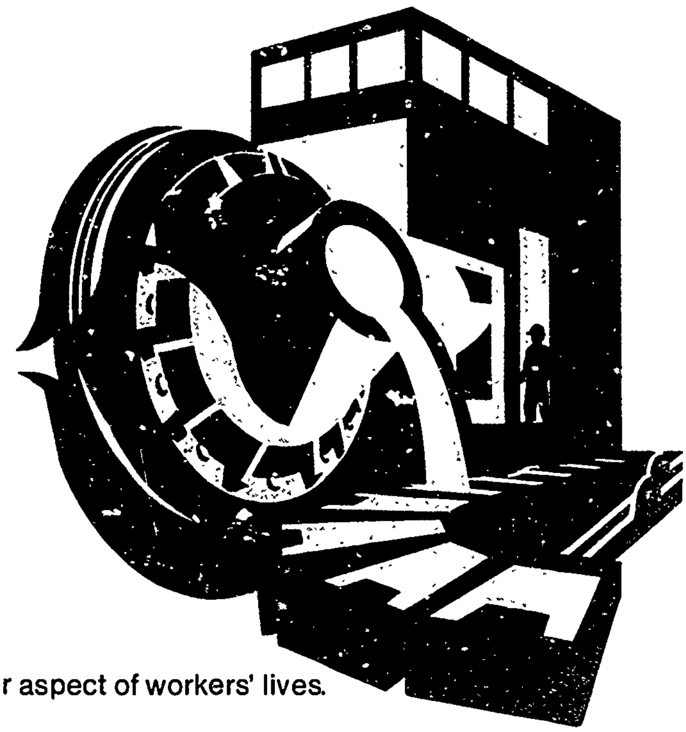
Laws need to be enacted to protect workers and ensure product safety.

New roads would be built.

Standard of living of country is raised.

Information about Mass Production

The items for the other categories will emerge as one begins to think about the processes, materials, and structures needed for industrialization. Operating machines required large quantities of energy; hence, factories were located near sources of power, or they generated their own power. If coal provided the fuel source, railroads had to be built to transport the coal. A rapid means of communication needed to be developed so that supplies could be located and ordered efficiently. The filling of orders and the delivery of goods also depended on a combination of new communication and transportation systems. With industrialization came developments in the scientific organization of work. It became important to know how to best divide the various tasks so that the production line would operate most efficiently. The accurate timing of each task became a critical factor in the system, and "time and motion" engineers or efficiency experts entered the factory scene. Industrialization depended upon large quantities of a variety of raw materials. The mining of iron ore and steel-making reached new heights with increased demands for machinery to produce goods. Mining left unsightly scars on the landscape. Manufacturing processes also produced wastes in the form of by-products, chemicals, smoke, and so on. In the early days of industrialization, the disposal of wastes was of far less concern than it is today. In recent years it has been recognized as a critical problem.



The human response to industrialization has been the subject of many books, some research, and even some movies. Workers flocked to cities for new job opportunities and higher wages. More people enjoyed goods that were once limited to the rich because the assembly lines made it possible to produce abundantly at lower costs. However, there was a growing feeling that work was no longer a creative and individual enterprise. Workers became tied to the machine and became part of the machine system. Although the machine eased the burdens of some types of work, it required workers to perform other tasks in a systematic, repetitive manner. On the positive side, mechanization shortened the working days and thus leisure time became a larger aspect of workers' lives.

- Part B: Other Technologies -

You will be provided with another copy of the Technology Inventory chart.

Your teacher will assign you one of the technologies listed below. Applying some of the strategies used in completing Part A of this activity, as well as any others you can think of, complete the Technology Inventory chart for the technology you were assigned by your teacher.

Automobiles	*Refrigerators*
Airplanes	*Television*
Electricity	*Skyscrapers*
Telephones	*Fertilizers and Pesticides*
Glass	*Copying Machines*

After completing your Inventory, share your ideas with other members of your class using the following questions as a guide.

Was anyone else in your group assigned the same technology? In what ways were your ideas similar? Different? Do you disagree with any of the items on their lists?

Were there any ideas that were common in all of the charts?

What were they?

In what ways did life change as the result of these new technologies?

What types of adjustments did people need to make in order to use the new technologies? Do you think it was difficult to make these adjustments?

Did the application of the new technology depend upon other types of new developments (technologies)? What are some of these technologies?

What new opportunities became available to people as the result of this technology?

What do you think are the major benefits of modern technology? Explain.

What unpredicted changes do you think have been most harmful? Explain.

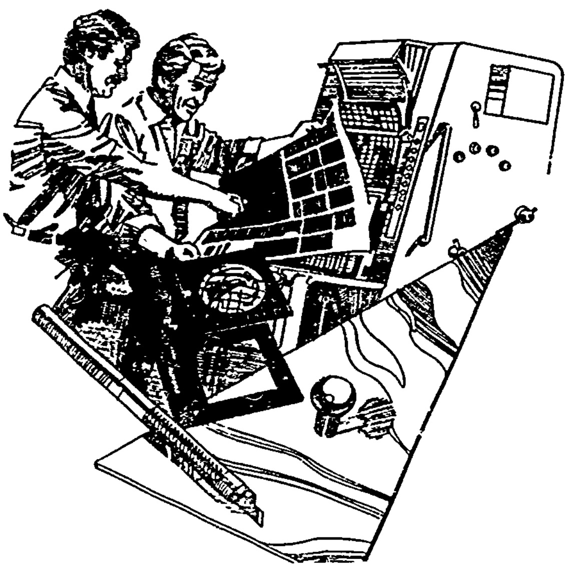
What is your definition of technology?

What Is Technology?
- A Definition -

The word "technology" is used in many ways. If we are to intelligently deal with the science-technology-society issues included in this program, we must first agree on a meaning or definition for "technology."

Most frequently, "technology" is used when referring to anything manufactured by humans. This would include such things as automobiles, televisions, airplanes, glass, furniture, books, saxophones, and thousands of other manufactured items. Of course, this excludes all natural objects such as trees, plants, rocks, minerals, iron, and water. How would you classify a sheet of plywood?

Sometimes "technology" is used to denote knowledge or "know how". This definition refers to the acquisition of the knowledge or the development of the methodology to manufacture different products. You have probably heard people say, "We have the technology to do the job." This simply means that we have the knowledge or "know how" to make a certain product.



"Technology" is sometimes defined as everything needed to manufacture a product. This includes people, machinery, various resources, and processes. For example, to build a bicycle frame, one would need the resource steel (which is also a manufactured product), and machinery to form the steel into tubing, bend it, and then weld the frame together. In addition, people are needed to operate the machinery. Stephen J. Kline at Stanford University also includes in this usage of "technology" the legal, economic, political, and physical environments.

While the last definition constitutes the common usage of the term "technology", Professor Kline has added a fourth concept or definition: "Sociotechnical System of Use". This fourth concept defines technology as the way we use manufactured articles. For example, "We embody automobiles in a system of roads, gas stations, laws for ownership and operation, rules of the road, etc., and use the combined system (automobiles and all the rest) to extend our capacity for moving vehicles and our possessions about - transport. We manufacture violins, pianos, drums, guitars, and other musical instruments. We then embody them in orchestras and bands to extend the ways in which we make music." (Kline, p. 3).

Thus, technology includes manufactured articles, knowledge and methodologies, people, machinery, resources, and the processes necessary for manufacturing these articles. It also includes legal, economic, and political considerations and the physical environment. Last, but of critical importance, "technology" includes how sociotechnical systems are used. Without such systems, the manufacturing of any article would have no purpose.

Clearly, the application of a technology has widespread and often all- encompassing effects. These effects influence and shape our social, economic, cultural, and political institutions. Critics of technology have raised a number of questions:

Do we control technology or does technology control us?

Is technology developing so rapidly that we are unable to adjust to the changes?

Are the adverse effects of technology greater than their benefits?

Does the use of technology to solve a problem create more new problems?

Has technology made us more machine-like and less human?

While these questions have no simple answers, you can begin to examine some of the issues raised by technology as you study and perform the activities included in this book.

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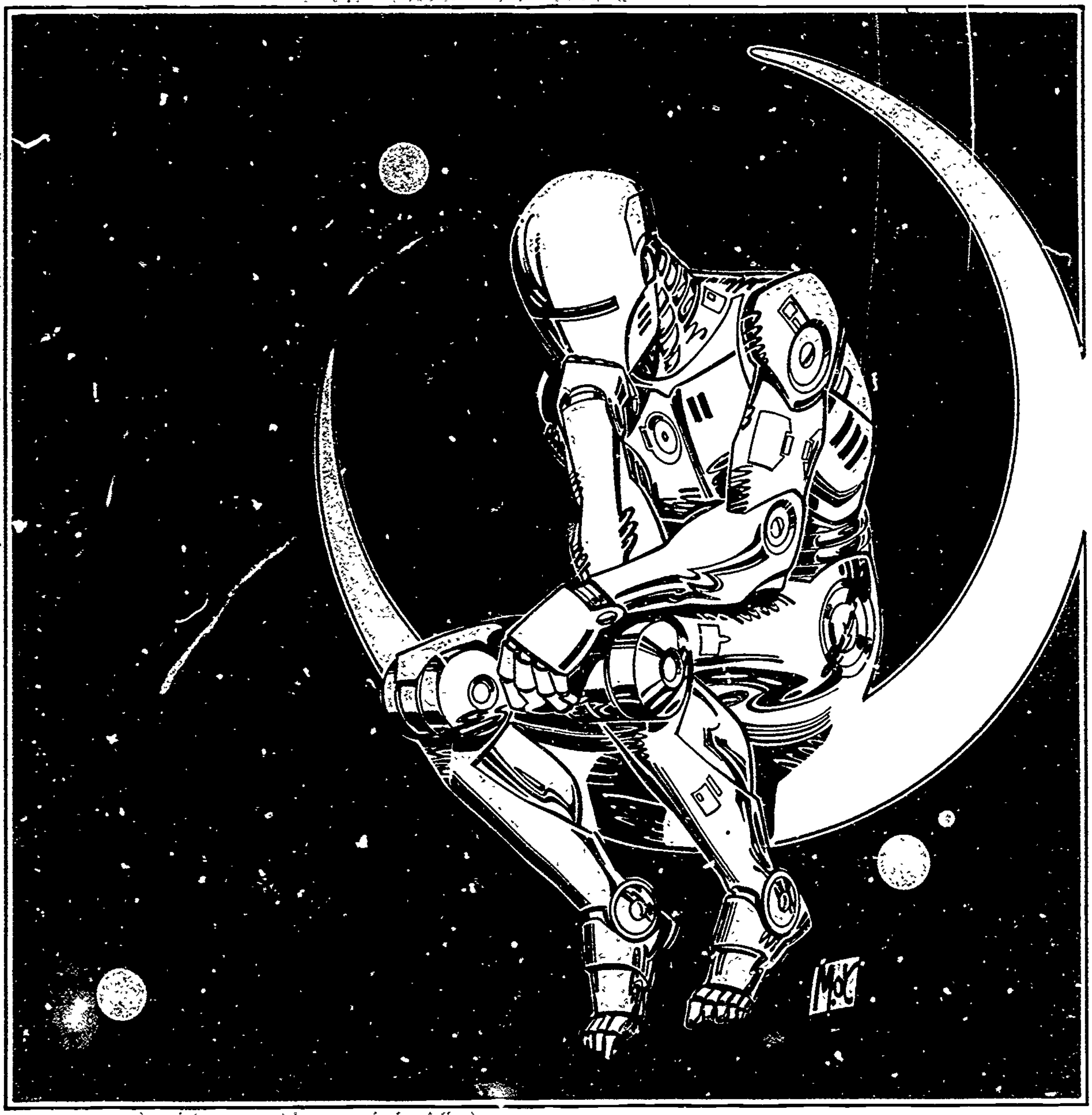
Iozzi, Louis A. et al *Technology and Society: A Futuristic Perspective.* Sopris West, Inc. Longmont, Colorado: 1982.

Kline, Stephen J. "What is Technology?" *SSTS Reporter*, volume 2 No. 1, 1986.

Chapter 2



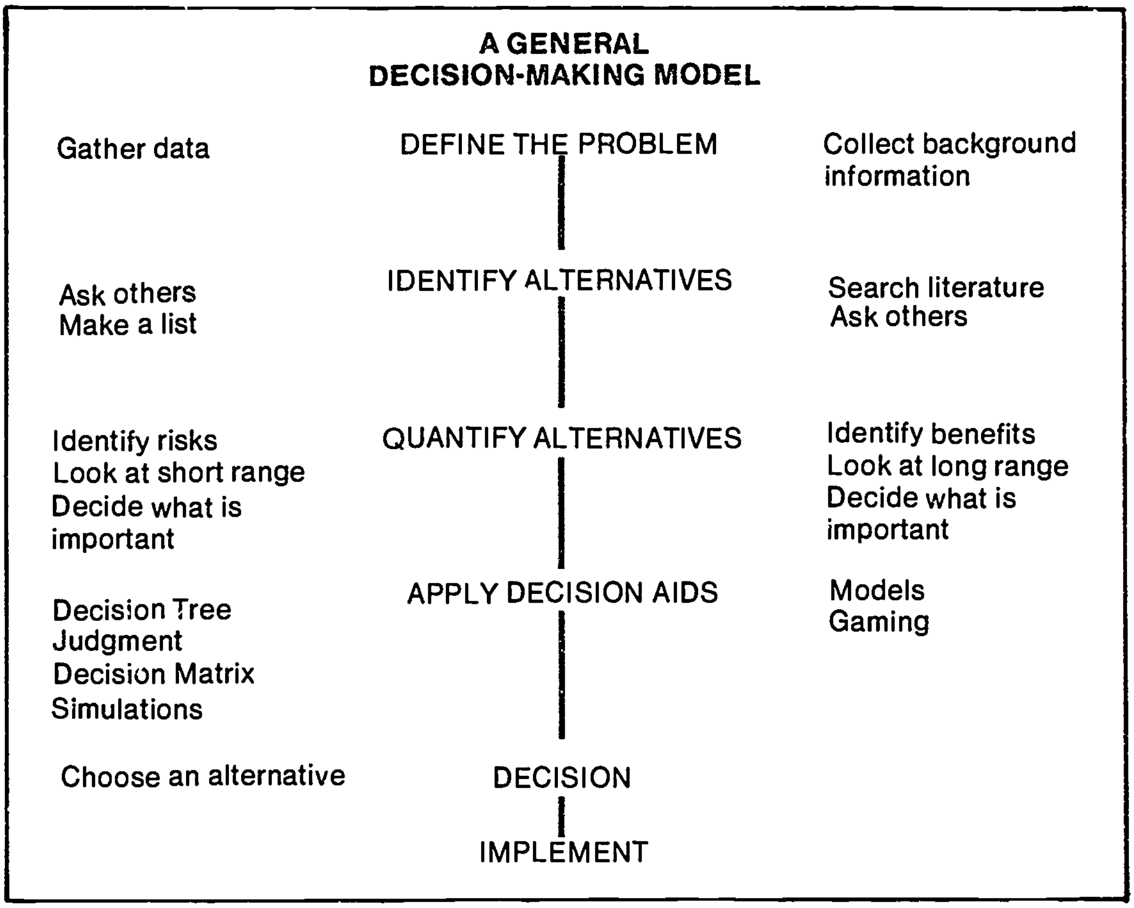
Decision-Making in a High-Tech World

Decision-making In A High-Tech World

People go about solving problems and making decisions in many ways. While some people were taught strategies in school, others may have developed their own strategies. While some people use "intuition" or a "gut" feeling, others simply guess or use a "no strategy" approach.

A General Decision-making Model

One general and very useful model for making decisions is illustrated by the following diagrams (Figure 2-1):



Based, in part, on Hill et al. *Making Decisions. A Multidisciplinary Introduction.* Addison-Wesley Publishing Company, Reading, Mass.

Let's examine this model more closely.

Define the Problem

The first step in decision-making is to carefully and accurately define the problem. Believe it or not, this can be one of the most difficult aspects of decision-making. It has been said that once you accurately define the problem, you are more than half way towards solving it. The margins of the diagram give some clues on problem definition.

Identify Alternatives

Whenever you are confronted with a choice between two or more alternatives, you must decide which course of action to take. Sometimes the choices are obvious, but at other times they are not. You might list as many possibilities as you can. Be creative. At this point in the process, no possibility is too far-fetched. Remember, you don't want to overlook anything. In doing this, be sure you ask others for ideas.

Quantify Alternatives

In the previous step you listed **all** possible alternatives. It is doubtful that you could, or would want to, try out all of the possibilities. Therefore, you must now quantify or rule out those that are not important to the problem solution. You must also weigh the relative importance of those that are important. In doing this, for each alternative as you go through the list, remember to

identify risks,

identify benefits,

look at the short range,

look at the long range, and

decide what is important

Apply Decision Aids

There are many strategies available to help you make decisions. Some are fairly easy to use whereas others are very complex and require the use of higher mathematics and even computers. You should be able to use the following quite effectively.

Judgment - this is acquired over time and enhanced by experience.

Decision Tree - particularly useful when dealing with problems involving a choice between only two alternatives.

Decision Matrix - particularly useful when dealing with problems involving several possible alternatives.

Models - the decision-making strategy described in this chapter is one example of a mental or procedural model.

Gaming.

Simulations.

The decision tree and the decision matrix will be explained in detail in this chapter. They will also be used in other chapters of this book. Gaming and simulations will be used in activities in other chapters and will be explained at that time.

Decision

A decision is the culmination of the process. Once a decision is made, there is often a strong tendency to stick with it. While this is understandable, it can be very risky. Even when you use a model to help guide you carefully through a process, there is no guarantee that the decision you arrive at is, in fact, the best. No system is foolproof. A mistake can be made at any point during the process. Hence, be on the lookout... there is no reason why you can't change your decision to a better one.

Implement This is it! Put your decision into action.

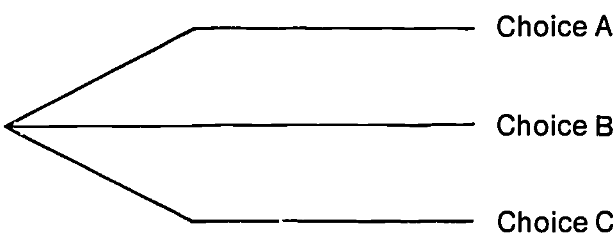
The Decision Tree

The decision tree can be very helpful in solving some problems. Basically, it is a visual display of the decision-making process. Through quantification (using mathematics), the decision tree helps organize and calculate the best choice. The model resembles a tree with branches spreading out from nodes. Actually, there are two types of nodes. a decision node (represented by a square) and choice nodes (represented by circles).

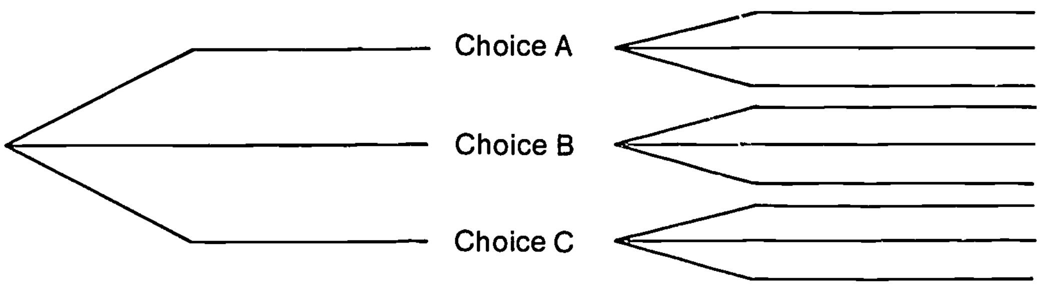
In using a decision tree one generally utilizes the following procedure.

1. **Structure the problem.** Make sure you fully understand the problem. You might even find it helpful to write out as concisely as possible, what the key or basic question is.

2. **Identify the significant decision actions** that can be taken.



3. **Identify possible outcomes** for each of the actions that could be taken.



4. **Weight the negative consequences** of the possible outcomes, e.g., 1, -2, -3, etc. If an outcome is not negative, weight that negative outcome as 0.

5. **Assign probablity values.** For each decision action, the maximum value can only be "1.0". The possible outcomes are a percentage of the maximum of "1.0".

6. **Calculate the best decision.**

   (A1)(B1) + (A2)(B2) + (A3)(B3)... = total.

   The **lowest** score is the best choice.

   Just a word of caution. Decision trees are simply **tools** to **help** you make decisions. They do not - and should not - actually make the decision for you. This tool will not make up for faulty or unsound thinking on your part. **You** must decide what should be included at each step. The end result - a recommended decision - is based on **your** thinking and the information and data **you** provide at each step in this process.

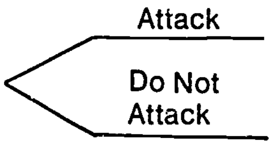
Let's try an example

Not too long ago, an American commercial airplane was skyjacked with all of the passengers on board. The skyjackers forced the pilot to land the aircraft at an airport while they negotiated their demands with the authorities. While the aircraft was on the ground, the President of the United States contemplated having the "Delta Team" - a top notch military commando and rescue team - storm the aircraft and rescue the hostages.

What should the President do?

1. **Structure the problem.** The problem is, how can the President rescue the hostages without causing any deaths?

2. **Identify the significant decision actions** that can be taken. The President has decided that there are only two courses that he can take:



3. **Identify possible outcomes** for each of the courses that can be taken.

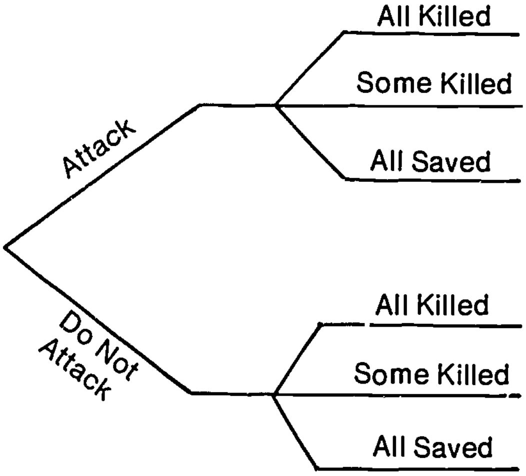
In this case, if the President attacks the aircraft, three things could reasonably be expected to occur:

all hostages could be **killed**

some hostages could be **killed**

all hostages could be **saved**

These same outcomes could also occur even if the President does nothing. That is, the skyjackers might still kill all, some, or none of the hostages.



4. **Weight the negative consequences.** Decision **Action 1** - attack the aircraft. There are 3 possible **outcomes** associated with this choice. The worst one is to have **all** hostages killed, the best is to save all hostages. Hence, the following weighting:

   all killed - 2

   some killed - 1

   all saved - 0

   The same is true for Decision **Action 2** - do not attack.

5. **Assign probabilility values.** Now we must determine what in our best judgment, the probabilility would be of each of the possible outcomes occurring. This is purely a matter of judgment here and based on the scanty information we have available.

   Decision **Action 1** - Attack the aircraft.

   There are 3 choices - the total probabilities cannot exceed (1.0).

   If the President attacks, chances are that some people will be killed, but it is doubtful that all will be killed. Hence, a "fifty-fifty" chance seems likely. Thus P = .50.

   The chance of all being killed is probably less than "fifty-fifty" - about .30.

   The chance of all being saved is least likely, hence .20.

   The same is done for the option do not attack.

   The ratings here are

   all killed = .2,

   some killed = .3, and

   all saved = .5.

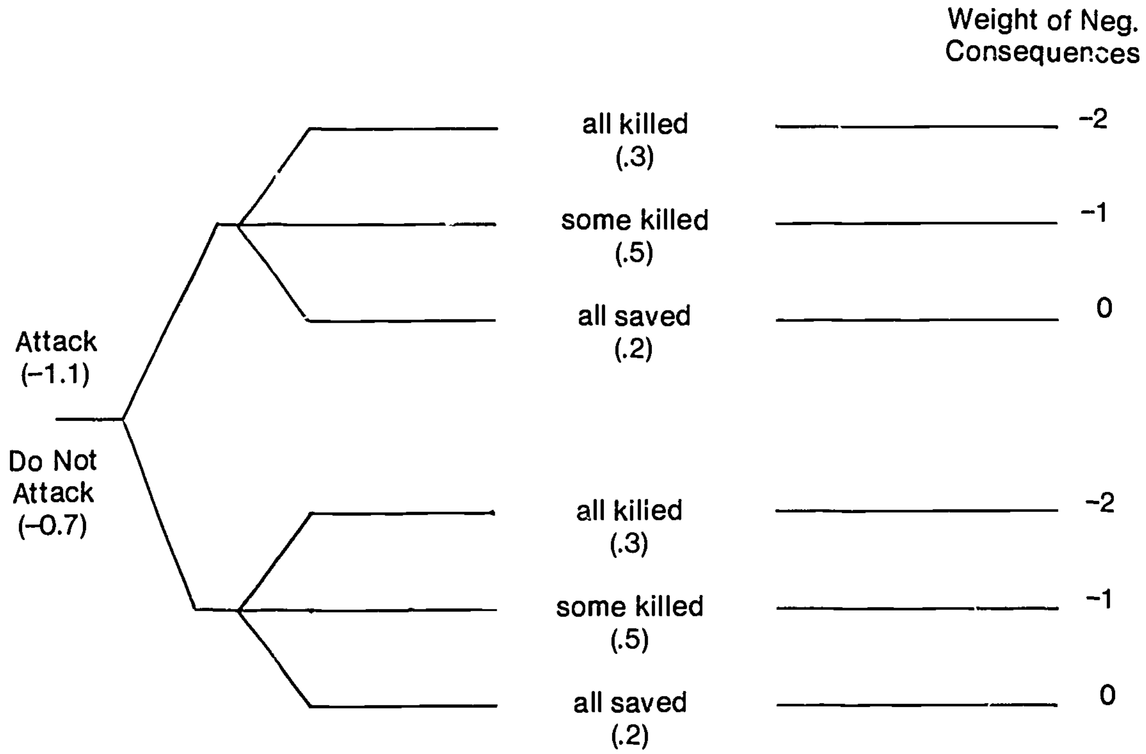
6. **Calculate the best solution.**

   Attack the aircraft: (-2)(.3) + (-1)(.5) + (0)(.2) = -1.1

   Do not attack the aircraft: (-2)(.2) + (-1)(.3) + (0)(.5) = -.7

   The best choice = Do not attack. This, by the way, was what the President did.

Figure 2.2 Should the President send in the Delta Team?



Attack = (-2)(.3) + (-1)(.5) + (0)(.2) = -1.1

No Attack = (-2)(.2) + (-1)(.3) + (0)(.5) = -0.7*

*Lowest figure is best choice

The Decision Matrix

The decision matrix is another helpful tool, particularly for solving more complex problems or more complex decision-making.

Once a number of alternatives has been identified and understood in sufficient detail (e.g., once you have identified and quantified all alternatives), a decision matrix may be helpful. A decision matrix is used most effectively when there are more than two alternatives, its efficiency increases as the number of alternatives increases. In the case of two alternatives, the decision tree seems to work out best (remember the previous example; the President had only two choices). This discussion of the decision matrix technique will be presented in the context of a case study. Put yourself in the position of the individual described.

Remember, as in the use of a decision tree, the decision matrix is simply a tool. It is not a substitute for intelligent thinking. You are probably familiar with the saying, "garbage in, garbage out", with reference to computers. The same is true when you use these decision- making tools. That is, the technique is only as good as the information **you** supply and the thinking that **you** provide.

A Case Study - American Hostages in Iran

Iran is holding several American hostages in its prisons. The President of the United States is being pressured by various groups and organizations to do something to get our people home. *What should the President do?*

The Procedure

1. **Identify the alternatives**; make a list. In this problem, the President could take any of several actions:

   a. Military action, such as bombing certain targets or sending in troops to try to rescue the Americans.

   b. Economic sanctions or action against Iran.

   c. Blockade all shipping into the country.

   d. Do nothing (an option that is as valid as any of the others).

   e. Ask Israel to release some of the prisoners they are holding and give in to the Iranian demands.

   f. Ask other mid-Eastern countries to intervene.

2. **Establish selection criteria** or important considerations. In this case, the following important condiderations were identified. That is, the President is particularly concerned about these issues:

   a. The safety of the American hostages.

   b. Public opinion in America

   c. World opinion of America.

   d. Possible economic repercussions (withholding oil shipments to America).

   e. Potential for major war in Mid-East.

   f. Possibility of more hijackings.

3. **Rank order selection criteria and calculate weighting factors.**

Examine the preceding list and rank order considerations from highest to lowest concerns. Then calculate weighting factor by dividing the rank number by the sum of the ranks. In this example,

Rank#		
6	Safety of hostages (most important)	6/21 = .28
5	More hijackings	5/21 = .24
4	Potential for major war in Mid-East	4/21 = .19
3	Public opinion in America	3/21 = .14
2	Possible economic repercussions	2/21 = .10
1	World opinion of America	1/21 = .05
21	(Sum of ranks)	1.00

Weighting factor for

Safety of hostages = $\frac{\text{Rank \#}}{\text{Sum of ranks}}$ = 6/21 = .28

Encourage more kidnappings = 5/21 = .24

Others

4. **Construct matrix chart** (See chart, step 5 following).

5. **Assign a rating factor** to each possible outcome, with 10 being the highest possibility and 1 being the lowest possibility. Remember, these judgments represent your best guesses.

   In the example (figure 2-3),

   The possibility of having a military action and safety is very low. Hence, the rating 1.

   The possibility of hostages being safe if no action is taken is fairly high. Hence, the rating is 7 .

   The possiblity of the hostages being safe if the U.S. gives in is very high. Hence, the rating is 9 .

25

Figure 2.3 Sample Decision Matrix Chart

Selection Criteria / Weighting Factor / Alternatives	SAFETY	MORE HIJACKINGS	MID-EAST WAR	AMERICAN PUBLIC OPINION	ECONOMIC REPERCUSSIONS	WORLD OPINION		SUM
Military Action	1 / ·28	8 / 1·92	5 / ·95	7 / ·98	1 / ·10	4 / ·20		
Economic Sanctions	4 / 1.12	5 / 1·20	2 / ·38	7 / ·98	2 / ·20	6 / ·30		
Blockade	4 / 1.12	5 / 1·20	5 / ·95	7 / ·98	2 / ·20	6 / ·30		
Do Nothing	7 / 1·96	5 / 1·20	8 / 1·52	3 / ·42	8 / ·80	5 / ·25		
Give In	9 / 2·52	1 / ·24	8 / 1·52	3 / ·42	8 / ·80	5 / ·25		
Intervention by Mid-Eastern Countries	5 / 1·40	5 / 1·20	5 / ·95	5 / ·70	5 / ·50	5 / ·25		

6. **Calculate the results and make decisions** (chart). This is done by multiplying each weighting factor by the rating factor and then calculating the sum for each alternative.

For example,

Safety and military action	= .28 x 1 = .28
More hijacks and military action	= .24 x 8 = 1.92
Mid East war and military action	= .19 x 5 = .95
Public opinion and military action	= .14 x 7 = .98
Economic repercussions and military action	= .10 x 1 = .10
World opinion and military action	= .05 x 4 = .20
Military action total	= 4.43

Make similar calculations for each alternative, including the sum of all possibilities.

Looking at the completed chart (Figure 2-3), according to this analysis,

What would be the best course of action?

The worst course of action?

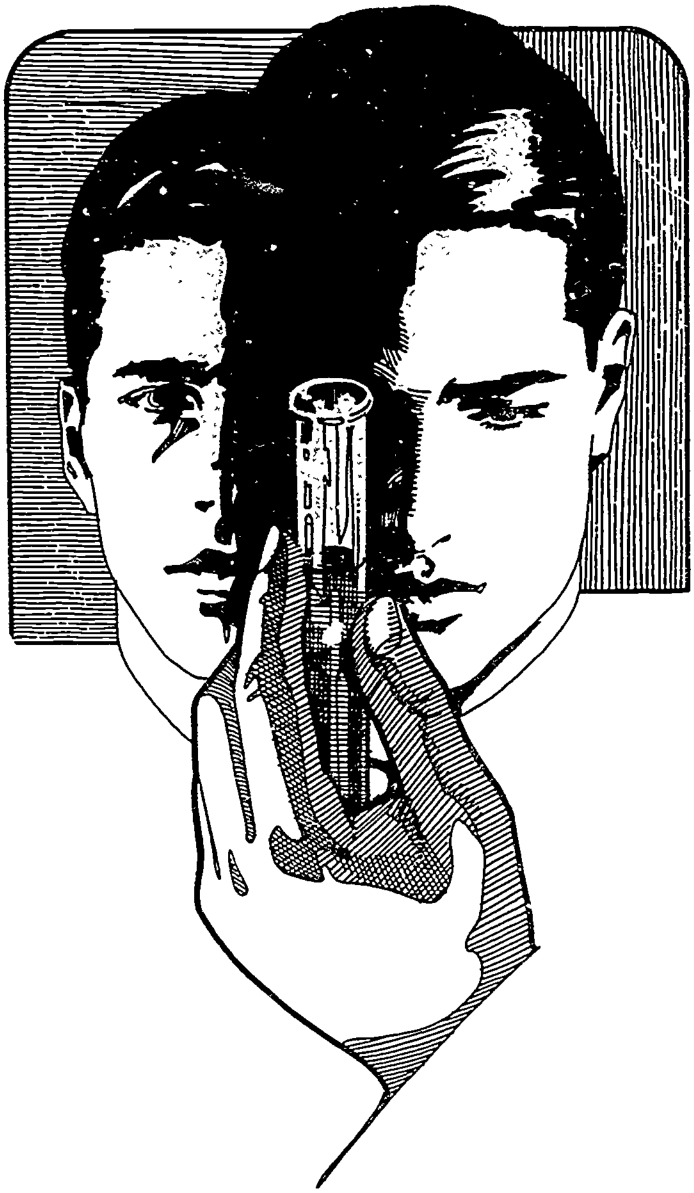
Try to use these strategies to solve other problems of all types. The more you use them, the better you will become at solving problems and making decisions. Your decision might not be **perfect**, but then what is perfect? However, when you use a systematic approach to solving problems and making decisions, such as the ones you used in this chapter and throughout this textbook, you can feel more confident that you have addressed the problem to the best of your ability. Generally speaking, a systematic problem-solving process will yield results superior to an emotional or unstructured process.

Your teacher has a blank Decision Making Matrix Form (Handout 2) for you to use to help solve future problems.

Bibliography

Hill, Percy, et al. *Making Decisions. A Multidisciplinary Introduction.* Addison-Wesley Publishing Company. Reading Massachusetts: 1979.

Chapter 3



Genetic Engineering

Genes And
New Life Forms
- Genetic Engineering -

Introduction

From your previous study of science, you might remember that the basic building blocks of living matter are cells. Each living cell contains, among other things, a nucleus. Within the nucleus of the cell are dark, rod-shaped objects - chromosomes - which are responsible for determining and transmitting hereditary characteristics. Contained within the chromosomes are small chemical units called genes which, in turn, contain a complex chemical called dioxyribonucleic acid - DNA, for short. The form and function of every living substance is determined by the molecules of DNA.

Whenever normal body cells divide, all the chromosomes that contain DNA divide in half. Each half of the long, rod-shaped chromosome chains then regenerates its other half to form two complete sets of chromosomes. Finally, the cell splits to form two new cells.

However, when sex cells (sperm and ova) form, this process doesn't work quite the same way. Each sex cell has only one half of a chromosome chain. But, when sperm and ovum unite, a whole body cell is formed. The sperm provides half of the chromosomes while the ovum provides the other half. In this way, each parent contributes one-half of the genetic material that determines the characteristics of the offspring. The specific combination of genes, and therefore, the specific characteristics of the offspring, are determined by chance. Thus, such things as hair color, eye color, skin color, posture, intelligence - to some degree, genetic defects, and even the tendency to contract certain diseases are determined by the chance union of specific genes.

As far back as the 1920's scientists were able to modify, in a rather crude and elementary way, the heredity of living cells by exposing them to blasts of x-rays or to chemical substances known as mutagens. Now, scientists are rapidly acquiring the knowledge and skills to enable them to systematically and more accurately alter the structure of cells.

Scientists known as genetic engineers can now take genes from one living organism and transplant them into other living organisms. This new technology is making it possible for scientists to create such substances as human insulin and other important hormones. Because of advances in genetic engineering, scientists will one day be able to produce vast quantities of medical substances, including serums and viruses to fight diseases ranging from cancer to the common cold.

According to *Newsweek* (17 March 1980), "The impact of genetic engineering on the world's economy could almost equal the recent revolution in microelectronics. Single celled organisms might yield the proteins that now come from cattle, which could alleviate world food shortages. Implanted genes could increase the yield of alcohol from corn. Genetically engineered bacteria are being designed to eat their way through oil spills and to extract scarce minerals from soil." Some people fear, however, that genetic engineers might be tempted to go "too far" with their experiments and begin to tinker with human life forms. Nevertheless, it seems that genetic engineers are rapidly moving the science of Biology into a golden age.

Recombinant DNA

The last time the community of biological scientists was so excited about advances in genetics was in 1953 when James Watson and Frances Crick discovered the structure of the DNA molecule. They detemined that the DNA molecule was in the shape of a double helix (Figure 3-1).

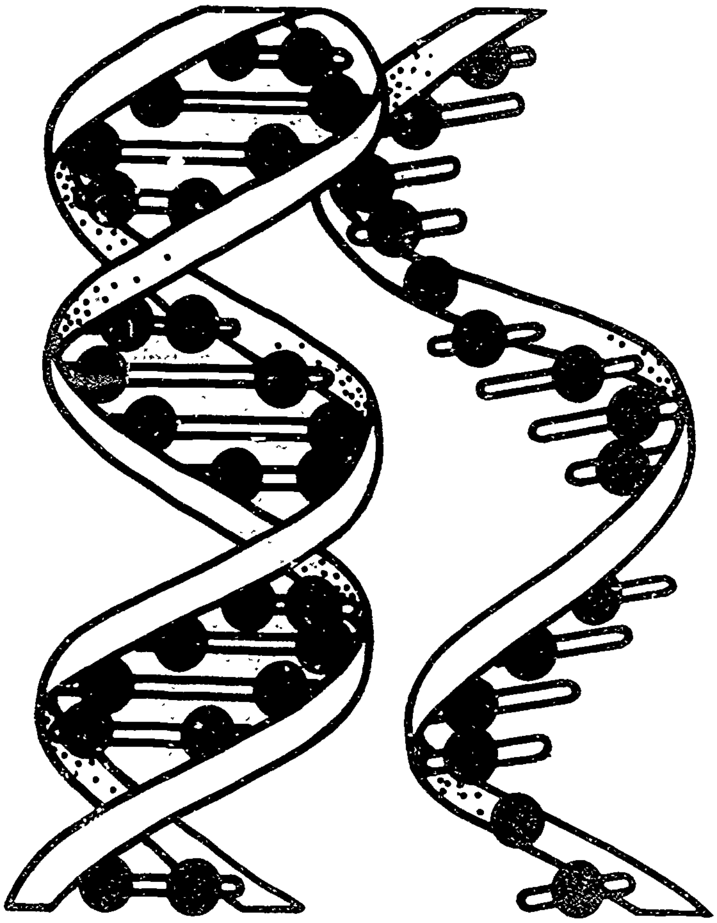


Figure 3-1: The double helix shape of the DNA molecule discovered by James Watson and Frances Crick in 1953.

The information stored in DNA allows the genes to duplicate themselves accurately. The amount of information stored in DNA is immense. However, methods learned since Watson's and Crick's great discovery now allow molecular biologists to understand how this process takes place.

It is estimated that advances in genetic engineering, particularly that aspect known as recombinant DNA, will enable scientists to identify each of the 100,000 genes that are found in the human cell. This, you might say, is all very interesting and might excite biologists, but of what **practical** value is "recombining" DNA?

How Can Recombinant DNA Help Us?

Armed with this new knowledge about DNA, scientists will be able to replace human cells that have defective genes with healthy cells. This procedure can help to cure such genetic diseases as hemophilia and sickle-cell anemia. The cure for various types of cancer might also be found in genes. In the near future scientists also hope to find the answer to such questions as

How do cells with the same genes produce skin, muscles, and nerves?

What makes normal cells turn into cancer cells?

Some genetic engineers even suggest that maybe a "better" human being might be produced. Perhaps recombinant DNA might even help us to understand ourselves better.

Helping to cure Lesch-Nyhan disease is a good example of how genetic engineering might soon help people. Individuals with Lesch-Nyhan disease have one defective gene in each of the hundred trillion cells in their bodies. Because of this defect, the cells lack the necessary instructions for making adequate amounts of an important enzyme. It is a rare disease that cripples one of the basic biochemical cycles of human cells and creates a buildup of uric acid that can cause gout and severe kidney damage. This illness leaves the victim experiencing uncontrollable urges to spit, curse, chew on their lips and fingers, and bang their heads against the walls. The condition is such that victims frequently have to be protected from themselves by being tied down in bed. Perhaps the saddest commentary on this disease is that the patients are fully aware of their self-destructive compulsiveness. They fear it, but there is nothing they can do to stop or to control themselves.

Genetic engineers hope to cure Lesch-Nyhan disease by transplanting into patients' cells "good" versions of the defective genes that cause the affliction. Lesch-Nyhan disease is known as a single gene disease. Other single gene diseases include muscular dystrophy, cystic fibrosis, hemophilia, and several types of arthritis. When scientists are able to cure Lesch-Nyhan disease, they will be able to apply that knowledge towards curing all single gene diseases within a relatively short period of time.

How Do Scientists Splice Genes?

The process in which DNA is spliced from one type of cell to another is not overly difficult to understand. In fact, if you've ever seen someone graft a branch of one type of tree or plant to another, you've seen a process that resembles gene splicing. Of course, understanding the basic process is one thing; however, fully understanding the science of recombinant DNA or actually performing the "operation" is something else. Let's see how recombinant DNA works. First, however, a brief review of how farmers graft trees might be helpful.

When a farmer wants to graft a branch of one type of tree onto another tree, he cuts out a portion of the branch on the tree. He then trims the branch he wants to graft to the tree so that it fits the cut-out portion of the branch of the host tree. For example (Figure 3-2):

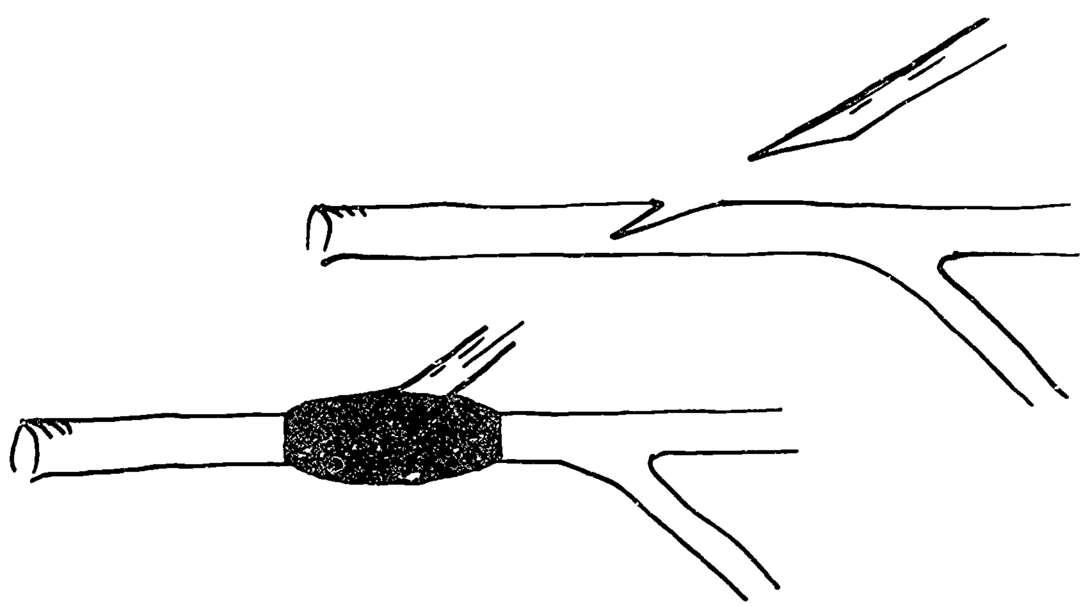
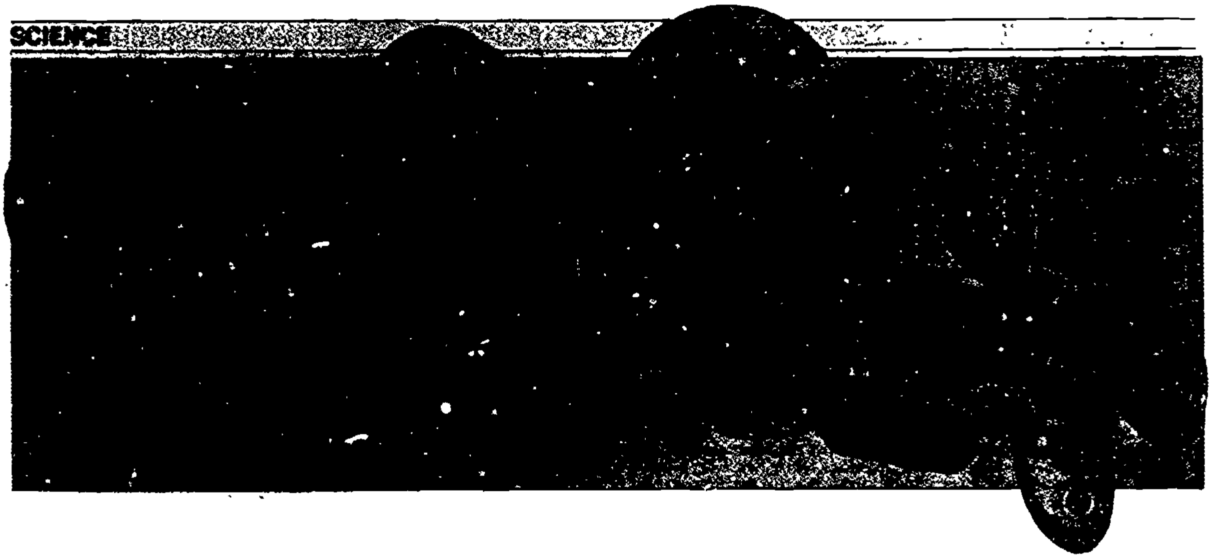


Figure 3-2: Splicing or "grafting" a branch from one tree to another

He then joins the two pieces, usually holding them together with a bandage until the graft "takes".

Now let's see how this same basic idea is used in gene splicing in recombinant DNA. (Figure 3-3).

Fig. 3.3 How Recombinant DNA Works



Once the process has been completed, thousands of bacteria are produced in a relatively short period of time. Each new bacterium has the hybrid (new form) DNA.

Safety Concerns

One of the first concerns regarding recombinant DNA research focused on safety issues. For example, as far back as 1973, researchers at Stanford University and the University of California at San Francisco inserted a gene into a bacterium known as *Escherichia coli* usually called *E. coli*). *E. coli* is found in the intestinal tract of animals, including humans, and is usually harmless. The gene that was inserted into the *E. coli* made the salmonella germ resistant to the antibiotic streptomycin. After the gene was inserted into the *E. coli* bacterium, the *E. coli* also became resistant to streptomycin.

Why do you suppose this experiment might raise concerns about safety? Would you be concerned about this kind of research? Why or why not?

It was felt by many biologists that the possibility of accidently spreading genes that make bacteria resistant to antibiotics could cause major problems. For example, some illnesses are caused by certain kinds of bacteria. To cure these illnesses, different kinds of antibiotics are used. It frequently requires long periods of time, years in fact, to find an antibiotic that cures a particular illness. If bacteria were produced that were resistant to the known treatments (e.g., antibiotics), what do you think would be the result?

Very early in the history of research in the area of recombinant DNA, scientists recognized the potential dangers of mixing genes of different substances. Some feared that bacteria containing harmful or destructive genes could escape from the lab and spread across the earth. During the early days of this type of research, horrifying scenarios were created; many resulted in horror movies. You've probably seen these movies yourself. Today, we realize that these scenarios very much overplayed the potential dangers of recombinant DNA. However, a quarter of a century or so ago, when this research was very new, even our best scientists weren't sure what to expect or what could happen.

Controlling Recombinant DNA Research

Nevertheless, to prevent any possible catastrophies from happening, the scientists went about setting up policies to control recombinant DNA research. Thus, in 1974, eleven prominent biologists led by Stanford's Paul Berg sent a letter to two highly respected journals, *Science* in the United States and *Nature* in England. The scientists warned that recent developments in molecular biology could have disastrous consequences. If certain gene-splicing experiments were carried out, they could create deadly organisms against which medicine and the human immune systems had no defense.

The scientists then made two very important proposals. First, they asked all researchers not to conduct experiments that involved the transplanting of cancer-causing animal viruses or genes into other organisms for the production of toxins or poisons. They also requested that the National Institute of Health (NIH) form a committee to evaluate and to oversee all work in the area of recombinant DNA.

Needless to say, these proposals generated much discussion. One very important question that came up was "Should society restrain the free pursuit of knowledge in order to prevent the development of techniques that might be misused?"

What do you think?

Do you think that scientists today should not work towards understanding nuclear physics because such knowledge could lead developing more powerful bombs?

Do you think that molecular biologists should not be allowed to continue their quest for knowledge because their work could lead deadlier forms of chemical warfare? Why?

Others challenged the wisdom of having the scientists themselves police their own research activities for fear that some scientists, in their excitement or eagerness to pursue knowledge in this new frontier, might not always use the wisest and most prudent judgment. On the other hand, the scientists argued that, more than any other agency, they were in the best position to monitor their own activities. They felt that as scientists they knew more about what they were doing, and more about the scientific theories upon which they were working, than anyone else. In addition, they were doing work that was vital to understanding biology and genetics, and ultimately human health. Even the prestigious World Health Organization agreed with the position of the scientists.

Approximately seven months later, an international group of scientists met at the Asilomar Conference Center near San Francisco to formally evaluate the recommendations regarding gene splicing by a group of scientists headed by Dr. Berg. For several months scientists voluntarily refrained from conducting any gene-splicing experiments with viruses and toxins. During the Asilomar Conference, it was, concluded that "while some concerns were warranted, fears of worldwide catastrophy probably were not." ("Attack on the Gene Splicers", *Discover*, August 1984). Even though gene splicing was not as dangerous as some originally thought, the Asilomar meetings produced a series of stringent guidelines to decrease the likelihood of any engineered organisms escaping from the lab and possibly infecting anyone.

For the most part the guidelines restricted research on resistance genes. They also controlled any experiments involving the DNA of any disease-causing bacteria or viruses and genes for the synthesis of potent poisons. Research in these areas could be carried out only in top-security labs. In these labs, called "P4" labs, workers are required to change clothes and shower before leaving. They also must handle bacteria under sealed hoods.

As time went on, however, the National Institute of Health, the agency responsible for enforcing the guidelines, revised and gradually relaxed its regulations. There were no ill effects. In fact, it was found that nearly all recombinant research could be done using the normal sterile procedures that are followed in any hospital.

One reason the "worst fear" of the scientists proved to be unfounded is related to the type of *E. coli* the scientists used in their gene-splicing experiments. The K-12 strain of *E. coli*, which was used in most types of experiments, lost its capacity to survive for long periods outside the laboratory. Therefore, the chances that they could spread dangerous genes were very slim. Scientists also learned that human genes vary so much from the genes of their bacterial hosts that they function only under highly controlled conditions. Professor Walter Gilbert was quoted as having said, "... scientists now know that they could not even deliberately create something dangerous."

Conforming to the Guidelines

Because there are guidelines for research and because the NIH tries to ensure that those guidelines are followed, doesn't mean that everyone will necessarily follow them. In 1980, a physician working at the University of California at Los Angeles (UCLA), attempted to transplant genes into two young women. One woman was in Italy and the other in Israel. Both were suffering from an inherited blood disorder that resembled Sickle-Cell Anemia. The illness was already beginning to affect the hearts of the two women.

The disease affecting the women stemmed from a defective gene for beta globin, an important building block of hemoglobin. Hemoglobin is the oxygen-carrying molecule in red blood cells. In this case, the physician, Martin Cline, inserted a long needle into each woman's hip and extracted some bone marrow. He then incubated the marrow cells with pieces of recombinant DNA that contained beta globin genes, undamaged versions of the patient's defective genes. Cline assumed that the marrow cells had absorbed the good genes. He then injected the treated cells back into each patient's blood stream. He assumed that the corrected cells would find their way into bone cavities and then multiply.

Cline's attempt had many flaws. According to a report appearing in *Discover* magazine (December 1984), "At that time (1980), the beta globin genes he gave his patients had never worked reliably in cultured cells. The genes had failed to function at all when Cline had put them into living mice. In addition, with the inefficient transfer method he used - merely bathing the cells in a gene soup - only a few cells could possibly be expected to take up the genes anyway. Most damaging of all in the eyes of a genetic engineering community that is highly sensitive to charges of recklessness, Cline had leapt from the lab to the clinic without approval from his University or from federal agencies."

Fortunately, Cline's patients were not harmed - nor were they helped. Because he was found guilty of violating the NIH regulations prohibiting the use of the recombinant DNA without prior approval, he lost nearly all of his grant money. Without financial backing, usually from government or corporate grants, scientists are quite powerless to conduct any kind of sophisticated research.

Most recently, a new method has been developed for getting foreign genes into human cells. The new method is far more efficient than previous methods and makes use of special viruses. These special viruses have been reengineered so that when they infect a cell, they also carry along foreign genes and even splice them into the cell's native DNA strands.

Future Benefits from Genetic Engineering

What are some of the future benefits that could be derived from genetic engineering?

Advances in genetic engineering are already paying off. Now, through recombinant DNA, scientists can make large quantities of insulin. Insulin for diabetics used to be extracted only from cattle or pigs. As a result, it frequently contained impurities that caused allergic reactions. The new insulin, manufactured by genetic engineers, provides a cheaper and safer substance for those needing it.

Another important drug, interferon, has been produced through gene-splicing techniques. Interferon has proven useful for treating and/or helping to prevent flu, hepatitis, and other viral infections. It is also an effective substance for treating certain types of cancer. Until recently, interferon research was slowed because the substance could be extracted only in small amounts from such sources as white blood cells. As a result, treatment costs were as high as $50,000. Now, interferon is available in much larger quantities and at much lower costs.

Genes have always been mysterious, and learning about them has proven to be elusive for years. Using recombinant methods, it is anticipated that scientists will be able to unravel the basic mysteries about genes. For example, one of the major questions puzzling scientists is "How are genes regulated?" All cells, except eggs and sperm, contain a complete set of genes. Most genes do not, however, do anything until they are somehow "turned on". Research now being conducted will unravel the principles of gene regulation. They may let scientists insert the genes of higher organisms into bacteria, and then "switch" them on.

A long-time puzzling problem to geneticists has been to determine the precise locations of genes within chromosomes. There are actually hundreds of thousands of possible combinations of sequences within genes. In the past, scientists rarely had enough genes to study; hence, their mapping efforts were severely hindered. Now researchers have the ability to produce enormous quantities of genes. This is a major breakthrough in genetic research.

Scientists can also tell how the more than 100,000 human genes fit into the 46 chromosomes. This is done by cloning a gene and mixing it with chromosomes whose DNA spirals have been split down the middle (remember the helix structure). The DNA bases of the "test" gene automatically find their natural partners in the appropriate split chromosomes. Thus, researchers can learn what chromosomes the gene naturally fits into and where in the chromosome the gene normally rests. Gene mapping might make possible the cure of inherited diseases like Sickle-Cell Anemia, Hemophilia, and Lesch-Nyhan disease, which result from defects in a single cell. If scientists locate the proper chromosomes, they could repair the defective gene and insert a properly functioning new gene into the cell (*Newsweek*, 17 March 1980).

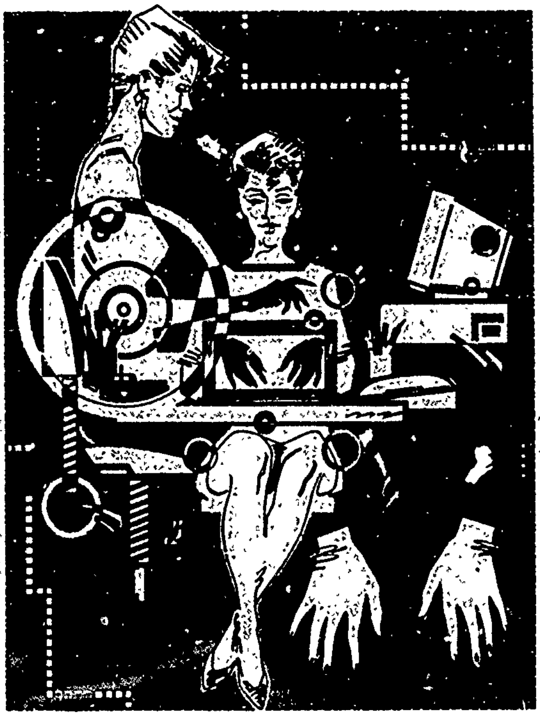
One of the brightest hopes in genetic engineering is the potential this area of research might have for curing and/or preventing cancer. Over the past few years, scientists at the University of California at San Francisco have cloned genes of viruses that cause tumors in chickens and isolated those that cause malignant cells. One of the tumor-causing genes instructs the cell to make an enzyme that transfers phosphate molecules to proteins. According to J. Michael Bishop, "our hypothesis is that this transfer of molecules causes cancerous growth." Perhaps one day this research might lead to a strategy for curing such malignancies.

An interesting finding is that tumor genes that invade cells are essentially the same as genes that already inhabit the cell. Perhaps this research might help scientists understand how cells grow and differentiate. This is a good example of how research in one field helps to provide a better understanding of another science. That is, the study of cancer, a medical problem, may lead to a better understanding of the science of cell differentiation.

Research using recombinant DNA procedures is shedding more and more light on more and more areas daily. These discoveries range from a theoretical understanding of living things to potential cures for dreaded and/or rare diseases. But this appears to be only the beginning. Aside from medicine and understanding the cell, genetics, and several other areas discussed in this reading, gene splicing holds great promise for agriculture, food production, and even mining minerals from the soil and the sea. Human regeneration of organs, the growing of a third set of teeth, or even regrowing severed nerve fibers, might become a reality one day.

Creating the "Perfect" Human

One question frequently asked is can gene splicing be used to create the "ideal" or "perfect" human being?



What do you think?

Do you recall what happened when Dr. Frankenstein tried to create his "perfect" human being? Do you think that could ever really happen?

Most reputable scientists view the possibility of creating the ideal human being as only fantasy. According to the experts, to understand the basic structure of the genes is one thing; to try to translate that structure or blueprint into a human being is a very different matter. In trying to form an organism, many gene products interact and the number of interconnections and interactions is extraordinarily complex. Besides, that is only half, at best, of what makes a human being. As you realize, human beings are products of both heredity (genes passed on by their parents) and their environment. "Because of these complexities," says Jonathan King of Massachussetts Institute of Technology, "attempts to modify human beings through genetic manipulation is a policy of false eugenics. It will do more damage than it will anything else." (*Newsweek*, 17 March 1980). Eugenics, by the way, is the science that deals with the improvement of hereditary qualities. Thus, while there is much that science knows about DNA, there is even more that it doesn't know - and maybe things that it will never know.

A Question of Ethics

Some people feel that when scientists attempt to alter human heredity, they are in some ways trying to "play God". Hence, they pose a very fundamental question, Is it ethical to give people foreign genes?

Assuming that gene transplantation really works, proponents argue that they will probably be able to do nothing more than give a patient the biochemical functions that other healthy people have when they are born. No new powers or talents, except those that the patient already had but couldn't use because of the illness, will be gained. In fact, the corrected genes could not even be transmitted to the patient's children.

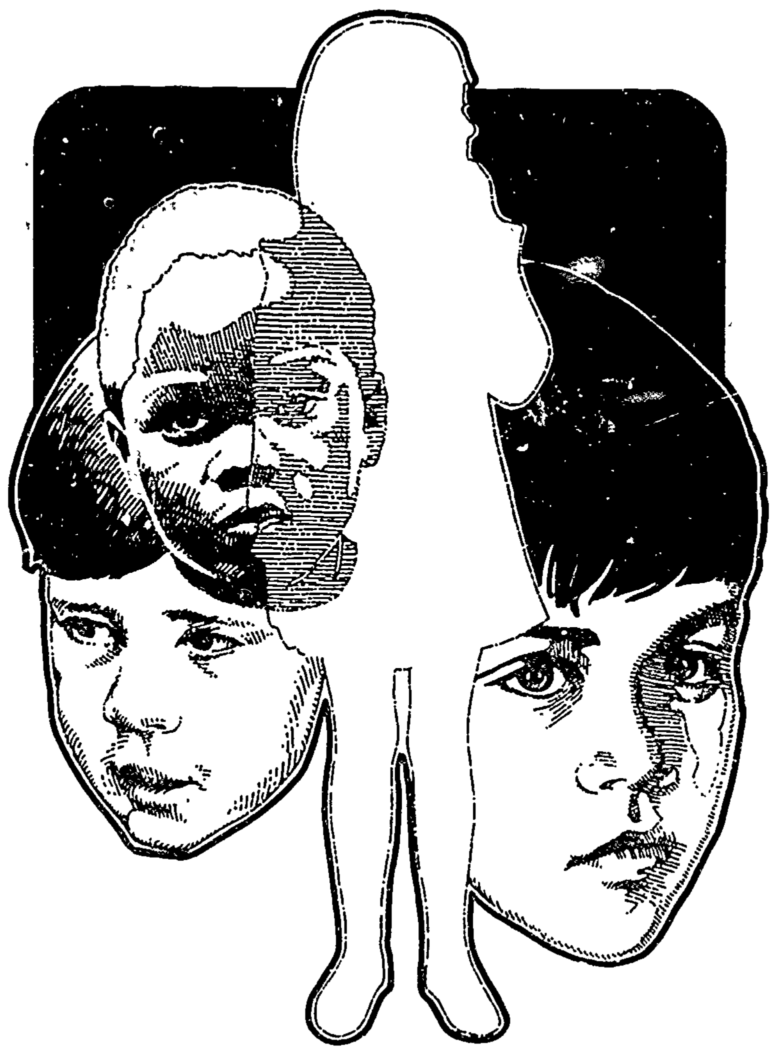
In 1982, when it became apparent that human applications of genetic engineering were being considered, Congress and a presidential commission examined the issue very closely. The President's Commission for the Study of Ethical Problems in Medicine and Biochemical and Behavioral Research lamented in its November 1982 report, *Splicing Life*, that genetic engineering has become a "target for simplistic slogans that try to capture vague fears". The commission found that the planned medical uses of genetic engineering "resembled accepted forms of diagnosis and treatment" and should be evaluated by the same ethical and safety standards. Hence, the same questions that apply to **all** medical research - safety, efficiency, adequate testing, choice of patients and procedures - should apply to genetic engineering as well.

Ethicist LeRoy Walters of Georgetown University stated, "Anytime you're dealing with questions like How safe is safe enough?' or Is the risk/benefit ratio appropriate for this proposed experiment?' you're inevitably into value questions and value judgments." Values- related questions and judgments are very difficult to evaluate since there frequently is no one "right" answer.

There is also another ethical question that seems to bother people. A few years ago, the U.S. Supreme Court ruled that new forms of life can be patented and sold by the owner of the patent. That is, a scientist and/or a company is entitled to sell anything they produce through genetic engineering exclusively for a period of 17 years. Some people feel that this is wrong.

What do you think?

Do you foresee any potential dangers in such an arrangement? What are they?



The Tule'ake Story

- A Case Study -

Despite the potential benefits that can be derived from genetic engineering and genetic engineering research, some people simply are against using this technology in any way. One individual, Jeremy Rifkin, thought that the release of any organisms altered by gene splicing could endanger public health and the environment. Although he had no formal training in science and genetic engineering, he was willing to back his position by using the courts. This case study illustrates how effective Rifkin was.

Two scientists at the University of California at Berkeley received permission from the recombinant DNA advisory committee of the National Institute of Health to perform a rather simple test using specially engineered bacteria, *Pseudomonas* syringae. *Pseudomonas* lives as a parasite in the leaves of many plants. When the temperature falls to freezing (0° C), the bacterium produces a protein that serves as a seed or a nucleus upon which ice crystals can form. The frost damages the plant, then the bacterium feeds on the plant's frost- damaged tissues. Plants free of *Pseudomonas* can, for brief periods, withstand temperatures as low as -1° C before being harmed, because without an ice-promoting seed, dew can be cooled to -1° C before it freezes.

The approach used by the two scientists, Steven Lindow and Nickolas Panopoulos, was to produce *Pseudomonas* bacteria without the gene that codes for the "culprit" protein, and spray them on crops in sufficient quantity to drive out the ones found naturally in the area. This approach would protect crops against unseasonal frosts, which cost agriculture $1.5 billion each year in the United States alone. It would also extend the growing season, enabling farmers to increase production.

The scientists had used these techniques very successfully in greenhouse experiments. Now they wanted to conduct an experiment to determine if their technique would work in the real world and on a real problem.

In 1977, Mr. Rifkin campaigned against all recombinant DNA research. At the time he equated such research with Nazi eugenics. He was obviously aware of the medical and scientific gains attributed to DNA research, but nevertheless he remained totally against gene splicing of any type.

Rifkin sought an injunction against the Berkeley researchers to prohibit them from releasing the bacteria. Much to the surprise of the scientists - shock might be a better word - Judge John J. Sirica complied with Rifkin's request. To complicate matters further, Sirica directed the NIH to no longer consider any proposals for experiments involving the release of engineered organisms into the environment.

Judge Sirica (you might remember him from the Watergate t. .ls) raised two significant questions during the proceedings:

> Did the NIH, in granting permission to Lindow and Panopoulos to conduct the experiment, assess the risks involved as required by federal laws?
>
> Should society (e.g., the courts), rather than the scientific community, regulate the growing field of biotechnology?

Until now, the recombinant DNA advisory committee had been the sole judge on any issues dealing with gene splicing experiments funded by the government. (Private companies did not have to go through this committee. However, many companies still sought the clearance of the committee voluntarily).

In making his judgment, what did judge Sirica imply about the jobs done by the DNA advisory committee, thus far?

From your reading, how well had the DNA advisory committee performed? Why?

Judge Sirica implied that the advisory committee had not done a vigilant and adequate job in handling DNA research. The records, however, show a very different story. Think back to your reading (or turn back to the appropriate pages). It is clear to most, at least, that gene splicing experiments approved by the committee made invaluable contributions to medicine and science, without in any way endangering researchers or the public.

During the hearing, both sides of the controversy tried to get the Judge to listen to expert testimony. Judge Sirica refused to hear either side's experts, maintaining that he was not there to judge science but to determine whether or not the NIH had followed required procedures. That is, did the NIH, as Rifkin charged, violate the National Environmental Policy Act (NEPA) which requires federal officials to file environmental impact statements or assessments before approving "action significantly affecting the quality of the human environment".

Some scientists, while not pleased with Judge Sirica's ruling, felt that he had raised some significant issues. Also, while they disagreed with Rifkin's way of dealing with the problem, some felt that his methods did not necessarily make him wrong.

The following are quotations from scientific experts.

There is an appropriate time and place for public debate on the introduction of genetic engineering techniques in our society. However, by vastly exaggerating the possibility of a genetic catastrophe, Rifkin obscured any legitimate concerns the public may have.

Frederick Ausubel, Genetic Professor
Harvard Medical School

To agree that it is a new life-form (Lindow and Panopoulos' genetically engineered **Pseudomonas***) and is capable of upsetting a delicate ecological balance is to suggest that two individuals who differ in an eye color gene are different life-forms, or that an individual who is treated with a drug to protect against the action of a deleterious gene product will upset nature's good design.*

Paul Berg, Geneticist
Stanford University
Nobel Prizewinner for pioneering work in recombinant DNA

Recombinant DNA technology is a tool, no more moral or immoral than electricity, fire, or the hammer. Let's not allow misguided fears to deny its benefits to ourselves and posterity.

Harold Slavkin, Biochemist
University of Southern California

The release of gene-spliced microorganisms into the environment at this stage, before any type of assessment has been made, would be totally irresponsible.

Liebe Cavalieri, Biochemist
Sloan-Kettering Institute

... the historical record shows severe problems have resulted when alien species have been imported into the United States. The Japanese beetle and gypsy moth have caused great problems. Genetically-engineered organisms could do the same... altered bacteria could get into the atmosphere and eventually change the climate by retarding the formation of ice crystals.

David Pimentel, Ecologist
Cornell University

I continue to believe that the factors need to be considered carefully, but if I were a member of the RAC (Recombinant DNA Advisory Committee), I would vote to allow these experiments to proceed.

Peter Raven, Botonist
Washington University, St. Louis

The approved test not only presents no threat to the environment, but the approach to be used is environmentally one of the least disruptive known for the protection of plants against harmful organisms.

James Cook, Plant Pathologist
U.S. Department of Agriculture

With which of the above positions do you agree?

With which do you think Judge Sirica would agree?

Judge Sirica has obviously ruled against genetic engineering research. *Do you agree with him?*

What would you do if you were the judge?

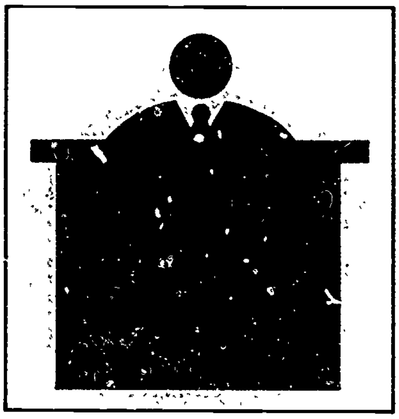
In the next activity you will have a chance to decide.

You Be the Judge
- Activity -

Part A. Should the experiment be stopped?

In this part of the activity you will be asked to place yourselves in the position of Judge John Sirica and make a decision on a very important issue.

Two University of California scientists have been given permission by the regulatory committee to conduct an experiment. The experiment involves spreading genetically engineered bacteria over a field of potato plants. The experiment has been successful in several tests in greenhouses. Now, the scientists must try out their experiment on real crops in the field.



An organization called the Foundation on Economic Trends felt that the experiment would pose a danger to the natural environment and to the people living in the area. The group is against gene splicing of any type. They argue that the procedure to be used has not been tested adequately. They also cite that on many occassions in the past, severe problems have been caused when alien species were imported into the United States. For example, organisms such as the Japanese Beetle and the Gypsy Moth have caused many problems. Genetically engineered organisms, they argue, could do the same.

To prevent the experiment from taking place, the Foundation on Economic Trends is seeking an injunction from the courts. You are the judge assigned to handle the case.

Should you issue the injunction to stop the experiment?

* * * *

In solving this problem, follow the decision-making model you studied in the first chapter of this textbook. When you get to the step that tells you to "apply decision aids" use the decision tree.

* * * *

What was your decision? Do you feel that the experiment should not be conducted? Why?

On what premise did Judge Sirica make his decision and do you think that he made the right choice? Why?

After completing this activity, share your decision with your classmates.

What were their decisions? How did your decision compare with theirs?

What might account for any difference?

Part B - Who should regulate and monitor the field of biotechnology?

In ruling on the Tulelake experiment, Judge John Sirica raised a very important issue, namely:

Should society, rather than the scientific community regulate the growing field of biotechnology?

Having society regulate biotechnology is one possibility that might work. On the other hand having the scientists regulate themselves might be a good idea. How about a combination? What are the positive and negative aspects of these possibilities?

You have now learned how to use a decision matrix to help in making decisions about questions involving more than two possibilities. In this activity, you will be asked to develop a decision matrix to decide who should regulate and monitor the field of biotechnology?

Use the reading to help you identify the "alternatives" (step 1) and the "selection criteria" (step 2). You can use the case study example "American Hostages in Iran" to refresh your memory on how to calculate the "best" decision for this problem. After completing this activity, share your decisions with your classmates.

What were their decisions?

How did your decisions compare with those of your classmates? What might account for any differences?

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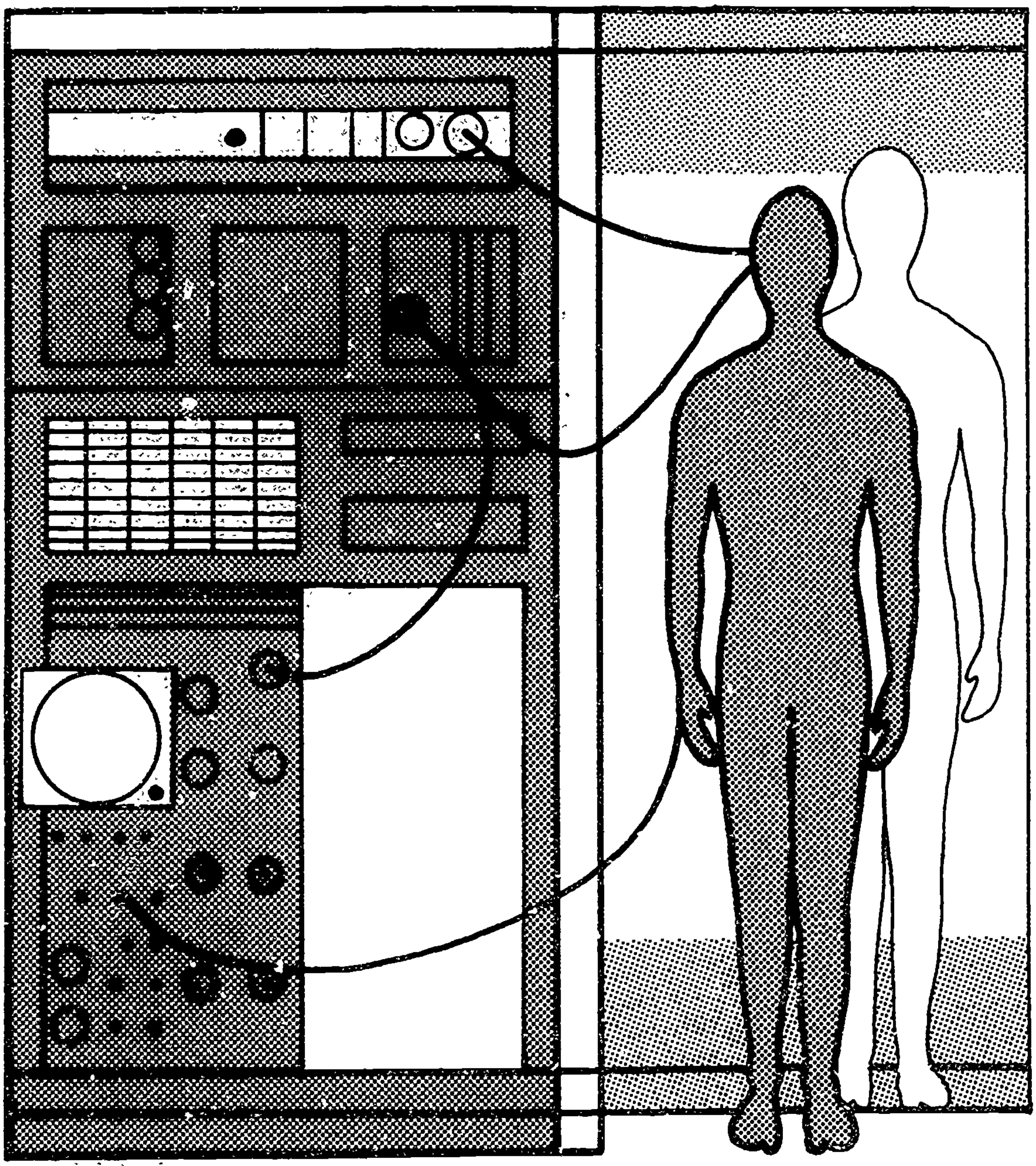
Chapter 4



Artificial Intelligence

Smart Machines
- Can Computers Make The Human Brain Obsolete? -

Introduction

Computers that can see?

Computers that can converse with you in French, Spanish or Italian?

Computers that can beat the world's greatest chessmasters?

Computers that can locate oil deposits?

Computers that can guide aircraft across the sky?

Computers that can conduct psychotherapy sessions?

Computers that can use common sense?

Computers that can think. . .really think?

Researchers are working on all of these projects, and many more. Computer scientists specializing in an area called Artificial Intelligence, or simply AI, are just beginning to make real progress after nearly a decade of frustrating work. "Artificial Intelligence"is defined by Marvin Minsky at Massachussetts Institute of Technology as "the science of making machines do things that would require intelligence if they were done by men".

AI types of programs were written as far back as the late 1940's. Those programs were rather simple ones because the computers available then were also quite simple. But those modest starts set the stage and got the field underway. By the 1950's, computers became more powerful and, of course, so did the new computer programs. AI at last began to emerge as a field of research in its own right.

As the field of AI continued to develop, two very perplexing and, frankly, troubling questions emerged:

1. Can machines be developed that are smarter than their human creators?
2. Will artificial intelligence make the human brain obsolete?

Before we examine in detail whether computers are smarter than humans or whether they will make the human brain obsolete, let's learn a little more about what AI is, what it can do, and what, presumably, it can't do.

"If-Then": The Logic of Early AI

Very early in the history of AI, researchers found that it was rather easy to duplicate some human mental powers on a computer. One of the earliest programs, *Logic Theorist,* was written by the AI pioneers Allen Newell and Herbert Simon at Carnegie Mellon University (Pittsburgh, PA) in conjunction with I. Clifford Shaw of the Rand Corporation. *Logic Theorist* was designed to prove theorms in mathematical logic. This early program performed so well that it generated proofs that were superior to those found in the standard mathematical textbooks.

As work progressed in the area of AI, researchers became very interested in trying to determine how well they could imitate "expert" behavior. In the 1960's, Newell and Simon pointed out that much of human knowledge could be represented rather simply by a series of "if- then" rules.

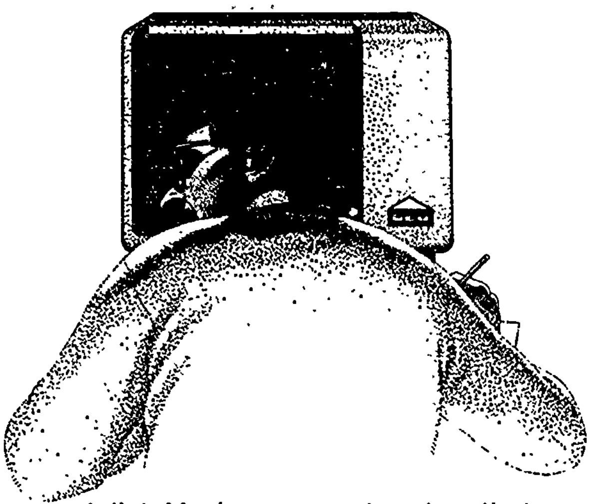
For example

"**If** it looks like a dog, and walks like a dog, and barks like a dog,**then**, it probably is a dog."

How about this one?

"**If** it looks like a tiger, and it looks hungry, and it's headed toward you, **then** , ______," (You guessed it) run!.

Try some "if-then" statements yourself. Try some with several more "ifs". Does this appear to be a useful finding? Do you think that "if-then" statements could be helpful in problem-solving? Why or why not? Try to solve some of your math problems using "if-then" statements. How about non-mathematical problems? Try some.



While the work of Newell and Simon on "if-then" statements might be interesting, it was too simple and, frankly, of very limited value in problem-solving. "If - then" statements are, however, very useful for diagnostic purposes and form the foundation for "expert systems".

Expert Systems and AI

Edward Feigenbaum at Stanford University (California) developed an "expert system" called *Mycin*. "Expert systems" are computer programs that give advice like a human specialist. *Mycin,* an expert system that was capable of diagnosing infectious diseases, was based on "if- then" statements. Here is an example:

If, (a.) the infection is meningitis, and

(b.) organisms were not seen in the stain of the cultures, and

(c.) the type of infection may be bacterial, and

(d.) the patient has been seriously burned,

then, there is suggestive evidence that Psuedomonas Aeruginosa may be one of the organisms causing the infection.

Mycin can also "interact" with the physician by responding to questions, making suggestions for further testing, diagnosis, and treatment. It can even, if requested, explain **its** reasoning pattern in order to acquaint the doctor with **its** diagnostic logic.

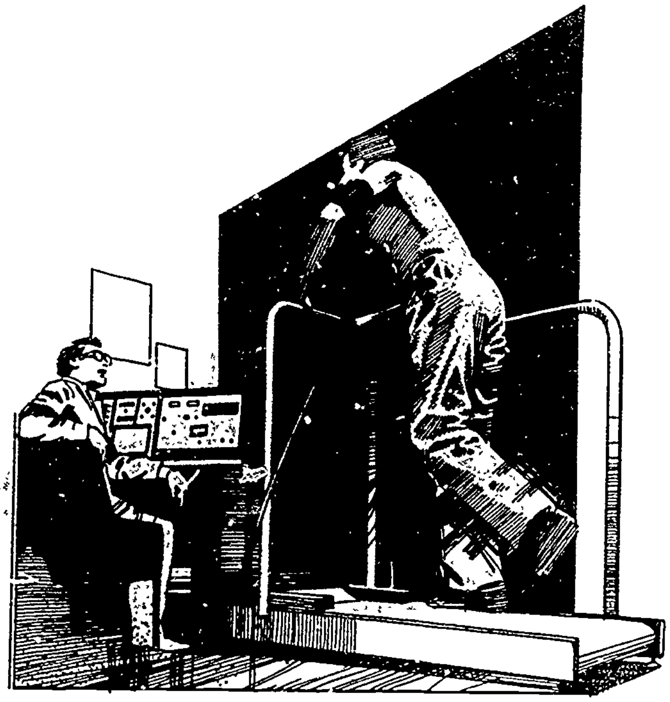
Does Mycin really explain **its** *reasoning pattern? Explain. Whose reasoning pattern does Mycin really explain?*

Several other programs have been developed to help diagnose other medical problems. *Internist* is a diagnostic program for internal medicine. *Internist* was developed at the University of Pittsburgh and deals with complex diagnostic problems. The program covers nearly 500 diseases and more than 3,000 individual indications of disease. While used primarily by physicians, it also helps physicians' assistants in remote rural health clinics, corpsmen on submarines, and maybe even astronauts on future space missions will rely on such an aid. *Puff*, a program for interpreting pulmonary (associated with the lungs) tests, has also received good "reviews" by health care professionals.

Physicians can now purchase several varieties of diagnostic programs for office computers or personal computers. Of course, none of these programs, including *Mycin*, *Internist*, and others, make the decisions, nor do they prescribe the treatments. Only the physician, after much thought and analysis, actually prescribes the treatment.

These types of programs seem to be gaining an unusual amount of attention from some sectors of the computer and AI community. Any ideas why?

"Expert Systems" based on "if-then" statements are also being developed for use in other types of diagnostic work. For example, *Prospector* is an expert system used by petroleum geologists searching out oil deposits.



Experts vs. Novices — How Do They Compare?

In order to develop "expert systems", even those based on "if-then" statements, researchers obviously had to study experts and how they went about solving problems. This research uncovered some very interesting facts. Experts, it appears, seldom consciously use logic and reason to solve problems. Instead, they just seem to look at a problem and say, "Aha, that's a conservation of energy problem," or, "Aha, that's an ideal gas law problem." Experts seem to store the appropriate problem-solving sequences in their heads and simply retrieve the information and/or solutions when needed. Experts are familiar with many tasks that they performed many times before. They have vast experience that they can call upon to solve a variety of problems.

Novices or beginners, on the other hand, approach problems in a very different way. That is, they painfully move step-by-step through the problem. They lack the background of information and strategies that the expert has. Hubert Dreyfus, an existential philosopher at the University of California at Berkeley, and his brother, Stuart, studied expert pilots and novice pilots to determine how each group functioned. They also compared expert chess players with novice chess players. After interviewing fighter pilots and studying data on chess players, they concluded that "only novices proceed according to formal rules; as they become more proficient, people rely increasingly on context and experience. Expert pilots, for example, don't think of themselves flying an airplane but as simply flying. Chess masters don't analyze hundreds of board positions, they sense the right move popping' into their heads. What guides them is not conscious analytical thought, but intuitive response." (*Science 85*, March 1985. p. 51).

Artificial Intelligence processes have also been used to study games - chess, backgammon, and checkers. In some cases the results have been impressive. A computer program developed by Dr. Hans Berliner of Carnegie Mellon University in Pittsburgh defeated a World Backgammon Champion by a hefty 7 - 1 score. Ironically, the defeated champion happened to be one of the consultants who helped in developing the victorious computer program.

Computer chess programs were developed as far back as the 1950's. Even then it was predicted that within a decade a computer program would become the World Champion. This did not occur, and only recently have computer programs severely challenged expert chessmasters.

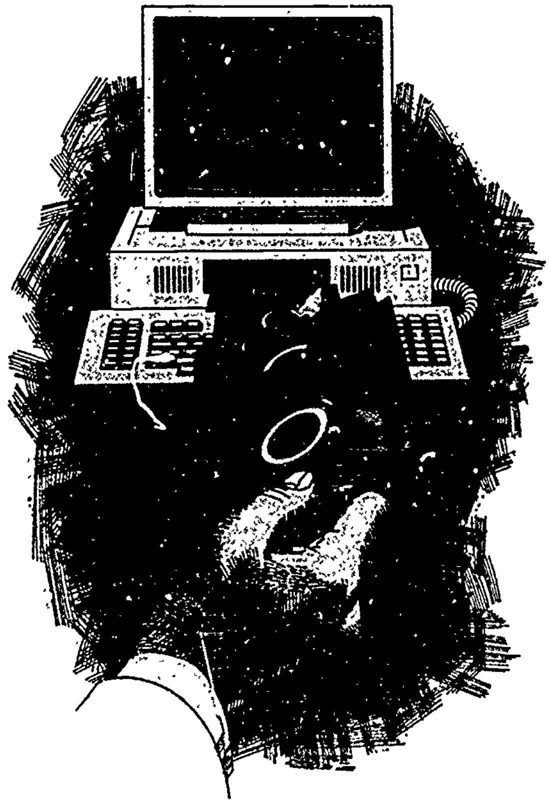
It seems that chessmasters and computers go about playing the game differently. "At any given point in a chess game, the number of possible responses carried out three moves ahead for each side is, for all practical purposes, infinite. With high-speed microelectronic currents, a chess computer like the one at Bell Labs in Murray Hill, New Jersey, can evaluate some 5,000 positions per second. But for the fastest of modern computers to calculate even ten moves ahead for each side, considering all possibilities, would take tens of thousands of years (*Smithsonian Magazine*, March, 1980). Skilled chess players are much more highly discriminating in the types of moves they consider. Instead of mentally "trying out" large numbers of potential moves, the serious player concentrates on evaluating a small number of promising ones. The very top players seem to employ highly original, intuitive methods of playing which, in many cases, they don't even understand themselves.

The surprising thing about most expert systems, according to *Science 85* (March, 1985), is not how smart they are but how limited they are. "Commercial systems are idiot savants." That is, they are idiots except in the one area in which they have a detailed knowledge. *Mycin*, for example, knew all about blood diseases but had no idea what a patient was or what a human being is all about.

Programming and Artificial Intelligence

Research in artificial intelligence is very similar to research in physics, mathematics, or most other abstract sciences. First, an abstract idea about the mind is turned into a computer program. In step one, the equations are written down for use in step two; in step two, the program solves the equation. If the process works, then your idea about the mind is validated. If the process doesn't work... well, you try again.

In AI research, just as in all computer programming, everything that is done, to the tiniest detail, must be explained to the computer. Roger Shank of Yale University describes the way AI researchers think about the human mind, a mind that is mechanistic: "Process. Seeing what the steps are, seeing what the inputs are and providing step-by-step procedures to get from plan A to plan B."



In studying how people tackle various tasks so that they can then develop AI programs to do similar things, researchers uncovered some other interesting ideas. It was found that some of the seemingly more difficult tasks were relatively easy to program, while ordinary, everyday things (walking, reading, writing, etc.) proved to be incredibly difficult to program.

To see how difficult it can be to program ordinary, "simple" tasks try the following:

Try writing down **everything** a child has to do to stack up three blocks into a little tower. Include everything in the procedure: how she finds the next block, how she moves her hand to it, in what position she holds her hand, how she grasps the block, what direction she moves it... and then at the end try to figure out how she knows what to do next.

Go ahead... try it!

This exact problem was actually the basis for a project that was conducted at Massachussetts Institute of Technology in the late 1960's and early 1970's. A simulated robot arm was produced that would build a tower with three blocks. The system, when completed. worked about as well as any three-year-old. The computer even had to be "taught" to not take a block from the bottom of the tower and put it on top.

This apparently simple task - to form a tower with three small blocks - proved to be anything but simple. At MIT dozens of computer engineering specialists and AI specialists worked on the problem.

In part, what seems to make our everyday, common-sense abilities so extraordinary is the sheer quantity of knowledge involved. Current expert systems can handle, at most, a few thousand procedures before the computer program gets to be intolerably slow. On the other hand, a chess player uses roughly 50,000 procedures in his or her area of expertise. We probably know millions, maybe even billions, of common-sense things such as tying our shoes, dressing, combing our hair, and so on. One couldn't begin to guess how many rules are involved in all of the common-sense tasks we do and things we know.

Knowledge: The Key To Intelligence

Knowledge, then, appears to be the critical element in intelligence - even more important than reasoning ability. Researchers have tried for years to develop a general problem-solver, a program that could reason its way through almost any kind of problem. None would work. It seems that to think about chess, for example, you need to know about chess. To think about physics or football, for that matter, you need to know physics and you need to know football.

According to Bruce Buchanan at Stanford University, the only way you can get a computer to act intelligently is to give it plenty of knowledge about the task at hand. The problem is that putting knowledge into the computer is like cramming for an exam. First you teach it a long list of facts, then some rules of thumb, then some examples from the real world, then ... it goes on and on. "So one of the critical research problems in AI is finding efficient means of building new knowledge bases." (Waldrop, 1985).

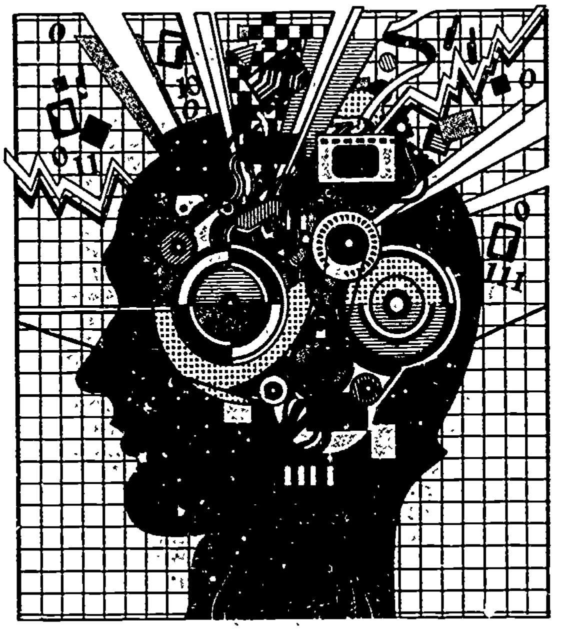
Buchanan is a leader in developing expert systems that take the experiences of the doctor, lawyer, accountant, or financial analyst/advisor and put them into a form so the computer can use the experiences to give near-human advice. Buchanan, like many researchers working on expert systems in AI, tends to focus on medicine and medical applications of AI. Buchanan is currently working on a project to teach computers how to learn in a medical setting - specifically, how to extract a general rule about diagnosi g jaundice by studying the case histories of many individual patients.

Knowledge is particularly important when it comes to understanding natural language. Language is a lot more than words. It includes an enormous body of knowledge about the world, a sharp sensitivity to how the words are used (i.e., context), and an intuitive insight into human goals and beliefs. This has yet to be built into a computer or a robot For example, if you asked a robot "Could you pass the salt?" The robot would probably reply "yes" but it would never "occur" to the robot to acutally hand you the salt.

Researchers in AI now admit that before they can make computers any smarter they will have to come up with an explanation of how intelligence works in people. This led to the emergence of cognitive science, a new discipline that links philosophy, psychology, anthropology, linguistics, neuroscience, and computers to develop a theory of the way humans think. The guiding principle of most cognitive science research is the idea that the mind, like the computer, is a system for manipulating symbols; a device for processing information. The task for cognitive science is to discover how the processing of symbols actually occurs.

Computers and the Human Brain

Will computers ever be able to imitate the human brain, much less surpass it? If machines are going to imitate the human brain, they will have to be able to store an enormous amount of knowledge. Hence, much of the work in AI over the past decade has been in finding ways to code and store knowledge in a form that machines can use. Two important systems, "frames" and "scripts", have been used for this purpose.



Marvin Minsky at MIT developed the system called "frames", a technique that tends to resemble a questionnaire filled with facts about a single subject or concept. *Science '85* (March 1985) provides an example of a frame of "Snoopy":

"Snoopy"

Breed - Beagle.

Owner - Charlie Brown.

Color - Black and white.

Frames could also use information from other frames, such as

Snoopy - a dog.

Dog - A mammal.

etc.

Roger Shank at Yale developed a coding system that he calls scripts. A script is a sequence of typical steps in an everyday scenario. A restaurant script might list the following (*Science 85*, March 1985):

Making the reservations.

Being seated.

Reading the menu.

Ordering.

Tipping before departing.

Shank also attempted to include human emotions such as love or ambition. Other researchers are trying to codify how we intuitively learn other subjects, like chemistry, geology, or history.

Geoffrey Hinton of Carnegie Mellon University has been working on an area called parallel intelligence. His point is that even the fastest modern computers still run one step at a time, the same way the first computers ran in the 1940's. The human brain gets around this by putting billions of neurons to work simultaneously. So people such as Hinton are trying to copy the brain by designing computers that have as many as a million processors working in parallel. Hinton believes that the new machines, besides being faster, will teach us new ways to think about thinking. "The kind of hardware you have determines the kinds of problems you can do well." For example, if you are in a jungle and see a tiger, you don't just make a visual identification. You recognize a great deal more about tigers, and danger, and running.

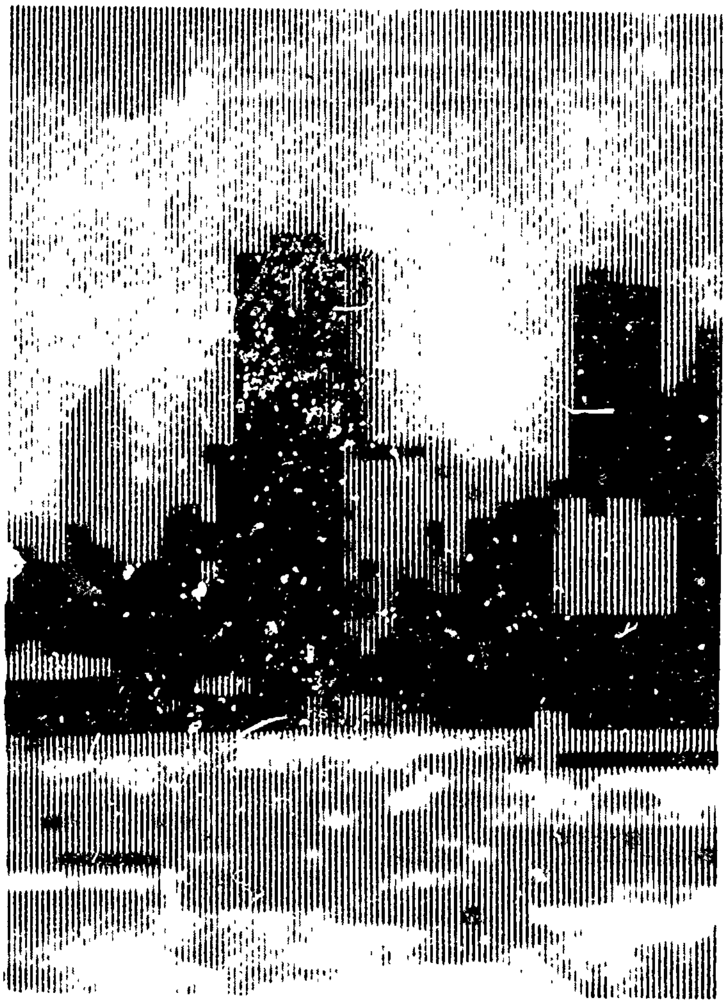
There are several other expert systems that have gone beyond "if-then" methods. Some are used to simulate national and man-made disasters. During the "Three Mile Island" incident, computers were used to simulate the reactor's problems and to estimate the amount of damage done to the reactor core. The New York City Police Department has a special unit that uses computers to help in rapidly identifying criminal subjects. The program can selectively scan photographs and information on 250,000 suspects arrested in the past several years and bases its analysis on 56 descriptive features of the criminal.

Can Machines See or Talk?

It might be interesting to note that at this point no computer can recognize a face - something that we typically do every day. However, with human brains and eyes, it's a "simple" task. But is it really so simple? As you walk down the street, unaware of the **billion** calculations that are taking place, you glance across the street and think, "Oh, there's Cara." Consider what that recognition involved. Without being aware of it, you

> compared the visual image from across the street with all the millions of people, as well as dogs, cars, houses, etc., you have seen in your life; and once you found the right image, you matched the face with Cara's name.
>
> That also set off a whole set of shared experiences: how you feel about her, what you might want to say to her, a joke she might enjoy, etc.

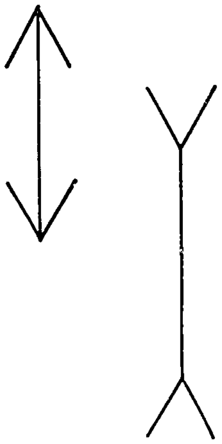
All this quickly "pops" into your head; it's there even before you can lift your arm to wave to her.



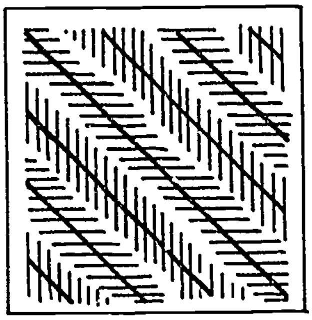
Tomaso Poggio at MIT has been studying how nerve cells respond to an image falling on the retina of the eye. He is studying the mathematics of vision to determine how a computer might recognize images through optic sensors.

"Vision can be defined as reverse optics," according to Poggio. "You start with a two-dimensional image on the retina (e.g., height and width), and from that you have to reconstruct the three-dimensional object that caused the image" (*Science 85*, March, 1985). In addition we must also deal with such things as traffic, stairways, and hard line drives to second base. The visual system doesn't have time for theories; it must be practically instantaneous.

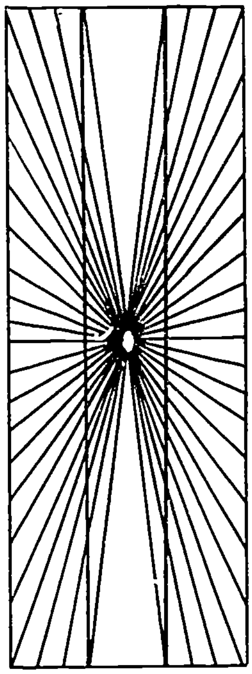
Thus, the eye uses a set of tricks to identify objects and to figure out what they are. These tricks include stereo vision, shading, colors, surface textures, change in the image with motions and what we expect to see. None of these tricks is foolproof. Sometimes the eye guesses wrong. For example see Figure 4-1.



Which line is longer?



Are the diagonal lines parallel



Are the two vertical lines straight?

Figure 4-1. Try these - were you fooled?

Poggio is now working on the idea that all of the visual system's tricks can be described by the same mathematical equations. If so, researchers would gain a very powerful tool for understanding the mechanics of vision. But there is much work to be done. Scientists need to know much more about how the brain extracts meaning from a visual scene. How does it recognize a face?

What about talking? Voices built of computer bits are becoming commonplace. The chatter through video games, announced fuel levels from automobile dashboards, and bellowing warnings from airplane instrument panels are all examples of this. People can learn to speak French or English from a computer. Computers can usher theater goers out of the theater in an emergency, and even dictate the day's chores in the morning. Existing computers are large enough and fast enough. But they can only speak when told explicitly and precisely how. That is a problem. A computer, for example, needs to be informed that the c's in chair and in choir are different.

Children learn to speak by joining tiny blocks of sounds into words. These blocks are called phonemes. English uses about 45 phonemes to create more than 200,000 words. For example, the spoken word "science" is made up of 5 phonemes that can be combined and represented as

/s//ay//uh//n//s/

People speak about 200 words per minute and an average word contains about 7 phonemes. That means that people speak about 1,400 phonemes a minute. Speech can be synthesized by linking strings of phonemes, but the results sound stiff and machine-like.

Speech recognition is another area of interest on the part of researchers. A machine that could communicate by voice, rather than by keyboard, would be very effective. Some machines of this type are available already. Perhaps in the near future such machines will be able to take dictation and then print out a draft of the dictated message.

Each speech pattern, like each fingerprint, is unique. This quality can be very useful for some tasks--for example, banking by telephone; your "voice-print" can serve to identify who you are.

Do you think that perhaps a voice machine could eventually replace an actual signature? A voice signature?

Voice "signatures" can also be used to identify "crank" telephone callers, a useful tool for the police.

There are some computers that can read a book aloud, a great aid for the blind. Such a machine is in use at the Library of Congress in Washington, D.C. Here, an opened book is placed face down in a scanner (something like a copying machine). As the machine scans the letters on the page, they are converted to digital signals that are analyzed by a small computer and transformed into voice by an electronic voice synthesizer. The speech produced by this machine is similar to natural spoken English; it is not a monotonous, machine-like type of speech.

Speech, however, is more than making sounds. It includes rules of grammar and syntax that are all learned and presumably a computer could do this same thing. But an intelligent machine, if it is to understand ordinary language, must be capable of drawing inferences. For example,

"I had a headache this morning; before I got relief, I had to go to three drugstores."

Implied in this sentence is the speaker's failure to find a headache- relieving medicine in the first two drugstores. But how can a machine draw such a conclusion since it is unable to have a headache and has never visited a drugstore?

What does a computer program need to be able to imitate a human brain?

What are the two most important things? (Remember our discussions earlier. Recall, too, the work of Shank and Minsky as well.)

While AI and computers can do truly remarkable things, none can perform anything with the ease of the human brain.

Will Machines Ever Really Think Like Humans?

Some people feel that AI searchers are trying to make machines too human-like. They argue that such attempts will never work. Although computers may reason and use logic, they cannot simulate intuition, sensuality, and emotions, which comprise the essence of humanity.

Marvin Minsky, however, argues that emotions are not necessarily more mysterious than reason. He maintains, "It is a mistaken idea in our culture that feelings and emotions are deep, whereas intelligence, how we get ideas, and how we think are easy to understand." Other things, humanness "and things people refer to as intuition, insight, inspiration - may be hidden parts of the mind. We seem to be oblivious to ourselves." For example, we walk down the sidewalk and give no thought to balancing, coordination, and so on. Even seeing where we are going, making sense of that ever-changing swell of motions, color, light, and shadows, presents no problem. To see and to make sense of what you see requires 100 million receptor cells - rods and cones - in each eye. Altogether the eye's system does the equivalent of 10 billion calculations each second before image information ever gets to the optic nervel Once the data reaches the brain, the cerebral cortex has more than a dozen separate vision centers to process it.

Will machines ever really be able to think? Hubert Dreyfus at the University of California at Berkeley maintains, "The way people are misled about artificial intelligence is by scientists who say that pretty soon computers will be smarter than we are, and then we'll have to worry about how to control them." Dreyfus maintains that computers will never be able to think because scientists will never come up with a suitably rigorous set of rules to describe how we think. To many computer scientists this is like saying the earth is flat. So far no one has proven Dreyfus wrong, however.

What might the earth "being flat" have to do with saying that computers will never think? Explain.

Others argue, "Who cares if machines will ever think or not? If a machine does its job very, very well, what does it matter if it really thinks or not?"

Some people agree with Dreyfus, however. They feel that thinking and feeling are too complicated. Even if we someday learn to understand all the principles and laws that govern the mind, that doesn't mean we can duplicate it. Understanding astronomy, for example, doesn't mean we can create a planet or a galaxy.

Another group of prominent scientists feel that machines will really think someday, but not as we do. Others respond by arguing that non- human thinking can't possibly be real thinking.

Seymour Papert of MIT and author of the book *Mindstorms*, responds that being against the idea of real thinking by machines is similar to being against "artificial flight" in the early days of the 20th Century:

> *This leads us to imagine skeptics who would say, you mathematicians deal with ideal fluids - the atmosphere is vastly more complicated or you have no reason to suppose that airplanes and birds work the same way - birds have no propellors and airplanes have no feathers." But the premises of these criticisms are true only in the most superficial sense: the same principles (e.g., Bernoulli's law) apply to real as well as ideal fluids, and they apply whether the fluids flow over a feather or an aluminum wing.*

Relate Papert's analogy to whether or not machines will ever be able to really think. How do the arguments of the opponents of machines thinking and the argument of opponents of "artificial flying" seem the same?

If a machine can be made to think, then perhaps we are machines. Although this statement seems to disturb some people, our bones, muscles, and blood obey the laws of physics; our enzymes and DNA follow the laws of chemistry.

John Searle at the University of California, Berkeley, suggests that the computer is an immensely useful tool in the study of language and the study of the mind, but it can't really think because all it does is manipulate symbols which don't really mean anything to the computer. People working in AI find these arguments less than compelling. While opinions differ on whether machines can really think, researchers tend to be more comfortable thinking of themselves as machines.

"What if we are machines? If so, we are marvelously complex and surprising machines . . . Perhaps a snowflake is only a collection of water molecules. Perhaps the Magic Flute is only a collection of sound waves. And perhaps, in trying to isolate the essence of the human mind, AI will only reaffirm how useful and precious it really is." (*Science 85*, March, 1985).

Now, let's go back to our original questions.

Can machines be developed that are smarter than human creatures?

Will artificial intelligence make the human brain obsolete?

What do you think?

The Delphi Survey
- Activity I -

Introduction

The Delphi Survey is a method of gathering opinions from a group of experts. The name Delphi comes from the ancient Greek city, Delphi. It was there that the Oracle resided, and people journeyed from afar to seek its forecasts and advice. The Delphi method, today, is most often used with other forecasting methods to study the future.

Forecasting, however, is not the same as consulting an oracle who supposedly knows the future in advance. In forecasting, information is gathered and studied to determine the possible ways that future events might occur, as well as what changes could take place to make an event happen. For instance, weather forecasters do not simply make guesses; they chart and calculate air pressures, wind directions, and amounts of moisture. Examining the possible forecasts, they then make a prediction about the weather for the next day or several days. The accuracy of their predictions depends on how much information they have, how well they use that information, and how well they understand the natural forces that produce weather patterns.

The Delphi Survey is basically a series of questionnaires presented to a panel of experts who then indicate their **opinion, preference**, or **judgment** on those questions. The idea is that a good estimation of a situation can be obtained when many persons are asked to provide advice. When the panelists complete the first set of questions, known as "Round #1", the moderator or manager compiles the answers and summarizes the results. The results are then presented to the full panel. After they examine the results, they may wish to change their first answer or stay with their original choice. The questions are presented again in "Round #2" and so on until some agreement has been reached. Panelists are required to explain the reasons for their choices.

By presenting the questions several times the panelists have a chance to re-think their own ideas, as well as the ideas of others. Each panelist works independently and does not publicly announce how he/she responded to the questions. Anonymity is an important characteristic of the Delphi Survey. It allows one to freely express one's opinion without being influenced or intimidated by others.

A moderator or manager serves to organize and present the survey results.

In this activity you will use the Delphi Survey to express your opinions about advances in artificial intelligence, computers, and the changes that will occur in the future. As you carry out this activity, you will have the opportunity to express your own feelings about artificial intelligence and computer technology.

Instructions

You will participate in two rounds of the survey by completing the questionnaire, *What Are Your Future Forecasts*, (Handout 3) provided by your teacher. The questionnaire lists several types of future advances in artificial intelligence and in computer technology that could occur.

On the questionnaire you will indicate

- whether you think the advances and changes are desirable,
- when you think they will occur,
- what are the effects of the advances and changes, and
- why you came to your conclusions.

If you need more space to explain your conclusions, use the back of the form.

When everyone in the class has completed the survey, the forms will be collected. A moderator or small committee will total the results and summarize the comments. The results, presented on a survey form, will be posted for the entire class to examine. After reviewing the results, the entire class will complete a second survey form.

Delphi Round #1

— Each student will receive one copy of the survey form and individually answer the questions. It is important that you do not discuss your responses with anyone else. As mentioned before, one of the major assets of the Delphi Survey is confidentiality. This allows members of the Delphi panel to freely express their opinions without being influenced by others.

— On the left hand column of the form is a list of advances and changes. Take each one in turn and decide whether you think it is desirable. There are four choices: VERY DESIRABLE, DESIRABLE, NEUTRAL, and NOT DESIRABLE. Mark (x) your choice in the proper box. Then indicate when you think it will occur:

Between 1990 and 2000?
Between 2001 and 2010?
Between 2011 and 2020?
Beyond 2020?
Never?

Again, mark (x) the proper box.

— In the next column, list some effects you think will occur.

— In the last column, explain why you came to that conclusion. That is, what information or events helped you make your decision? (Use the back of the form if you need more space for your answer.)

Delphi Round #2

— Review the results of Round #1 presented on the summary survey form. How did your responses compare with the responses of the other panel members?

— *Where were the responses similiar? Different?*
— *Do you agree or disagree with the explanations given? Why or why not?*
— *Do you think that the forecasts can be supported by the evidence?*
— *Where was there greatest agreement among the panel members? Greatest disagreement?*

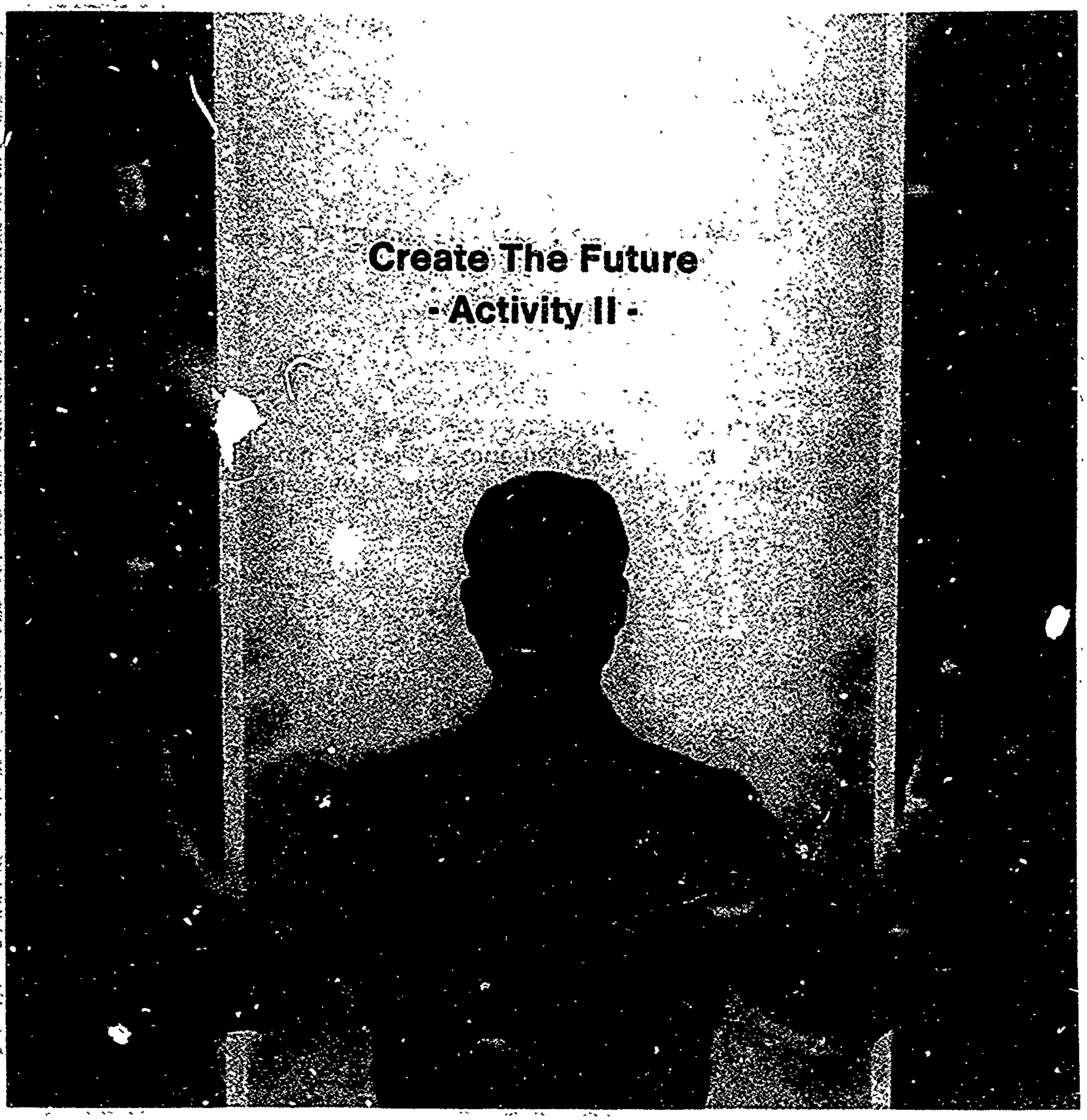
— Your teacher will distribute a second copy of the survey form. Complete the form in the same way as you did on the first round. This time, however, you know the opinions of the rest of the panel (although you should not know which specific student gave each response). What do you think about the majority opinion? Are there any changes that you would like to make? Again, explain how you made your decision in the space provided. Be sure to indicate the facts that support your decision.

— A moderator or committee will again summarize the results and present the findings to the rest of the class.

Discussion of the Results

— The results of the two rounds will be put on the chalkboard or projected on a screen for everyone to see.
— During the class discussion, consider the following questions:

  — *Are the results of the two rounds similar or different?*
  — *Were there many changes made in the second round?*
  — *On which items was there the greatest agreement? Greatest disagreement? Can you explain the reasons for the agreement and/or the disagreement?*
  — *What does the panel like most about computers? Least?*
  — *In what ways will advances in artificial intelligence and computer technology change the way we live?*



Introduction

A scenario is a story or description of a possible future - what could be. In writing a scenario one forecasts certain kinds of changes and tries to imagine the effects of those changes. A single change can bring about other changes. When one examines possible changes and tries to put everything together into a "total" picture, as in a scenario, it becomes easier to see how one event relates to another to create a possible future event.

Scenarios are frequently used in conjunction with or as a "follow-up" to other future forecasting strategies. They are also used, sometimes, as a planning guide. One may determine one's goals for the future and use the scenario to lay out the steps necessary to get there. For example, if one's goal were to establish a community in space, the scenario should describe how the community functions. The descriptions would include the number and types of people living there, the work that will be done, the kinds of food and shelter needed, the methods for obtaining supplies, types of leisure activities, the possible effects of living in outer space, and so on. As problems and needs begin to emerge, the planner will have a framework from which to work out the necessary details and consider the different ways to create a space community.

Scenarios are also used to examine the effects of decisions. Different decisions lead to different futures. The scenarios in this case would describe where a particular decision will lead. By looking at that possible end result, one can perhaps decide better whether or not that's the change desired. For instance, one might decide that all the work in the space community will be performed by robots. What, then, will the human residents do? With all that free time will they pursue other creative activities such as painting, composing music, writing novels, or what? Will there be enough activity in that small area to keep people entertained. Will they become bored and lazy?

What are the advantages of being served by robots? Disadvantages?

Science fiction is one form of scenario writing. Some writers base their scenes on today's current trends and try to project what the future holds if the trends continue. Jules Verne in the 1800's predicted the existence of submarines, airplanes, and spaceships for the future. Other writers have suggested new and different styles of living; for example, societies where everyone is identical and people live free from conflict and competition, such as Aldous Huxley's *Brave New World*. Others have used their stories to point out in a more diametric way the problems of our current society. In all cases, science fiction writers test new visions by letting their imaginations explore different and unusual ideas.

Instructions

In the previous reading, *"Smart Machines - Can Computers Make the Human Brain Obsolete?"*, you learned about artificial intelligence, what it is, what it can do now, and what researchers are trying to make it do in the future. Social questions were raised throughout the reading regarding concerns about AI and computers and their impact on society. Two of the more significant questions dealt with the possibility of developing machines that might be smarter than their human creators and whether AI might make the human brain obsolete.

You have read the opinions of the experts. Some of them are in full agreement, others agree partially, and still others are in total disagreement. You also have the results of the Delphi Survey which provide the opinions of your classmates on these same issues. In this activity you are to write your scenario for the future insofar as AI is concerned. What will AI enable us to do ten years from now? What kinds of intelligent machines will there be? What will they be like? Will they be able to think? Will they be able to "talk" with us? Will they be able to hear or see? Will they be able to cry, laugh, or feel pain? How might they change our lives? Change the workplace? Change schools? Change the ways we spend our leisure time? Change travel? Change medicine? Change . . . ?

Here are some additional helpful questions to guide you.

— What are some of the known facts or trends that might support your ideas?
— How well does the story hold together? Does one idea relate to another to build a complete story?
— Do you have any suggestions about how a different problem might be solved?
— Are your arguments well presented? How might you make your ideas more believable?
— Is the scenario intriguing to the reader?

In this activity, the future will be in your hands. Good luck and do a great job.

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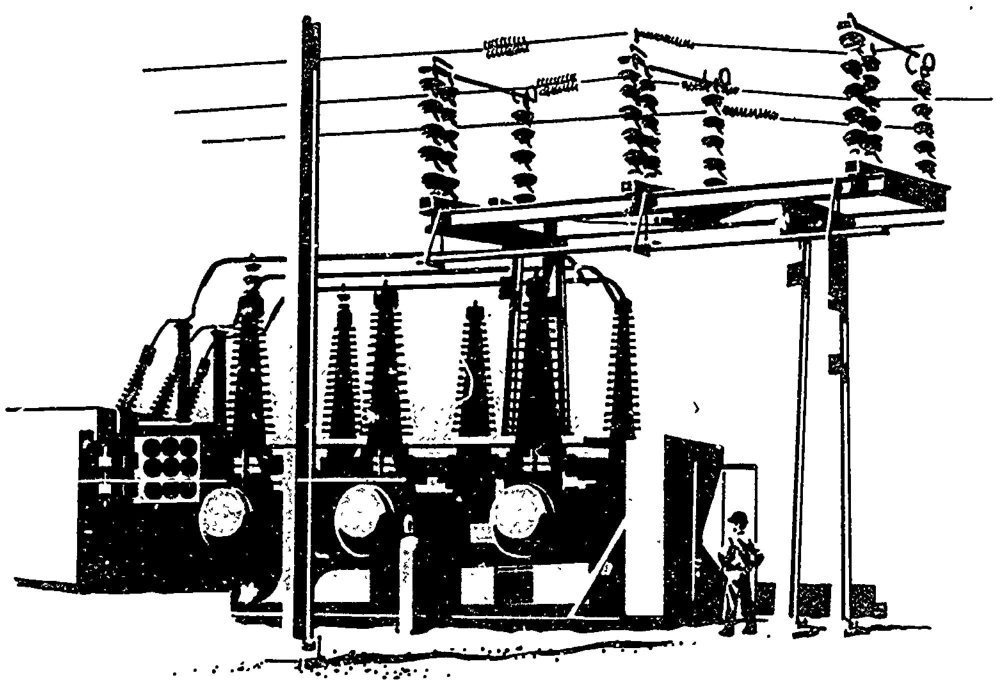
Chapter 5



Nuclear Energy

The Smithville Decision[1]

- Reading 1 -

As a citizen of Smithville, you are about to vote on a proposal that will have a significant effect on you and your neighbors. The Metropolitan Electric Company wants to build a nuclear-fueled power plant 20 miles from the center of town. Your vote will help to decide the fate of the proposed plant. Many different and new changes will come about if this plant is approved. Therefore, consider the issues carefully and discuss the question with others before coming to a final decision.

To give you some ideas concerning the issues surrounding the question of nuclear power, read the following transcript of a tape recording of the town meeting that took place earlier this month in Smithville. At this meeting people from all sections of the town came to give their opinions about the building of the nuclear plant. Examine each of the opinions critically and use worksheet No. 1 to help you reach your decision.

Reading 1: A transcript from Smithville Town Meeting - Proposal: The Construction Of Smithville Nuclear Power Plant

MRS. MILTON: There is no question that the present power generating plants supplying our area are old and can't produce all the electricity that our town will need in the future. Most of you probably remember what happened during the hot spell last August. It was unbearable without air conditioning. When we all had our air conditioners on full blast, the increased electricity load proved too much for the system to handle and we were "blacked out" for two days. Having no lights was bad enough, but what was worse was that we couldn't cook. There was no hot water for showers, and when the freezer defrosted I had to throw out my frozen vegetables that had just been harvested from our garden. Don't even mention all of the meats that had to be thrown out.

MR. SHOAR: Yes, indeed, do I remember that calamity! With my arthritis I couldn't get up to my tenth floor apartment without the elevator and had to camp out in the lobby of the building. Half of the people in the building were down there! Even the people who could get up to their apartments weren't any better off. With the water pumps out of service there was no way to get water upstairs unless you carried it yourself. Those people upstairs couldn't even flush their toilets!

MRS. LEON: The electric utility company has put in more safety devices to keep that from happening again. But we still have to put up with those annoying brownouts when they cut back on power. And the brownouts always come at the most

[1] Adapted in part from Iozzi, Louis A. et al. *Energy: Decision for Today and Tomorrow*. Sopris West, Inc., Longmont, Co. 1982.

inconvenient times - when I'm cooking nner or in the middle of my favorite TV show, or when the kids are doing their homework at night. Have you noticed that there were more and more brownouts in the last few months, ever since they built that new section of houses and the new refrigerator assembly plant came into town?

MR. ADAMS: I think that the nuclear generating plant is going to be a good thing for all of us. Electricity from the oil- generating plants has been getting more expensive every year. On my social security pension I can't afford much of anything else after paying the rent and electric bill. I don't know what I can do if it goes any higher. Last winter I turned my electric heater down as low as I could stand. But I have asthma and rheumatism and have to keep the rooms warm.

Electricity from a nuclear generator will be quite a bit cheaper. Our taxes could also be lowered because the new nuclear plant would be selling electricity to our neighboring town. Taxes from that will mean that the town wouldn't need to collect as much tax money from our local people.

MR. THOMSON: The price of oil has fluctuated dramatically over the last ten years. There have been temporary oil gluts that dropped prices, but because much of our oil is imported, both prices and supplies are dictated by foreign countries. While we continue to import oil, we also continue to increase our vulnerability to possible cutoffs of supplies, to rising prices and political pressures, and to interferences from exporting countries. I'm tired of having my electric bills rise each month.

MRS. FLETCHER: I'm not sure that nuclear generated electricity is going to be any cheaper. It's my understanding that the design and construction costs of nuclear plants are very high. In addition, experience has shown that very few plants are completed at or below the original projected cost. Someone has to pay this expense. Won't this cost be added to our electricity bills?

MR. BROWN: I am an economist for the power company. The power company feels that in the long run it would be more economical to generate electricity from nuclear power. We realize that the initial capital investment (the construction costs, etc.) is greater for nuclear power plants than coal fired power plants because of the added safety and envrionmental features. However, the fuel costs will be less and with the depreciation and capital investment over time, we project that the cost per kilowatt-hour (kWh) will be less. If we examine the economic data for our nuclear plant, which has been in operation since 1980; our coal plant, which has been in operation since 1976; and our oil plant, which has been in operation since 1970, we can see the cost savings that nuclear power provides.

Power Plant Type	Fuel Cost	Capital	Operations & Maintenance	Total Cost/kWh
Coal	1.8¢	1.1¢	0.4¢	3.3¢
Nuclear	0.8¢	1.8¢	0.6¢	3.2¢
Oil	5.7¢	1.0¢	0.6¢	7.3¢

It should be noted that the capacity factor — the percentage of electricity produced compared to the amount capable of being produced — affects the kWh cost. The higher the capacity factor, the lower the cost. The capacity factors for the above plants were: nuclear 71%; coal 73.7%; and oil 30.0%. The reason the oil capacity factor is so low is because we use it as a backup power plant — that is, it is used only when the demand is above normal. We have projected that the cost per kWh for our new nuclear plant will be between 8 and 38% less than coal. The variation is due in part to the sulphur content of the coal we are allowed to burn, and the necessary environmental features required. I must also mention that the actual costs are influenced by inflation, construction delays and price changes in fuel.

MR. JACOBS: I think sometimes we should learn to give up a few of our modern-age comforts and conveniences and perhaps try to cut back on the amount of electricity we use. There are some things money can't buy. I'm talking about Stevens Lake where they plan to build the nuclear plant. The lake has the best trout fishing and swimming in all of Tatum County. Water will be needed to cool the nuclear generator, and the water going back into the lake will be several degrees warmer. No one knows for sure what might happen to the lake by increasing its water temperature. Warmer waters can lead to increased growth of algae and bacteria and can cause changes in the numbers and types of fish that live there.

I don't want our natural recreational area changed and marred by that monstrous concrete and steel generating structure.

MR. FETTER: I agree with Mr. Jacobs. It's vitally important to protect our natural lands from such drastic changes. Building the plant doesn't end with just the plant alone. High-voltage transmission lines will be needed to carry the electricity. Roads will be widened to permit the heavy truck traffic. Large parking lots will be needed for the plant employees' cars, and the entire area will have to be fenced off and heavily guarded to prevent intruders or possible saboteurs.

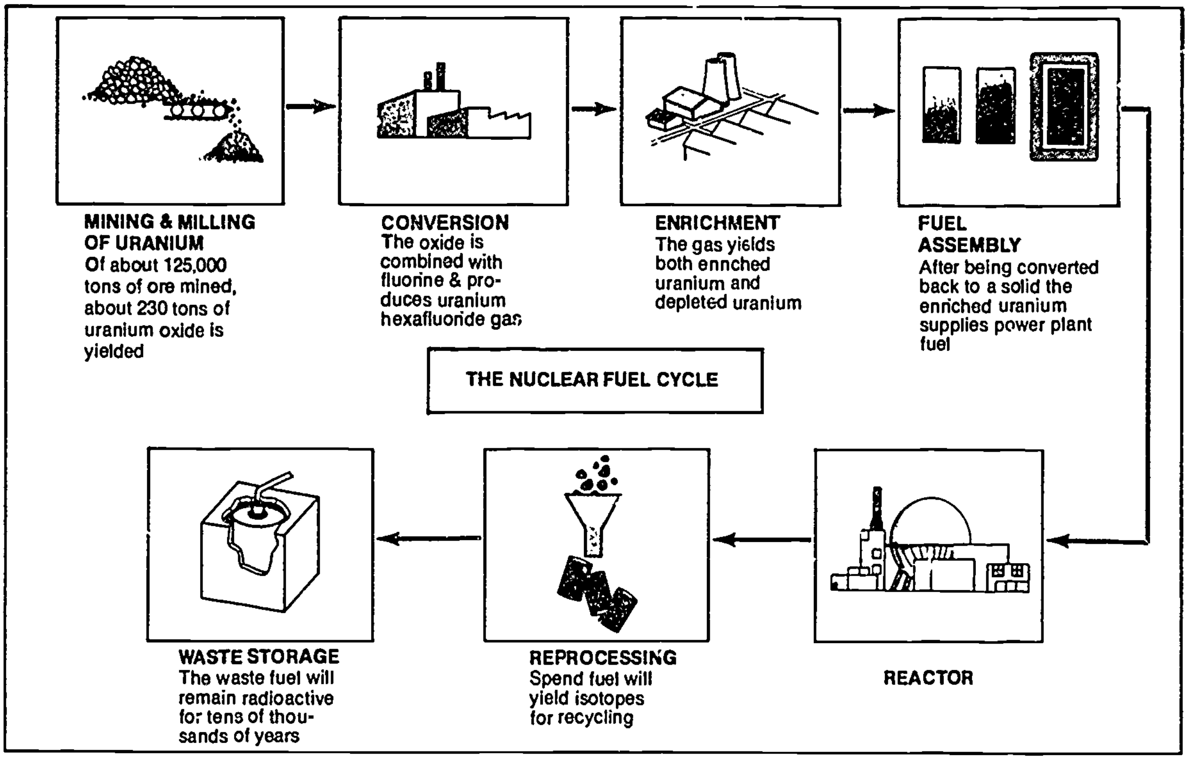
MR. JACKSON: This is all very confusing to me. I am not really sure how a nuclear plant actually works.

MISS SPENCER: I'm an engineer with the Metropolitan Electric Company. Let me see if I can explain it to you. Nuclear plants produce their energy through a process called nuclear fission. Nuclear fission takes place when an atomic particle strikes the nucleus of an atom and is then absorbed in the nucleus. This causes that atom to become unstable so that it splits apart into two smaller particles. Uranium, found in nature, is a substance whose atoms readily split. This makes it an excellent fuel source to use in a nuclear reactor. The nuclear reactor is used in the nuclear power plant as the boiler is used in the fossil fuel plant.

Nuclear fission, the process of splitting the atom, produces the heat necessary to turn water into steam. A nuclear plant uses steam in the same method as a coal- or oil-fueled plant. The steam is forced against blades in a turbine, causing them to turn a shaft that extends into a generator. This motion causes the spinning of poles of an electromagnet between coils of copper wire, thus producing electricity.

Water from Stevens Lake would be needed in the cooling process; however, our engineering design will include cooling towers so that the hot water will not be directly discharged into the lake. Hot water from the power plant will be cooled in the cooling tower and recycled. Some water used in the cooling process would be returned to the lake at a slightly, but insignificantly higher temperature than the lake. Most of the heat would be lost to the atmosphere as steam from the cooling tower. We feel that there would be no negative thermal pollution to the lake.

This chart helps to describe what is known as the nuclear fuel cycle. It tracks the life cycle of nuclear fuel from the mining of uranium to the storage of waste material.



MR. HAYES: As mayor of the town, my concern is to see to it that the community has sufficient electricity to satisfy its needs and has enough for future needs. We all want our town to grow and prosper and that won't happen if we don't have enough electricity. A nuclear generator has less effect on the environment than any other type of electricity- generating plant now in general use. You can see for yourself the smoke that comes out of our oil-generating plant. With an oil shortage we might have to change to coal generators and that too will affect the air quality. Let me give you some facts: a typical fossil fuel plant generating 1,000 megawatts of electricity throws out into the air each day several hundred tons of particulate matter, sulfur dioxide, nitrogen oxide, and ash, as well as carbon monoxide. To keep a coal generator operating, railroad cars will be needed to bring in the coal.

MRS. CANTOR: If our town allows a new generating plant to be built, that plant can't be smoky and dirty. The air around the town is bad enough with our coal-burning steel mill. I just read in a recent study that places with high air pollution have many more cases of lung disease and deaths as a result of the polluted air. Children and older people are more easily affected, and I don't want anything that might risk the health of my children.

A nuclear-generating plant doesn't throw out dirty smoke with carbon monoxide and sulfur. Sulfur dioxide is what causes our cars and other metals to rust so quickly around here. If it does that to our metals, can you imagine what it does to our lungs?

MR. ANDERS: You have some very good arguments against coal generators, Mrs. Cantor, and I must admit I agree with you wholeheartedly. In terms of the visible effects on the land and air, nuclear fuel is by far the cleanest. I am, however, a bit concerned about the small amounts of radioactivity that come from nuclear plants. I know that amount is very little compared to the amount of radioactivity every person is naturally exposed to. This is called background radiation and comes from radioactive elements that are part of the earth and from radiation from space. Background radiation amounts to about 80 to 200 millirems per person per year. Radiation from nuclear plants is about 5 millirems. Dental x-rays or x-rays to detect broken bones often amount to 50 millirems for each examination. We know that radiation is one of the causes of cancer and defects in our genes. The amount of additional radiation from nuclear plants may be very small, but I don't know how much that would increase our chances of getting those diseases. And what if there were a plant accident? Then very large amounts of radiation could leak out.

MRS. HANSEN: After reading quite a bit about nuclear energy, my greatest fear is the possibility of a core meltdown. I know there are bundles of fuel rods containing uranium pellets that make up the reactor core and this core is usually submerged in thousands of gallons of flowing water. This flowing water is what keeps the temperature down. However, if this cooling does not take place, the fuel could heat up to its melting point of about 5,000 degrees F. The material making up the core could dissolve into a molten mass or a core meltdown.

As far as we know, the occurrence of a 'meltdown' has taken place once in the history of commercial nuclear power. In May 1986 at the Chernobyl nuclear power plant, 80 miles north of Kiev in the Soviet Union, a reactor meltdown and explosion caused untold deaths and long-term health and environmental damage. Thousands of people were exposed to high levels of radiation, and tens of thousands were evacuated from the endangered regions. Radioactive gases and particles spread over large sections of farmland in the Ukraine, while water supplies for more than 6 million inhabitants of Kiev were threatened with contamination. It will take years to measure the long-term effects of this accident in the Soviet Union and the surrounding countries that received exposure from the fallout of radiation.

MR. DALTON: As the representative from the power company, let me assure you that radiation leakage has never been a problem at any of our other plants. Our plants operate under the strictest of safety regulations. The level of radiation inside and outside the plants is constantly being monitored. In fact, the level of radiation in the water leaving the plant is less than 10% of the maximum allowed by the government agency. The plants are designed to guard against any possible accident that we can imagine. No other type of industrial plant has so many safety measures; we "over-engineer" our plants. To guard against any meltdown, nuclear plants have multiple Emergency Care Cooling Systems (ECCS). These systems of pipes, valves and additional water supplies are designed to flood and cool down the core as a back-up in case of an accident. The Nuclear Regulatory Commission (NRC) has estimated the chance for the worst meltdown is 1 in 100,000.

Admittedly, Chernobyl was a disaster that did take place but you must understand that the nuclear plants in the United States are built under a different set of design specifications and governed by more stringent regulatory policies than are plants in the U.S.S.R.

Nuclear reactors in the U.S. are safer than those in the U.S.S.R. The two major differences are: (1) the U.S. does not use graphite cores, which are capable of catching on fire should they be heated at higher temperatures than normally exist in nuclear reactor cores; and (2) the U.S. constructs nuclear reactors with containment structures which prevent the release of radiation. U.S.S.R. reactors do not have containment structures.

MS. ROBERTS I represent the local economic development council. My job is to attract business and industry to locate in our town. Smithville has a lot to offer. We have a good road and rail system, plenty of water, a large potential workforce, and the area is a pleasant place to live. Our major problem is that we can't provide the power that many businesses need and it is for this reason that several companies have declined to locate in Smithville during the past three years. I can promise you that we will become the home to many new companies if we can provide the power. I say we must build the plant.

MR. HAYES: Well folks, if there are no further comments, I declare this meeting closed. We have heard some informed comments and excellent arguments both for and against building the plant. We all have a lot to think about.

Use Handout 4 (distributed by your teacher) to identify the main arguments presented at the Smithville Town meeting.

The Smithville Decision
— Activity I —

Committee Discussion

The class will divide into small groups (of 3 - 5) to discuss the opinions presented at the Smithville Town Meeting. At the beginning of the group meeting, make sure you complete Handout 4.

During the small-group session, discuss what you think are the best reasons for supporting or rejecting the proposed plant. Discuss what opinions given at the Smithville Town Meeting are important considerations for you.

Use your completed Handout 4 to help you identify the important opinions. From your other readings and study activities you may find additional reasons for making a decision about a nuclear power station in your town. Present these in the discussion.

Each group will try to come to an agreement on whether or not to allow a nuclear power station to be built at Smithville. In addition, each group will select the best reason for making such a decision. If no agreement can be reached, select the best reasons from each of the opposing sides.

One member from your group should be elected to present the group's decision to all the townspeople. He/she will give a summary of your group's discussion and include the reasons why the decision was made. This summary should be no longer than 5 minutes.

Class Discussion: The Smithville Decision

The class will meet as an entire town to vote on the new nuclear plant. Each person in the class will represent a citizen in Smithville.

A member from each of the small-group committees will present a summary of the group's opinions. This presentation should not be longer than five minutes.

After all the presentations have been made, you, as Smithville residents, will have an opportunity to ask any additional questions.

The Vote At Smithville:

Each Smithville citizen will cast his/her vote "for" or "against" the proposed nuclear power plant by a secret ballot. One does not have to vote according to the decision made at the committee discussion.

A moderator will count the votes and announce the results. Would you have predicted this result after hearing the different committee speeches?

Questions For Class Discussion:

What decision should be made so that the needs of the townspeople are best served? Why? What needs should be more important than others?

If the town could not obtain sufficient electrical power, what group/groups of users should be asked to reduce their electricity usage? Why?

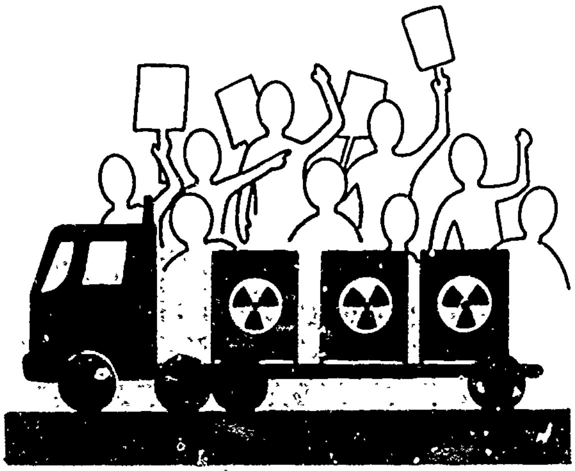
Should preserving the land in its natural state ever interfere with the growth and progress of a community? Why?

How does a nuclear accident that occurs in a foreign country affect decisions made in this country? Why?

Smithville Today

- Reading 2 -

The residents of Smithville decided to allow the nuclear plant to be built and the plant has been in operation for a number of years now. The local residents are generally quite satisfied with this development. New industries have moved into the area, bringing with them new jobs and adding new tax revenue to the local government. The landowners are particularly happy with the rise in their land values; many, in fact, have recently sold large parcels of land for new housing developments to provide homes for the recent arrivals. At first some townspeople were quite fearful of the nuclear reactor, but now they seem to have become used to the idea and have accepted this as a fact of life.



Two Hundred Miles from Smithville

- Scene I -

County Highway 237 is clogged with cars as far as the eye can see. Traffic is barely moving, if at all. The cars have bumper stickers which read "Too Hot for Our Roads" or "Radioactivity - not for Our Roads", and the chanting of "Keep them off our roads" carries over the hum of the auto engines. Tom Jones, newscaster for Station WRAC, is interviewing the motorists.

NEWSCASTER: (Tom Jones) Can you tell me what is taking place here? Why have so many people come to stage this traffic slowdown demonstration?

DEMONSTRATOR ONE: We have come to fight for the health and safety of people who use this road or live close to it. We are going to put a stop to trucking radioactive waste materials on our roads.

NEWSCASTER: Where is the radioactive waste coming from and where is it going?

DEMONSTRATOR ONE. It's from the nuclear power plant up in Smithville. You know that uranium, the fuel for a nuclear plant, doesn't get all used up. The unused fuel and leftover waste products from a nuclear reaction contains several new types of radioactive elements, including plutonium. This waste is among the most deadly substances known. It is being taken to be stored in a safe place or to a reprocessing plant where usable uranium can be separated out and put into new fuel rods.

NEWSCASTER: Why are you so against transporting this waste? It has to be taken away.

DEMONSTRATOR ONE. Well, radioactive materials just don't belong on the roads. There are simply too many chances for accidents. Do you know what might happen if one of those trucks had an accident and one of the containers broke, spilling radioactive materials all over the area? The substance released is like that from a nuclear bomb. People close to the accident would be exposed to high doses of radiation and would die from radiation sickness. People further away would be exposed to lesser amounts, but any increased exposure to radiation will increase the chance of getting cancer. Others will not become sick but radiation can cause genetic defects and when people have children, the children could suffer from serious defects.

NEWSCASTER: What makes you think that an accident could happen? Aren't the trucks well protected against the possibility of accidents?

DEMONSTRATOR ONE: Sure you can guard against accidents but you can't absolutely prevent accidents! Just beause you have a seatbelt on doesn't mean that you wouldn't run into another car or that another car won't run into you. No one can prevent the truck-driver from blacking out or suffering a heart attack. So they have a back-up driver who could take over. What about other drivers on the road? How can you order back-up drivers for everyone on the road?

DEMONSTRATOR TWO: There is also the possibility of people stealing the radioactive material for making bombs. Nuclear bombs are not that difficult to make once one gets hold of plutonium, which is part of the waste "spent" fuel. Terrorist groups can easily hijack planes. They can just as easily steal a shipment of waste materials or the enriched fuel that has been reprocessed at the reprocessing plant. It's not possible to guard every inch of the road. Even guarded areas can be broken through!

NEWSCASTER: It seems to me that bringing fuel rods in and taking out the 'spent' fuel and other waste products are part of the process of generating electrical power from nuclear reactors. Don't you think that if people want electricity, they must accept some of these risks?

DEMONSTRATOR TWO: Not at all. We feel that the risk in this case is just too great. One tiny speck of plutonium getting into the lungs can cause death. What's more, the radioactivity of plutonium can be considered as lasting almost forever. It takes over 24,000 years for only half of it to lose its radioactivity. That's a long time!

NEWSCASTER WALKS OVER TO INTERVIEW DEMONSTRATOR IN ANOTHER CAR.

DEMONSTRATOR THREE: We, too, do not see why we should suffer the possible consequence of a decision made by another town and the power company. We had no say in the decision. Nobody asked us! Why should their decision be forced on us?

NEWSCASTER: I can see your point, but the electricity from the plant also goes to other communities. You probably use products made by companies that are also customers of that nuclear generator.

DEMONSTRATOR FOUR: We still feel that nuclear power is not a safe energy source, and right now we have to get the trucks off the road. Look at what the railroads have done. The Association of American Railroads has refused to transport radioactive waste on the grounds that it is too dangerous. If they ship the waste, they demand that special trains and crews be used and that the trains operate at much lower speeds and on different tracks. So, if the railroads have recognized the dangers, there is even more reason for road users to do the same. Some of those trucks have to go many hundreds of miles to the disposal or reprocessing center. Roads don't only go through deserted areas but also through cities, across bridges, and into tunnels. There are people everywhere along the way.

NEWSCASTER: What does your group suggest be done? The waste has to get to the storage center somehow.

DEMONSTRATOR FIVE: First things first, and the first step is to order all trucks carrying radioactive materials off the roads. If they can't use the roads, they will have to come up with another solution.

Office of the Nuclear Regulatory Commission

- Scene II -

The action shifts to the offices of the Nuclear Regulatory Commission. The newscaster is interviewing a spokesman for the government regulatory agency and a representative from the power company.

NEWSCASTER: You are well aware of the demonstration on Highway 237 that has created the massive traffic tie-up. I want you to tell the listeners what you think of the situation.

SPOKESMAN: Personally, I feel that the demonstrators are acting much too emotionally. Just the word "radioactivity" and they are ready to shut everything down. The shipment of radioactive waste is closely regulated and better safety measures are continually being developed. The materials are shipped in specially designed metal casks with layers of lead casing. They are constructed to shield people from radiation and to disperse the heat generated by radioactive decay.

The trucks carrying the casks are specially marked on top so that helicopters or planes can be used to watch their movement.

NEWSCASTER: What might happen if the casks were involved in an accident?

SPOKESMAN: We have considered such a possibility. The design of the cask takes into account what we consider to be the worst possible situation. The casks can be dropped from a height of a three- story building onto concrete. That is like a crash at 60 mph. They can't be punctured from a fall of 4 feet onto a steel spike 6 inches wide. If there were a fire, the casks can stand heat up to 1,475° F for half an hour. If they happen to fall into water, they can stay submerged for at least 8 hours. I would think those are very high standards.

NEWSCASTER. Have there been any accidents involving shipments of radioactive materials?

COMPANY REPRESENTATIVE: Yes, there have been a few minor accidents. But if you look at the statistics, you will find our safety record is very good. In all cases there was no significant escape of radioactivity, nor was there any injury caused by radioactivity. One driver died, but that was from the crash and not from what was carried on the truck.

NEWSCASTER: Nonetheless, even with all the safety regulations, do you think that such dangerous materials should be permitted on public roads? There is always a possibility that a danger was not considered in the safety design.

SPOKESMAN. We are not the only ones who ship dangerous materials. The highways are filled with trucks carrying highly flammable fluids, deadly poisonous chemicals, explosives, and unstable industrial chemicals. Millions of tons of these materials travel the roads yearly. I think those present more dangers to the public than the few shipments we make each year. Only the other day a chemical truck overturned

	and released a poisonous gas covering miles, and several people were killed.
NEWSCASTER:	What is the chance of an extra severe accident occurring and radioactivity being released?
SPOKESMAN:	Our government calculations show that such an accident might occur in 4,000 years. This is based on figures for the year 2000 when 1,000 nuclear plants are in operation. So there doesn't seem to be much to worry about for now or in the future.
NEWSCASTER:	That figure is for a serious catastrophe. What are your estimates for lesser accidents? How many shipments are made each year?
SPOKESMAN:	According to our estimates, for every 20 years a plant is in operation, a loaded cask would be involved in a truck accident. Accident estimates involving rail or barge shipments are much lower, about one in every 170 years for each nuclear plant.
REPRESENTATIVE:	To answer your question on the number of shipments we make, our plant at Smithville makes 60 truck shipments, 10 rail shipments and 5 barge shipments. We are certainly not crowding the roads. A coal power plant, for example, uses thousands of trainloads of coal each year.
NEWSCASTER:	What about the possibility of some terrorist group hijacking a truck transporting radioactive wastes. Could they use the spent fuel to make a bomb that could be used against us?
SPOKESMAN:	Well, that's possible, but not very likely. For example, there really isn't enough Plutonium in spent fuel to make a bomb unless you utilize very expensive and complicated reprocessing procedures. You see, it takes ninety percent Uranium 235 to produce a bomb; reactor fuel contains only three or four percent. So, converting that fuel into a form usable to build a bomb will require a very expensive enriching process.
NEWSCASTER:	Thank you, gentlemen, for your informative comments.

Discussion Questions:

What are the primary concerns of the demonstrators?

Do you think the demonstrators have valid concerns? Why?

Do the demonstrators have a right to stop and disrupt traffic?

What could the consequences be of such an action?

Do you feel the consequences are worth the action?

Do you think the company representative presented reasonable arguments for transporting nuclear wastes? Why?

Are there any problems with these arguments? What are they?

The Governor's Decision

- Activity 2 -

The demonstration has completely brought to a standstill all movement of traffic on Highway 237. A health and safety hazard has been created because no vehicle can get through over the stretch of 15 miles, not even ambulances or firetrucks. The demonstrators have stated that

they will continue to block traffic until the government outlaws trucks carrying radioactive waste materials. The Governor recognizes the near impossibilities of such demands because the "spent" fuel cannot be left at the power plants, which have no long term storage or reprocessing facilities. With 5 nuclear power plants in the state, this would create a more critical situation.

To stop the demonstration, the Governor considers calling in the National Guard to arrest the demonstrators. Should Governor Curtis take this action?

Discussion Questions:

What should be the Governor's most important concern when making his decision? Why?

As the Governor of the state, should he make sure that the laws are obeyed? Why or why not?

Often, when soldiers or police are called in to stop demonstrators, riots break out and people are injured. Who should be blamed if injuries occur? Why?

Should the possibility of an accident involving a shipment of radioactive materials be considered by the Governor in making his decision? Why or why not?

If the demonstrators are arrested, how should they be punished? Why?

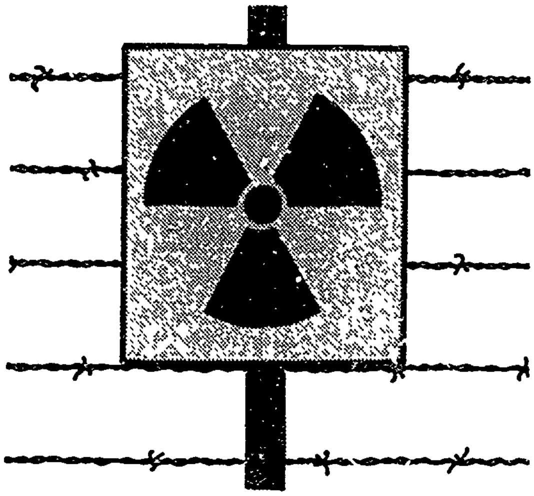
If during the demonstration an ambulance is unable to get to the aid of a heart attack victim, who should be blamed? The demonstrators? Operators of the nuclear plant? The Governor?

If the demonstrators object to the shipment of radioactive materials, should they also object to shipments of other types of dangerous materials? Is there a difference? Why or why not?

The demonstrators are concerned about the health and lives of the people using the roads. Shouldn't that be enough reason for what they are doing? Why or why not? Should they continue their protest until some action is taken?

Technology, Consequences And Responsibilities

- Activity 3 -



Many scientists and engineers contend that the application of new technologies calls for new responsibilities and perhaps even changes in human behavior. The use of nuclear energy, for example, has created the dilemma of nuclear waste storage. Nuclear waste, which remains radioactive for tens of thousands of years, requires safeguards for protecting living things from its deadly radiation. There are hundreds of thousands of tons of discarded uranium left over in spent fuel in thousands of steel vessels at various sites. There are cancer-producing radioactive substances contained in these wastes that can cause problems for areas where the material is stored or buried.

Our society has the long-term commitment to ensure the safe containment of this highly dangerous substance. This also means the responsibility that we have presently created for ourselves must also be passed on to future generations, centuries from now.

We are passing on a tremendous responsibility and we must question whether or not human society can maintain nuclear safeguards over the long period. Will we need to create systems of government in order to do so? What "price" must we pay for this bountiful source of energy from nuclear power plants? If a nuclear energy generation has created new risks and responsibilities, do other technologies also pose problems?

In this activity, you will consider this question by examining some existing technologies and some of their possible consequences.

On the chart "Technology, Consequences and Responsibilities" (Handout 5) are listed five technologies. Next to each technology is an abuse, misuse, or undesirable effect of that technological application.

Under the appropriate column

1. indicate new responsibilities that confront people because of that technology, and
2. suggest remedies to safeguard people or the environment from those undesirable consequences. That is, what must we change, learn, give up, or do in order to ensure a safe and healthy earth for living things?

Describe the types of actions that you feel need to be taken.

1. Will people have to learn to behave differently?
2. What type of new laws or regulations might we need, if any?
3. How can people be trained to act wisely?
4. Are there things that we must be willing to give up?
5. How can we guard against human error or unwise decisions?
6. How can we reduce the risks to ourselves and future generations?

Procedures:

Your teacher will distribute copies of *Technology, Consequences and Responsibilities* (Handout 5).

Meet in small groups of 3 to 5 students to complete the handout.

Examine each of the technologies in turn and discuss how the technology has influenced our lives. That is, what does the technology permit us to do that we could not have done without that technology?

From your discussion you should be able to identify some new responsibilities that people now face. List these in the column "New Responsibilities for People". For example, the manufacturing of automobiles places a responsibility on engineers to design reliable safety features and auto workers to put the parts together with care. Drivers are expected to learn how to operate the car properly, obey traffic rules, and maintain the car in good working condition. (Whether people do, in fact, behave responsibly is another question.)

Under the column "Possible Solutions" suggest a solution for the situation described under "An Undesirable Effect". The members of the group should agree that the proposed solution is indeed the best solution. Consider the following questions before you arrive at your decision.

Will it be easy for people to accept the solution? What inconveniences must they learn to accept?

Does the solution require drastic changes or sacrifices?

Will the solution be fair to everyone?

Will the solution restrict personal freedom, and how important is personal freedom compared to the undesirable consequences?

Will the solution require voluntary action or government regulations?

What effects will the solution have on our existing life-style?

Who will be responsible for carrying out the solution?

Which is the more desirable and effective solution?

After all the groups have completed the handout, a spokesperson from each group will report on the group's results.

Following the reports, discuss the questions below.

Which of the undesirable effects are more difficult to prevent?

In light of the many benefits of that technology, should people be willing to tolerate the undesirable consequences?

Were the undesirable effects the direct result of the technology or the consequences of frailties in human nature? Are there ways in which human nature might be improved?

Could the undesirable effects have been avoided from the beginning?

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Chapter 6

Acid Precipitation

A Growing Problem

- Acid Precipitation -

An expanding body of evidence points to acid precipitation as being responsible for adverse effects on our environment and on society. These effects include acidification of lakes, rivers and streams causing death to fish and other forms of aquatic life. There is also evidence pointing to possible reductions in forest and crop productivity through acidification and loss of minerals (demineralization) to the soil.

The problem of acid precipitation has touched many parts of the United States, Canada, Europe, and Scandanavia. In 1984, the Office of Technology Assessment estimated that 27 states in the eastern half of the United States contain areas sensitive to acid precipitation. Included in these areas are 17,000 lakes and 15,000 miles of streams. The report further stated that 55% of these streams are either at risk or have already been altered by acid deposition.

In the Adirondack region, for example, where acid precipitation has been severe, more than 100 lakes are now without any fish because of the acidity of the water. Nova Scotia has at least nine rivers that are so acidified that salmon living in these waters can no longer reproduce. There is also evidence that forests in Vermont, New Hampshire, Connecticut, New Jersey, and Virginia have been damaged by acid precipitation.

Acid precipitation effects are most severe in the northeast portion of the United States. However, growing evidence shows the spreading of this problem to the southwest and midwest states, with all states east of the Mississippi River affected at least to some degree. The most recent evidence has also shown the spread of acid precipitation into the far western states, the majority of it being found around large cities such as Los Angeles, San Francisco, and Seattle.

An extensive area of Canada, including a large part of the eastern region and portions of Western Alberta, has been affected by the acid precipitation problem. In Scandanavia, the problem is even more prevalent. A Norwegian study of the effects of acid rain in that country stated that a majority of inland waters have completely lost their fish populations.

Acid precipitation is not a new problem. Back in 1852, a British scientist, Robert Angus Smith, reported on the smoke-filled air covering the city of Manchester. He suggested that this "polluted" air was related to the increasing acidic precipitation that was falling around the city. Acid precipitation, however, has only become a major focus of concern and research since the 1960's. Over 3,000 studies dealing with acid precipitation have been conducted in North America and Europe since 1960. What was once seen as a minor problem located in one section of the country, now has spread to national and international proportions. Along with the spread of acid precipitation comes the corresponding spread of national and international concerns, conflicts, and politics. This reading was prepared to help you examine some of the many aspects of acid precipitation, including the following:

What is acid precipitation?

What causes it?

What are its effects?

What are some conclusions and solutions?

There are, obviously, many complex explanations written in scientific journals describing the issues and concerns of acid precipitation. This reading should, however, provide you with enough information to discuss the problem and actively participate in the accompanying activities. Before you continue with this reading, think about and respond to the following questions:

What do you know about acid precipitation where you live?

What do you think are the causes of acid precipitation?

What are some international problems that might occur because of acid precipitation?

What Is Acid Precipitation?

There are acids that occur naturally in the air and fall to earth through rain, snow, or fog. Nature has the capacity to neutralize them and reduce their harmful effects. The problem now, however, is that at times the atmosphere has an overabundance of man-made acids. In certain areas the amount is so great, nature cannot adequately perform this neutralizing process.

Acid precipitation refers to the deposition of damaging atmospheric pollutants on surface waters, soils, vegetation, and man-made objects (buildings, statues, etc.). Some pollutants are acidic when deposited, while others only become acidic after deposition. Pollutants may be deposited as either wet or dry particles. Pollutants also take the form of gases.

Acid precipitation can fall to earth anywhere downwind from its source. When it lands in large cities, it is one more element added to the pollution problem already found there.

What are other pollution problems generally associated with cities?

Do you think there would be more or less acid precipitation found in cities as opposed to the countryside? Why?

Pollutants can drift in various directions depending on the wind currents. Pollutants travel with the air currents that form the various weather patterns of our hemisphere. This movement allows the air to deposit its pollutants downwind from the location where it originated. The trip can take many days and cover thousands of miles. During the voyage, pollutant molecules chemically interact with sunlight, moisture, and oxidants to become weak, but destructive, acids.

Reports indicate that Lake Superior has received acid precipitation fallout from cities as far away as St. Louis, Cincinnati, and Pittsburgh. These cities are all more than five hundred miles from Lake Superior. Weather conditions permitting, pollutants can travel hundreds of miles in one day. Scientists have estimated that the average time in air for most pollutants is approximately two to four days. However, some pollutants have been traced in air for weeks. With this amount of time in the atmosphere, it's possible for pollutants generated in the United States to cross thousands of miles of ocean and be deposited as acid rain in foreign countries.

How would local officials react to acid precipitation landing in your town's streams and rivers that were from pollutants originally generated in Europe?

The dangers of acid precipitation are genuine and getting worse. Rainfalls in the eastern half of the United States and southeastern parts of Canada are about twenty-five times more acidic than they would be from rainfalls containing nature's acids only.

Scientists use pH to note the degree of acid in a solution. The expected pH value for pure rainwater is pH 5.65. Anything below this level is considered acidic. However, during recent rainstorms in the southern and western portion of the United States, pH values of between 3.0 and 4.0 were recorded. If these levels were found in this part of the country, what would you estimate the pH levels to be during rainstorms in the northeastern part of the United States?

Figure 6-1 shows the pH of precipitation in the United States and southern Canada for the year 1981.

What was the pH of precipitation for the area in which you live?

How does it compare with other parts of the U.S. and Southern Canada?

Where are the heaviest concentrations of acid precipitation? What might account for this?

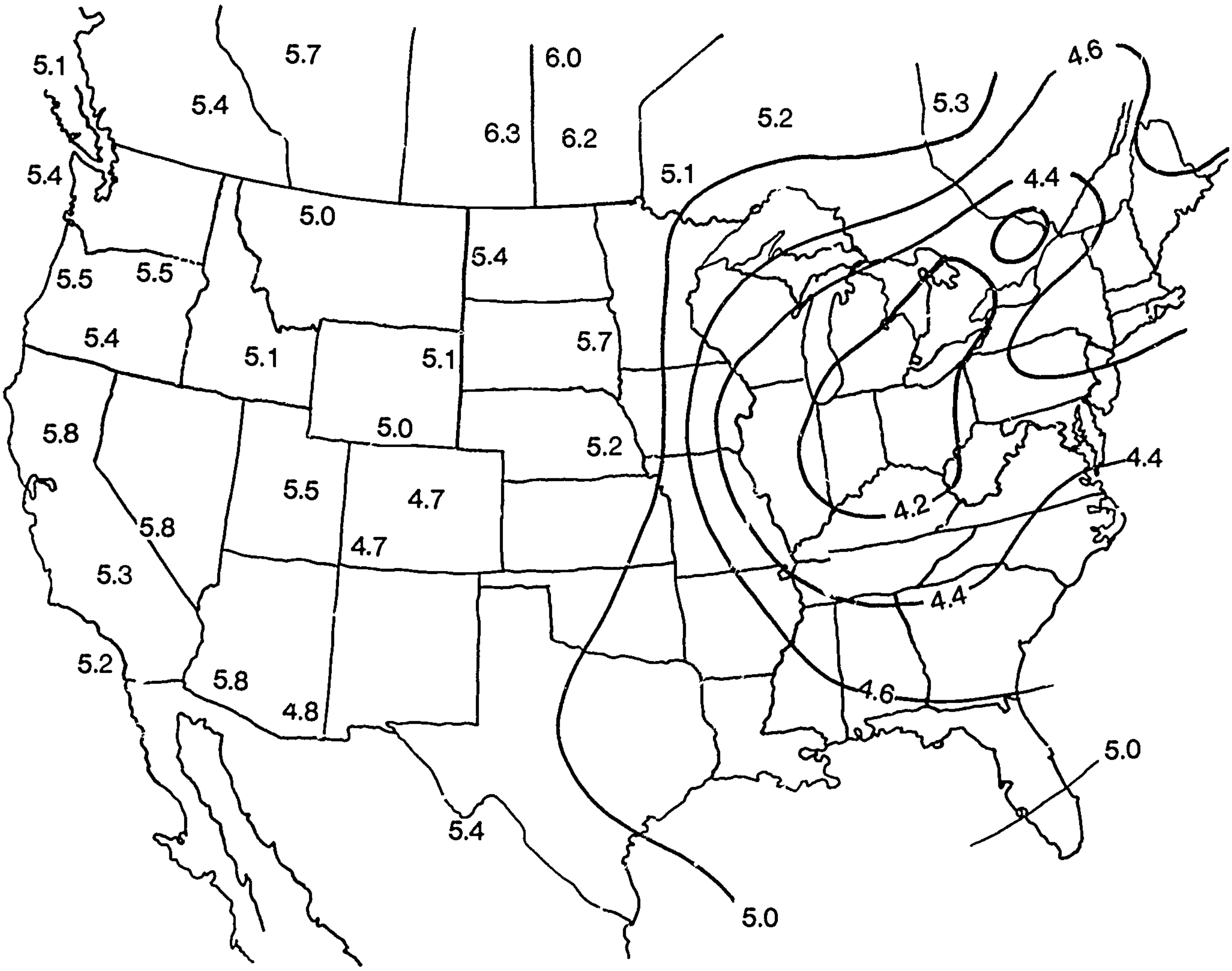
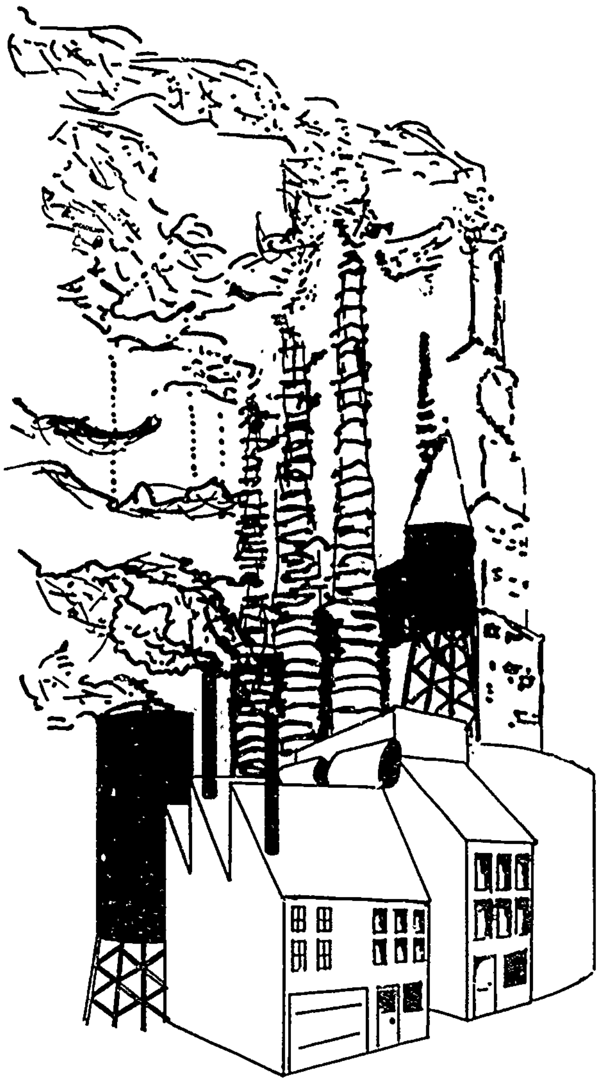


Figure 6-1. pH of precipitation in 1981 based upon data from approximately 100 National Atmospheric Data Program sites in the United States and numerous sites in southern Canada. The respective volumes and pH values of precipitation from the precipitation events at individual sites have been combined in such a way as to estimate for each site the pH value the precipitation would have had if it all had been received at one time. The locations of the NADP stations are indicated by dots. No lines have been drawn in the western part of the country, and the average pH value is given at each location because there are too few stations to define pH regions adequately (NADP, 1980, 1981).

What Causes Acid Precipitation?



Acid precipitation is primarily caused by emissions of sulfur and nitrogen oxides that are eventually oxidized into sulfuric acid and nitric acid in the atmosphere and in soil. Precipitation is responsible for delivering these pollutants to the earth. Studies conducted in New York and parts of New England tell us that approximately 60 to 70 percent of the acidity in acid precipitation comes from sulfuric acid and 30 to 40 percent comes from nitric acid.

When there are high amounts of nitric acid in acid precipitation, this usually means that the pollutants came from the exhaust of automobiles or other mobile sources. A high proportion of sulfuric acid derivatives, however, indicates stationary sources, such as power plants, smelters, or heavy industry.

The primary causes of acid precipitation originate from human activities. Most of it starts with the burning of fossil fuels - coal, oil, and natural gas. In the United States today, there are more than 200 tall smokestacks rising 400 to 1,200 feet above smelting and power plants emitting sulfur and nitrogen substances into the atmosphere. This problem becomes compounded with the possible construction of many new coal-generating facilities. The United States is placing greater reliance on coal as an energy source because of the prices of crude oil, problems with foreign supplies, and public concerns about the safety of nuclear energy. With this emphasis on coal, air emissions from energy-producing plants will increase.

Operating within standard environmental regulations, the smokestacks of electrical plants, smelters and refineries, most of which are found in the Ohio Valley (21 of them), emit sulfur dioxide and nitrogen oxide into the air. These sources are the major contributors to the acid precipitation problem.

Why do you think power plants can meet existing environmental regulations and still contribute to producing acid precipitation?

Many of these pollutants are carried off beyond the site where they are manufactured. The higher the smokestack, the greater the distance smoke will travel fro where it was generated. Some pollutants hover above the site or city where they are produced, allowing them to settle back down locally through rain or dew.

It is estimated that in the United States approximately 26 million tons of sulfur dioxide are discharged into the atmosphere each year. Current estimates are that 23 million tons of nitrogen oxide are also pumped into the atmosphere yearly. This total of approximately 50 million tons has tripled over the last 30 years in our country alone.

The 1977 Clean Air Law mandates the best available technology to be used in new plants. The best preventive devices now are "scrubbers". Scrubbers can catch 90 percent or more of the sulphur dioxide from a plant's flue gas. However, many of the older plants do not have the devices needed to trap these pollutants. Also lacking is the technology to sufficiently control the other major pollutant, nitrogen oxide.

Effects Of Acid Precipitation:

Agriculture

The ill-effects of acid deposition and polluted air on plants and soils near some smelter operations, power plants, and other sources emitting large amounts of sulfur dioxide are well documented. A report of impact on crops related to these emissions suggests that acidity probably was responsible for some of the effects found, but other constituents capable of causing injury were also present.

Most attempts to judge the significance of the potential harmful effects of acid precipitation have involved experiments with simulated acid rain. Simulated acid rain has been found to decrease the yields of some crops within the pH range of acid rain measured under field conditions and to injure the foliage of numerous crops when the acidity exceeds that usually found in most acid precipitation.

Acid rain can affect agricultural crops in two ways. First, the precipitation can directly affect the foliage of the plant by acting on the leaf or stem of the crop plant. The most apparent damage of this effect would be on crops such as spinach or lettuce where the foliage is considered the most important, edible part of the plant. Second, acid rain can affect the soil, which in turn directly affects the crop plant. When the pH of the rainfall is changed, this can have an effect on the rate at which nutrients are recycled in the soil. It also affects the rate and speed at which litter and other organic material are broken down through microbial action in the soil.

Data related to the effects of acid rain on crop yield and production are limited. However, there has been enough evidence gathered to indicate that acid rain does have negative effects on certain crops and soils.

Forests

The severity of damage to forests depends on how much the soil can filter out the effects of acid precipitation. One noticeable effect on forests is called "crown dieback". This is the process where leaves or needles on treetops turn yellow, then brown, and finally drop off.

Nitrate in acid rain will initially benefit the growth in the forest because nitrogen is a helpful, and often needed, nutrient for trees. Too much acidity, however, may interfere with the natural ability of the forest's bacteria and various fungi to recycle nitrogen from decaying plants.

Acidification of forested soils from atmospheric deposition and internally generated acids may accelerate the leaching of potassium, calcium, magnesium, and sodium from soils. This process leads to reduced soil fertility. Accelerated losses of nutrients over several decades under the influence of acid deposition could result in nutrient deficiencies or could increase the severity of existing deficiencies.

Acidification of forested soils from atmospheric deposition and internally generated acids may accelerate the leaching of potassium, calcium, magnesium, and sodium from soils. This process leads to reduced soil fertility. Accelerated losses of nutrients over several decades under the influence of acid deposition could result in nutrient deficiencies or could increase the severity of existing deficiencies.

Soil acidification may result in increased concentrations of aluminum in the soil solution. Aluminum in low concentrations is toxic to plants. In sufficient concentrations it reduces tree root development and has deleterious effects in aquatic ecosystems.

The effects of acid deposition upon forest vegetation are complex, involving not only the indirect effects through the soils, but also possible direct effects upon the vegetation itself. There is evidence of unfavorable direct effects in some areas near local sources of large amounts of sulfur dioxide. Some experiments with simulated rain having pH values below 3.8 have produced visual injury to the foliage with more than five applications.

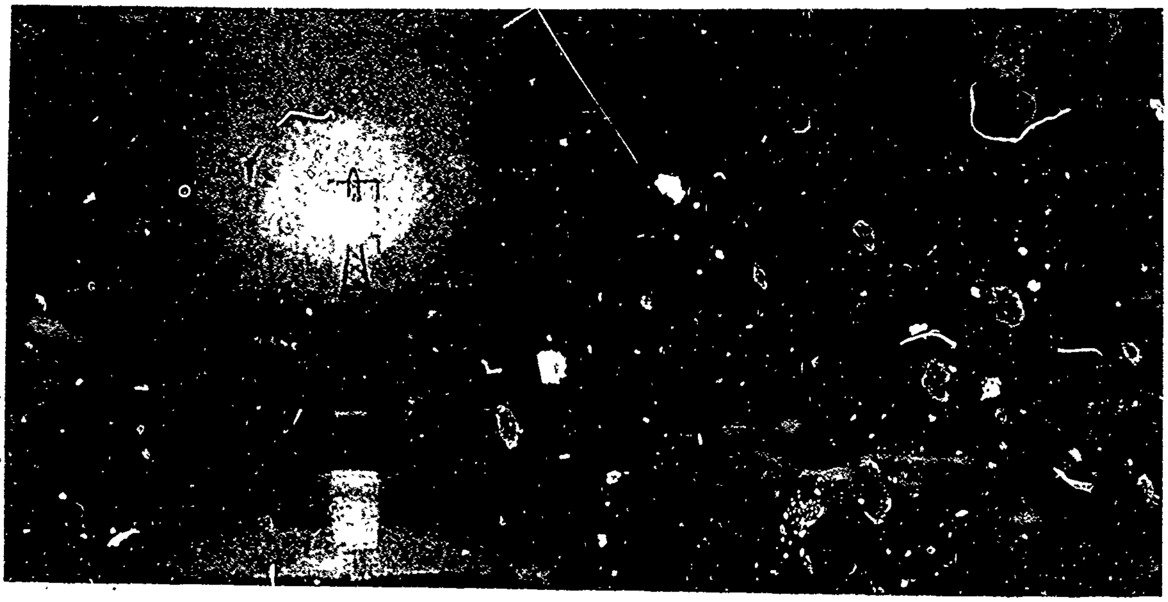
Because juvenile and reproductive stages of trees may be more sensitive to acid conditions than mature vegetation, the possibility exists that the cumulative indirect impacts of acid deposition over a period of several decades may be significant, both ecologically and economically. Studies are under way to characterize seed production, seed germination, and seedling behavior in natural forest stands so that possible changes in species performance can be evaluated in light of atmospheric deposition. Evidence now available indicates that exposure to strongly acid-simulated rain may have both negative and positive effects.

What do you think some positive effects could be?

The recent dieback of forests in Scandanavia, Germany, and the northeastern United States has been studied by researchers in relation to acid deposition. Although acidity of the soils and acid deposition may well have contributed to forest dieback, it is not possible at this time to determine the specific relationship between tree growth reduction and acid deposition. Death of spruce, pine, and birch in Germany is seemingly a response to more than just acid precipitation. Dieback of red spruce in the northeastern United States may also be related to drought.

Aquatic

Acid precipitation has had its most serious effect on the water systems, including lakes, rivers,



and streams. These water systems were the first apparent "victims" of acid precipitation. The United States, southwestern Canada, Scandanavia, and Scotland have hundreds of acidic lakes that are now devoid of any life. Generally, these lakes are located in areas where the soil and underlying bedrock are composed of minerals that are low in neutralizing chemicals. Rock formations made up of granite or lava, for instance, do not react with acid. In these formations acid precipitation can eventually disrupt the total ecosystem. In other formations, such as limestone, the resident calcium carbonate provides a neutralizing effect.

The most seriously acidified aquatic systems in the United States are in the Northeast. The acidification is considered to result from an interaction of several factors:

- Bedrock with only limited capacity to neutralize acid.
- Soils that are sandy and have only limited capacity to neutralize acid.
- Coniferous forest vegetation on the high ground and wetland vegetation (especially sphagnum moss) that promote soil and water acidification.
- Precipitation adequate to promote continuous leaching of dissolved substances from soils.
- Deposition of acids from the atmosphere.

Several major reservoirs in the Northeast have had long-term increases in acidity, and a long-term increase in acidity of groundwater-fed streams in eastern New Jersey has been noted. A number of lakes in the Adirondack Mountains are strongly acid. Surveys indicate that about 180 Adirondack lakes (6.4% of all lakes in that area) have no fish populations. The distribution of fish is strongly correlated with the acidity of the waters, and the absence of fish appears to be associated with increased acidity. In a survey of high elevation lakes in the Adirondacks, about 50% of the lakes had pH values below 5.0, and 82% of these relatively acid lakes had no fish.

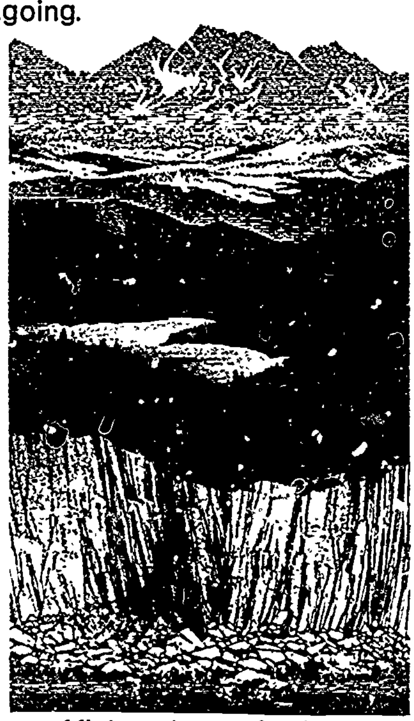
As reported by Jenkins, acidification has been observed in Sweden in approximately 2,500 lakes that also had fish damage. A Swedish scientist estimates that 20,000 out of the 100,000 lakes in his country will soon house no fish. In southern Norway 1,750 lakes out of 51,000 have lost all their fish, while 900 others are seriously affected. Reports from Canada say that almost 20% of all examined lakes in Ontario have turned acidic or are extremely sensitive to the process. The salmon in nine Nova Scotia rivers can no longer reproduce, and Ontario claims that 147 of its lakes house no fish.

Jenkins also reports on an article that appeared in the September 21, 1983, issue of Sports Illustrated that summarized findings on the effects of acid precipitation in 24 states. Below are some of the findings:

- In Maine, native brook trout have ceased reproducing in all small lakes at altitudes higher than 609 m (2,000 feet). The pH in these lakes is 5.
- In Vermont, several lakes located in the Brooks Wilderness Area of the Green Mountain National Forest have a pH of 4.
- In Massachusetts, acid precipitation is pelting the state. One summer, the pH of a rainstorm in Lawrence was 2.9. The Quabbin Reservoir, which supplies the Boston area with drinking water, often registers surface water pH values in the 5's and 4's, according to Alan Van Arsdale, head of the Massachusetts Department of Environmental Quality Engineering's Acid Deposition Assessment Program.
- In Rhode Island, officials are keeping a watch on the Scituate Reservoir system, which serves as the drinking water supply for nearly half of Rhode Island. The total alkalinity of the reservoir is low, ranging from 3 to 7 mg/L. The average pH of rain is 3.5.
- In New York State, it has been documented that 212 Adirondack lakes and ponds totaling some 4,233 ha (10,460 surface acres) are acidified and incapable of supporting fish life,

and another 256 lakes and ponds totaling 25,496 ha (63,000 acres) are judged to be in danger of losing their fish.

- In Pennsylvania, there are streams that cannot be stocked before the trout season begins because of the acidity of the snowmelt. The central and northern sections of the state routinely have the most acidic rainfall of any large area in the country, with an average pH of 3.8 in the summer.
- In Kentucky, acid deposition is leaching heavy metals into watersheds in the southern part of the state. Lake Nevin, which is close to the Kentucky-Indiana border, has detectable levels of lead.
- In the Great Smoky Mountains National Park, which covers 509,000 acres in North Carolina and Tennessee, visibility has been greatly reduced by an ugly gray haze composed of man-made particulates, mostly aluminum sulfates. The average pH of precipitation in the park has gone from 5.3 in 1955 to 4.4 in 1973 and 4.2 in 1980. In the spring, stream pH levels drop as low as 4.3, and aluminum leaching is ongoing.
- In Colorado, the pH of precipitation from 1974 to 1978 dropped at a rapid rate, from 5.4 - 5.0 to 4.8 - 4.7 at a research station adjacent to the Indian Peaks Wilderness Area.
- In Washington State seven lakes in the Olympic and Cascade Mountains had a pH of less than 5.5. All are located in the Alpine Lakes Wilderness, due east of Seattle. In Seattle, 70 percent of the rainfall monitored ranged in pH from 5.2 to 4.2.



These observations on acid lakes have been supported by studies of experimental acidification. In one study, fish failed to reproduce at pH values below 5.3. Adult fish appear to be more resistant to acidity, but in general experiments have shown reduced survival at pH values of 4.8 to 5.2. Laboratory experiments suggest that 50% fish-kills should occur with a 2-day exposure to water of pH 3.5 to 4.0 and that with longer exposures lesser acidities are critical.

A gradual change occurs in the character of the populations of other aquatic and amphibian animals as the acidity of the water increases, and these changes may affect the populations of fish and waterfowl through their influence on the food supply. In addition, the concentration of aluminum increases with the acidity of the water. In sufficient concentrations, aluminum is toxic to fish.

Bodies of water may contain both lower plants and higher plants, and the composition of the populations of both may be influenced by the acidity of the water. Plants are the basic source of food for fish and other animals in aquatic systems. In most instances, the change in plant populations with increased acidity seems to be in the direction of lower productivity. The effects of acidity on the plant populations are paralleled by effects on some of the animals. For example, snails and freshwater mussles are particularly vulnerable because sufficient acidity makes it difficult or impossible for these organisms to produce new calcareous shell material. As a result, the animals die or grow in an abnormal manner. Acidification of aquatic environments in nature is a complex system of changes.

Predict some long-term problems if the acid lake problem continues to worsen.

What could some possible solutions be to these problems?

What might the consequences be for each alternative you listed in your solutions?

What effect do you think the increasing acidity in lakes could have on human health?

Conclusions And Solutions

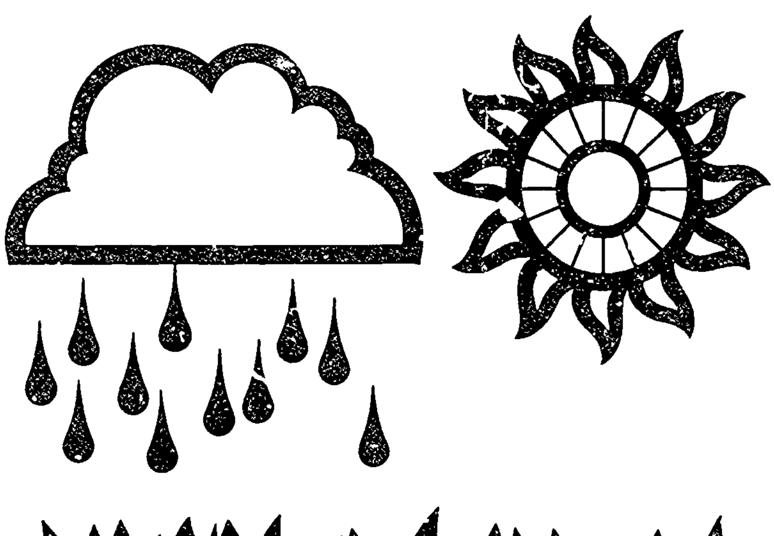
Acids and acid-forming substances are deposited on the earth from the atmosphere in all forms of precipitation and in solid particles. Some are absorbed directly by soils, plants, and waters from gaseous forms of these substances in the atmosphere. Most of the available information on forms and amounts is derived from studies of precipitation. In the United States, acid deposition from precipitation is greater in the East than in the West, and it is greatest in the Northeast.

The ill effects of acid deposition and polluted air on plants and soils near some sources emitting large amounts of sulfur dioxide are well documented. Simulated acid rain has been shown to decrease the yields of some crops within the pH range of acid rain measured under field conditions and to injure crop foliage when the acidity is greater than that usually found in most acid precipitation. Forested soils generally do not receive limestone or fertilizers. Thus, chronic losses of nutrients over several decades under the influence of acid deposition could lead to nutrient deficiencies in some soils.

Although the recent dieback of forests in Scandanavia, Germany, and the northeastern United States has been attributed in part by some researchers to acid deposition, the connection is not clear. Other factors seem to have been involved, and the importance of acid deposition is not yet known.

The most seriously acidified aquatic systems in the United States are in the Northeast in locations where the combination of conditions is favorable to acidification. The major popular concern is for the effects of acidity on fish. Losses of fish populations from lakes appear to be associated with increased acidity. The observations on fish populations in individual acid lakes have been supported by findings in research on experimental acidification.

A gradual change occurs in the species composition of populations of other aquatic and amphibian animals and of aquatic plants as the acidity of the water increases. These changes alter the aquatic food chain. Generally, the shifts are in the direction of lower productivity as the acidity increases. Thus, acidification of aquatic environments in nature is a complex system of changes.



Options available to combat the decreases or losses of fish populations from acid waters include acclimating the fish populations to acidity before using them to stock acid waters, developing fish populations that are relatively resistant to the conditions in acid waters, and decreasing the acidity by applying ground limestone or other substances that will react with the acid. Studies of the first option have been inconclusive. The second option is considered to have possibilities. The third works but has been little used. The cost of liming aquatic systems exceeds that for cropland because of the greater costs of transporting and applying the limestone to the remote aquatic systems where acidity is a problem. The total cost of liming the 180 acid Adirondack lakes that have no fish may be estimated at approximately one million dollars. The liming would need to be repeated at intervals of a few years. The New York State Department of Environmental Conservation has adopted the policy of liming acid lakes on only a limited scale to preserve desirable fisheries.

The acid precipitation story goes beyond the scientific descriptions presented here and includes political and economic considerations. Jenkins quotes the United States Environmental Protection Agency (USEPA) Administrator, William Ruckelshaus, from a speech in December, 1983, "I can close my eyes and listen to somebody start to talk about acid rain and I can tell you within 100 miles where he or she lives. Westerners say they want it cleaned up, but they don't want to pay for it. New Englanders say their lakes are poisoned and that midwesterners should pay for the cleanup. Midwesterners don't think there's a problem, and Southerners say, 'It's your problem, don't bother us.'"

Jenkins further states that the United States economy and standard of living depends on power plants, factories, smelters, and vehicles that have combined to put much of the country in noncompliance with the Clean Air Act and its regulatory requirements. He estimates the damage is extensive and that acid rain causes as much as five billion dollars in environmental damage annually, most of it taking place in the northeastern United States and southeastern Canada. There are further estimations that reducing emissions will cost three to seven billion dollars annually in higher utility rates to get back the costs of retrofitting existing power plants' smokestacks with scrubbers, plus the loss of 80,000 coal-mining jobs. Midwestern utility companies that burn high-sulfur coal say they would have to raise utility rates by 20 to 50% in order to comply with a 50% emissions reduction. All of the direct emissions controls such as coal washing, installing scrubbers, and switching to low-sulfur coal, are effective to some degree but not in reducing nitrogen oxide emissions. The controls would all impose costs on the coal producers, coal consumers, and finally the customers.

Many people feel that at the heart of the acid precipitation problem lies the use of coal as a fuel source. Major opponents to this view and to emission-control measures are organizations representing the coal and mining industries. These organizations are pressing for further research and fewer immediate controls. The President of the American Mining Congress said that the true causes of acid precipitation are still not fully understood. He supports congressional bills that are industry-oriented and call for further research. There are others who want to wait and not immediately react. Chairman of the Board of Southern Company, one of the largest investor-owned power utilities in the United States, said "As a nation we are losing our sense of balance on the acid rain question. Major facts about acid rain are yet to be understood. The questions are clear and crucial - the answers only tentative and uncertain. We don't yet know for sure if acid rain is increasing, and we can't be sure that reducing the emissions of power plants in the East and Midwest will reduce acid rain." He went on further to state, "Whatever damage is occurring is taking place at a slow rate; we have the time to design an appropriate response." (Public Utilities Fortnightly, June 9, 1983).

This industry view, however, is not supported by everyone. A report conducted by the National Academy of Sciences, National Research Council, said they found a direct link between sulfur dioxide emissions by coal-burning plants (chiefly in the Midwest) and depositions causing damage to lakes, streams, and aquatic life in northeastern United States and parts of eastern Canada. The report further states that reducing sulfur oxide in the aggregate would reduce acid rain.

There are a series of bills before Congress designed to reduce emissions now and in the future. All solutions not only involve questions of science and technology, but include politics, economics, and the environment.

Obviously, various people and groups have different solutions to the problem. Some don't even see it as a problem. Acid precipitation produces many questions that citizens, such as yourself, will be dealing with now and in the future. You will need as much information as possible about the issue to make the best decision.

What do you think the government's role should be in solving the problem of acid rain?

Who does the government have a responsibility to protect? The environment? Power plant owners? Human health?

What other interests should the government protect?

What responsibility do the owners of power plants have to protect the environment?

Who has the most interest in finding a solution to the acid rain problem?

Who should pay the cost for solving the problems associated with acid rain?

Acid Lakes And Jobs
- Scenario -

Acid Lakes And Jobs

The trout in Lake Lawson, the state's prime fishing area, were diminishing at an alarming rate, according to the latest park survey. The decline in the fish population was traced to the increased acid content of the water, which affects the fish's ability to reproduce. This report gave Governor Jones great cause for alarm, because it meant that an important and scenic area was threatened! Those responsible for the problem were the glassmaking companies and electricity-generating plant located 50 miles west of the park. The plants burn the less expensive high-sulfur-content coal, which emits large quantities of sulfur dioxide. Winds carry the particles eastward and they mix with rainwater to form sulfuric acid. This acid rain then falls over the park forest and empties into the lake.

However, the companies had been issued special permits allowing them to burn the high-sulfur coal. Despite their use of this type of coal, the state's air quality met the rigorous standards set up by the federal government. If the glass companies were not permitted to use the less expensive coal, they would be forced to close down. Over 20,000 workers would lose their jobs. Since glassmaking happens to be an important industry to the state, shutting down operations would be a severe blow to the state's economy. Without the glass companies, the entire western section of the state might become a depressed area. If the electric powerplant had to switch to the higher-priced coal, it would have to charge its customers more for electricity. With the cost of everything being so high already, the residents of that area would have a hard time making ends meet.

Should Governor Jones order the companies to burn low sulfur coal? Or, should he allow them to continue to burn high sulfur coal?

Discussion Questions

What responsibilities does the governor have to the people of his state? Why? To the parklands and wildlife? Why?

What should be the governor's main concern? Why?

Should the protection of natural areas and recreational activities be an important consideration? Why or why not?

From the perspective of the glass workers, what action should the governor take, if any? Why?

Should people have the right to expect good recreational areas? Why or why not?

In addition to recreation, how might the increase of acid rain be detrimental to the wilderness park area? To the state and its people as a whole?

Would the governor be treating the glass companies and their workers unfairly if the special permits were withdrawn? Why or why not?

Is there any way that the glass workers' jobs can be protected?

An Evaluation of Possible Effects

Meet in small groups of 3 to 5 students to briefly discuss "Acid Rain and Jobs". Consider some of the "Discussion Questions" in your analysis of the situation.

Your teacher will distribute Student Handout 6, *"An Evaluation of Possible Effects."* On the worksheet list some of the possible consequences of Governor Jones' decision. If he continues to permit the use of high-sulfur coal, the soil and water in the park would become more acid. If he withdraws the permit, the glass companies would close and the cost of electricity would increase.

List the consequences/effects in both the immediate and future categories.

According to your opinion, how harmful is each effect? Indicate the level of severity with a number from 1 to 4 in the "Harm" column.

- 4 - most harmful
- 3 - very harmful
- 2 - somewhat harmful
- 1 - least harmful

Review the readings for additional information to help you complete the worksheet. You may also wish to consider some of the consequences of strip-mining low-sulfur-content coal.

This worksheet may be completed individually or with your group members. If the worksheet is done individually, each person will present his/her analysis to the group for discussion. The findings are then combined to produce a group report.

From the results select (1) what the group believes are two of the most harmful effects from a short-term perspective, and (2) what the group believes are two of the most harmful effects from a long-term perspective. List these for the class to examine.

After examining the consequences with the entire class, try to reach a consensus as to what Governor Jones should do. What are the best reasons for supporting this decision?

Amending The Clean Air Act
- A Role Play Simulation -

Overview

Acid rain has raised many heated debates in Congress over the last decade or so. The United States government is currently involved in trying to develop legislation to help solve this problem. Developing legislation is not easy because of the many different interest groups who pressure government representatives to "see it their way".

In this simulation activity you will conduct a Senate hearing on a proposed bill amending the Clean Air Act specifically dealing with the problem of acid rain. Seven members of the class will represent senators who will decide whether or not the bill will be made into law. Other class members will represent different interest groups, each with different reasons supporting or not supporting the bill. After hearing the arguments presented, the senators will vote on the bill.

The purpose of this activity is to examine some of the concerns related to the acid precipitation debate; these concerns span a wide range of issues - economic, social, technical, scientific, and political.

Simulation Procedures

Senate Committee

Seven members of the class will serve on the Senate committee. Each person will assume the role of one of the senators listed.

Senators from New York (1), California (1), Nebraska (1), Ohio (1), Texas (1), New Hampshire (1), Illinois (1)

Each senator will need to do the following:

- Learn about the state he/she represents.
- Understand the needs and concerns of the people he/she represents. (How do you think the people of your state feel about acid precipitation?)
- Determine if the state will or will not benefit from this bill. (What advantages will this bring to your state?)
- Identify some of the arguments given in favor or against the bill.
- Prepare a list of questions to be asked of each witness based on the concerns he/she has identified. This list of questions should reflect the ideas and opinions of the senator he/she represents.
- Elect a chairperson to conduct the meeting so that it will progress in a smooth and orderly fashion. This includes making sure that each group has an equal amount of time to present its case, that witnesses do not speak out of turn, and that questioning does not become irrelevant or sidetracked.

Special Interest Groups

The remaining members of the class will represent one of the six different interest groups. (There should be approximately the same number of members in each group.) Each group will develop a presentation supporting its position to be given before the Senate Committee.

Group A - Concerned Consumers Group

Group B - Powerplant Owners Association

Group C - Anti-Nuclear Power Group

Group D - National Committee for a Better Environment

Group E - Northeast Coalition of State Governors

Group F - Canadian Tourist Industry Association

Members of each group will need to do the following:

- Understand the position, opinions and feelings of the group he/she represents.
- Reread the background article carefully and identify the important points that support the group's position.
- Conduct any necessary outside research that may provide additional information. (Each member of the group may wish to examine a different phase or aspect of the argument or the group may wish to work together.)
- Identify the most important arguments in support of the group's position and discuss those ideas.
- Develop a logical and convincing set of arguments to present to the Senate hearing.
- Select spokesperson(s) to give the presentation. Or, each member of the group may give part of the presentation, providing a different aspect of the argument.

Use the *Interest Group Fact Sheet* (Handout 7) to help organize your presentation.

Hearing

- Each group is allowed ten minutes to make its presentation.
- After each group presents its position, each senator may ask a maximum of three questions. Use the "Senator's Worksheet" (Handout 8) to help organize your thought he group members may discuss the question among themselves before answering the question.
- When all arguments have been presented and all questioning completed, each group will be allowed three minutes to give a summary of its arguments before the senators.
- Upon completion of the hearing, the senators will meet to vote. The chairperson of the committee will announce the outcome and give an explanation for its decision. (It is suggested that the explanation of the decision be written out so that all the senators can express their opinions. One possible format for this announcement is to indicate how each senator voted and the main reason for that vote.)

PROPOSED BILL

The Johnson Bill (introduced by Senator Frank Johnson, Democrat - Illinois) is a bill that would establish an acid precipitation superfund. The money in this superfund would come from a tax on all utility bills from electrical power plants in the United States. The only exception would be plants that use nuclear power generation. The money would be used to retrofit existing power plants' smokestacks with scrubbers. This action would reduce emissions by 14 million tons by 1990 at a cost of nineteen to twenty-one billion dollars. Half the tax would have to paid by the utility companies and the other half could be passed on to the customers.

INTEREST GROUP A
CONCERNED CONSUMERS GROUP

As a member of this group, you are opposed to this bill because of the significant rate increase you will face on your monthly electric charge. The majority of people you represent live in the western and outhern parts of the country. Your group feels that they are being punished by this bill. They feel that they will have to pay increased utility costs when they have nothing to do with the acid precipitation problem. The majority of the pollutants are produced east of the Mississippi, not where your group lives. You are not even affected that much by the results of the pollutants as they travel. Your group feels that the states that are causing the problems should be forced to pay the extra taxes, not the states that have nothing to do with it. You should not have to pay for the problems of other people.

INTEREST GROUP B
POWER PLANT OWNERS ASSOCIATION

As a member of this group, you are strongly against the passing of this bill. Your group feels that the power plant companies cannot absorb the additional tax that will be levied against them. Besides having to pass along higher utility charges to your customers, you will also have to lay off many employees in your plants. You also feel that by reducing the number of your employees, you are creating an unsafe condition at the plant along with the personal loss of employment to your loyal workers. These people will have to collect unemployment benefits and may become part of the welfare roles. You are also concerned with showing your board of directors that you can earn a profit. Many private investors have put much money into your companies. You must convince the senators of how bad things will be if this bill is passed.

INTEREST GROUP C
ANTI-NUCLEAR POWER GROUP

As a member of this group you are against this bill. You represent a national organization that is against the existence or creation of nuclear power plants. You feel that the way the bill reads now provides an incentive for nuclear power plants. The bill may cause the building of new nuclear power plants because of the "tax breaks". You not only don't want any new nuclear plants, but you want the ones that are now open to be shut down. You know the dangers of coal-burning plants but will accept them over the possible problem of a nuclear disaster. Your group feels that additional research should take place concerning acid precipitation before the senators agree to this bill. You feel that the problems associated with the production of nuclear power far outweigh the loss of "a few dying lakes and forests." (See Chapter 4 for information regarding the issues surrounding nuclear power.)

INTEREST GROUP D

NATIONAL COMMITTEE FOR A BETTER ENVIRONMENT

As a member of this group, you are in favor of this bill. Your group is deeply concerned with the need to keep our environment a healthy place to live and feel people can no longer continue to abuse it. A large number of your group members are outdoor enthusiasts and enjoy the rivers, streams, and forests and do not want to see any more damage caused to them. You realize this bill will add costs to all citizens of the country but feel that the benefits outweigh the costs. Your group feels that if something isn't done, we may lose many of nature's resources. You cannot wait for additional research on acid precipitation; enough evidence points to the damages caused by this process. It is time for citizens and government to join forces and prevent any further damage to our natural environment and health.

INTEREST GROUP E

NORTHEAST COALITION OF STATE GOVERNORS

As a member of this group, you represent some 15 governors from the northeast part of the country. The states you represent have been the hardest hit by acid precipitation effects. Your states, by themselves, do not have the funds to help retrofit the power plants' smokestacks and this bill is the only way this could be done. You know this will be a financial hardship on some of your constituents but feel that the loss to the natural environment and health will be even greater if something isn't done now. You also know that people are hesitant about moving into your states because they fear the health hazards attached to the acid precipitation stories in the news. You owe it to the residents of your states to convince the Senate to pass this bill to make your state a better place to live.

INTEREST GROUP F

CANADIAN TOURIST INDUSTRY ASSOCIATION

As a member of this group, you are very much in favor of the passing of this bill. You represent the interest of a national organization of an adjoining country that promotes tourism both in Canada and in the United States. You realize the effect acid precipitation is having on many of your country's favorite vacation spots, particularly those along the Canadian/United States border. Many of the lakes, both in Canada and the United States, are being damaged and are no longer attractive to vacationers. Your group feels that if something is not done immediately, not only will the environment be damaged but so will the multi-million dollar industry of tourism and recreation in these affected parts of your county. You must continue to bring vacationers here from foreign countries, especially from the United States. However, the acid precipitation issue is beginning to develop into an international dispute. If something isn't done, Americans might be discouraged from vacationing in Canada. If this bill is not passed, people from other countries, as well, might decide to spend their vacations elsewhere. The acid precipitation problem has already hurt tourism in the United States. You don't want the same thing to happen in your country, particularly since your government feels that industries in the United States are the major cause of acid precipitation in the area, anyway.

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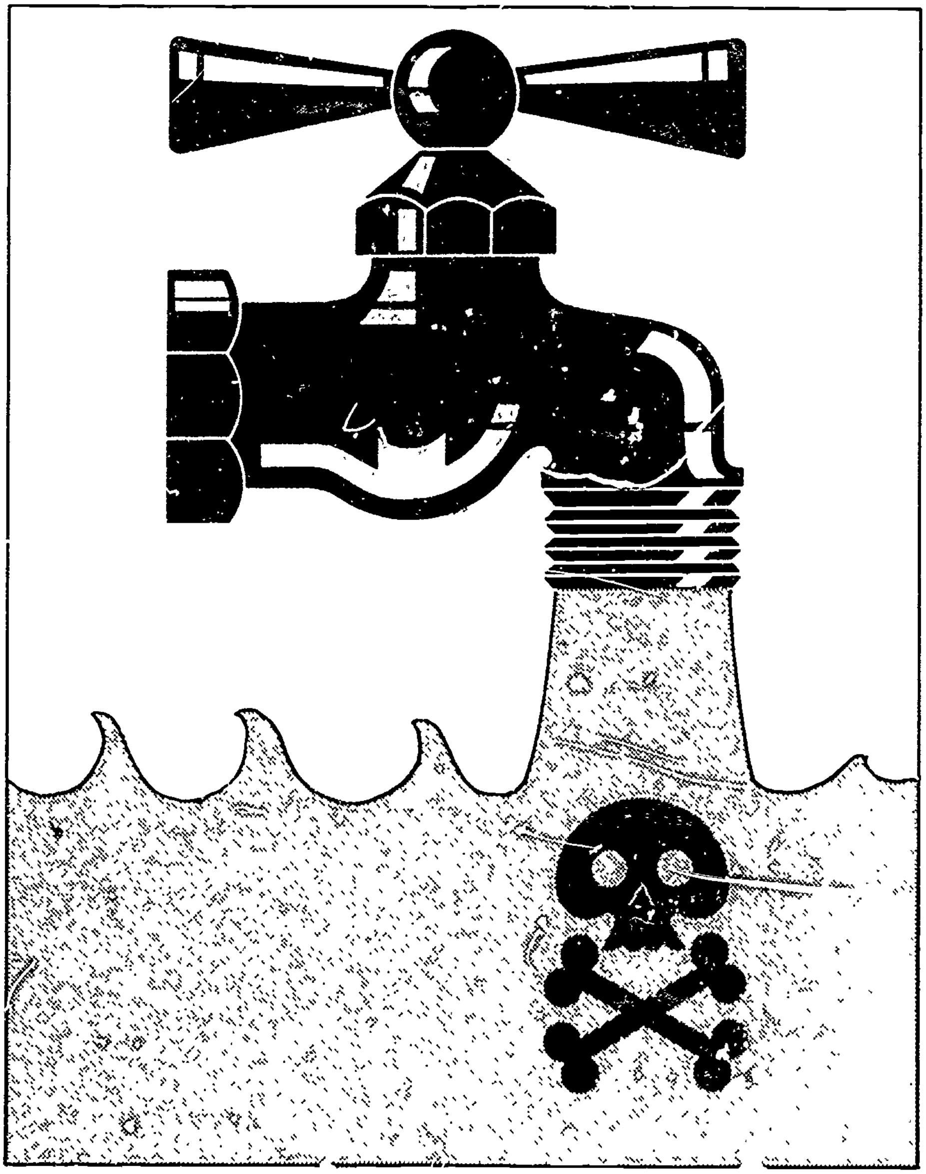
Chapter 7



Hazardous Wastes

Hazardous Wastes

- Reading 1 -

Just how bad is the hazardous waste problem, **really**? It's doubtful that anyone or any group really knows the overall scope of the problem. Toxic substances appear in so many products and in so many forms that the total number of different toxic wastes, many of which we know absolutely nothing about, could easily run into the thousands.

While there is much that we don't know about hazardous wastes, there is also much that we do know. In this reading, we will attempt to respond to the following:

- *What do we mean by "hazardous wastes"?*
- *How do toxic wastes get into our bodies?*
- *What effects do hazardous wastes have on us?*
- *What effects do hazardous wastes have on the environment?*
- *What can be done about hazardous wastes?*

What Are Hazardous Wastes?

The term "hazardous wastes", or as they are sometimes called, "toxic wastes", refers to discarded materials considered to have little or no raw economic value. However, they do often have value for recycling and reuse. In contrast, hazardous substances or chemicals may have obvious economic value and can include products as well as discarded materials. Although this reading uses the term hazardous or toxic wastes, the principles discussed here apply to hazardous substances as well (Eptstein et al., 1983). The rather special considerations of nuclear wastes are not addressed here.

This definition, while useful for economic purposes, gives little indication of the danger hazardous wastes pose to society and to the environment. For our purposes an examination of the term, toxic substances, might be more useful.

- *What does the word "toxic" mean?*
- *Are toxic substances always harmful?*

Essentially the word "toxic" means "poison". The word "poison", in turn, can be defined as "any substance capable of producing an unobscure or unexpected harmful response in a biologic system, seriously injuring functions or producing death" (Casarett and Doull, *Toxicology,* Second Edition).

- *In your judgment is this a useful working definition of the term "poison"? Why or why not?*

According to this definition, virtually every known chemical can be considered a poison, every known chemical has the potential to produce death if present in sufficient quantities. Paracelsus (1493- 1541) probably stated it best when he said, "All substances are poisons, there is none which is not a poison. The right dose differentiates a poison and a remedy."

- *Can you give some modern day example of what Paracelsus meant?*

Depending on the substance, a wide range of doses are required to produce negative effects, serious injury, or death using chemicals. Toxicologists (people who study the adverse effects of chemicals on living things) use "LD50" to describe the potency of various chemicals. LD50 is a figure that shows how much of a chemical is needed to produce death in 50% of the dosed animals. As the following table shows, while some chemicals will produce death in microgram doses, others are relatively harmless.

Agent	LD50(mg/kg)
Ethyl Alcohol	10,000
Sodium Chloride (salt)	4,000
Phenobarbital Sodium	150
DDT (pesticide)	100
Strychnine Sulfate	2
Nicotine	1
Dioxin (pesticide)	0.001
Botulinous Toxin	0.00001

- *What do the above figures mean?*
- *How many times more toxic is dioxin than nicotine?*
- *How much more toxic is nicotine than DDT, a chemical pesticide banned in the U.S.?*
- *Does it surprise you that alcohol and salt (Sodium Chloride) can also be poisonous?*

Risks vs. Benefits

In practical everyday situations, the important factor is not how toxic a substance is, but the risk associated with its use. "Risk" means the possibility that a substance will do harm under certain conditions. In other words, a very toxic substance can be less toxic than a relatively low toxic substance, depending on how it is used. "Risk assessment" is often used to determine whether or not the use of certain chemicals is warranted in various situations. Thus, one chemical might be selected over another chemical to be used in the manufacture of certain products because it is less expensive than a less toxic chemical. However, the risk associated with using the more toxic but cheaper chemical is, in the judgment of the decision-maker, negligible, in light of the cost saving realized in using the more toxic chemical. A different decision-maker could, of course, make a very different judgement.

In the past, not much was known by society about such "risk-benefit" considerations. In recent years, however, more and more people and organizations are beginning to challenge the decision-makers (those who decide to use toxic stubstances - i.e. industry, farmers, consumers etc.) when it comes to making decisions about issues that affect public and environmental health. Society wants to be involved in making decisions regarding how much of a risk should be acceptable. It wants to be involved in deciding what criteria should be used in determining what is "acceptable risk". We now realize that direct impact on human health is only one aspect that needs to be considered. It is also important to consider the ill effects on the environment, as well as the more direct effects on human health.

Although the determination of acceptable risk is really a "judgment call" on the part of the decision-maker, the following criteria are generally used in assessing what constitutes an acceptable risk.

— How important is the need for the substance? Does the danger to human health posed by the use of DDT to control pests justify its use? In the U.S. it was determined that the risks outweighed the benefits. In other countries, particularly those plagued by malaria and other harmful diseases, decision-makers felt the benefits derived from the use of DDT outweigh the risks.

— What is the adequacy and availability of alternate substances to meet the need? Again, using DDT as the example, other adequate substances and techniques were available to control pests in the U.S. There were apparently no alternate substances available to deal with the problem of pests and disease control in other countries. Hence, the U.S. banned DDT, while many other countries (obviously those with more serious problems) decided to continue it's use.

— What is the anticipated extent of public use? In other words, how much of the chemical will be used by the public at large? If it is thought that too much will be used, then the risks might outweigh the benefits. Of course, the opposite is also a reasonable possibility.

— What are the employment considerations? How many people will be put out of work if a particular chemical is not used? This includes job losses in manufacturing the chemical, as well as job losses associated with those needing the chemical.

— What are the economic considerations? How much money will be lost if the chemical is not used? For example, how much do farmers stand to lose if their crops aren't sprayed with pesticides? Economic considerations are included in just about all decision-making of this type.

— What are the effects on environmental quality? What impacts, both positive and negative, would the use of certain chemicals have in the environment? For example, DDT might make our environment more pleasant and rid the area of pests. Plants might flourish if they are no longer attacked by pests. The only problem with spraying DDT is that

  — we can't get it out of the crops very easily once they are sprayed,

  — it poisons animals, birds and useful insects in the area,

  — it poisons our water supplies, and

  — it poisons us, if it gets into our bodies.

— How does it affect the conservation of natural resources? Would the use of a particular chemical result in saving natural resources?

It should be noted that each of the preceding factors does not receive an equal weighting in risks vs. benefits decision-making. In addition, all of the factors are considered together in an effort to examine the entire picture before a decision is made.

How Do Toxins Get Into Bodies?

Toxins are classified according to

the target organ they attack (e.g., liver, kidneys, heart, etc.),

the way they are used (i.e., pesticides, solvents, food additives yes, some food additives are poisonous),

the source from which they are obtained (plants, animals, etc.),

their effects (carcinogens - cancer producing; mutagens - produce mutations, etc.),

physical state (solids, liquids, gases, dusts), and

labeling requirements (explosives, flammables, etc.),

chemistry (analines, halogens, etc.).

Harmful effects are produced only when the substance reaches the target organ at a sufficient strength and for a sufficient length of time. Toxic substances get into the human body through several routes.

What do you think these routes might be? Try listing them before reading on.

The major routes through which toxic substances enter the body are the gastrointestinal tract (eating them), the lungs (inhaling or breathing them), or the skin. Once in the body, toxins are carried by the circulatory system and attack the various target organs. In cases where the quantity of toxins is not sufficient to cause immediate death, the toxins are stored in various organs. If a sufficiently high concentration is reached, death can occur.

Toxicants are stored mainly in the liver, kidney, fat, and bones. The liver and kidneys usually contain the highest concentrations of toxic substances. This is understandable. Why? These organs are mainly involved in eliminating toxicants from the body. Hence, they tend to be the major places in which toxicants are stored. The fat areas in the human body are the places that tend to store such harmful pesticides as DDT and chlordane, while the liver tends to be the major place for storing lead.

Toxicants are removed from the body through several organs and/or routes.

Kidneys -	very efficient. Eliminates most toxicants.
Liver and Bilary System -	eliminates lead and DDT.
Lungs -	eliminate Carbon Monoxide, gases of various types, and water vapor.
Feces -	eliminate various toxicants.
Milk - (cows and humans)	DDT mainly, some metals.
Perspiration -	of minor importance.
Saliva -	of minor importance.

It should be stressed that m... ajor route through which human females and cows rid their bodies of harmful chemicals) is al... urce of food for babies. Hence, nursing mothers need to be extremely careful with their die... 's milk is usually checked sufficiently before it is marketed to ensure that it contains no ... al substances. What about mother's milk?

* * * *

Obviously, a reason to study poisons and toxic substances is that hazardous wastes (poisons) surround us, and have for many years. In the early 1960's the eminent scholar, Margaret Mead, warned, "Not war, but a plethora of man made things... is threatening to strangle us, suffocate us, bury us, in the debris and by-products of our technologically inventive and irresponsible age."

- What does Dr. Mead mean?

- Explain in your own words and give some examples.

Pesticides and *Silent Spring* - Then and Now

In the early 1960's a very important book, *Silent Spring*, was published. It's author, Rachel Carson, received eight major awards for her monumental work. The *Saturday Review* referred to the volume as "a devastating attack on human carelessness, greed, and irresponsibility". Former Secretary of the Interior, Stuart L. Udall, praised Dr. Carson as "a great woman (who) has awakened the nation by her forceful account of the dangers around us". And the *Chicago Daily News* said, "Miss Carson is a scientist and is not given to tossing serious charges around carelessly. When she warns us, as she does with such a profound sense of urgency, we ought to take heed. *Silent Spring* may well be one of the great and towering books of our time."

Indeed it has become one of the "great and towering books of our time". Not only was Rachel Carson's work of significant importance when she wrote it in 1962, but, amazing as it may seem, nearly all of it is still valid and important today, nearly a quarter of a century later.

What is *Silent Spring* all about? What was it attempting to warn us against? Miss Carson was writing about the ways the by-products of man's "new" chemistry and new advances in science and technology are having a devastating effect on us and on our surroundings; how pesticides (and other toxic chemicals) are slowly and almost imperceptively poisoning us.

Unlike their forerunners, such as arsenic, modern insecticides are mostly synthetic and extremely potent and more deadly.

Essentially, there are two groups of synthetic pesticides:

(1) chlorinated hydrocarbons, such as DDT, and

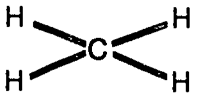
(2) organic phosphorus insecticides, such as malathion parathon.

Chlorinated Hydrocarbons

These chemicals are built on a base of carbon atoms, which are indispensible building blocks of the living world. Let's take a closer look at these organic substances and how they are created.

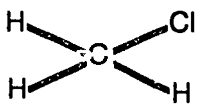
Carbon, an element that has an almost infinite capacity for joining with itself and other elements, combines with other elements to form chains, rings, and other configurations. Each of these configurations represents a different chemical.

The simplest organic compounds combine atoms of Carbon (C) and Hydrogen (H). An example of this is methane (marsh gas) which is formed by the breakdown of organic matter by bacteria under water. The compound looks like this:

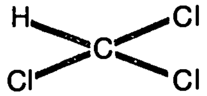


Chemists quickly discovered that new compounds could be developed by simply detaching, or removing, one or more of the H atoms and substituting other elements. Thus:

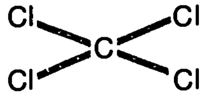
Substituting one Chlorine (Cl) for one Hydrogen (H) atom forms Methyl Chloride:



Or, substituting three Cl atoms for three Hydrogen atoms creating Chloroform:



Or, substituting Cl for all four H atoms to produce Carbon-tetrachloride, a very hazardous chemical that was once widely used as a cleanser.



Hence, by making seemingly slight changes in existing formulas, new chemicals with vastly different characteristics are created. Such simple, yet ingenious, manipulations have created a battery of poisons of truly extraordinary power. Let's look at some of the more common insecticides known collectively as Chlorinated Hydrocarbons. DDT is a good example.

DDT was first synthesized in Germany in 1874 (more than a century ago) but it wasn't until 1939 that its insect-killing properties were revealed. The chemical worked so well that farmers used it in abundance. DDT was hailed as such an important discovery that its developer, Paul Muller, was awarded the Nobel Prize.

The widely used DDT went unnoticed as a poison for many years. During World War II, the chemical was sprayed on soldiers, refugees, and prisoners alike to combat lice. One might question, "If DDT was so harmful, how could it go so long before anyone noticed its poisonous effects on humans?" Simple! In its solid or powdered form, DDT is not very readily absorbed through the skin. BUT dissolved in oil DDT is deadly. Once it enters the body, DDT is stored in the liver, kidneys, and fatty areas of the body. These fatty storage depots act as biological magnifiers. That is, if a small amount - as little as 1/10 of 1 part per million (ppm)-is taken into the body, it magnifies in storage to about 10-15 ppm. Expert opinion differs regarding how much DDT can be safely stored in the body. Government safety standards for exposure to DDT are revised as new knowledge is obtained.

What makes Chlorinated Hydrocarbons so dangerous is the way they are passed through the food chain from one organism to another. For example,

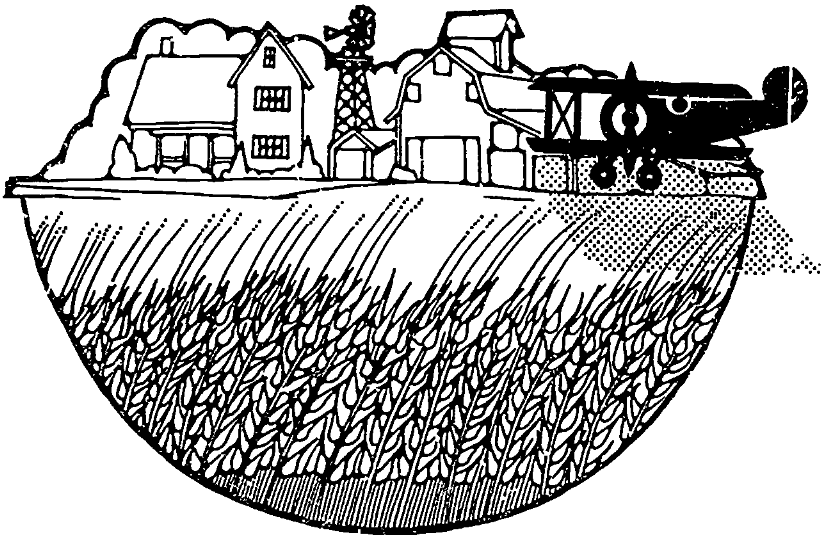
> Alfalfa sprayed or dusted with DDT is processed into meal for chickens. The hens ingest the DDT in the meal, which in turn, contaminates their eggs. Eggs are then eaten by humans and they, too, take in the DDT.
>
> Or, DDT is deposited on hay which is eaten by cows. Cows absorb about 7-8 ppm of DDT. This then contaminates cow's milk, a concentration of 3 ppm (some of the DDT is absorbed by other organs of the cow). When the cow's milk is churned into butter, it then reaches a concentration of 65 ppm. Similar problems exist when mothers, after ingesting foods contaminated by DDT, also pass on small, but regular, amounts of DDT to their babies when nursing them.

Another chemical that is very similar to DDT is Chlordane. It has all of the same unpleasant symptoms of DDT - and more. Chlordane can, for example, be absorbed by the skin, breathed in as spray or dust, and/or be absorbed by the digestive system. Its effects, like those of all Chlorinated Hydrocarbons, are cumulative and magnified in the body. Chlordane was used quite freely for killing termites and for spraying on lawns. It is so deadly that when one victim spilled a 25% solution on himself, he was dead in 40 minutes. Other very potent toxics similar to DDT are Dieldrin, Aldrin, and Endrine. Dieldrin is 5 times more toxic than DDT when swallowed and 40 times more toxic than DDT when absorbed through the skin.

Organic Phospates

The second group of chemicals, the Organic Phosphates, include some of the deadliest toxins known to man. The most significant hazard associated with these chemicals is to people who spray them or who come into contact with drifting spray. They affect the living organism by destroying the enzymes that perform many of the necessary body functions. These chemicals attack the nervous system producing uncoordinated tremors, muscle spasms, convulsions, and in some cases, death.

Parathion is one the best known and one of the most powerful organic phosphate insecticides. Carson (1962) reported an instance in which a chemist seeking to ascertain (by the most direct possible means) the dosage toxic to human beings, swallowed a minute amount (equivalent to about 0.00424 ounces) of Parathion. Paralysis followed so instantaneously that he could not reach the antibiotics he had prepared at hand, and he died. Nearly 7,000,000 pounds of parathion were applied annually to fields and orchards in the United States during the 1960's.



Unfortunately, many commonly used chemicals are more dangerous than people realize. For instance, herbacides and weed-killers are poisonous, not only to plants, but also to animals. There are many types of poisons in this group. Some are general poisons, while others are powerful stimulants of metabolism which produce fatal increases in body temperature which, in turn, cause the body to literally burn up.

How about today? DDT was banned in the United States in 1972 with several of the other chemicals discussed in this reading. As a result, levels of DDT declined over the years. Recently, however, DDT levels have again risen, even though the chemical supposedly hasn't been used since 1972.

- *If DDT cannot be used in the U.S.. how could it be that levels of this chemical are increasing?*

Six days after the ban on DDT in the United States, Rohm and Haas, Inc. of Philadelphia, Pa., applied to the U.S. government to register a pesticide called Dicofol. Even though the company indicated clearly on their application that Dicofol contained DDT, a permit to manufacture the pesticide was awarded. Dicofol, like DDT, is a Chlorinated Hydrocarbon pesticide. It differs from DDT because it contains an additional oxygen atom. Thus, it is insoluble in water, unaffected by light and moisture, and lasts for more that one year before it begins to break down.

- *If Dicofol has these properties, what does this mean for the environment? Plants and animals? People?*

Since Dicofol is manufactured directly from DDT, some DDT and DDT related impurities remain unchanged in Dicofol.

Dicofol is marketed under the name of Kelthane and can be found in at least 65 commercially available pesticides. Two million pounds of this chemical are used annually to control mites on cotton and citrus crops. In New Jersey, the Agriculture Experiment Station at Rutgers University has recommended the use of Kelthane on crops of peppers, snap beans, lima beans, and on ornamental plants. It is also recommended for use as a spray for apple orchards and in home gardens.

— *If Kelthane (Dicofol) is a harmful chemical, why might its use be allowed in the United States? Why would a major University, known worldwide for its outstanding record of agricultural achievements, recommend the use of Kelthane on crops?* (Hint: Remember the discussion on risk/benefit analysis. Turn back and reread that section again if you need to; then respond to this question.)

There are about one million different species of insects in the world. Of this number, only about 1 percent interfere significantly enough with the health and well-being of life to be considered pests. Table 7-1 identifies the major families of insecticides that have been used to kill these pests. Many are still used today.

Table 7-1

MAJOR FAMILIES OF INSECTICIDES

FAMILY GROUP	EXAMPLES	EFFECT ON INSECTS	HUMAN TOXICITY	PERSISTENCE IN THE ENVIRONMENT
ARSENICALS	lead arsenate, calcium arsenate, Paris Green	stomach poison; inhibits respiration	acutely toxic	forever
BACTERIALS	BT, Dipel, Thuricide, Bacillus, popilliae (doom)	fatal disease	none known	days to years
BOTANICALS	pyrethrum, rotenone, nicotine	contact poison	high (nicotine) to low (rotenone)	short (degrades in light and moisture)
CARBAMATES	Sevin, Temik carbofuran (Puraden) Zectran	nerve poison; cell growth inhibitor	highly toxic in small doses	days to 2 weeks
CHLORINATED HYDROCARBONS	DDT, aldrin, endrin, kepone dieldrin, heptachlor, chlordane, docofol	nerve poison	moderately toxic but builds up over time	2 to 15 years
ORGANO-PHOSPHATES	parathion, malathion, diazinon	nerve poison	varies in toxicity	2 weeks to 2 years
TRAP BAITS	pheromones, light	confuse, disorient, and trap	none known	

Hazardous Waste*
- Everybody's Problem -

There are chemicals other than pesticides that threaten the environment and human health. The U. S. Environmental Protection Agency (EPA) has stated, "Every year, billions of tons of solid wastes are discarded in the United States. The wastes range in nature from common household trash to complex materials in industrial wastes, sewage sludge, agricultural wastes, mining refuse, and pathological wastes from institutions such as hospitals and laboratories."

In 1980, at least 57 million metric tons of the nation's total waste was classified as hazardous. Many dangerous substances that society had thrown away have come back to haunt us. Hundreds of cases of damage to life and the environment have resulted from indiscriminate or improper management of hazardous wastes including such famous cases as "Love Canal" and the "Valley of the Drums". The following section describes the effects of improperly disposing of hazardous wastes and a series of brief vignettes of exemplary cases in the United States.

Fact: Hazardous waste can pollute groundwater.

Groundwater in a 30-square-mile area near Denver was contaminated from disposal of a multitude of wastes in unlined ponds (unlined ponds allow chemicals to seep deeper and deeper into the earth and into groundwater supplies). These wastes (from manufacturing activities of the U.S. Army and a chemical company) were deposited from 1943 to 1957. Decontamination, if possible, could take several years and cost as much as $80 million.

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* Adapted, in part from the EPA's "Pollution, Everybody's Problem". **Hazardous Waste**. 1980. Environmental Protection Agency, U.S. Government Printing Office

Fact: Hazardous waste can contaminate rivers, lakes, and other surface water.

About 17,000 drums littered the "Valley of the Drums" (a 7-acre site in Kentucky) about 25 miles south of Louisville. Some 6,000 drums were full, many of them oozing their toxic contents into the ground. In addition, an undetermined quantity of hazardous waste was buried in drums and in subsurface pits. In 1979, EPA identified about 200 chemicals and 30 metals at this site.

Fact: Hazardous waste can pollute the air.

A truck driver died as he discharged toxic waste from his truck into one of four open pits at a disposal site in Iberville Parish, Louisiana. He was asphyxiated by hydrogen sulfide fumes when liquid wastes mixed in the open pit. The area was surrounded by water and had a history of flooding.

Fact: Hazardous waste can burn or explode.

A bulldozer operator was killed in an explosion in Edison Township, New Jersey. He was burying and compacting drums of unidentified chemical wastes. Of the 200 truckloads of waste the landfill received daily, about 50 contained industrial waste.

Fact: Hazardous waste can poison via the food chain.

Over a four-month period in 1976, an Indiana family consumed milk contaminated with twice the maximum concentration of polychlorinated biphenyls (PCB's) considered safe by the U.S. Food and Drug Administration. The milk came from the family's cow, which had been grazing in a pasture fertilized with the city of Bloomington's (Indiana) sewage sludge. The sludge contained high levels of PCB's from a local manufacturing plant. A federal law passed in 1976 banned production of PCB's after January 1, 1979. PCB's still remain in the environment today.

In 1986, an Arkansas supplier sold tainted feed to beef and pork growers. The feed contained the banned pesticide, heptachlor. As a result, some brands of milk, ice cream, and cheese had to be removed from stores in Arkansas, Oklahoma, and Missouri. More than 300 dairy farms were quarantined and children and pregnant women in the area were warned to avoid the use of these dairy products.

Fact: Hazardous waste can poison by direct contact.

In 1978 and 1979, the health of some residents of Love Canal, near Niagara Falls, was seriously damaged by chemical wastes buried a quarter of a century ago. As drums holding the waste corroded, their contents percolated through the soil in yards and basements, forcing the evacuation of over 200 families. About 80 chemicals, a number of them suspected carcinogens (cancer producing), were identified.

Also in 1979, cattle in a Kansas feedlot were affected after scratching against pads manufactured using waste oil contaminated with PCB's. The waste oil (from electrical transformers) had been purchased from a salvage yard in 1972, before the effects of PCB's were widely known. Inedible by-products (e.g., skins for leather, etc.) from 54 head of contaminated cattle had been shipped to a number of states and had to be traced and disposed of properly, another 112 head had to be destroyed.

These brief but dramatic examples provide evidence of damage to life and the environment from the mismanagement of hazardous wastes. Largely to prevent future tragedies such as these, Congress enacted Subtitle C of the Resource Conservation and Recovery Act (RCRA), Public Law 94-580. This law imposes strict controls over the management of hazardous wastes.

While the resulting costs for proper environmental controls will exceed expenditures seen in the past, they pale when compared to the astronomical costs of cleaning up damage caused by poor disposal practices.

An EPA study made in 1979 indicated that cleaning up abandoned hazardous waste sites and those currently operating under environmentally unsound conditions could cost as much as $44 billion, only part of which is likely to be paid for by the owners of the sites. However, in many cases, it is impossible to assign dollar values to the long-term harm to the health and the environment that has resulted from improper management of hazardous waste.

Disposal of commonly used products, especially in drains or in the garbage, often results in potentially dangerous wastes. Table 7-2 summarizes these.

Table 7-2.

COMMONLY USED PRODUCTS AND THE POTENTIALLY HAZARDOUS WASTES THEY GENERATE.

Products We Use	Potentially Hazardous Waste They Generate
Plastics	organic chloride compounds
Pesticides	organic chloride compounds organic phosphate compounds
Medicines	organic solvents and residues, heavy metals (mercury, zinc, etc.)
Paints	heavy metals, pigments, solvents, organic residue
Oil, gasoline, and petroleum products	oil, phenols, organic compounds, heavy metals, ammonia, salts, acids, caustics
Metals	heavy metals, flourides, cyanides, acid and alkaline cleaners, solvents, pigments, abrasive plating salts, oils, phenols
Leather	heavy metals, organic solvents
Textiles	heavy metals, dyes, organic chlorine, compounds, solvents

The Disposal of Hazardous Wastes

Recently, a greater regard for the environment and the increased costs of disposal created by the introduction of federal and state regulations has caused industry to greatly reduce its production of hazardous wastes. Homes too can cut down on the amount of hazardous waste they produce. There will, however, always be waste.

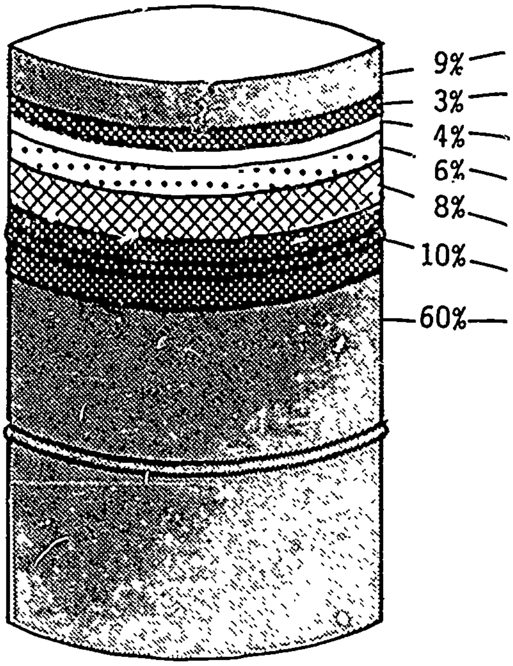
Basically, the less hazardous the waste we have, the easier it is to deal with. Some wastes can be harmless biologically, others require chemical treatment. Acids are neutralized with bases while some pesticides are rendered harmless by chemical reation. Different wastes require different treatments.

In the industrial setting, the ability to determine exactly what is in a waste and how much there is of it, make it practical to build and use chemical or biological treatment systems. In the household hazardous wastes are often an unpredictible mixture of substances, and consequently, it is not practical to systematically make them nonhazardous.

Whatever the source, hazardous wastes are a fact of life. It is the responsibility of our technological society to develop and implement the means to dispose of them effectively.

Most people want the benefits that come from using the products that create hazardcus waste, but they also don't want a hazardous-waste management facility near their community. Unfortunately, there is no place that isn't somebody's backyard.

Figure 7-1 Percentage of Industrial Hazardous Waste by Industry

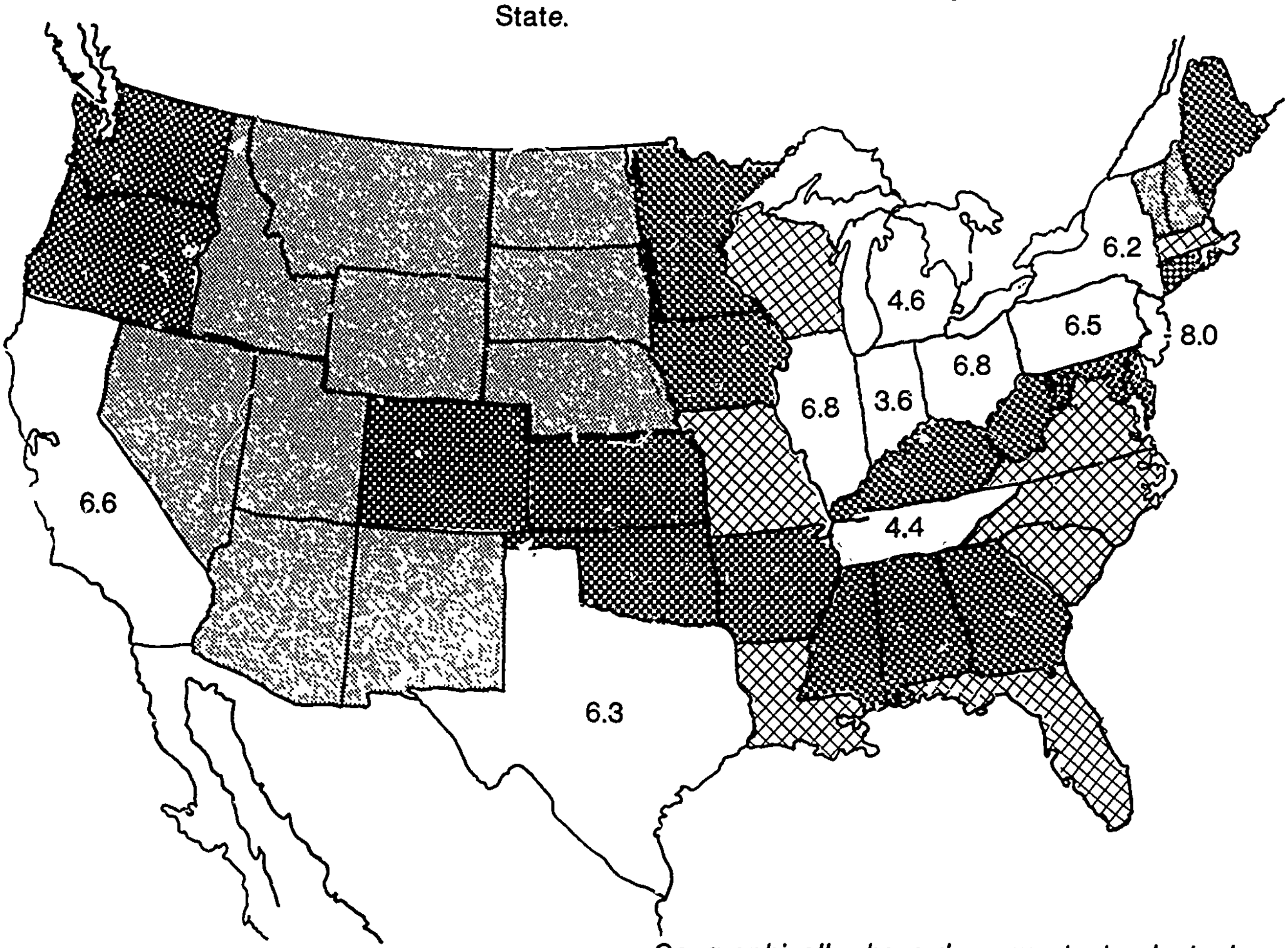


The chemicals and allied products industry generates 60 percent of industrial hazardous waste

Source - EPA, Draft Environmental Impact Statement, 1979

Which industry is responsible fc most of the hazardous wastes? The least?

Figure 7-2 The Impact of Hazardous Waste by State.



3 - 8% | 2 - 3%

0.5 - 2% | below 0.5%

Percent of total hazardous waste

Geographically, hazardous waste tends to be concentrated in certain regions. About 60 percent is generated in 10 states: New Jersey, Illinois, Ohio, California, Pennsylvania, Texas, New York, Michigan, Tennessee, and Indiana.

Source; EPA, Draft Environmental Impact Statement, 1979.

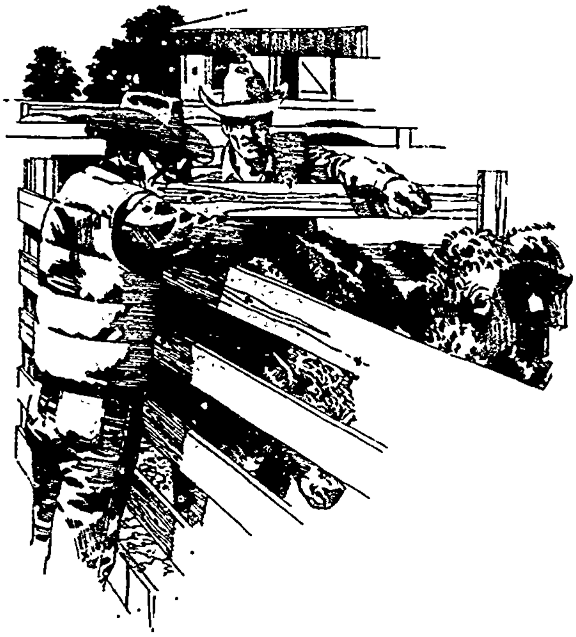
Which state has the highest concentration of hazardous waste?

What part of the country seems to be affected most by hazardous wastes? Why might this be? What kinds of products are these states noted for?

How does the state in which you live rate relative to hazardous wastes?

Harry Carter's Grain Company
- A Scenario -

The Great Midwest Grain Company (GMGC) was experiencing much difficulty in keeping the grain supplies free of molds and various pests while in storage. In recent years, the problem had grown so great that something had to be done. Customers were canceling orders and business was going downhill very quickly. If the company closed, the town of Junction would be devastated.



Harry Carter, the owner of GMGC, tried several ways to correct the problem; nothing worked. He knew that at one time Heptachloride was used in homes, in gardens, and on farms to ward off pests and prevent molds from forming. However, in 1983 the EPA banned the use of Heptachloride because it was suspected of causing damage to the liver and kidneys of infants and increased the risk of birth defects and cancer.

Harry reasoned that Heptachloride was effective and inexpensive. He used it for years without observable negative effects and he questioned the EPA's judgement in outlawing its use. He felt that the EPA could not conclusively demonstrate that it caused damage.

Before it was banned, Harry's company had purchased a large supply of Heptachloride. After checking, Harry found that hundreds of bags were still in the warehouse. Harry wondered what would happen if he mixed small amounts of Heptachloride with the feed? He reasoned that he had eaten beef from cattle that had consumed grain with large amounts of Heptachloride in it and he was still ok. In addition, Harry was faced with the harsh realities of his declining business. If he didn't do something soon, both he and all the people who worked for him would be ruined. Harry also knew that mixing the prohibited chemical with the grain was illegal and punishable with a jail sentence.

What should Harry Carter do? Why?

Questions for Discussion

In making his decision, what factors should Harry consider?

What should be Harry Carter's most important considerations in deciding what to do? Why?

Does it matter that Heptachloride is only suspected of being harmful, rather than proven, to be harmful to humans? Why or why not?

Does Harry have a responsibility to do all that he can to save his company? Why or why not?

Does he have an obligation to save the jobs of his employees? Why or why not?

Does it matter that what Harry is considering is illegal? Why or why not?

Does Harry have a responsibility to the people who buy his grain? Why or why not?

Harry Carter Continued

Harry decided that he had to take a chance. Rather than involve anyone else in breaking the law - a law that he felt was unjustified - he personally mixed the Heptachloride in with the grain each night. Since no one was at work when he did it, no one else in the company was aware of what was happening. He continued the personal crusade to "save the town" for nearly two years. During that time it appeared that maybe Harry was right. Nothing happened.

* * * *

Gary and Joan Carlson had been operating their small farm for the past two years. They weren't making much money and were working long hours but they were happy. "At least we have fresh air," Gary remarked.

"Yes, and fresh food and milk from our own cows," responded Joan.

"At least we know that our baby will be born healthy out here," said Gary as he gently patted his wife's "tummy."

The baby was born and the new parents were proud and happy. After she left the hospital, Joan spent much time with her new baby. As time went on, however, she began to notice that the baby didn't appear to be developing as quickly as she thought he should. She mentioned to her husband,

"You know, I'm getting worried. Little Gary was born about the same time as baby Carol down the road, yet Carol seems to be much more advanced. She can do several things very easily, things that our baby is nowhere near doing."

Gary responded, "Maybe it's because he's a boy and maybe boys don't progress as quickly as girls when they are babies. But have Dr. Young check him out if it makes you feel better."

The Carlsons brought little Gary for an examination. Their worst fears were realized - little Gary was "severely" brain-damaged. The doctor had no explanation.

Trying to get over their grief, Joan commented, "What could have gone wrong? During my pregnancy I did everything I was supposed to do. I didn't drink alcohol or smoke; I even gave up coffee. I did no hard physical work. Why did this happen? No one in my family or yours has a history of this type of thing. What could have gone wrong?"

Gary remained silent. Then he said, "Maybe the doctor is wrong. Maybe he isn't going to be too bad. Let's wait and see."

One day, not too much later, Gary came into the house. "I don't understand it. Another cow is very sick. . . this makes the fourth one. The other three have died. What could it be?" he asked.

After an investigation, heptachloride was found in the bodies of the cows that had died. Not only were the Carlsons' cows affected, but so, too were all the cows in the area. No one said anything immediately because they didn't want to create a panic. However, shortly after the news broke, Harry Carter admitted that he had been mixing Heptachloride with the grain he was selling. To make matters even worse, the grain company sold its products to farmers in about a dozen states in the central part of the United States. All of their cows would be contaminated.

When the Carlsons learned about the effects of Heptachloride, they began to suspect that heptachloride had caused the brain damage in their child. Joan drank the "fresh and wholesome" milk from her own contaminated cows. She in turn became contaminated and passed on the harmful effects of the chemical to her baby before it was born. "Baby Gary didn't have a chance," she thought.

On behalf of their baby, the Carlsons brought suit for damages. When the case came up in court, the Carlsons argued that their baby's health was ruined as a result of Harry Carter's lacing the grain fed to their cows with Heptachloride, an illegal and harmful chemical. Harry's lawyer argued that it was not proven, nor could it be proven, that the Heptachloride was responsible for baby Gary being born brain-damaged.

Harry's lawyer noted, "My client admits to illegally mixing in Heptachloride with the grain his company sold' however, he did that to save jobs for the community and to keep the town of Junction alive. It has never been proven that Heptachloride causes any harm. The government has only said that they **suspect** it of causing some problems. In fact, when the government found out that the milk sold in the stores contained that substance, they didn't even require it to be removed from the shelves. They only recommended that people not drink it. Yes, my client feels deeply for the problems of baby Gary. But the baby's condition was not caused by my client."

The Carlson's lawyer argued, "How many infants need to be damaged before something is done? There is ample evidence that lab animals are harmed by Heptachloride. Livers and kidneys are damaged. Cancer was caused in those animals. Need babies die first? Harry Carter is without question responsible for the baby's condition and the jury can help serve the cause of justice by ruling in favor of my client."

In his closing argument Harry Carter's lawyer argued, "You can't say that because lab animals are harmed by a chemical, humans will also be harmed. Lab animals and humans are very different. Besides, in lab tests large quantities of chemicals are fed to the animals, not the very small quantities that my client used. He benefited the community for all those years. Don't abandon him now."

How should the jury rule - in favor of Harry or in favor of the Carlsons? Why?

Questions for Discussion

What factors should the jury consider in making the decision?

What should be the most important factor? Why?

Since jobs are so important to the community, shouldn't the residents of Junction be willing to risk some possible side effects? Why or why not?

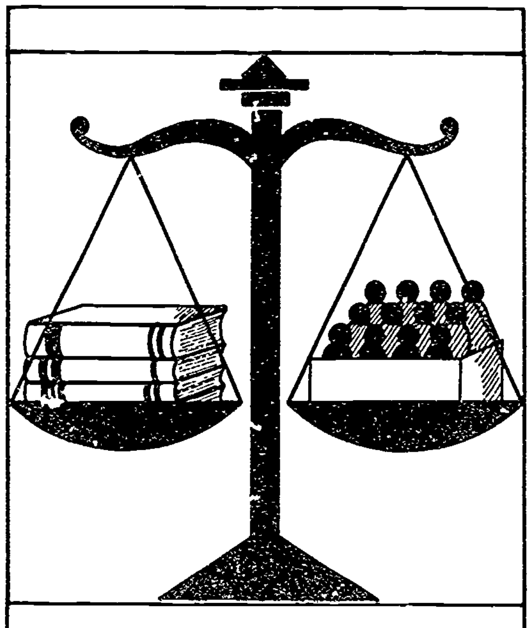
What objectives or responsibilities should manufacturing companies have toward the community?

Researchers have frequently been criticized by various industries for tests using animals and applying those findings to humans. Do you think that such conclusions could be valid? Why?

How do you think the community would want you to vote - in favor of Harry or in favor of the Carlsons? Why?

Can Society Really Help?
- A Debate Activity * -

More and more legislation enacted by the Congress of the United States is requiring that the public be involved in the decision-making process. The National Environmental Policy Act (NEPA) provides for public input, as does the Coastal Area Facilities Review Act (CAFRA); the Clean Water Act; the Save Drinking Water Act; the Clean Air Act; the Toxic Substance Control Act; and the Refuse Act. In part, the reason for including citizenry in this process is that if the people and their surroundings are going to be affected by this legislation, they should be involved in deciding what happens. Moreover, the costs of implementing and enforcing the legislation are borne by the public treasury. A significant provision of the Resource Conservation and Recovery Act (RCRA), the major legislation covering hazardous substances, states that "public participation in the development, revision, implementation, and enforcement of any regulation, guideline, information, or program under this act shall be provided for, encouraged, and assisted".



Largely as a result of advances in science and technology, the world becomes increasingly more complex almost on a daily basis. Unfortunately, as the world becomes more and more technologically advanced, society becomes increasingly less knowledgeable about these advances. Joseph F. Coates, a former senior associate at the Congressional Office of Technological Assessment has said,

> *At the same time, there has never been a greater amount of ignorance about the human environment than there is now among middle-class Americans. Ask the ordinary citizen a series of simple questions about our world: What is nylon? Where is the TV picture when it is not in your living room? Where does your sewage go when you flush the toilet? Why do flourescent lights flicker? See what kinds of answers you get. . . every new technology generates even greater ignorance.* (1980)

In the future, more issues regarding the application or misapplication of various technologies will be determined in the courts. In many cases, judges with little or no training in science or technology will have to rule on such issues. In other cases, juries will be required to decide cases dealing with issues that are technically very difficult to understand. In the past, experts made most of the decisions; however, with more recent legislation, the general public is asked to make decisions about technically complex issues. Some argue that the general public is incapable of making decisions on highly scientific and technological matters and therefore our existing jury system should be replaced by panels of experts in cases dealing with technical questions.

DEBATE ISSUE

The jury system should be abolished in cases involving technical questions because the average citizen is not qualified to make decisions on issues requiring highly technical knowledge. Instead, cases should be decided by panels of specialists who have expertise in the areas in question.

* Adapted from Iozzi, Louis A. *Technology and Society: A Futuristic Perspective*, Sopris West, Longmont, Colorado. 1980.

Your teacher will provide you with the procedures and the rules for conducting and scoring the debates.

- Concluding Observations -

The class debate no doubt raised some new issues and concerns regarding the role of citizens in a highly complex technological society. Some of these ideas are listed below. How do you feel about these issues?

In a world where scientific and technological information is growing by leaps and bounds, how can the average citizen keep up in order to understand his/her surroundings? How can one be best educated?

Can the average citizen have a role in making public policy or should it be left to the experts? If so, how should "experts" be selected?

Does being technologically knowledgeable about an issue necessarily insure that the "expert" will represent the best interests of the public?

Will our democratic system be jeopardized if decision making were left to a small group of experts? That is, will citizens be relinquishing some of their rights?

Will advances in science and technology require changes in our existing system of government?

Our Bill of Rights guarantees individuals the right to a fair trial. What should the elements of a fair trial include? Will a trial be fair if the jurors do not fully understand the technical information presented?

The term "information overload" has been used to describe the increasing amount of information we are exposed to each day through different forms of mass communication, education, other people, and personal experiences. How can we learn to digest and understand all that we encounter?

What might happen to our society if the common citizen chooses to remain ignorant of advances in science and technology?

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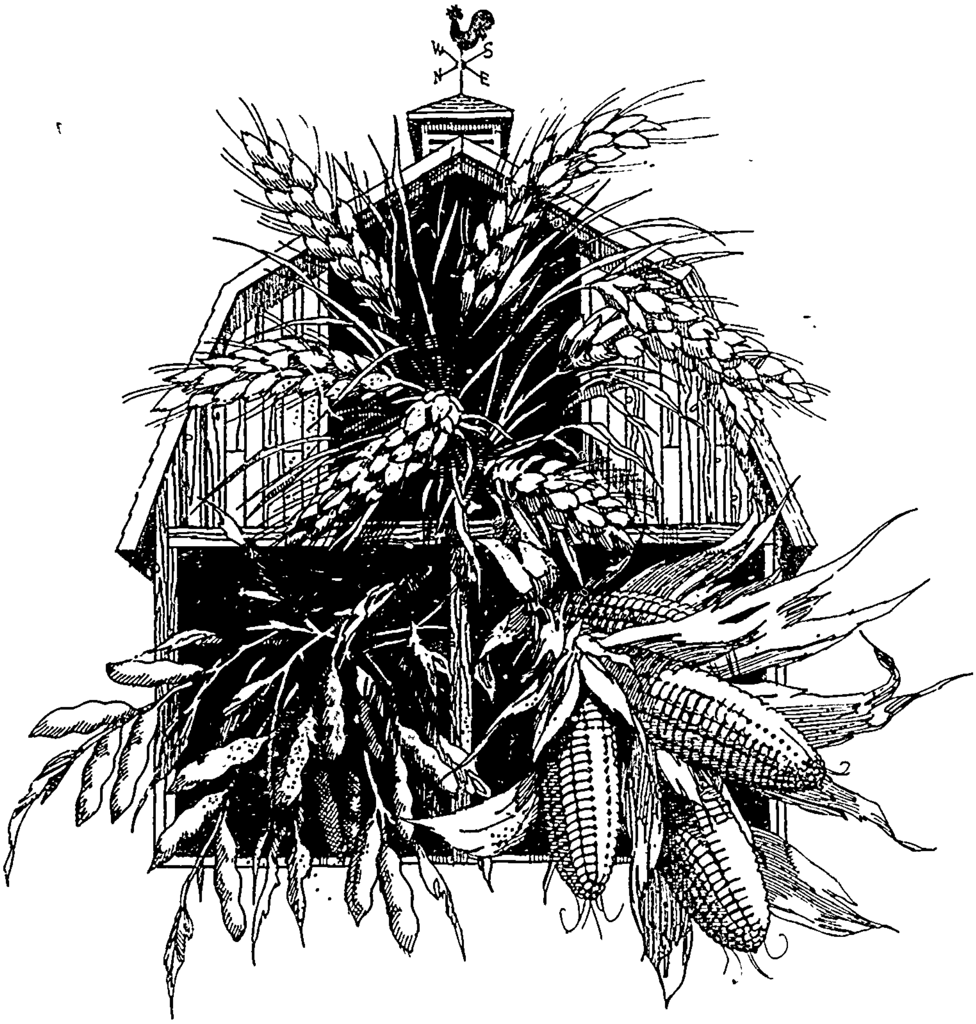
Chapter 8



Food And Agriculture

Food And Agriculture

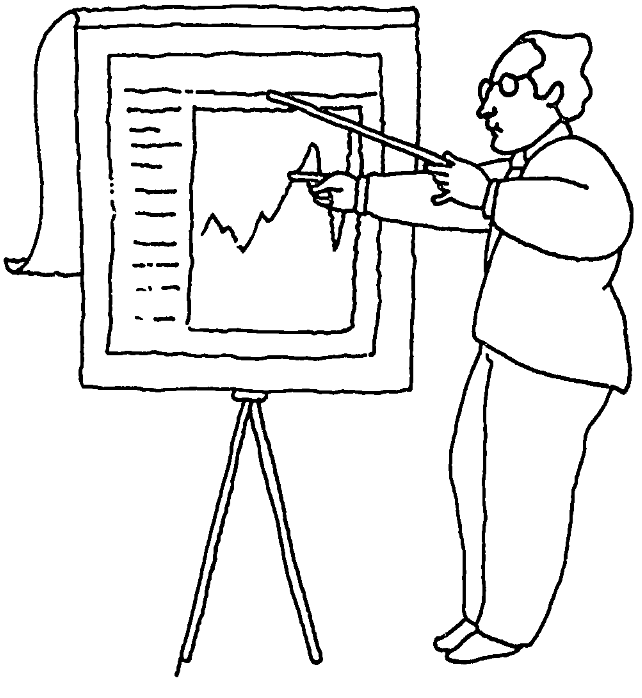
- Forecasting the Future -

Trying to accurately forecast the future can be an intriguing, useful, but very difficult activity. All of us are interested in knowing what tomorrow's weather might be because it helps us to plan much better. People who invest in stocks try to predict or forecast which stock prices might go up and which might drop. The more accurate their predictions, the better they can plan their investment strategies. People working in sales, various businesses, industry, education, and government all utilize forecasts to help them do their jobs better.

The accuracy of a forecast depends on how well one predicts the change in variables and the consequences of their interactions. A **variable** is something that is subject to change. For example, when forecasting the weather, one examines such variables as wind direction, wind velocity, barometric pressure, temperature, and so on. Each of these variables changes, perhaps many times each day, and each variable in some way helps to determine what we commonly call weather. Similarly, the price of stock is determined by several variables. If a company develops a new product that the investor feels will make a lot of money for the company, stock in that company will be in great demand. The higher the demand for that stock, the higher the price of the stock. As the demand for that stock continues to go higher, so too does the value of the stock.

In this example, what are the variables that help to determine the price of a stock?

In order to make reasonably accurate forecasts, one needs to know what the variables are relative to a particular forecast and how those variables interact (some think that perhaps a crystal ball and a little bit of luck might also help). The more experience one has working on forecasts in a certain area, the greater the likelihood that accurate forecasts can be made. For example, any good forecaster could probably make a reasonably accurate forecast of the weather for almost anywhere in the country. All that a forecaster needs are the necessary data for that area. However, sometimes certain variables have a greater impact on determining the weather in some areas than in others. In these situations a local forecaster - one who is very familiar with the specific area - tends to make more accurate forecasts than one who is not so familiar with the area.



Many strategies have been devised for making forecasts of all types. Some strategies are more difficult to use than others. Sometimes different strategies work better than others, depending on the forecast to be made. One particularly useful strategy that works reasonably well, and at the same time is not too difficult to understand, is called **extrapolation.** Extrapolation involves using present trends to construct an image of the future. For example, if you are considering the purchase of a certain stock, you could look at the performance of that stock for the past week or two. If the price of the stock showed a continuous increase, you could use extrapolation to forecast that the price of the stock will probably continue to increase tomorrow and have a reasonably good chance of being correct.

If the price of the stock increased an average of ¼ point each day for the past week, how much of a change would you forecast for tomorrow? Will the price be higher or lower? Why?

Could you use this strategy to forecast what will happen to the price of that same stock next week? Do you think your prediction will be accurate? How about two weeks from now? Why?

In 1972, Massachussetts Institute of Technology conducted a major study for the Club of Rome. This study was designed to determine the future of the world by examining several variables. These variables included population growth, natural resources, and several others. The basic finding of that study was that either exhaustion of non-renewable resources or environmental pollution would put an end to economic growth within 100 years. This in turn would most likely result in a "rather sudden and uncontrollable decline in both population and industrial capacity". The report, *Limits to Growth*, also warned that even if no arable land is lost; if food production can be doubled or even tripled; even if resources of raw materials are much greater than we now assume; the point at which demands for these resources exceeds supplies will be delayed for only a comparatively few years.

This major study was completed more than 15 years ago. From what you see happening around you today, how accurate do you think it will be? Why?

In 1980, President Jimmy Carter commissioned a study which resulted in *The Global 2000 Report*. Part of that study considered the issue of world and U.S. food supplies for the years 1985 and the year 2000. Like *Limits to Growth*, this report also expressed concerns over the increasing pressures on the world's resources and environmental balances. This study warned that the increasingly heavy use of fertilizers and pesticides in developed countries will result in limited benefits and decreasing returns.

A recent study was completed by the futurists Julian Simon and the late Herman Kahn. Their book, *The Resourceful Earth*, maintained that global and U.S. trends in regard to food supplies and relevant factors such as climate, mineral and fuel resources are improving - or at least not deteriorating. If present trends continue, by the year 2000 they claim that population, resources, and environmental stresses will lessen, and the outlook for food and other necessities will be much better.

How can it be that the different forecasts cited in these studies arrived at different conclusions?

What might account for such different forecasts?

Which of these radically different scenarios of the future will be realized? Why do you think so?

Can man's technological ingenuity outpace and even overcome the limits to growth?

Could the demands for resources and products exceed supplies sooner than anyone predicted? How? What changes could cause this?

Farms, Farmers, Farmland, and Food

The Cornucopia Project Newsletter recently published a summary chart (Table 8-1) of some key trends in the U.S. farm and food system. Part of Table 8-1 is reproduced here and will be used to help put together a scenario for America's food system in the year 2000.

Table 8-1
SUMMARY CHART OF SOME KEY
TRENDS IN U.S. FARM AND FOOD SYSTEM

TREND	1900-2000 % CHANGE	70-PRESENT % CHANGE	PRESENT-2000 % CHANGE	2000
1. U.S. Population	+267	+13	+20	279 million
2. Total farm population	-88	-31	-54	3 million
3. Percent of U.S. population in farming		-35	-64	1.1%
4. Farm labor		-29	-60	1.27 million
5. Farms		-18	-25	1.84 million
6. Large farms		+6	+140	714,000
7. Farms going out of business		+15	+19	4.8 million
8. Total number of farmers in U.S.		-18	-25	1.84 million
9. Number of farmers out of work		+14.9	+14.8	4.614million
10.Total USDA employees	+4048	+8.7	+3.0	129,776
11.Farmland	+20	-5.1	-8.2	960.000 A.
12.Irrigated farmland		+30	+63	83 million A.
13.Farm machinery cost		+231	+115	5244 billion
14.Transport		+190	+113	532 billion
15.Rail costs		+210	+117	378 index
16.Pesticide use		+71.5	+62.5	2.45 billion lbs.
17.Fertilizer use	+2869	+31	+37	71.2 millionT.
18.Fertilizer use/acre	+2796	+75	+74	.243 T.
19.Cost of nitrogen fertilizer cents/lb.	+540	+83	+60	S.36 per lb.
20.Production cost per farm		+324	+128	5134,000
21.Farm debt		+407	+198	5429.8 billion
22.Farm interest on debt		+460	+142	545.8 billion
23.Government payment		+729	+115	567.7 billion
24.Real estate debt		+107	+249	S211 billion
25.Organic farms	-99	+69	+80	45,000
26.Food cost per capita		+160	+75	S2741
27.Grocery stores		-18	-72	50,000
28.Vegetable gardens		+25	+20	45.9 million
29.Population below poverty		+35	+133	80 million
30.Conservation tillage		+368	+280	331.00 A.
31.U.S. agricultural exports		+376	+822	S320.7 billion
31.U.S. agricultural imports		+164	+329	S65.6 billion

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What's Happening to Farming?

- Activity -

Using Table 8-1 respond to each of the following questions

U.S. Population

What will be the estimated population in the year 2000?

Will our present population grow or become smaller by the year 2000?

What percentage change will occur?

Using the data provided in the chart, determine about how many people currently live in the U.S.

Write a statement summarizing your conclusions about the preceding questions.

Farmers

What percentage of our population will live on farms in the year 2000?

How many people will live on farms in the year 2000?

Between now and the year 2000 will the number of people living on farms increase or decrease?

By what percentage?

Write a statment summarizing your conclusions about the preceding questions.

Number of Farms

Is the number of farmers out of work projected to be higher or lower by the year 2000?

By what percentage?

How many farmers will be out of work by 2000?

How many farmers are currently out of work?

How does the percentage of farmers out of work between 1970 and the present compare with the percentage expected to be out of work between the present and 2000.

Write a statment summarizing your conclusions about the preceding questions.

USDA Employees

How many USDA (Department of Agriculture) employees will be employed in the year 2000?

How does that compare with the present number of employees?

By what percentage?

If the number of farmers is decreasing, does it make sense that the number of USDA employees should increase? Why or Why not?

Write a statment summarizing your conclusions about the preceding questions.

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Farm Sizes

How many large farms will there be in the year 2000?

How will that number change from the present (percentage and actual number)?

What do you suppose will happen to small and medium-size farms as the number of large farms increases?

Write a statement summarizing your conclusions about the preceding questions.

Farm Labor Jobs

How many farm labor jobs will probably exist in 2000?

How many farm labor jobs are there currently?

What percentage change is that?

Write a statement summarizing your conclusions about the preceding questions.

* * * *

Currently, 1% of our farms produce 25 % of our agricultural products. Between now and 1995 this small number of farms will produce 50 % of our agricultural products. By the year 2000, our 50,000 largest farms will account for 63 % of all agricultural sales, as compared to 31 % in 1974.

What factors do you suppose are partly responsible for this?

In addition to adequate sunlight, fertile soil, and seeds, what is needed for crops to flourish? Of course, water! Given enough water, even deserts can flourish (the Imperial Valley in California is a good example of this).

Many areas of the United States have all the ingredients necessary for successful farming except water. These areas exist primarily in the Midwest and in the Southwest. With irrigation these areas can be developed into excellent farmland. Hence, there is a strong trend today towards irrigating land for farming. If the present trend continues, the amount of irrigated acreage would increase by 63 % by the year 2000. However, there is one major problem or limiting factor: the amount of water available! The demand for irrigation water in the year 2000 will be 4,000 times the 1980 supply and, as far as we know, that additional water does not exist.

Most of the water consumed in the United States - fully 81 % - is used for irrigation. By the year 2000 many areas in the Southwest and Midwest will probably find surface water supplies in very short supply. Already groundwater supplies are jeopardized in many parts of our country. For example, in South Central Arizona, the high plains, and parts of California, only three of every four gallons of water being withdrawn from the earth are currently being replaced.

The Futurist (April 1983) reported that the Ogallala aquafer, which underlies eight states from South Dakota to Texas, furnishes water for

- 25 % of our cotton
- 38 % of our sorghum
- 16 % of our wheat
- 13 % of our corn
- 40 % of grain-fed cattle.

The Futurist forecasts that by the year 2000, well yields from this underground lake will be too low in many places to make irrigation profitable. Experts also forecast that sometime between 2000 and 2020 irrigated acreage above the Ogallala will drop by 40 percent. Clearly the management of water resources will become a key issue in the near future. Agriculture, industry, and people will all be competing for the same water.

Who do you think should/could decide who gets what?

Cornucopia Newsletter predicts that "the cost of producing food will escalate dramatically between now and the next century, with the average production cost per farm zooming to $134,000 - a 128 percent increase from 1982."

The Cost of Farming
- Activity -

Return to Table 8-1 summarizing key trends in the U.S. farm and food system to explore how costs of various supplies and materials will affect the farmer.

Agricultural Costs

What is the forecast for

the use of pesticide, between now and 2000?

the use of fertilizer between now and 2000?

the cost of nitrogen fertilizer?

What is the estimated production cost per farm?

It is estimated that by the year 2000 the average farmer will spend over $100,032 on fertilizers. What portion (percentage) of his/her production costs will be devoted to fertilizer?

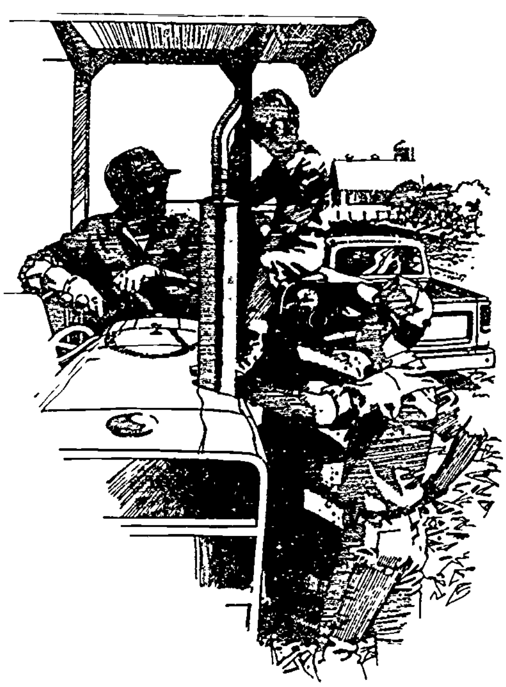
Write a statement summarizing your conclusions about the preceding questions.

* * * *

As you may know, some farmers receive help from the U.S. government in the form of price supports and direct payments. Between 1970 and the present, government assistance to farmers has increased a whopping 729 %! That figure is expected to increase an additional 115 % to $67.7 billion dollars by the year 2000.

Even though farmers receive help from the U.S. Government, the farm debt will almost double by the year 2000. In fact, farmers are now paying out more in interest on their debts than they receive in net income from farming.

If you pay out more money than you receive, what happens?



Cornucopia forecasts that by 2000, "the average farm will lose $7,500 each year - despite an average gross income of $153,000."

Again turning to Table 8-1 let's look at food prices and food markets for us, the consumer.

Consumer Food Costs

How much will food cost per capita in 2000?

How much does food cost per capita now?

Will there be more or less food stores in 2000 than there are now?

By what percentage will the present number change?

How many food stores will there be in 2000?

What do you think will happen to the price of food by the year 2000? Why?

Write a statement summarizing your conclusions about the preceding questions.

* * * *

Did you know that low income and elderly shoppers actually pay more for food than people who use suburban chain stores and warehouse stores? A recent study conducted by The Hartford Food System in Connecticut found that a family of four shopping in Hartford (a relatively large city) spends up to $1,500 more a year for food than a similar family living and shopping in a Connecticut suburban area. It is very likely that by the year 2000 when there are fewer stores and therefore less competition for customers, everyone (not just the poor) will pay more for food.

How might we, as individuals. help to reduce our food costs?
(Hint: Look at the chart and the forecast for the number of vegetable gardens in the year 2000.)

The United States is one of the richest and most affluent nations in the world. Yet, what does the chart tell us about the number of people expected to have an income below the poverty line by 2000?

Will the number of people below the poverty line be higher or lower in 2000?

By what percentage?

What percentage of our population in 2000 will be below the poverty level?

Will the percentage of people below the poverty level be higher or lower than it is presently by 2000?

Write a statement summarizing your conclusions about the preceding questions.

Averting Future Food Shortages

- Summary Activity -

A recent study completed by the Complex Systems Research Center at the University of New Hampshire predicted that "no matter what we do" there will be a shortfall in U.S. food production and /or a nationwide retrenchment for several decades beginning as early as 1990.

From the information you have collected in the two previous activities, do you agree with this prediction?

What action might we consider taking now to avert food shortages in the future? (Note: many clues can be found in the chart from the answers to the questions and from the "Summary Statements" you wrote in the preceding activities).

Prepare a written plan of action to avert future food shortages. Compare your plan with those of other members of the class. How do they compare? Similarities? Differences? What might account for any differences?

Using the information and plans developed by the various members of your class, compile a comprehensive class plan to avert future food shortages.

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"Farming Is Who I Am"

- The Human Factor -

A plow rusts idly in a field covered largely with wild grass. A house with boarded windows is just now beginning to show neglect and lack of care. Raindrops and snowflakes fall between exposed roof joists upon machines that once hummed smoothly through now overgrown and parched fields. The only sign of life is rats and other rodents scampering in and out of the buildings. These are the signs of the decline of the small family farm. As some of the country's farms grow larger and more productive, others whose owners run out of luck, patience, or money leave their farms for the nearby cities. Some leave by choice, others are forced out by foreclosures on mortgage payments and on bank loans.

These are hard times for many of the nation's farmers. In addition to seeing their land - land that was "in the family" for generations - being sold at the auctions for a fraction of what it was once worth, the hard times are also having an impact on the life of the farmer in other ways. Traditionally, farmers have been fiercely independent and self-reliant, and the farming family structure has always been known for being as "solid as a rock". Much of this is now changing.

The troubles of the farmer are showing up i.. several ways. According to the *New York Times* (20 November 1984), cases of "abuse of wives, children or even animals, alcoholism, severe depression, and suicide" are increasing drastically among farming families. The suicide rate in some rural Iowa counties, for example, is twice the national figure and still climbing. At one time Iowa State University's extension service published booklets on farming issues such as pest control and soil erosion. Now, according to the *New York Times*, "its literature covers more foreign types such as stress management, with detailed advice to wives on signs of impending suicide in husbands."

It's not just farmers who are feeling the effects of hard times in rural America. Many associated businesses such as banks, grain elevators, and stores in farming communities have gone bankrupt. Bankers are often criticized by farmers for not understanding their economic plight. The farmers argue that banks should lower their interest rates instead of forcing farmers to lose their land. At least that way banks would get all of their money (over a longer period of time, of course) instead of having to settle for what the auctioneer brings in.

Banks, on the other hand, argue that they have already lowered interest rates for many farmers as much as they could. Bankers claim that the situation is so bad that even their private lives are being affected. Former friends now turn their backs on them and some fear for their safety.

As farms fail and families move to the city seeking jobs and a better life, additional pressures are placed on already overburdened cities. There aren't enough jobs for people already residing in the city, much less for the newcomers.

A *New York Times* (November 20, 1984) article quotes an old farmer who sums up the plight of rural America today:

> *You farm the soil yourself. You work hard and it gives you a wonderful feeling and then for reasons beyond your control, suddenly it's all crumbling. No one understands. No one seems to care. It's not just my job that's threatened. It's my way of life. Farming is who I am.*

The Agricultural Mechanization Controversy

- A Court Case -

Background

In 1980, a lawsuit was filed in the State of California on behalf of 19 farm workers. The lawsuit charged that the University of California at Davis (UC) had unlawfully spent public funds on research that put farm workers out of jobs. According to California Rural Legal Assistance (CRLA), the basic goal of the research being conducted by UC was to develop "machines and other related technology in order to reduce to the greatest extent possible, the use of labor as a means of agricultural production". The CRLA charged that such research

eliminates jobs for farm workers,

eliminates small farms,

harms consumers,

impairs the quality of rural life, and

restricts and hinders collective bargaining.

The CRLA demanded that all mechanization research by UC be stopped until the University creates a fund to be used to assist and train farm workers being put out of work.

This is not only an important case for researchers working on farm mechanization projects, but also for researchers in many other fields. For example, a similar lawsuit could allege that University-developed information technologies (e.g., computer research) put clerical workers out of jobs.

The Positions

In this case the plaintiffs are specifically attacking mechanization research. Their position is that the expensive machines developed by such research, funded with public monies, helps only large farmers and gives them an unfair advantage over small farmers. Representing the plaintiffs, the CRLA argues that in 1963 the average tomato grower planted 32 acres. At that time the total industry in California employed 50,000 farm workers. According to the CRLA, when the University developed a mechanical tomato harvester in 1970, the number of farm workers fell to 18,000. Today, the average farm is 363 acres.

How much larger is today's average size farm compared to the average-size farm in 1964? What percentage change is that?

How does the number of farm workers in 1964 compare with the number in 1970? What percentage change is that?

There are two kinds of tomatoes. Most of those grown in California are harvested by machine and are for processing (e.g., canning). Hand-picked tomatoes are grown mainly in Florida and are for the fresh tomato market. According to researchers at UC, the two types of tomatoes together were worth $1.1 billion in 1982 and "are the most valuable vegetable grown in the United States".

The UC maintains that before 1963 and mechanization, 38,000 Mexican and 6,500 American workers picked and sorted 2.5 million tons of processing tomatoes in California. Today, fewer than 8,000 harvest workers, primarily American women, ride machines and sort more than twice as many tomatoes.

According to UC, how many farm workers were employed in California PRIOR to mechanization?

How many were Americans?

How many were Mexicans?

What was the dominant sex of the California farm tomato worker in 1963?

According to UC, how many farm workers were employed in California AFTER mechanization?

How many are Americans?

How many are Mexicans?

What is tne dominant sex of the California tomato farm worker today?

How do you feel about the changes in the number of farm workers employed in California?

UC points out that in 1942, Mexican farm workers were temporarily admitted into the United States primarily to harvest asparagus. In 1964, when that practice stopped, the laborers returned to Mexico but so did most of the canned asparagus industry. UC argues that mechanization helped to keep the processed tomato industry in the United States, thereby actually preserving jobs for American workers. They also maintain that mechanization created jobs for irrigators, equipment operators, and canning workers.

The UC maintains that job losses due to mechanization have been more than offset by the expansion of other agricultural opportunities. While mechanization may have eliminated several hundred thousand seasonal farm jobs in California, affluence, population growth, and awareness of health have increased the demand for other types of fruits and vegetables. The increased demand for these hand picked products created new jobs faster than technological changes eliminated them. In defending its position, the UC cites the following data.

Year	Number of Farm Workers Employed
1960	192,000
1970	211,000
1980	224,000

University research led to the creation of many of these new jobs.

The CRLA argues that mechanization research eliminates small farms because the new machines require large acreages to operate efficiently. This enables large farms to spread their fixed costs over more acres, reducing prices, and forcing small farmers out of business. Since a tomato harvester costs over $150,000, mechanization is possible only for the wealthy owners of large farms.

The CRLA points out that the number of processing tomato farms in California decreased from 4,000 in 1963 to 600 in 1973. At the same time, the average acreage planted in tomatoes increased from 32 to 363 acres.

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UC counters by pointing out that structural changes in the 20 years before mechanization (between 1945 and 1964) accounted for a 63 % decrease in the number of farm workers and an average tripling of farm acreage in tomatoes. In the 1960's and 1970's other factors also contributed to increasing the sizes of farms. For example, completion of the California water system in the 1960's allowed very large farms in the San Joaquin Valley to grow tomatoes.

UC maintains that the number of farms in America peaked at 6.8 million in 1935, then dropped sharply in the 1950's and 1960's as farmers were pushed by overproduction and low prices and hired away from agriculture by relatively high industrial wages. Thus, the efficient and ambitious farmer who remained bought additional land to utilize machinery more efficiently, and the average size of farms increased. Even without mechanical tomato harvesters, concentration and specialization would have occurred in the tomato industry because other factors promoted fewer and larger farms. For example, federal support payments stabilized prices and encouraged farmers to expand.

Some of the struggling small and medium-sized farms undoubtedly need technical assistance in management and in marketing. UC maintains that many of these farms are operated as hobby or tax loss enterprises. It may not be, they argue,

> *in the public interest to reallocate research funds to benefit primarily 2 million farmers that produce less than one-third of the nation's farm products until much more is learned about the diverse goods, motives, and needs of the nation's farmers.*

According to UC, the number of small farms continues to increase. The numbers of small farms in California has increased by more than 4 % annually since 1978.

> *The structure of agriculture is becoming polarized. "Large and specialized farmers produce 70 % of the nation's food and fiber while numerous small farmers, who depend on their non-farm revenues, contribute little to total farm output. Mechanization plays a role in this evolving structure of the U.S. farming industry, permitting some farmers to manage large units effectively while allowing others to operate small farms as part-time or hobby operations."*

The CRLA argues: "We're not antimechanization."

> *We're not saying farmers or farm workers should be dedicated to doing hard, dirty work, and we know every research project can't benefit every single interest group. But you don't help people by taking their jobs away. And at the University of California, a series of projects across the board violates the intent of the law which was to help rural people.*

The plaintiffs are not seeking money for damages. Rather, they want the courts to

- prevent research that benefits only agribusiness or large farmers,
- force the University to assess the social impact of research,
- require the University to include small farmers, farm workers, and consumer representatives on research advisory panels, and
- establish a fund for research for small farmers and farm workers.

UC is against the proposal because it would "violate the University's reason for being. If they (the plaintiffs) win, it could stop biological and genetic research. . . A social impact analysis might also be more expensive and time-consuming than the research project."

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According to Successful Farming (October 1984)

> *Scientists themselves are split on the issues. Many will testify for UC, but several agricultural economists and research sociologists from across the country will also testify in favor of a social impact statement and reseaich for small farmers...*

Peter Bloom, an agricultural engineer at the University of Illinois says,

> *We scientists shrug our shoulders and say, well, people are better off building the machines than in stooping in the fields,' but this is an inadequate treatment of social issues. Also, in the past we just haven't had people in university laboratories building billion dollar products. With bioengineering we are facing that.*

The Agricultural Mechanization Controversy

- A Court Simulation Debate -

This activity will simulate the court case you have just read about, the farm worker (plaintiff) vs. the University of California - Davis (defendents). The debate should attempt to resolve the issue.

Should the court rule in favor of the farm workers or should it rule in favor of the University of California-Davis?

Your teacher will provide you with the procedures and rules for conducting and determining the winner of the debate.

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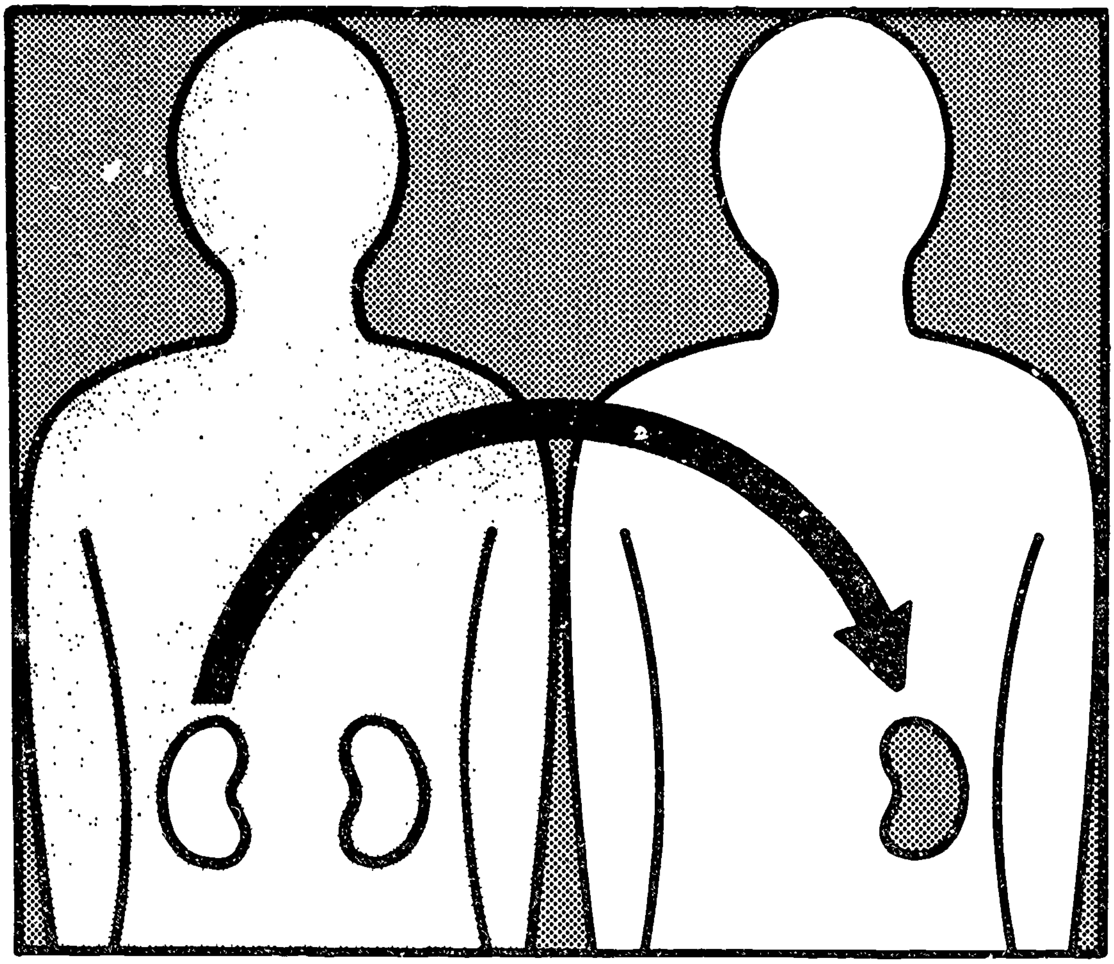
Chapter 9



Organ Transplantation

Recycling Human Bodies

- Organ Transplantation Issues -

Introduction

For years environmentalists have been trying to change the wasteful habits of our "throw away society" by promoting recycling. Glass bottles, aluminum cans and paper are but a few of the many types of materials that are commonly recycled today. Recycling is not only useful for preserving our natural resources; many "weekend mechanics" visit the local automobile junkyard to purchase used parts to repair their automobiles. Used parts make auto repairs much less expensive than the cost of using new parts. It also helps to save natural resources. In some cases, such as with very old or antique cars, you can get replacement parts only from automobile "graveyards".

Now modern medical technology has made the human body recyclable providing the gift of life for some and improving the quality of life for others. What began with isolated instances of corneal and kidney transplants, has become an industry. Human kidneys, livers, corneas, bones, bone marrow, hearts, lungs, skin, cartilage, and brain linings are all used in transplants on an almost daily basis. Having said this, it must also be noted that organ transplantation has not been without its pitfalls.

Obtaining Organs for Transplantation

One of the problems encountered by physicians and surgeons who perform organ transplants of various types has been the lack of organs available for transplantation. But it seems that a new breakthrough might have occurred. At the writing of this article, 15 states had enacted laws requiring hospitals to seek organ donations from families of dead or dying patients. The new laws require medical institutions (the place where 80 % of all Americans now die) to ask the next of kin for organ donations. Even though about 20 % of Americans carry a signed organ-donor card, in practice no hospital will take an organ without the additional approval of the next of kin.

Organ transplant officials in California, Oregon, and New York (the first 3 states to pass "required request" laws) say donations increased immediately after the laws took effect. At the same time hospitals had to quickly train personnel to deal effectively with the delicate and emotional issue of arranging to move parts of one human body into another.

In a relatively short period of time after the new laws were passed, hospitals learned that certain types of organ transplant coordinators were more successful at getting organ donations than others. According to a *New York Times* report (1 June 1986), grieving families were much more likely to approve an organ donation if the hospital official seeking the organ was

- a woman,
- wearing a dress (but not a green one), and
- sitting at least 5 feet away from the family in an informal setting.

If the hospital official was a *female* nurse, then it was recommended that she

- soften her authority image by removing her cap,
- discard her clipboard, and
- never touch a family member, even if consoling.

About two-thirds of the families asked give permission to remove the organs from a dying or dead family member. Some feel that an organ donation can help the donor's grieving family because they can then feel that the relative continues to live on through someone else.

The number of donors grows daily, yet the number of people needing organs far exceeds the number of organs available. For example, recent donations from 10 victims of accidents, disease, or old age helped to restore sight in 20 New Yorkers. But at the same time there were more than 300 sightless people in the same city waiting for transplants.

Some large companies and businesses are trying to promote organ donations among their employees. The Dow Chemical Corporation encourages its employees to sign donor cards and to speak before local groups about the need for organs of all types. This firm lent one of its executives to the Boy Scouts for one year to run an organ donation drive. Dow Chemical lobbyists also promote transplant legislation among their legislative contacts.

As quickly as organs are made available, they are transplanted into waiting patients. At this time, on an average day in the United States, 1 heart, 20 kidneys, and 65 eyes are transplanted. The success rate for some of these transplants is as high as 90%. Moreover, these numbers are increasing regularly. The transplanting of organs involves more than removing an organ from a live donor or a cadaver and implanting it into the body of someone else. Other issues and concerns focus upon

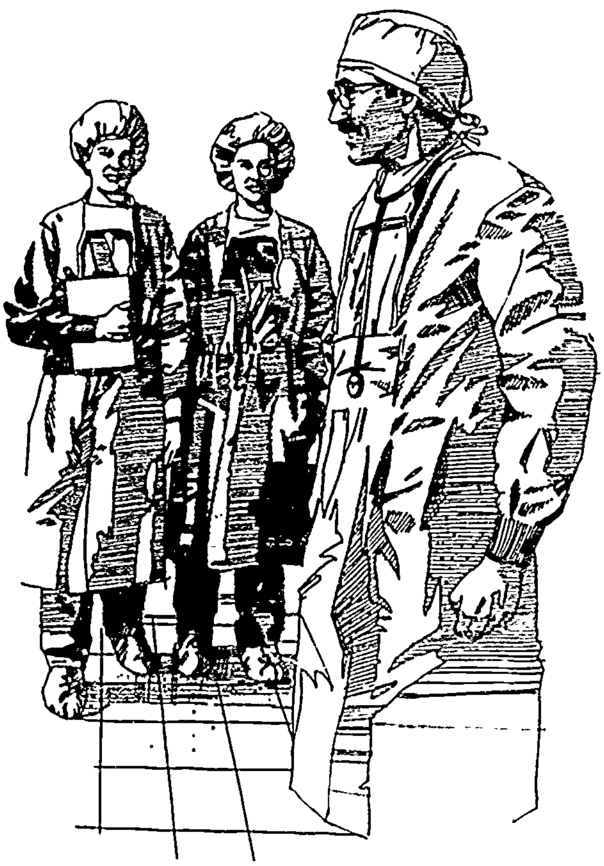
- keeping patients alive while waiting for a transplant,
- transplanting organs from animals into humans,
- technical issues, such as organ rejection, and
- patient selection.

While there are similar problems associated with all types of organ transplants, it must be realized that each type of organ transplant presents its own peculiar problems. Of course it is impossible to cover the complexities of each type of transplant here. This reading should, however, provide an ample background for the reader to intelligently deal with transplant issues from the standpoint of an informed citizen. Rather than focus on only one type of organ transplant in depth, examples will be given using several different types of organ transplants. If the reader is particularly interested in one type of transplant and would like more detail, there are many books and articles available about each type.

Keeping Patients Alive - Heart Transplants

The organ-recipient match is critical. Nearly one-third of the patients waiting for a heart transplant die before a suitable heart becomes available. Heart transplants require careful donor and recipient matches. That is, surgeons must match available hearts to patients as closely as possible or overwhelming complications can occur. Organ suitability is such an important issue in all transplants that it is discussed in a separate section of this reading.

Using medication and/or mechanical means, heart surgeons try to keep the patient's own heart functioning efficiently and for as long as possible. At times, however, the patient's own heart is so badly weakened or damaged that it must be removed. In these situations, surgeons have these options:



(1) Use a mechanical heart to keep the patient alive until a suitable heart can be found.
(2) Transplant the heart of an animal such as a baboon or a chimpanzee into the patient until a suitable human heart can be found.
(3) Do nothing and simply let the patient die.

At the risk of stating the obvious, for most people this last option is the least attractive of the three. Other people feel that transplanting the heart of an animal is wrong or unethical. But more on that later. For the most part, mechanical means are used to keep waiting transplant patients alive.

Can you think of any other possibilities that might work? Some of the ideas that you can think of might not now be technologically possible but may work very well in the future.

The Heart-Lung Machine

Keeping patients alive mechanically is not new. However, prior to the 1950's, any operations that involved stopping the flow of blood to the heart were simply not possible. During an operation, if the flow of blood to the heart is stopped, the surgeon has six minutes to get the blood flowing again before the patient dies. Think about that for a moment. Do you think that six minutes is enough time to complete most kinds of operations? Have you or anyone you know ever had an operation? How long did it take? If surgeons were ever going to be able to keep patients alive during operations, they needed to find a way to keep blood and oxygen flowing through the patient's body while they were operating.

In 1935, Dr. John Gibbons developed the first heart-lung machine. Gibbons' machine worked so well that it kept a cat alive for 3 hours and 50 minutes. However, even though the machine was capable of taking over the functions of the heart and lungs of a cat, it was incapable of performing the same functions in a human. It wasn't until 1953 that a machine capable of pumping enough blood to keep a human alive was developed. This machine had to pump thirty times more blood than the one used on the cat in 1935.

The Artificial Heart

The first operation in which an artificial heart was implanted into a human being took place in

1982 at the University of Utah Medical Center in Salt Lake City. In 1984, doctors at Humana Heart Institute in Louisville, Kentucky, removed the diseased, dying heart from a 52-year-old man and replaced it with an air-driven aluminum and plastic heart. The machines used were very large and severely restricted the patient's ability to get around or to try to lead anything resembling a normal life. However, they did keep the patient alive.

The latest version of the mechanical heart can be hooked up to a 12-pound portable power pack about the size of a camera bag for up to three hours a day. This battery pack can be worn over the shoulder and can temporarily replace a refrigerator-sized, 323-pound, $40,000 air compressor. This new device enables the patient to move about quite freely and easily.

Advances in artifical heart technology are occurring very rapidly and, it seems, are limited only by the lack of research funds.

The ultimate artificial heart model will probably feature a miniaturized drive system permananantly installed inside the chest alongside the heart. The heart will get its power from a battery pack which will probably be worn around the waist. With this device the patient will probably be able to live a normal life.

There are currently 2 artificial hearts approved for use with humans by the United States Food and Drug Administration, the "Jarvik 7" heart and the "Penn State Heart". The Jarvik 7 is approved for permanant use while the Penn State heart is approved only for emergency situations or until a suitable human heart replacement can be found.

According to William Pierce, chief of the artificial organ division of the Hershey (Pennsylvania) Medical Center, nearly two-thirds of human heart transplant recipients now survive the first year after surgery. The survival rate for 5 or more years is about 50%. The current artificial heart can't improve upon that record. However, if a patient is very ill, the artificial heart can serve as a short-term bridge until a donor heart can be located.

Serious consideration is being given to the possibility of using the artificial heart in place of a human heart in some cases. Some even think that the artificial heart might eventually replace the human heart as the treatment of choice for certain individuals. According to Pierce, "That'll be an interesting competition. What we're going to have is a period of time when heart transplants will be used for patients under 55, and those older than that will get motorized hearts. Then we'll begin to see if the age for transplants can't be increased, or if the age of a candidate for a mechanical heart might be moved up. There'll be a choice." (*Science News*5, 1 December 1984).

In March of 1985 quite a furor was created at the University of Arizona Hospital in Tucson. A team of doctors implanted an unapproved device — "Phoenix Heart" — into a 33-year-old mechanic. The heart, developed by a dental surgeon, Kevin Chang of St. Lukes Hospital in Phoenix, sustained the life of the patient for 11 hours until a donor heart was located and transplanted. The Arizona team's decision to use the unapproved Phoenix heart rather than the approved Jarvik 7 heart led some medical ethicists to question the operating team's decision. The Arizona team stated that it tried to get a Jarvik 7 heart, but the Phoenix heart arrived about three hours earlier and was used because "something had to be done".

Bruce Jennings, associate for policy studies at the Hastings Center, a medical ethics institute, maintained that "if the Arizona group was motivated to save the patient's life, there's no justification for using a device that's untested if they can get their hands on a better device." The Arizona group was also criticized for performing the operation at the University of Arizona Hospital since neither the physicians nor their hospital were approved to perform such operations by the U.S. Federal Drug Administration.

Who do you think was correct, the surgical team or Bruce Jennings? Why?

Should the surgical team have waited for the approved Jarvik 7 heart? Why or why not?

Do you think that more information is needed to answer these questions better?

What additional kinds of information about this case do you think would be helpful?

What do you think the patient would have wantod the surgical team to do? The patient's family?

Animal to Human Transplants

A major controversy was created in 1985 when a team of researchers transplanted the heart of a healthy baboon into a two-week-old baby girl. The operation, which took place at the Loma Linda (California) University Medical Center, drew praise from some, skepticism from others, and criticism from still others.

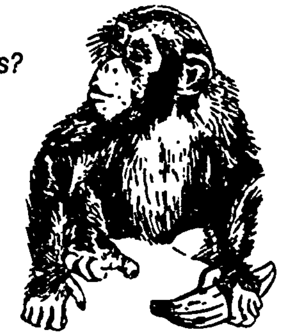
This, however, wasn't the first cross species transplant. Other attempts to transplant organs from animals into humans occurred during the 1960's and 1970's. The major differences between previous cross-species transplant attempts and this one were the extreme youth of the patient, her relatively undeveloped immune system; and the availability of a new powerful drug (Cyclosporine) to fight rejection of the heart. Leonard Bailey, Chief Surgeon for this operation, felt that these three factors would significantly improve the infant's chances for survival.

His position was supported by others, such as Mark A. Handym, director of transplantation at Columbia University Presbyterian Hospital in New York. Handym agreed with sceptics that transplanting a baboon heart into a human may be more difficult than transplanting a human heart into a person, because a human being's immune system would more severely reject a baboon heart than it would a human heart. However, Handym pointed out that the last time anyone attempted to transplant a baboon or chimpanzee heart into a human being was in the 1960's. Since then, he argued, many new advances in organ transplantation technology had occurred and, in his judgment, this infant might stand a much greater chance for survival. (*Science News*, March 16, 1985).

The facts were that most patients transplanted with chimpanzee or baboon hearts had died within hours. The longest reported instance of survival was only 3 1/2 days. However, attempts at kidney transplants with donor organs from non-human primates were far more successful. New patients were given chimpanzee kidneys at Columbia University in 1963. At that time, little was known about tissue typing and immunosuppression research was in its very earliest stages. Despite that, several of the chimpanzee kidneys worked well for several months. One patient lived for nine months and died of an unrelated pneumonia problem. His kidney was fully functioning when he died.

As success rates using transplanted organs from human cadavers increased, fewer researchers and hospitals pursued cross-species transplantation. Presently, the main efforts focus on transplanting human organs, from live donors, as in the case of kidneys, or organs from human cadavers. However, perhaps under the right circumstances and with the right types of organs, transplantation of animal organs into humans is practical.

On one hand, the Loma Linda baby probably could not have survived without a transplant, on the other hand, questions other than organ rejection were raised by this attempt. These questions include effects of Cyclosporine on immature blood systems, whether an animal's heart can grow to sustain an adult human; and whether accurate tissue typing for non-human primates can be developed (*Science News*, Vol. 126).



Do you think organs should be transplanted from animals into humans?

If you needed a heart transplant, would you allow a chimpanzee heart to be transplanted into your body?

If the patient needing a transplant was a family member, would it make a difference?

Organ Rejection

Rejection is not just a problem when attempting to transplant animal organs into humans. Immune reactions and rejections are also major problems preventing successful transplantations of organs from one human to another. Some of the earliest work in the area of transplant rejection was done by Dr. Emile in the 1940's and 1950's. Then in the mid-1950's, Dr. Peter Medawar and a team of researchers in England discovered that an animal reacts to a skin graft from another animal just as it does to viruses or bacteria. They found that the graft carries a response or reaction in the cells. The individual receiving the transplant or graft (host organism) then puts out other proteins called antibodies[1] which, with the help of another substance called the "complement", destroy the antigens[2] of the organ that was transplanted.

Drs. Jack Cannon and William Longmere of the University of California at Los Angeles (UCLA) and Sir Macfarlane Burnet of Australia found that the body produced chemicals that react against materials that are foreign to it. In later experiments with baby chicks, these researchers found that if the chicks were very young, they were more likely to tolerate the presence of foreign material. For example, when pieces of skin from a different animal were grafted to newly hatched chicks, most grafts "took". However, after 14 days, the chicks, immune systems developed and none of the grafts "took". Then Drs. Medawar, Bellingham, and Burnet discovered that human babies and fetuses reacted in a similar way to the introduction of foreign substances into their bodies. They found, for example, that if a human fetus was injected with donor cells before birth, skin grafts attempted after birth were very successful. The younger the transplant recipient, the greater the chances for a successful transplant, because infant immune systems are not well enough developed to pose difficult rejection problems. Adults, with fully developed and functioning immune systems, present the greatest rejection problems.

Think back to the case involving the transplanting of a baboon heart into the two-week-old baby girl at Loma Linda Hospital. Do you now see why Dr. Bailey was so optimistic that the baby had a good chance of surviving with a baboon heart? Why? Dr. Medawar's work, which was published in 1953, confirmed that transplantation would be successful only if the antigens in the recipient, or if the recipient's rejection mechanism, could be weakened or immobilized.

One way, then, of improving the chances for organ transplantation is by performing the transplant using an organ that is genetically identical to the one being replaced, a graft from one identical twin to another. Skin grafts, for example, can be performed successfully between twins. Like skin, an individual can usually spare a kidney or even a lung to help an ailing twin. In 1954 the staff at Peter Bent Brigham Hospital successfully transplanted one kidney from an individual to his identical twin brother. Kidney transplant operations between identical twins have typically been highly successful. In recent years the two-year survival rate with this type of operation has been 100%. However, rejection still occurs even between identical twins and requires the supression of the host's immune system.

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[1] Antibody — Any of the various proteins in the blood that are generated in reaction to foreign substances, neutralizes them, and then produce immunity against certain microorganisms or their toxins (poisons).

[2] Antigen — Any substance that, when introduced into the body, stimulates the production of antibodies.

The first method to reduce the impact of the body's natural immune responses was whole body irradiation or subjecting the entire body to x-rays. This method proved to be too dangerous, both in tests with animals and later in tests with humans. Too low a dose of X-rays meant the graft would not survive; too high a dose meant the patient could not produce enough antibodies to fight other infections. The antibody response, it seems, could be suppressed only at great risk to the patient (e.g., "the graft lived but the patient died").

Most recently, a variety of immunosuppressives (drugs that tend to reduce or block the antigen-antibody reaction) have been developed. Since immunosuppressives are still in their infancy, many questions concerning their proper use and even how they work, remain. The availability of immunosuppressive drugs has dramatically increased the use of cadaver organs. Cadavers now account for more than 70 percent of all transplanted kidneys, even though this technique is less successful than using closely related donors. Of course, the advances in immunosuppressive drug development, which have been so useful in cadaver transplants, have also improved related donor results by reducing the body's rejection reaction.

With increased knowledge of molecular biology, "tissue typing" has played an increasingly important role in organ transplantation. Dr. Paul Terasaki of UCLA has developed an automated, routine method of typing cells using only very small samples of white blood cells. The system is very similar to the ABO system for typing blood but it is much more complex. Yet, much more needs to be learned. Present measures are not really adequate to assure that well-matched organs will "take" even when employed in conjunction with immunosuppressive drugs.

Survival Rates

Survival rates for people receiving organ transplants are improving rapidly. Paul Terasaki reported that one-year survival rates for patients receiving kidneys from relatives is 97 percent today compared to 90 % 10 years ago. Thomas Starzi, a liver transplant pioneer at the University of Pittsburgh, reported that the one-year survival rate for patients getting liver transplants between 1980 and 1982 was 72 %, compared to 33 % for patients between 1963 and 1979. Survival for lung transplants is also up. According to Norman Shumway at Stanford University, of the 39 lung transplants reported in the past, only 2 survived longer than two months. Of the more recent lung transplants, seven patients lived from two months to two years.

There are several reasons for the increase in survivor rates for various types of organ transplants:

Since 1981, Norman Shumway at Stanford University has used a heart-bilateral lung transplant technique instead of a single lung transplant method. The combination method provides blood vessel connections that are more likely to heal than does the single method.

Thomas Starzi (University of Pittsburgh) uses a blood bypass technique in making liver transplants a much less treacherous operation. During transplantation, one of the large veins returning blood from the body to the heart must be temporarily blocked, possibly endangering the patient's life (remember Dr. Gibbons' important invention). The new bypass technique compensates for the temporary blockage by routing blood from the obstructed vein externally to the upper half of the body.

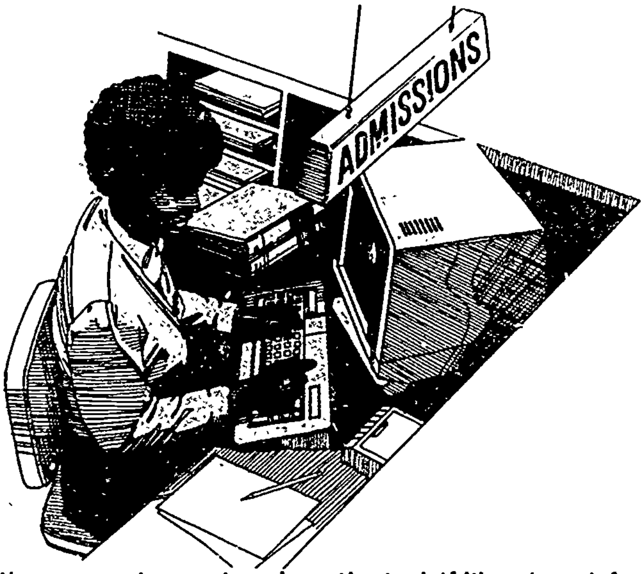
A recent chance discovery showed that if kidney transplant patients receive blood transfusions before transplantation, their immune systems are less likely to reject organs. This allows doctors to give patients lower doses of cortico steroids and other immunosuppressive drugs and still prevent organ rejection. No one really knows why blood transfusions tend to have this effect.

The use of the revolutionary new drug (Cyclosporine) by heart transplant patients has reduced both post-operation infection and organ rejection. Eighty percent of the heart transplant patients who received cyclosporine are alive two years later whereas only 58 percent of those receiving conventional drugs live more than two years.

Why Cyclosporine is so superior to other drugs is not entirely known. Probably it is better at preventing the immune system from rejecting the foreign organs while still allowing it to fight infectious organisms and cancer. Simply, Cyclosporine probably dampens only certain fighters in the body's immune system but not all of them. Since Cyclosporine still impairs to some degree the immune system's ability to fight infectious organisms and cancer, it is still not the final answer to transplant rejection. Many feel that other more improved immunosuppressive methods will be developed that promise even greater longevity to persons getting transplants within the next decade or so.

Patient Selection

Because there are so many people waiting for organ transplants and so few organs available, a national organ system was organized to help match organ donors and recipients. When candidates for organ transplants are identified, all significant information regarding that individual (e.g., tissue type, age, blood type, etc.) is placed on a computer system. Similarly, whenever organs become available, all significant information regarding that organ is also entered. The computer then matches organs to those who need them. In addition to the national organ system, regional organ systems have been established in several areas across the country. Two of the largest ones are in New York City and in Los Angeles.



Ordinarily, if an individual is in need of a heart transplant, that person's physician contacts the national organ system, usually by first going through the regional system. All necessary information regarding the patient is put into the computer. If a match or a reasonably close match is made **and** if no one else is waiting for that organ, then the patient has a **reasonably good chance** of getting the organ. If there is no organ available, the individual is then placed on a waiting list for the next available organ.

As soon as an organ is made available, the computer system is activated. If it's a heart, for example, the computer matches the data on the heart with that of all the patients waiting for a heart. If the heart can be used for more than one waiting patient, the one next in line is considered first. This does not mean that the next in line will automatically get the organ, however.

After a patient or patients are matched adequately with an available organ, a selection team from the hospital convenes to review all the available information about the case. Once the selection team makes the final decision, the patient and the heart are transported to the operating hospital. From start to finish, more than 100 people are typically involved in a heart transplant.

In recent years, this last step, the final patient selection process, has come under severe criticism from various sources.

The major controversy regarding patient selection focuses on the following issues:

— Who should serve on the selection team? Should it consist of physicians only or should others be involved, such as nurses, clergy, business people, and so on?

— What criteria could be used in selecting patients? Should decisions be made only on the basis of medical facts, such as tissue match, chances of success, etc.? Or should non-medical factors also be considered. Non-medical or social factors might include ability to pay for the treatment or ability of the family to provide the necessary post-operative treatment and care.

— Should donors be allowed to designate their organs for specific recipients?

In addition, questions have been raised about the adequacy of national organ systems. Even though the national organ system was set up largely to ensure that organs were fairly and equitably distributed among those needing them, the system seems to be easily circumvented. For example, people have used media appeals to successfully "get around the system". More and more people are beginning to feel that, as one sociologist put it, "the family that commands the media commands the heart."

Who Gets the Heart?

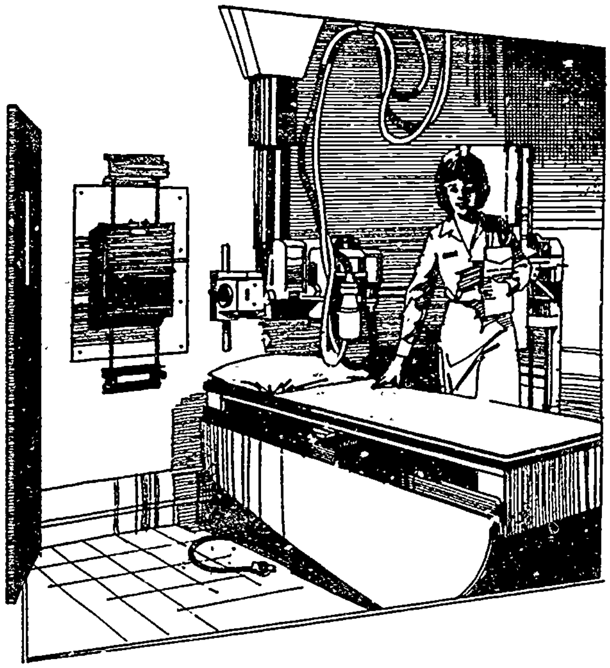
- A Case Study -

Baby Jesse was born with hypoplastic left heart syndrome, a congenital defect that is usually fatal. Simply, Baby Jesse was born with only half a heart!

The parents of the baby asked to have their son put on the list for a heart transplant at Loma Linda University Medical Center. Loma Linda is one of only two hospitals in the world that has done baby-to-baby transplants.

The infant's case was quickly brought before the hospital's 20-member screening committee that reviews transplant candidates. The committee is headed by Dr. Leonard Bailey, a heart transplant surgeon at Loma Linda. Dr. Bailey had previously made newspaper headlines in 1984 when he transplanted the heart of a baboon into an infant known as Baby Fae.

Since there are so few infant hearts available, doctors tend to favor transplants for those who seem to have the best chance of surviving. While most doctors want to save these very rare hearts for the healthiest babies, they also have other criteria for determining which babies are selected for transplants.



Baby Jesse was turned down for the heart transplant. His parents felt they were rejected because his mother was only 17 years old and because they were not married. Jesse's father was 26 years old. The hospital argued that Baby Jesse was turned down because the selection committee feared that the couple could not provide adequate care for Baby Jesse after his operation. Post-operative care is crucial to recovery. Dr. Gerald Bailey said, "It's not good enough to go off in a corner, take a valium and hope it all goes away." The possibility that the heart can be rejected is constant and requires much parental attention. "The family has to be very dependable," he added. Several members of the transplantation committee were reported to have said privately, however, that Jesse's parents were turned down because his mother had a substance abuse problem.

In the meantime, the parents, with assistance from the National Right to Life Committee, appeared on a popular nationally broadcast television program to make a public plea for a heart. While on the air a telephone call came into the studio with the news that a couple in Michigan was donating a heart to Baby Jesse. The couple donating the heart of their brain-dead son, Baby Frank, was at first reluctant to agree to a heart donation. However, they finally agreed to donate the heart to Jesse after learning that their son and Jesse were born on the same day and that both couples were unmarried. In response to the offer of a heart, the hospital agreed to perform the operation only after the couple agreed to turn over custody of Baby Jesse to his paternal grandparents. The transplant was completed and Baby Jesse continued to show improvement. A happy, almost fairy-tale like ending to the Baby Jesse case - right? Wrong!

At this point in the Baby Jesse case, two important issues were brought out:

(1) Should a hospital be permitted to use social factors to reject a child in need of a heart?

Initially baby Jesse was turned down for non-medical reasons. The guidelines utilized by Loma Linda included the ability of the parents to understand and follow a complex treatment program after the transplant had been performed. In addition, the guidelines also disallowed transplants to infants whose parent(s) had a history of drug or alcohol abuse, or of mental illness.

(2) Has the communications media become an important participant in determining who gets an organ transplant?

Is it true, as one social scientist said, that "the family who commands the media commands the heart?" Some argue that Loma Linda Hospital gave in to media pressure.

How would you feel after giving up one of your kidneys if a national agency said, "No, you can't give your kidney to your relative, he is not next in line. Someone else who is waiting longer is going to get your kidney." Is that fair? Why or why not?

Questions similar to these were asked of several individuals by *USA Today* (16 June 1986, p. 8A). Here are some of the replies.

It's the doctor's duty to help... What if an orphan with a heart defect was found on the hospital steps? Should we let it die because we cannot find its parents?... If we start rejecting children for operations because their parents aren't married, who will be next? Will we let the poor babies die? Or the brown babies?

Editorial
USA Today

All the parents of the baby had to do was to raise the charge of discrimination because they were unmarried parents, and Loma Linda set a new speed record for reversing its position...

Having been so badly burned earlier this decade by the chimpanzee heart transplant incident, Loma Linda apparently intends never again to annoy anybody...

Remember, a heart transplant recipient has to take Cyclosporine daily and must be watched to see if the process of rejection has begun. Meanwhile, the number of baby hearts available is far less than the demand, and if Baby Jesse gets one, then some baby who has a far more adequate family support mechanism will be sentenced to death...

What appalls me most is the selfishness, thoughtlessness, and immaturity of the parents. We would have thought that, at the least, they would have offered to get married...

It's inevitable that some babies will die... It's not need or suitability that determines who gets a heart transplant. What is often decisive is the success of a particular parent in getting access to newspapers or television... It's a scandal of which we should all be ashamed.

- Henry Schwartz
Columbia University
College of Physicians and Surgeons.

"We live in a society that doesn't respect life...Baby Jesse is no different now than he was 3 months ago in his mother's womb. He had a right to life then; he has a right to life now...Treatment decisions based on family circumstances rather than on medical criteria, or on social criteria point systems are a reflection of what the medical community hears from society...Too many people are saying by their actions that life is cheap. We cannot tolerate the attitude that one life is less valuable than another."

- Susan Carpenter McMillan
National Right to Life Committee.

"Baby Jesse illustrates the ethical problems brought by the new world of high tech medicine. Society is no longer willing to leave such decisions to doctors. That's good because advanced modern medicine has outstripped doctors' ability to decide when to apply what new technology. For too long, doctors have automatically ruled the world of medicine. This has led us down a dangerous path. . . Doctors make life and death decisions every day. It's not fair or wise to require them to make ethical decisions as well...we all need to get involved. . ."

Steven Findley
USA Today

"The parents must be capable of carrying out the complex medical care required for the rest of the baby's life."

- Loma Linda Hospital.

"We don't feel that our marital status and my age reflect on the baby's health. . . we could give him all the care in the world and let him live his life and survive."

- Deana Brinkley, 17,
Jesse's Mother

"I can understand wanting to maximize as completely as possible the chances of success, and family stability and other factors play a role."

- Albert Jonson
Medical Ethics Expert
University of California.

What do you think?

The Baby Jesse case didn't end there. It seems that another infant, Baby Calvin, was next in line on the national organs procurement list to receive a heart. It also seems that Baby Calvin was bypassed by accident, but that wasn't the only problem. Officials at the organ transplant agencies around the country were furious that the parents of brain dead Baby Frank donated his heart specifically for Baby Jesse.

Doctors at the Loma Linda Hospital said that they originally went through the national organ agency to find a heart for Jesse. It was their opinion that the donor system was circumvented when the Michigan family **named** Jesse as the heart recipient. However, a hospital spokesman in Michigan commented that the confusion was due to a miscommunication problem.

When it was learned that Baby Calvin was bypassed for a heart transplant, his surgeon turned to the news media for help. Guess what happened? A heart was almost immediately found for Baby Calvin, too!

This series of events prompted Senator Albert Gore Jr. of Tennessee to comment. "What do we tell families such as these? That they have to go on (television)? Is this the best we can do?" (*N.Y. Times*, 15 June 1986). It seems that once again the organ procurement system broke down.

In addition to the impact of the media in getting the quick action that was discussed previously, these new events raised another question: Should organ donors be allowed to circumvent the national network system by designating their organ donations for specific recipients?

What do you think? Why?

What are the positives and negatives of allowing such things to occur?

Could certain segments of society be denied their "equal rights" if the designation of recipients by donors was to occur?

Which is fairer, a system in which the first in line gets the organ or a system which allows a donor to designate an organ for a specific individual? Why?

What if a close relative needed a kidney transplant and you were asked to give up one of yours (you can live with only one kidney). Would you do it? Why?

The Baby Jane Case

- Activity -

You are a member of a committee that was set up to decide whether Baby Jane should be given a heart transplant. Baby Jane's father is a high school student and her mother is mentally retarded.

During an interview, the baby's father said he loves Baby Jane and is willing to quit school and to get a job to support her. He is not, however, willing to marry the mother of the baby. Insofar as Baby Jane is concerned, it's too early to determine if she, too, will be retarded like her mother. That is a possibility, however. At this time, it appears that the baby's only problem is her heart.

Medically the doctors feel that Baby Jane is a good candidate for a transplant. They caution, however, that post-operative care will be extensive and expensive. As long as the infant lives she will require constant care and supervision.

Questions for Discussion

Should Baby Jane be given the heart transplant? Why or why not?

Does it matter that Baby Jane's mother is retarded and that her father is a high school student? Why?

What should be the most important reason for you to consider in making your decision? Why?

Should social factors be considered in making judgments about whether someone should receive an organ transplant? Why?

Would it matter if the person needing the heart transplant was an adult? Why? Should social factors be considered in the case of adults? Why?

Do you think you have enough information about the case to make the best judgment possible? Why? If not, what other kinds of information about the case do you think you would need? Why?

Would it matter if Baby Jane's parents were a well-to-do, happily married middle-aged couple? Why?

Is it right to save some lives and let others die? Always? Why? How do you choose who should live and who should be allowed to die?

Guidelines for Organ Transplantation Patient Selection

— Activity —

During the preceding discussions and activities, you encountered situations created by new scientific knowledge and technological developments. In some cases, these situations have caused much public discord because society has not had previous experience in dealing with such problems. To put it simply, organ transplantation was not a problem in the past because we didn't have the capability of performing such operations successfully (unless, of course, you were Count Frankenstein). Another reason is because there are no universally agreed upon standards or regulations to guide these types of activities.

In this activity you will have an opportunity to offer some of your ideas by developing a set of guidelines for organ transplantations. You should prepare a set of guidelines to cover such issues as the following:

— *How should patients be selected for organ tranplantations?*

— *Who should be involved in the selection process (e.g., physicians, nurses, clergy, etc.)?*

— *What specific criteria should be used for selecting patients?*

— *Should only medical factors be considered? What medical factors?*

— *Should social factors (non-medical) be considered? Which social factors? Why are they important?*

— *Should donors be allowed to designate their organs for specific recipients? Why?*

— *On a national scale, how should it be determined which hospitals get which organs? Who should decide?*

— *Is a national organ system necessary? How should it be organized? Should there be any provisions for circumventing the system? For what reasons?*

There are several other factors that should be included. What are they? If you have trouble thinking of additional topics/issues to include, perhaps your teacher might be willing to offer some suggestions. Remember, try to make the guidelines as complete and all-inclusive as possible.

The guidelines should consider the issue or problem from different perspectives such as hospital policy, government regulations, citizen organizations (such as Right to Life), an organization of physicians and/or surgeons, and so on.

The guidelines need not be elaborate; they can simply be a series of short statements. They should, however, indicate that you have given some thought to the topic and have considered how the guidelines affect the people involved, the progress of medical knowledge, and society at large. Will your guidelines protect the rights of the individuals involved as well as the general public? Will your guidelines treat everyone fairly?

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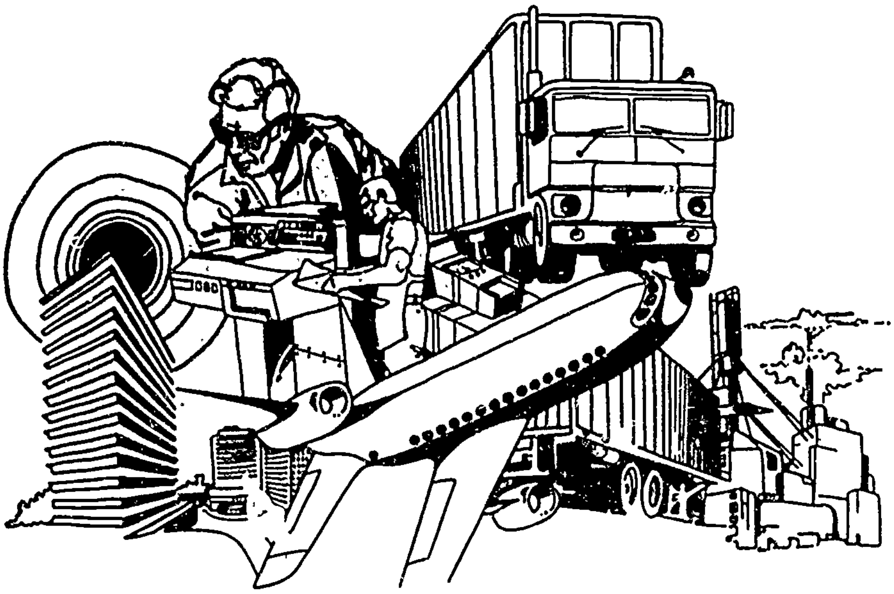
Chapter 10

Transportation

Transportation
— A Reading —

Some of the most exciting advances in science and technology over the past hundred years have come in the area of transportation. Many of the tales told by science fiction writers such as Jules Verne in the 1800's, are now everyday occurrences. We can jet across continents in just a few hours, stay submerged in the depths of the ocean, or explore space for many days at a time. Our world has changed in many ways with the rapid developments in transportation. The man-made landscape we inhabit has been shaped by our various forms of transportation. Our daily lives have been dramatically affected by our mobility - moving people and goods quickly, efficiently, and economically. From a once rural agrarian society, we are now essentially a cosmopolitan, urban population. Modern travel has opened opportunities and new horizons for you that your grandparents never imagined.



Modern vehicles provide a wide range of choices for moving you where you want to go. Additionally, they deliver nearly all the food you eat, clothing you wear, and necessities you use in your daily lives.

The transportational modes of today offer speed, luxury, and convenience to meet society's many demands. Automobiles, buses, and trucks maneuver through streets and highways moving people and products. Ships and tankers channel through oceans and along lakes and rivers delivering their supplies. Trains crisscross the country carrying passengers, mail, and various products, such as coal, cattle, and food. Pipelines transport petroleum and natural gas hundreds of miles throughout the country.

The development of our modern society in the United States is based to a large degree on advances in transportation. For example, when the transcontinental railroad was completed in the 1860's, the states were effectively linked together as a single country. Until then, it took six months to sail from New York to San Francisco. The development of rapid forms of transportation has made possible the growth of large cities and suburbs. Without our modern network of transportation systems, our society might have to return to a more agrarian way of life and be limited to the particular food one could grow in the area where one lives.

The new developments and benefits of modern transportation, however, do not come easily. They come with a new and different set of issues. Land, sea, and air transportation each have different problems and create new types of conflicts. Automobile exhaust fumes are the major contributors to air pollution. The quality of our environment is threatened by oil spills, waste from chemicals that are used in the manufacture and upkeep of our vehicles; road de-icer salts that contaminate farmlands and water supplies; and off-road vehicles that trample fragile plant and animal communities. These are just a few of the threats to our environment caused by transportation developments. What others can you think of?

While we cannot turn back to the horse and buggy days, we do need to examine the consequences of our modern mobility and try to avert serious harm in the future. The issues surrounding transportation are many. The daily newspaper reveals numerous news items related to transportation concerns, problems, and controversies.

What are some recent transportational issues you can recall from the news media?

How would your life be changed if you did not have the transportational systems that are presently available?

How would your future plans change if these systems were gone?

Could we ever go back, at least partially, to the "good old days" of the horse and buggy era? How? Should we?

How have our landscapes changed over the years due to advance in transportation? Were the changes good? Why?

Is moving quickly and efficiently always better? When is it not better? Why?

Land transportation is the most common form of travel. Included in this mode are such machines as automobiles, trucks, buses, trains, motorcycles, and other types of wheeled carriers that traverse our streets and rails.

Progress in science and technology has led to new, improved forms of travel since the invention of the wheel. With new inventions have come new types of problems. Hundreds of years ago, land travel was very slow and laborious. It used to take weeks to travel the same distances we travel in just a few hours today. However, in those days, carbon monoxide was a term not used in the normal vocabulary. In the days before the automobile, air was fresh, clean, and free from health hazards. Today our air is not as clean, but we have the convenience and luxury of visiting and traveling to any part of the country by just the turn of the ignition key.

Our society today is so mobile that people can work great distances from their homes with little difficulty, arriving at work daily and on time (usually). Extensive networks of roads and highways link many rural and, at one time, isolated areas to cities and centers of trade and industry.

How much of this great mobility is necessary?

Is it worth the hazards to ourselves and the environment?

Will we run out of fuel to run our cars?

Should government exert more control on the use and production of cars?

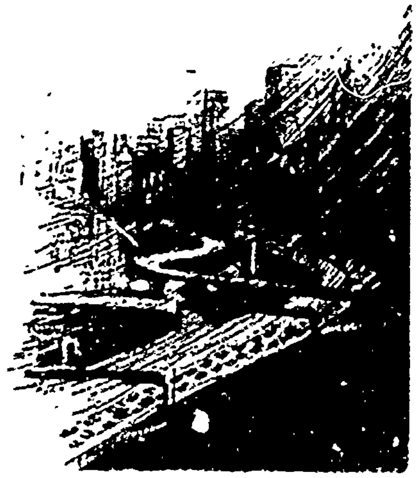
What effects does the auto have on the life-style of the people in the United States?

The automobile is considered the favorite form of travel by Americans. Unfortunately, automobiles are also the leading cause of air pollution, using over 100 billion gallons of gasoline a year and spewing approximately 200 million tons of pollutants into the air. It is estimated that cars produce approximately 80% of the air pollution in the United States. Some physicians claim that breathing the air in New York City for one day is as harmful as smoking two packs of cigarettes. Every day air becomes less fit to breathe, traffic jams become worse, excessive noise from roadways becomes a way of life, and gasoline prices and consumption are always a concern. However, automobiles have become a necessity for most people.

What would your life be like without the family car(s)?

What are some possible solutions to the problems mentioned previously (pollution, traffic congestion, noise, gas consumption)?

Should government put more controls on the production and use of automobiles? If so, what?



Water transportation includes a variety of seaworthy vessels and the waterways in which they travel.

Water crafts come in all sizes, from huge luxury ocean liners to small, two-oar rowboats. Each type is designed for different purposes. While some carry cargo, others carry passengers. Some are sea-going factories, such as fishing boats where fish are cleaned, cut up, packaged and frozen. Others are used purely for sport.

Many boats and ships are engine powered and thus burn fossil fuels. Moreover, a significant portion of them are pleasure crafts. Modern luxury ocean liners consume enormous amounts of fuel to take vacationers on long cruises. Add to this amount of fuel the millions of gallons of fuel used by the small craft owners boating across our oceans, rivers, and lakes, and one can begin to understand the vast amounts of fuel being used for pleasure boating in the United States. Many of the issues arising from boating deal with the question of fuel usage.

Given our current energy needs, can our country continue its present large fuel consumption for pleasure boating?

Should there be a limit to the amount of fuel one can use?.

Should fuel be used only for necessary travel?

The answers to these questions and questions similar to these are not easy. The question of how to use fuel most beneficially is a modern social problem. One fact is certain, the United States depends on large quantities of fuel to satisfy its energy appetite, and this fuel comes from oil. The United States is dependent on import oil from foreign countries. Unless the United States changes its habits, it will never be able to meet all its oil needs by depending on its own wells. We must rely on importing the additional amount of oil from foreign nations. Importing oil also presents another type of problem--the transportation of the oil. The current and most popular way is using the supertanker or VLCC (very large crude carriers). These tankers carry hundreds of thousands of tons of needed oil across the ocean. Because of their enormous capacity, these ships are truly sophisticated feats of engineering. The larger the ship, the bigger the profit per voyage. While these ships are remarkable, they have introduced a new threat to both the ocean environment and to people.

Many people feel that it is only a matter of time before one of these supertankers goes aground in a storm, pollutes miles and miles of United States coastline with escaping oil, kills marine life, and ruins harbors indefinitely. Another possibility is a repeat of what happened in Spain a few years ago. A supership caught fire while at sea. Its oil burned with such ferocity that its heat caused a rainstorm that pelted a huge inland area with oily rain. Crops were ruined, cattle killed, people became ill, and millions of dollars worth of property became coated with oil.

Further damage is also being done to oceans by accidental spills and deliberate dumping of oil by ships' captains. As recently reported, a United States Agency estimates that deliberate dumping totals approximately 1,720,000 tons a year. A Swiss oceanographer says that the total oil pollution of oceans is between 5 and 10 million tons a year. He further states that if it doesn't stop, sea life will end in 25 to 30 years.

What do you think some of the major concerns are in water transportation?

What are the dangers involved in shipping oil by supertankers?

What are some alternatives to shipping hundreds of thousands of tons of oil in these supertankers?

What are the consequences to each alternative.

Are there ways we can reduce our oil consumption? How?

Air transportation today offers travelers opportunities that were never before thought possible. Modern airplanes can carry people and cargo thousands of miles in a few short hours. Contrast this speed with that of early flight and one can easily recognize how advances in science and technology have contributed to "shrinking" our world. Orville and Wilbur Wright successfully achieved the first sustained flight in a power-driven aircraft on December 17, 1903. The flight lasted only 12 seconds and the aircraft travelled a total of 120 feet. Air transportation has come a long way in a short time.

We now have supersonic transports that break the sound barrier during routine commercial flights. These advanced planes, however, come with their own set of concerns, including huge fuel consumption, noise pollution, and possible damage to the ozone layer. A question commonly asked is how much faster do we really need to go? Another question currently on the minds of many citizens in the world today is how much further do we want to go in air travel--specifically, space exploration?

The space shuttle is one of the most recent and dramatic advances in transportation. The space shuttle represents an attempt to conquer the limits of space and to reap the benefits that space has to offer. This type of transportation, which was a mere dream in the minds of science fiction writers a few decades ago, is now a reality for our present generation. Science and technology have brought us into an era where space travel will take place alongside the other more conventional modes of travel.

Many space enthusiasts feel that this shuttle could solve numerous earth-related problems ranging from future energy sources to providing new places to live. Some feel that with the shuttle we will be able to conduct a variety of scientific experiments not possible on earth. The shuttle can launch and repair satellites that are used for communications, surveying natural resources and monitoring military activities. The possibility of space colonies, space industries and harnessing solar energy to be beamed back to earth are all exciting and fascinating ideas.

The shuttle takes off like a rocket. maneuvers in earth's orbit like a spacecraft, and lands like an airplane. If we are to someday build cities or colonies in space, a shuttle-like vehicle will be vital to accomplish this mission.

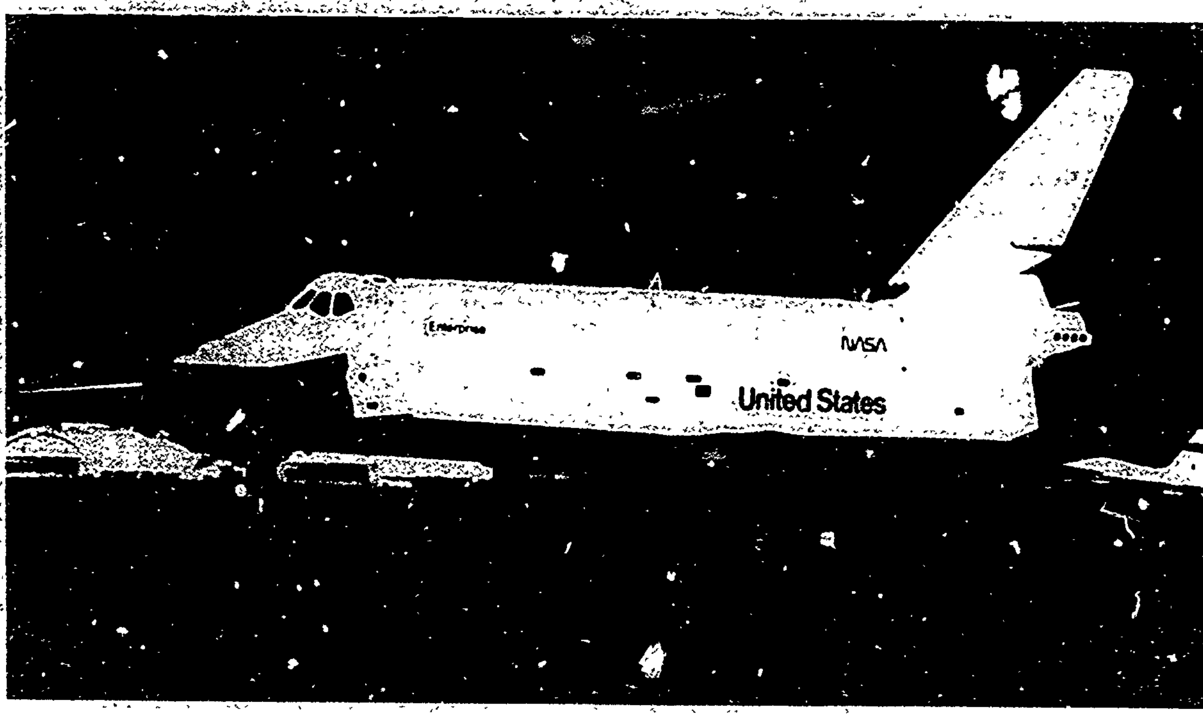
Does any nation have the right to claim any portion of space to be used for building space colonies, as well as the space path for the shuttle? Why or why not?

Earth inhabitants have polluted, drained resources and irreparably damaged parts of the earth. Should safeguards be taken to ensure this does not happen elsewhere in the universe because of the space-shuttle system? If so, what should be done?

The Space Shuttle

- A Case Study -

The mission is set for January 20, 1986. It must be cancelled, however, because one of the three other space shuttles, Columbia, has run into delays with its mission. The new date for liftoff is January 25, 1986. The date arrives and the crew is told of a dust storm that has developed across the Atlantic Ocean at the emergency landing area in Senegal--another delay. The crew has to wait twenty-four more hours. This time, rain and a cold front cancel the flight for January 26. On January 27, again the astronauts are strapped into their seats ready to go. The countdown reaches T minus nine minutes and holding. This hold lasts for three hours because a sticking bolt cannot be undone. The bolt is fixed. However, wind gusts up to 35 mph begin to sweep across the Kennedy Space Center and again the mission is postponed.



Temperatures at the space center fell to an unseasonable 27 degrees the night of January 27th. January 28th is a clear, cold morning in Central Florida. NASA's engineers check the icicles that have formed overnight. They feel the icicles pose no problem. The mission is set to go. "Nine minutes and counting" is heard over the NASA public address system.

"T minus seven minutes and 30 seconds and still counting." The walkway is pulled from the shuttle. The order is given to pilot Smith to prestart the auxiliary power units.

"T minus three minutes and 30 seconds." The internal electrical power system of the shuttle is now in operation.

"T minus ninety seconds and counting." All systems are go.

Streams of gushing water flood the launch platform to muffle the roar of the liftoff and avoid damaging the craft from the tremendous noise level.

"T minus 45 seconds and counting."

"T minus 40 seconds and counting." Computers take over the main engine firing system.

"Ten - Nine - Eight - Seven - Six . . . "

The gallery of spectators is staring, their eyes fixed on the huge, rust-colored cylinder that overshadows the sleek vehicle that will transport seven astronauts into space. American ships have successfully ventured into space 55 times in 25 years. The gallery includes many of the wives, husbands, and parents of the astronauts who eagerly sit atop the shuttle pad. Included in the gallery are the nine-year-old son and six-year-old daughter of one of the astronauts. This astronaut is really a teacher. She was selected as the first "citizen in space" participant. Eighteen students from her son's third-grade class are there with him to watch the liftoff. All eyes are glued to the shuttle.

"Five - Four - Three - Two - One - Liftoff!"

The scene just described was relived over and over again as millions of TV viewers watched in horror as the shuttle Challenger burst into an orange fireball after 73 seconds into flight on January 28, 1986. People across the world searched for words to describe their disbelief and sorrow over the tragedy that they witnessed. All seven astronauts perished.

Successful space voyages had become an event that most people just took for granted. NASA (National Aeronautics and Space Administration) is considered a trusted and reliable organization. What happened? Why did this terrible tragedy take place? Could it have been avoided?

Many people worked on trying to answer these questions. A Presidential commission headed by former Secretary of State, William Rogers, conducted an investigation. As reported in the *USA Today*, June 10, 1986, the Rogers Commission reported the following findings and recommendations:

The Findings

Cause Of The Accident: Failure in the joint between solid rocket booster segments, specifically destruction of o-ring seals intended to prevent hot gases from leaking through.

- Evidence indicates that no other shuttle elements or the payload contributed to causes of the leak. Sabotage was apparently not a factor.
- Launch time temperature was 36 degrees Fahrenheit, 15 degrees lower than the coldest temperature for any previous launch.
- A warm o-ring will extrude properly into the joint gap. A cold o-ring may not. It's probable the cold o-ring wouldn't seal in time to prevent joint failure from hot gas erosion.

Conclusion: Seal failure between rocket booster segments was due to a faulty o-ring design which was unacceptably sensitive to low temperatures and to other factors.

Contributing Cause: Decision to launch was flawed. Those who made the decision were unaware of the recent history of o-ring and joint problems and rocketmaker Morton Thiokol's initial written recommendation against a launch at temperatures below 53 degrees. They didn't know of the continuing opposition of Thiokol engineers when the company's management reversed its position and ok'd the launch. If the decision-makers had known all of the facts, it's highly unlikely that they would have decided to go ahead with the launch.

Accident Rooted In History: The shuttle's booster problem began with the faulty joint design. Problems increased as NASA and Thiokol failed to recognize what was happening and then they failed to fix it. The final error was in treating the problem as an acceptable flight risk.

The Silent Safety Program: The commission was surprised to realize, after many hours of testimony, that NASA's safety staff was never mentioned.

- Organizational structures at Kennedy Space Center and Marshall Space Center have placed safety, reliability, and quality assurance offices under the supervision of the very organizations and activities whose efforts they are to check.

- As the scheduled numbers of flights increased, Marshall's safety, reliability, and quality assurance workforce declined. This adversely affected safety.

Pressures on the System: When NASA began accelerating the shuttle launch schedule in 1982, it hadn't provided adequate resources to support such a schedule.

- Capabilities of the system were stretched to the limit to support winter 1985-1986's flight rate.

- Spare parts were in critically short supply, and lack of spare parts would likely have limited 1986 flights.

Ascent: A Critical Phase: Challenger's flight dramatically illustrated the dangers of the first stage of a shuttle ascent.

- The shuttle wasn't designed to survive failure of the solid rocket boosters. There's no way to separate an orbiter safely from thrusting boosters and no ability for the crew to escape the vehicle during first-stage ascent.

Recommendations

The commission urged NASA's administrator to submit, within one year, a report to the President on the progress made in adopting the commission's recommendations.

Design: The faulty joint and seal must either be redesigned or replaced with a totally new design.

Independent Oversight: The NASA administrator should request the National Research Council to oversee and approve booster redesign.

Astronauts In Management: NASA should encourage qualified astronauts to enter management positions. Astronauts should be involved in all future launch decisions.

Criticality Review And Hazard Analysis: To ensure safety, NASA and the main shuttle contractors should review all potential safety problems and identify those that must be corrected before flight. A National Research Council panel should verify the adequacy of the effort and report directly to the NASA administrator.

Improved Communications:

- NASA should take energetic steps to eliminate Marshall Space Flight Center's tendency to be isolated.

- A policy should be developed to determine when, if at all, a shuttle can be cleared for launch when known problems exist.

Landing Safety:

- NASA must improve tires, brakes, and nosewheel steering of the shuttle.

- The specific conditions necessary for landings at Kennedy Space Center should be identified and tested.

— During unpredictable weather at Kennedy, officials should plan on Edwards Air Force Base landings.

Launch Abort and Crew Escape: NASA should try to provide a crew escape system for use during controlled gliding flight and increase the range of flight conditions that would allow an emergency runway landing if two or three main engines fail early in ascent.

Flight Rate: The USA's reliance on the shuttle as its principle launch vehicle created a relentless pressure on NASA to increase the annual flight rate. Such situations should be avoided.

Concluding Thought: The commission urges that NASA continue to receive the support of the administration and the nation. The agency constitutes a national resource that plays a critical role in space exploration and development. It also provides a symbol of national pride and technological leadership.

The findings and recommendations presented in this report are intended to contribute to the future NASA successes that the nation both expects and requires as the 21st century approaches.

What were some of the factors contributing to this disaster?

Should any one person be held responsible for this accident? Who? Why?

Do you think NASA was foregoing safety standards in order to launch more shuttles?

What should NASA be required to do before resuming shuttle flights?

Does the United States government owe anything to the families of the dead astronauts? What? Why?

Many people are starving and dying of many diseases in the world. Why should so many billions of dollars be spent on this space shuttle? Why not use the money to help the poor, or use it for research to cure diseases (such as cancer, children's diseases, birth defects)?

The United States government spends billions of taxpayers' dollars for space research and to send space shuttles into orbit. Both rich and poor people contribute their tax money to this exploration. However, when it comes time to use this space shuttle system, perhaps only the rich will have the money or possible need to use it. Is this fair to the poorer taxpayer? Why? What could or should be done?

Great strides have been made in air transportation since the time of the Wright brothers. These achievements can be attributed to our highly developed science and technology. We now have a great mobility as a society. Compare this mobility to the adverse effects brought upon our environment (such as resource depletion, pollution, increase in accidental deaths). Has it been worth it? Should limits be put on future development? Do we need this great mobility? Why?

Space Shuttle Discussion
— Activity —

Use the guidelines below to discuss the following question.

In view of the space shuttle tragedy, should the space shuttle program be allowed to continue?

— The class will form two teams - one for continuing the shuttle program and one for ending the shuttle program.

— The teams should be seated facing one another.

— Arguments will be presented by a team member from one side then a team member from the other side. Arguments are presented alternately until all students have had an opportunity to speak.

— Each speaker will be allowed one minute. (A person should be selected to be timekeeper.)

— This debate should be a spontaneous activity. Teams should not prepare in advance but try to develop the arguments as the debate progresses. Each student will need to listen carefully to the arguments that are presented and introduce his/her own new ideas.

— In this type of debate the object is to try to think and organize ideas quickly. It is almost like "brain-storming" where someone presents an idea and that idea leads to another idea. Each debator can build his/her idea from the previous idea or present a totally different idea.

— After all arguments have been presented, the class will then discuss some of the main points that were brought out by each side. What were the best arguments presented by each team?

Transportation In The Future

- A Scenario Writing Exercise -

Overview

A scenario is a short story or a description of a possible event or action. It is a useful exercise to explore new or different ideas. In writing a scenario one takes an idea and follows where that idea might lead. It is like asking the question, "What would happen if I did this?" One tries to think of the many effects of a certain decision and the kinds of changes that might take place. One type of change may cause other changes. When one starts thinking about the changes that might occur, a new scene unfolds - a scenario story.

A scenario is more than just a *list* of changes or effects. It tries to tie in the different and possible kinds of changes and weave together a complete story. Many people develop scenarios to help them make future decisions. With a scenario, one can begin to picture new or different ideas more completely because many effects are being examined at one time.

For example, if one wanted to establish a space community, one would want to think about all that is required and plan to meet those needs. The scenario's description might include the number and kinds of people living there, the work to be done, kinds of food and housing, what people would do for recreation, and so on. One might decide that all the work would be done by robots. What, then, would the humans do? Would all the free time be used for such activities as playing baseball, watching television, painting, composing music, hobbies? Will the people have enough to do to keep them busy? Would they become bored and lazy? What are the advantages of using robots? What are the disadvantages of using robots?

Here are some helpful questions to help guide you in writing your scenario?

— What are the main ideas of the situation?

— How well does the story hold together? Does one idea relate to another to build a complete story?

— Do you have any suggestions about how the different problems might be solved?

— Are your arguments well presented? How might you make your ideas more believable? Are they interesting to the reader?

From the following list of scenario themes, select one to develop into a two- or three-page scenario. Put yourself into the future and try to imagine what could be. Your scenario should be a complete story. You can make up characters and describe how they might act in that situation.

1. New cities are developing all over the country. Greater care is being placed in the planning of transportation systems that will help reduce traffic congestion, noise, and air pollution.

Imagine that you have been selected to prepare a transportation plan for the new city of Metro. In preparing your plan, address the following tasks: a) Give a brief description of the city; b) Develop a plan that is flexible in adjusting to future needs such as population growth; c) Have your plan address environmental concerns; d) Include an economical and efficient mass transportation system in your plan; e) Have your plan address the city's downtown traffic problems; and f) Have your plan discuss the primary forms of transportation.

2. As chief designer for a major auto maker, you have been asked to design a car for the year 2000. This car has to have features to please many divergent groups (e.g., consumers, manufacturers, and environmentalists).

   Write a scenario describing this type of vehicle of the future. It does not need to have all the technical aspects, just the points that could be appreciated by the average consumer. Keep the following points in mind when writing your scenario: a) What do consumers want in a car of the future? b) If there is an oil shortage, how might this affect the car you design? c) What safety devices might be included? d) Will manufacturers have to make drastic changes in the way they produce cars? e) If you design a car that is not fueled by petroleum products, what changes will result? What will happen to gasoline stations?

3. Imagine being in the year 2500. You are living on a space colony. This space colony may resemble some of those seen in space adventure movies on TV and in the movie theaters.

Describe the type of transportation that might be used on this colony. Discuss the following: a) personal transportation, b) mass transportation, c) inter-galactic travel and any other type of futuristic transportation vehicle or systems of transportation you can think of for your story. Include your ideas on the benefits and desirability of those forms of travel.

4. Suppose that there is a sudden gasoline shortage because the oil-producing countries cannot produce enough oil to meet the world demand. Our country's gasoline supply has been reduced by one-half. As the Secretary of Energy, develop a plan to distribute the limited supply of gasoline. Should the gasoline be rationed? How should the gas be rationed? Would this be fair to everyone? How might a traveling salesman be affected? Should there be a ban on using gasoline for recreation or vacation travel? How would our systems for conveying people and goods be affected (trucks, airplanes, buses, etc.)? Might it be necessary to limit the distance that we transport food and other items?

5. The President has asked you to develop an alternative to the gas-powered automobile, one that does not use any gasoline or very little gasoline. What type of vehicle might this be? How will it be powered? How many passengers would it transport? Would special roads or rails be needed? Would it be difficult to convince people to use this vehicle? How might you convince them?

6. Imagine that by the year 2000 people are earning higher incomes and working shorter hours. The widespread use of telecommunications has made it possible for businessmen to hold meetings with people in different places without leaving their offices. Cities have increased in size (90% of the population lives in metropolitan areas) and are centers of industry, business and entertainment. How might this situation affect air transportation? Will there be differences in the number of short trips and long trips? Would the amount of air travel decrease or increase? Who will be the major customers? Will airplanes be designed to carry more passengers and fly over longer distances?

   In your scenario describe some of the changes in air travel that you think might result. Do you think air travel will decrease or increase? What other new developments need to occur in order to bring about the change you predict?

7. Suppose that in the year 2020 mopeds became a major form of transportation. What types of changes might have to take place to allow for large numbers of mopeds? Will they simply replace autos on the roads or will special roads have to be built for mopeds? Shopping centers today are designed around the automobile. If they were designed with the moped in mind, would they need to be designed differently? Would the number of serious accidents be increased or decreased? Would different types of safety regulations be necessary?

8. Imagine that in the year 2000 the number of automobiles has doubled, but no new major highways have been built. Traffic congestion in the major metropolitan areas has reached a point where workers driving to work often spend up to four hours in their cars just to complete a 30-mile round trip. As traffic commissioner of a large city, you are assigned the task of developing a plan to reduce the massive congestion. What types of changes would your plan recommend? How might you convince people to adopt the recommendations?

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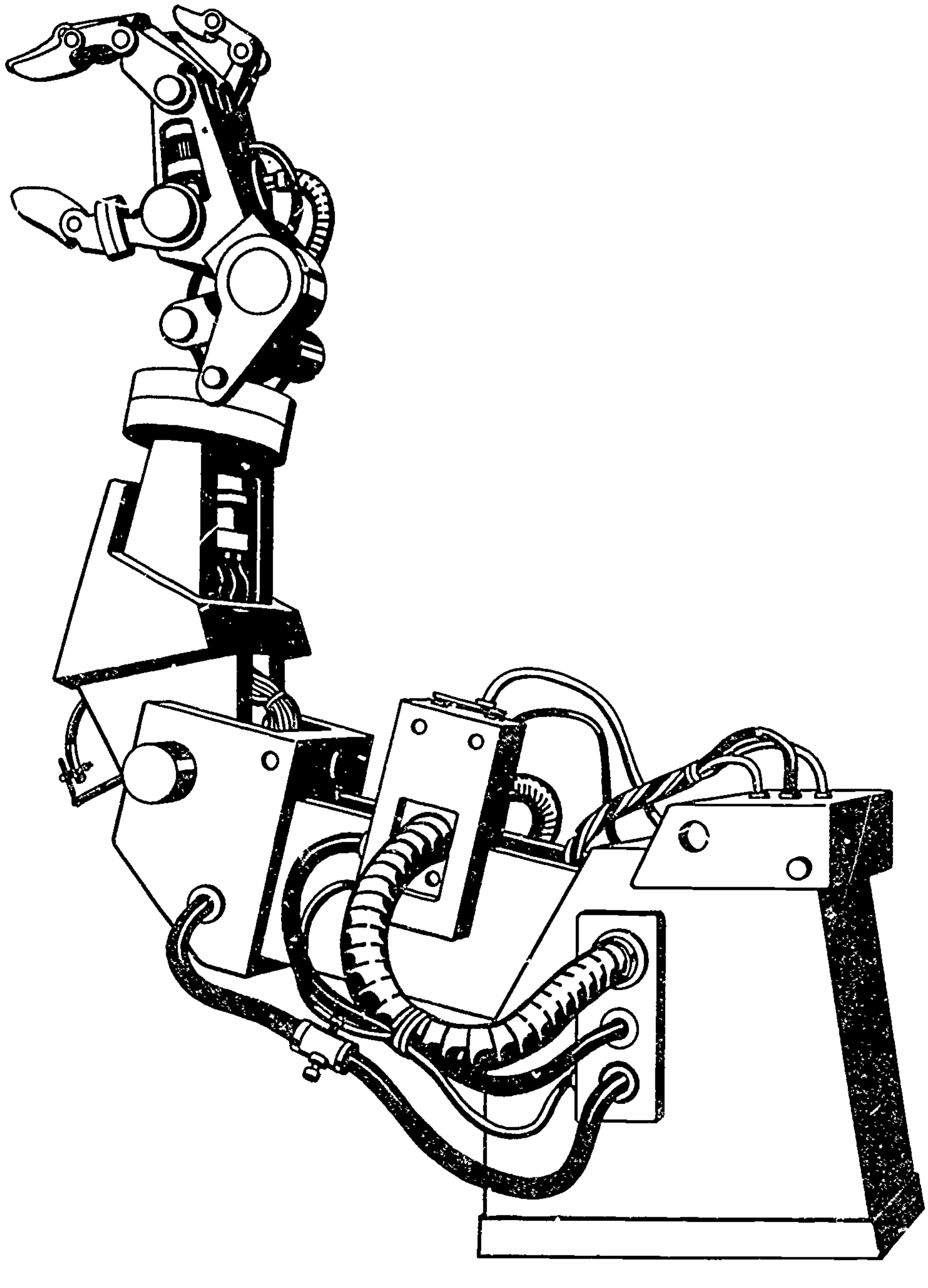
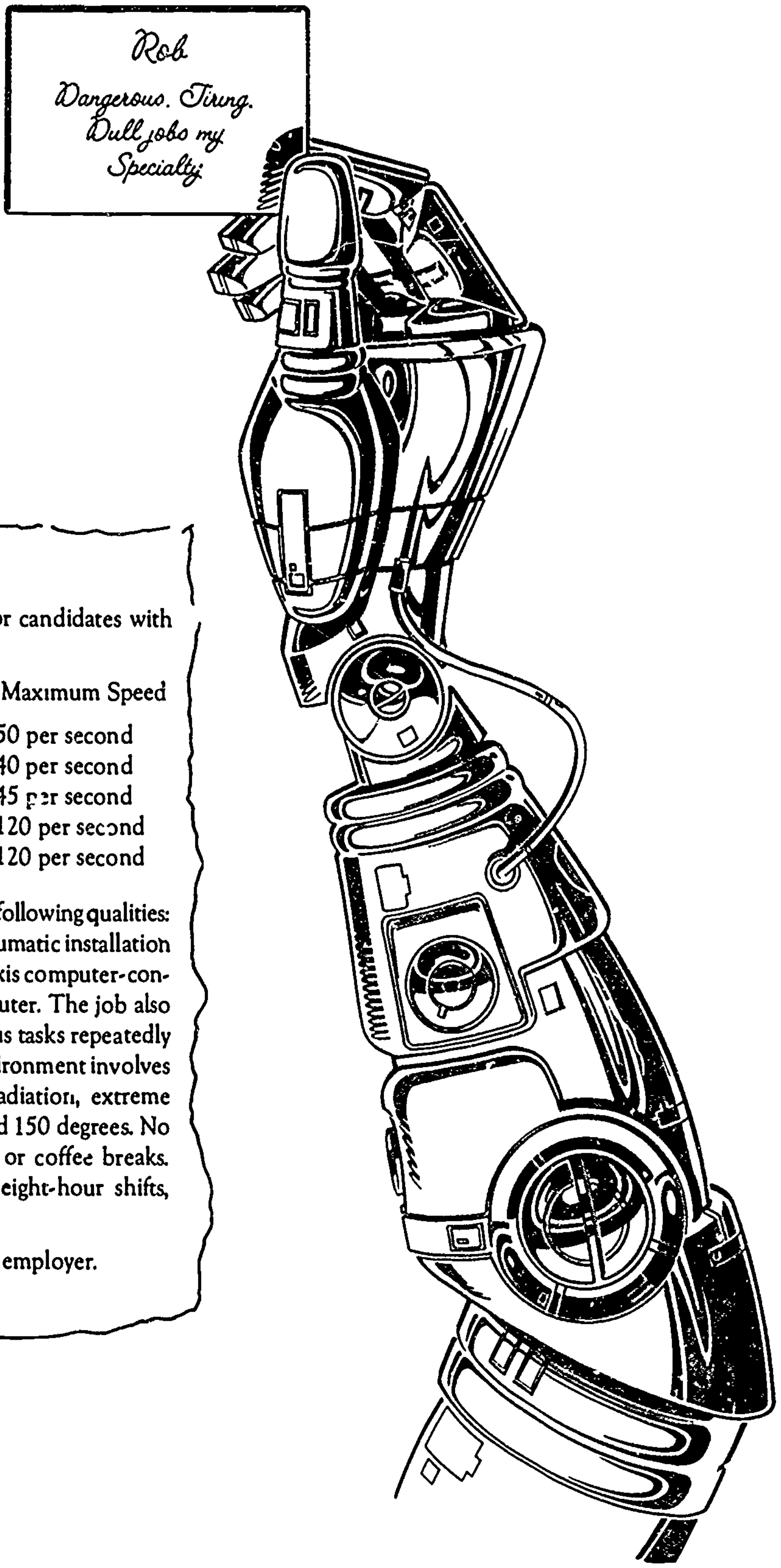
Chapter 11



Robotics

Robotics
— A Reading —



Job Openings

Industrial positions are now open for candidates with the following qualifications:

	Motion Range	Maximum Speed
Body Sweep	+ continuous	50 per second
Shoulder Sweep	180 + 90	40 per second
Elbow Sweep	230 + 90 - 130	45 per second
Wrist Sweep	+ continuous	120 per second
Wrist Pitch	240 + 120	120 per second

The ideal candidates will also have the following qualities: universal end-effectors, memory, pneumatic installation kit, back-up battery, 5 independent axis computer-controllers, and a dedicated safety computer. The job also requires the ability to do monotonous tasks repeatedly with detailed accuracy. The work environment involves exposure to hazardous chemicals, radiation, extreme noise levels, and temperatures beyond 150 degrees. No vacation, holidays, sick days, lunch, or coffee breaks. The work schedule includes three eight-hour shifts, seven days a week.

We are an equal opportunity employer.

Introduction

The preceding job description may seem a little odd, however, the future may bring just this type of advertisement. Would you be interested in this position? Would you meet the qualifications? Can you understand the qualifications? Here is a brief description of the "ideal candidate" who got the job.

> A programmable, multifunctional manipulator designed to move materials, parts, tools, or specialized devices through variable programmed motions in the performance of a variety of tasks. This candidate can learn and remember tasks, respond to its work environment, operate other machines, and communicate with plant personnel when malfunctions occur. It represents a new technology - one that is predicted to reshape the way we think and work.

Obviously, a robot got the job.

By now, most people have either seen robots on TV and in the movies or read about them in magazines or science fiction novels. However, most robots do not resemble the charming characters depicted as R2D2 or C3PO in the Star Wars movies. Rather, the majority of robots appearing in many factories around the world today are basically mechanical arms.

There were approximately 200 robots in the world in 1970. Today, there are almost 6,000 robots in the United States and 17,000 robots working in Japan. Robots are valued because they don't get tired, they can repeat monotonous tasks with great accuracy, and they do not let heat, noise, or fumes bother them. At the present time, most of the robots in use cannot see, hear, speak, or think.

As mentioned previously, most of the industrial robots are mechanical arms mounted on a secure base. These arms can bend, slide, or rotate and usually have between two and six joints. The hand, which is technically called an end effector, can be used as a welder, riveter, spray painter, or small shovel. Sometimes robots are attached to a ceiling beam where they slide across the length and width of a factory, pouring molten liquids from high-temperature furnaces.

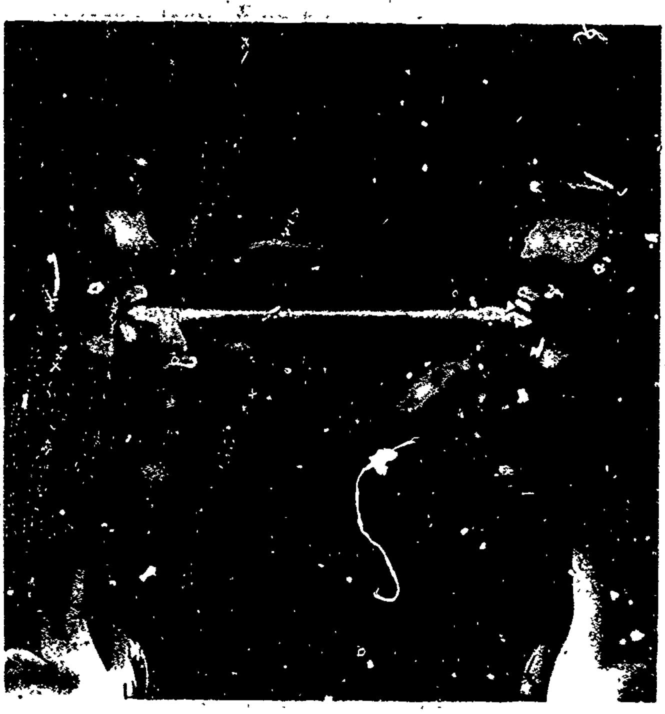
The future generation of robots, however, will be capable of performing many more tasks than the earlier generation of robots. Early robots were controlled by external electronic circuits that restricted them to performing very limited and specific sets of tasks. Now, more and more robots are computer controlled. Computers built into the "bodies" of robots allow them to have greater flexibility and mobility. They can also be programmed and reprogrammed to do many different tasks. Robots can even be connected to other mechanisms such as video camera "eyes" and other sensory systems to further enhance their abilities.

> *What factory tasks currently done by humans could be done by mechanical arm robots?*
>
> *What other occupations might use mechanical arm robots?*
>
> *What effects would using robots instead of humans have on factory workers?*

Robots do not have intelligence as we know it, they must be taught each job they are required to perform. Robots are taken through a series of routine tasks. Each task is recorded as a series of points in space. These recordings are entered into the microcomputer's memory and then replayed whenever the task must be done. To program any task, a person must first go through all the motions with the robot, record the motions, and then play them back. During the playback, the robot repeats the exact motions that were programmed into it. Robots must be programmed for each new task they are required to perform in the workplace.

Robotic Senses

Robots in the future will have additional capabilities, including "vision" and an improved feedback control system so that they can monitor their own movements. The majority of the robots being used in factories today do not see in the human sense, which frequently causes problems as robots maneuver and manipulate various materials around factories. Robots that are equipped with "sight" have video cameras for eyes. As with the robot's other motions, the vision system must also be preprogrammed so that the robot recognizes different objects and materials. Whatever objects will be used by the robot in the factory must be shown to the vision system, recorded by the robot in all its different positions, and then stored in the computer's memory. Some robots are being equipped with a laser system. This system allows the robot, after performing some high-speed calculations, to locate distant objects and to judge how far away the objects are.



Voice commands for robots are in their initial stages of development. The possibility of using voice commands to direct robots is an exciting idea, and one that has been popularized through TV and movies. The voice command system in these robots uses a microphone for an ear. The microphone is connected to a computer which receives the sound waves. These messages are then compared with messages that are stored in the computer's memory. Once the sound message is reviewed by the computer, the robot can then react to the programmed message and respond to the voice commands. As you can well imagine, voice command robots are very difficult systems to perfect.

The possibility of incorporating other senses into robots is also being explored. Researchers are trying to develop robots that can sense heat changes from ultraviolet light and infrared radiation. Some researchers are working on developing artificial skin for robots so they can have a "sense of touch". This "skin" is actually composed of sheets of thin rubber and electrical wire. The outermost sheet has an electrical current passing through it. This sheet transfers electrical currents to the lower sheets as different pressures are applied. As the different levels of pressure are passed through the skin, the amount of pressure applied is measured by the computer. The computer then develops and forms a picture of the object. It sends this image back to the robot so it can determine where the object is and how hard to grip the object so that it does not crush it.

There are many factory and industrial jobs that humans do not want to do or that are so dangerous that human workers cannot be used to do them. Robots to the rescue!!! Robots have no fear of danger and really have no feelings about how boring and routine the work happens to be. For example, robots are being used around the world to feed furnaces and work all night by themselves, or to work on weekends and holidays. Welding has become a trade that robots have adapted to quite well. Robots can withstand the hot sparks and smoke caused by welding operations. They can also operate more than one torch at a time. Robots can work longer hours and accomplish much more work than humans.

Robots never become ill when exposed to hazardous or toxic chemicals and high doses of radiation don't bother them. This makes them capable of doing a variety of activities in a job setting. They might even become the future soldiers of the next generation. Imagine robots that can be used as front-line soldiers!

Advanced sight, hearing, and touch are intriguing developments for robots of the future. These senses will allow robots to do many things that they are not capable of doing now. The robotic industry is still a few years away from developing an actual R2D2 and C3PO.

What could robots with these types of advanced senses do that mechanical arm robots cannot do?

What could "advanced" robots do that humans are now doing in factories?

How could "advanced" robots change the way a factory is operated?

What could these robots do around your house?

What other uses can these types of robots have in society?

What problems may be caused by using numerous robots in the work force and around the house?

Robotic Economy

The majority of robots cost between $60,000 and $100,000 to build and install in a factory setting. A robot that works two to three shifts can pay for itself in 2 to 3 years when compared, for example, to the average salary of an auto worker in the United States. While robots will not totally replace humans in the industrial work force, semi-skilled workers will be the group hardest hit and most often replaced by robots.

Many of the routine, monotonous, and dangerous tasks may be taken over by robots. However, they still cannot take over tasks that require complex thought processes and/or decisions that involve reactions that are not programmed. The senses of sight, sound, and touch in robots must be developed to a more sophisticated level before they can compete with skilled laborers. Besides, humans will be needed to maintain, supervise, and manage robots in the workplace.

The current state of the art in robotic engineering uses a computer system that can be programmed and reprogrammed so that robots can adapt to various changes in the work setting. When a new line or product is introduced to the assembly line, all that is needed is a change in the computer program. No change in machinery (hardware) is required. All these robotic possibilities could add to an increase in production of goods and a decrease in associated costs. With the advancement of artificial intelligence and computer technology, it is inevitable that robots will be used more and more in our society.

Some people estimate that by 1990, as many as 20,000 to 60,000 robots may be produced each year. Dr. Robert Ayres at Carnegie-Mellon University (Pittsburgh, PA) predicts that by the end of this century 40% of the 9 million semi-skilled factory workers who operate machines will be replaced by robots. He believes that many workers feel robots are a threat to their jobs. However, he sees robots taking over mainly the dullest and most inhuman jobs. "They can make our society wealthier, thus increasing overall employment. Robots can go places humans can't, giving us the capability to go deep into the ocean and to explore space."

However, if the prediction of robots taking over some three-and-a-half million jobs comes true, it will have a significant impact on employment and the work force of the future. Estimates are that by the early 1990's when robots become more advanced, they will be able to move freely in unstructured environments such as construction sites, roadway developments, farms and forests. Some robots are now controlled by as many as ten computers dedicated to storing information. With such large memories, robots in factories and construction sites will be able to select, cut, and attach materials, construct sections of buildings, pick crops, paint, and do many industrial tasks.

The technology of robotics has implications that are far-reaching with respect to the possibilities of improving productivity and economic growth while also improving the competitive position of this nation. Some people feel that the impact of the completely automated factory on society will be similar in magnitude to the impact of the industrial revolution. The industrial revolution saw muscle power replaced by mechanical power in the production of food, materials, and goods. This revolution spawned an increase in productivity, less poverty, and a redistribution of economic and political power within and among nations. The robot revolution could substitute computer power for human brain power in the control of machines and industrial processes. The next revolution could free humans from the routinized, regimented duties required in factories and offices.

Obviously, the influx of robots into the work force introduces a very important concern - unemployment. If predictions hold true for robots and their use, a problem of competition for jobs between humans and robots could become an issue. However, James S. Albus (2), an expert on robotics and automated manufacturing systems, feels the threat to employment is vastly overrated. His view is that robots are growing at less than 35% per year and there is little historical evidence to suggest that robots have ever caused an increase in unemployment. The Japanese, he says, have more robots than all other countries combined, and they have the highest productivity growth rate of all industrial nations. Yet the unemployment rate in Japan is less than 3%.

Albus feels the current rate of unemployment in America is not attributable to robots putting people out of work. Instead, he argues, American industries are becoming obsolete and, as a result, the United States is finding it increasingly more difficult to produce goods and services at competitive prices on the world market. Albus summarizes the concerns of robots and the economy as follows:

- The massive loss of jobs in the textile, shoe, camera, consumer electronics, steel, and automobile industries is not because of automation but because of lack of modernization to meet and beat competition from foreign manufacturers. In fact, unless the nation increases productivity through greater use of automation, it may soon become impossible for U.S. industries to make enough profit to pay for high salaries and benefits, generous vacations, and comfortable retirement programs that Americans have come to expect.

It is also wrong to assume that a human job is lost for every robot installed. The new technologies of robotics and computer integrated manufacturing will create entirely new industries, employing millions of people (and robots, too) in jobs that don't exist today. Robots will make possible new methods of manufacturing, construction, tunneling, and deep drilling. They will be used for undersea mining, manufacturing in space, and farming of the oceans, all of which would otherwise be impossible or impractical. Robotics could make solar and geothermal energy sources economical and may substantially reduce the hazards of nuclear power.

Of course, there will be many new human jobs created just in the industries that manufacture, sell, install, and maintain robots.

A recent study conducted for the state of Michigan predicts that by 1990 the number of jobs created in the robot-manufacturing industries alone will be between 35% and 75% of the number of jobs lost in the robot using industries. And if the increased productivity resulting from more efficient production technology makes American products more competitive on the world market, the net effect on employment will be overwhelmingly positive in almost all sectors of the economy.

Many occupations will survive and prosper even in the most advanced robot economy. Doctors, nurses, teachers, entertainers, social workers, psychologists, and religious counselors will continue to be required as long as there are humans with needs for such services. A robot-based economy should produce sufficient material wealth to increase the demand for health, education, recreation, and social services by making them available to more people. Occupations in leisure industries, the arts, and many types of personal services would then abound. Scientific research and exploration of the oceans and outer space will offer unlimited opportunities for many types of fascinating careers into the indefinite future.

We can, of course, always spread the available work around. A shorter workweek of 20 hours, or perhaps eventually 10 hours, may be possible. Longer vacations, sabbatical leaves, and increased adult education all have the capacity to raise the number of jobs while reducing the amount of work.

What type of industries would best be served by robots?

What type of jobs could be eliminated?

What should happen to the people whose jobs are eliminated?

Is it fair for a company with no robots or automation to have to compete with a company that is completely automated?

What are the economic advantages for a factory to change over completely to robots? What are the disadvantages?

Who should be responsible for any unemployment caused by using robots in the workplace?

Robotic Future

If even the most conservative prediction of the robotic industry analysts holds true, the number of robots working in American factories will triple over the next two to three years. How do we get people trained to develop and maintain all of the robots that will be needed to meet this demand?

Presently, a person who would be called a robotics engineer is one trained in either mechanical or electrical engineering, computer science, physics, or neuroscience. The field of robotics is growing as technology gets cheaper. Colleges and universities are preparing for the robotic revolution by offering courses and programs in robotics.

There are two basic areas of robotics: technological and scientific. Those people who work on ways to make robots more time-efficient and cost-effective for various industrial purposes are considered in the technological branch. Researchers who are working on ways to give robots more advanced senses of sight, hearing, and touch, as well as increasing their artificial intelligence, work in the area of scientific robotics.

Early in their development, robots were very expensive to build. In 1960, the computer portion of a robot cost approximately $1,000,000. Today a computer with much more capability can be made for $200. The reduction in computer prices over the last few years has resulted in an equivalant drop in the price of robots. This in turn has made robots more accessible to people and has thus opened up and accelerated the development of the whole field of robotics.

The growth of robot use has placed new demands on finding qualified trained people to work in this area. The demand for trained people in robotics has also increased because of the interest in the "personal robot". There are approximately twelve to fifteen companies that manufacture them. However, most of these robots are no more than sophisticated toys. Some people estimate that the manufacture and sale of the personal robot will be a $2 billion industry by 1990. There are many technological companies that are devoting time, energy, and money to the development of robots.

One Japanese company, for example, has developed a mechanical musician that can sight read music with its video camera head while playing the keys and footing the pedals of a standard electric organ. A second company has developed a robot that maps its surroundings and compares them to its own map so that it can go around obstacles placed in its way. A third company has developed a robot costing around $40,000. This three-hundred-pound or so machine incorporates a self-navigation system that allows it to patrol warehouses and prisons; it can also wash floors in supermarkets and airports.

The home or personal robot industry is still a long way from allowing one to own a cheap, mechanical servant. However, if you examine the growth of the computer industry over the last 25 years and apply this rate of growth to the robotic industry, it should be no time at all before R2D2 could bring you a cold drink or change the channel on your TV.

The computer industry has already had a dramatic impact on the industrial and technological work force. Robots have the potential for a still greater impact in the future. They could easily change the industrial and technological work force. It could change the way we do things and the people (or machines) that do them. Training of students who are planning to enter the work force in the future may look very different. Education including technical, scientific, skilled, and non-skilled will have to be adjusted to meet the new demands of a robotic society. Are we on the verge of a new revolution — the robotic revolution?

If robots do become a large part of our future, how will society change? What are the advantages/disadvantages of these changes?

What will our future factories/offices look like 25 years from now?

What will our future homes look like 25 years from now?

What effect will a robot revolution have on schools? On what is taught? On how it is taught?

How could robots themselves be used in the schools?

What part of society would benefit most from a robot revolution? Least?

How would you compare the growth in computers to the growth in robotics?

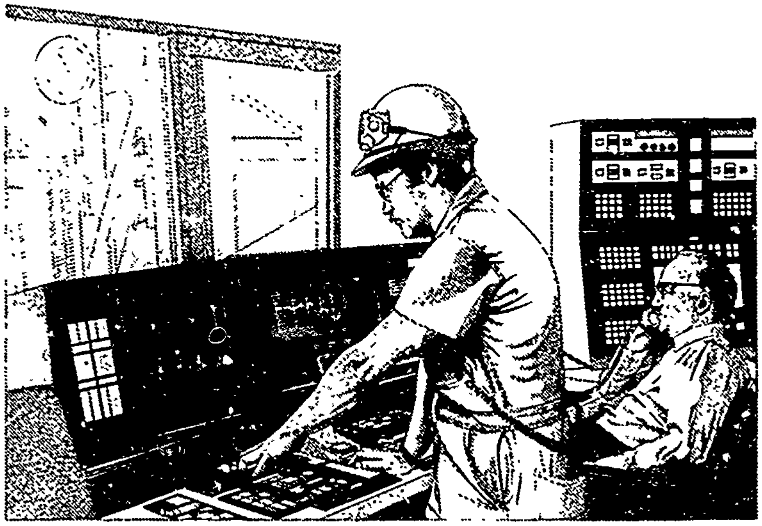
Mr. Harris' Factory

Case Study

- Part 1 -

Mr. Harris is the owner of a moderate-sized factory in a small town. He employs approximately 300 people in skilled and semi-skilled jobs. A sales representative from the National Robotics Company, Inc. has recently shown Mr. Harris how he could triple production at his factory while at the same time reduce his costs.

Mr. Harris would have to purchase and install approximately 10 robots to accomplish this savings and increased work production. The problem Mr. Harris is facing is that if he installs the new robots, he would have to lay off 150 semi-skilled workers in his plant.



Mr. Harris knows these have been very loyal employees over the years and all have worked very hard. But he also knows that the competition is very strong in his business and that new companies are constantly taking away his profits. Profits have been slipping and Mr. Harris needs to increase production without increasing his overhead. The money he would save on salaries plus the increased production could more than pay the cost of the robots in 2 to 3 years.

Mr. Harris knows that the layed-off workers will have a difficult time finding other employment because of their limited skills. He also knows, however, that if he doesn't make the changes much of his business will be lost to new automated competitors entering into the market.

What should Mr. Harris do? Why?

Questions for Discussion

What alternatives does Mr. Harris have?

What should be the primary concern of Mr. Harris?

Does he owe anything to his workers for their years of loyal service?

What does Mr. Harris owe to the remaining workers in the factory to keep the factory going?

Mr. Harris' Factory

Case Study

- Part 2 -

Mr. Harris' factory problem can also be considered in another way - as a simulation game. While games of all types, including simulation games, can be fun to play, they are also very useful for examining problems of many types. For example, they can be helpful for examining problems from a variety of viewpoints, and as a result, often uncover issues that might otherwise go unnoticed. This simulation is based upon the well-known and widely used "Prisoners' Dilemma".

Mr. Harris has met recently with a salesman from the National Robotics Company, Inc. to learn how robots can improve production at his company. During the discussions, Mr. Harris finds out that Mr. Fredericks, his only competitor, is also considering automating his company using robots.

The two factories are located in a moderate-size town in the Midwest. The average weekly gross receipts total approximately $14,000 for EACH business. Both companies, while doing well, would like to improve production and earn more money. One way to do this is to use robots.

If only Mr. Harris installed robots in his factory, he could increase his profits from $14,000 per week to $18,200 per week. If, at the same time, Mr. Fredericks decides NOT to install robots in his factory, he will lose some of his normal business to Mr. Harris because Mr. Harris will be able to offer much faster service. Hence, Mr. Fredericks' gross income will go from $14,000 down to $11,900 per week. The opposite would be true if Mr. Fredericks decides to automate his factory with robots and Mr. Harris decides not to automate his factory. If both factory owners decide to use robots, they will each earn $9,800 per week because of the added costs for robot purchase, installation, and maintenance. If, on the other hand, NEITHER Mr. Harris nor Mr. Fredericks install robots in their factories, they will both continue to make the same $14,000 per week. Neither Mr. Harris nor Mr. Fredericks is aware of the other's decision. The decision of each, of course, will be very much affected by their prediction of what the other person will decide.

Summary of Possible Incomes

1. If neither owner decides to install robots in their factories, then both will continue to earn $14,000 weekly.

2. If both owners decide to install robots in their factories, then both will earn $9,800 weekly.

3. If one installs robots and the other does not, the one who installs the robots will earn $18,200 weekly while the other will make $11,900 weekly.

A "pay-off chart" (Figure 11-1) is another way of summarizing the possible outcomes of any actions taken by Mr. Harris and/or Mr. Fredericks.

Figure 11-1

PAYOFF CHART: WEEKLY INCOME

		Mr. Fredericks: Install Robots	Mr. Fredericks: Do Not Install Robots
Mr Harris	Install Robots	$9,800 each	$18,200 (Harris) $11,900 (Fredericks)
	Do Not Install Robots	$11,900 (Harris) $18,200 (Fredericks)	$14,000 each

Instructions

In conducting this simulation, you will work in groups of two students. One person will represent Mr. Harris while the other represents Mr. Fredericks. Your teacher will provide a record sheet for you to keep track of your decisions, those of your opponent, and the penalty for each decision made by you and your opponent.

During the simulation

a. There should be no talking until after the 10th round of the game.

b. Players should sit back-to-back. Then, privately decide to either install robots or not to install robots. Each player then writes his/her decision on a piece of paper. Simply write, "install" or "not install".

c. After writing your decision, pass the paper over your shoulder to your opponent. Remember, talking is not allowed.

d. After reading your opponent's decision, fill in the first row of the summary sheet. The penalties for you and your opponent can be read directly from the "payoff chart" at the end of the scenario.

e. Continue this process nine more times for a total of ten rounds. The process is (1) write decision, (2) pass paper to opponent (3) record decision.

f. When ten rounds have been completed, face your partner and talk together for 3 to 5 minutes. Discuss what happened during the 10 rounds. Use the scenario sheet, payoff chart, and the completed record sheet to help guide your discussion. Your teacher will also be available to assist you at this time.

g. Your teacher will give you further instructions about what to do next.

Examining the Effects of Robotics

- The Futures Wheel -

In this exercise you will use a picture-like technique to examine the effects of some predictions or trends you make about robotics. You will do this by constructing a "futures wheel". The futures wheel allows you to see the many possible effects that can occur when a new invention is used or when a change takes place. You will show how one effect leads to a secondary effect and how different effects are related. When you have completed the futures wheel and studied the many effects, you can then decide whether or not a new trend, new invention, and/or another change is desirable.

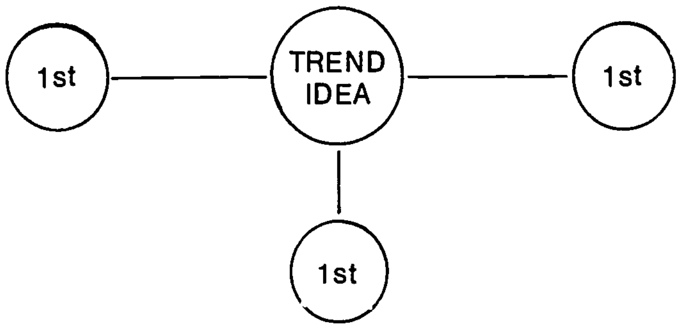
Instructions

— You will work in pairs or small groups of three to four members.

— Each group will construct a futures wheel similar to the one shown in Figure 11-2. An example of a completed futures wheel is shown in Figure 11-3. (Do not copy the wheel shown in Figure 11-2 because your futures wheel may "branch out" quite differently.)

— First select a new development or trend to study. A number of possible ideas are listed below. However, you may wish to identify another idea and use that for your futures wheel.

— On a large sheet of paper draw a circle in the center. Enter the trend/idea you selected in the circle. What are the main effects of this idea/trend? How many did you think of? Draw in as many circles as main effects you identified and connect each to the center circle with an arrow. These are the first order effect.



— Examine each first-order effect and decide what types of effects it produces. Some effects may produce one effect, others more. Enter the second-order effects and connect them to the first-order effects.

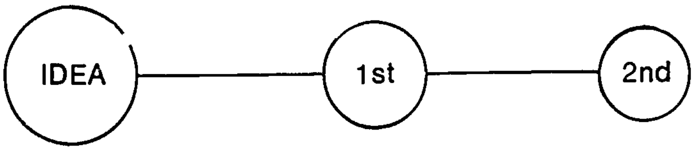


Figure 11-2. Futures Wheel.

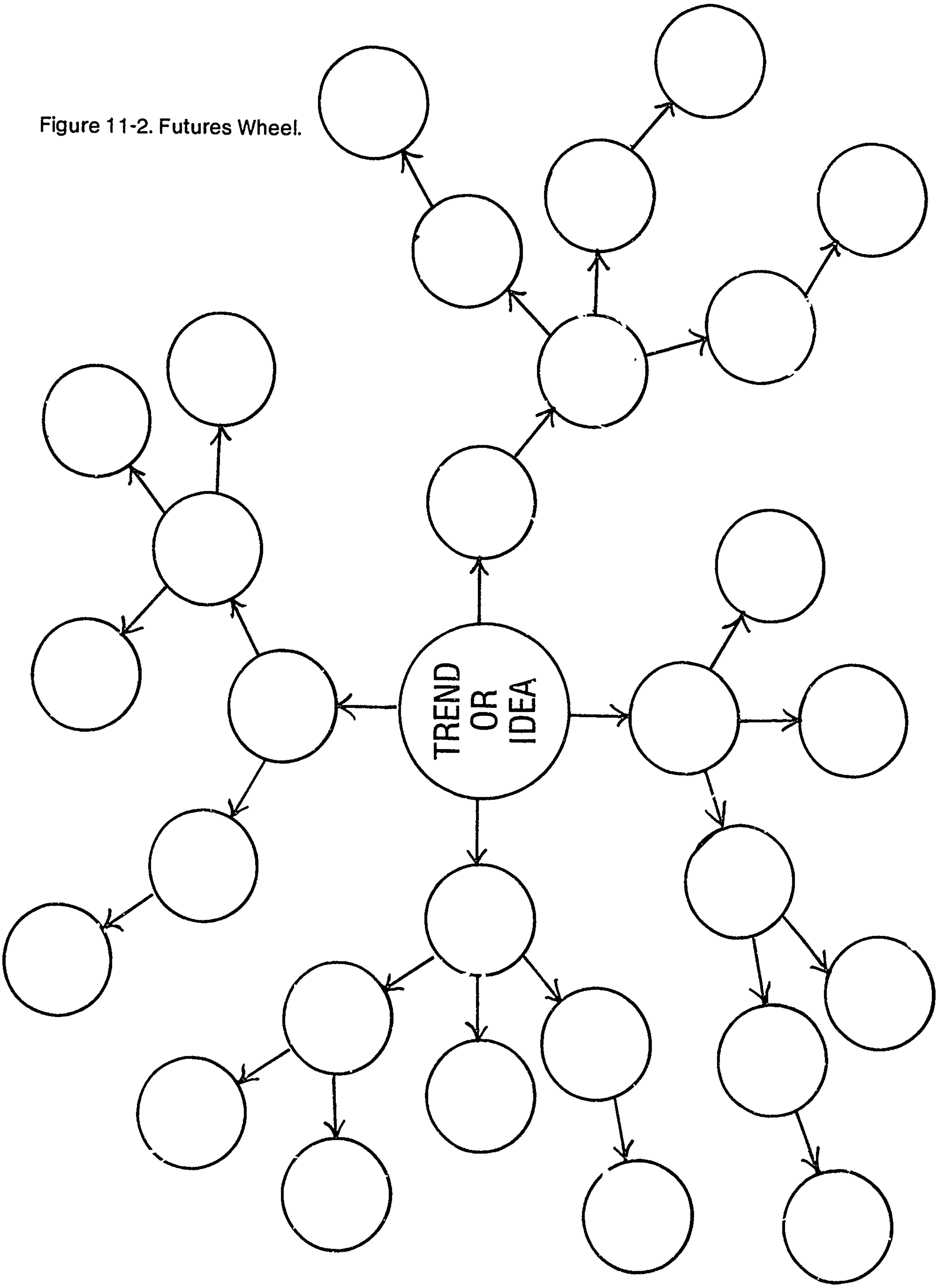
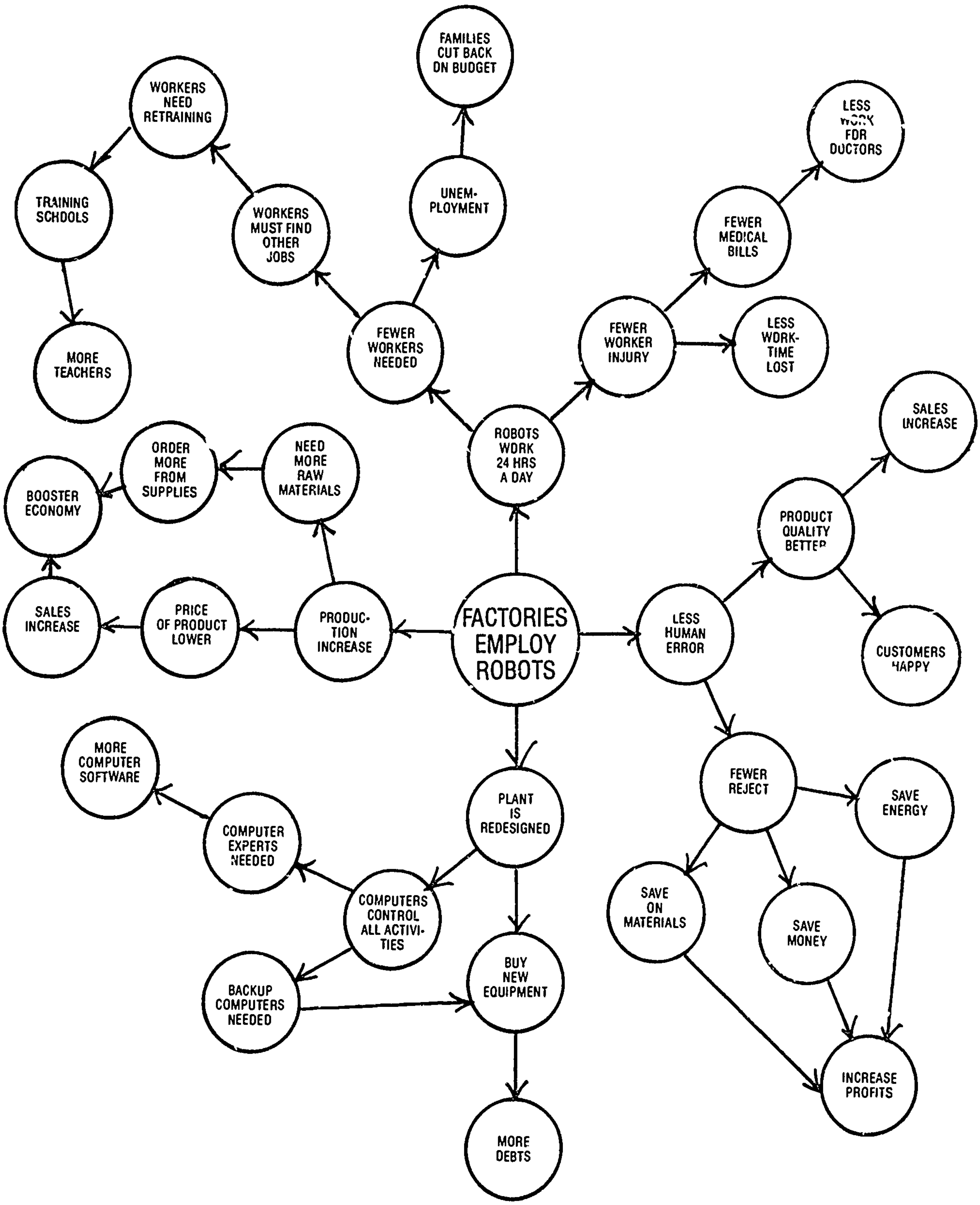
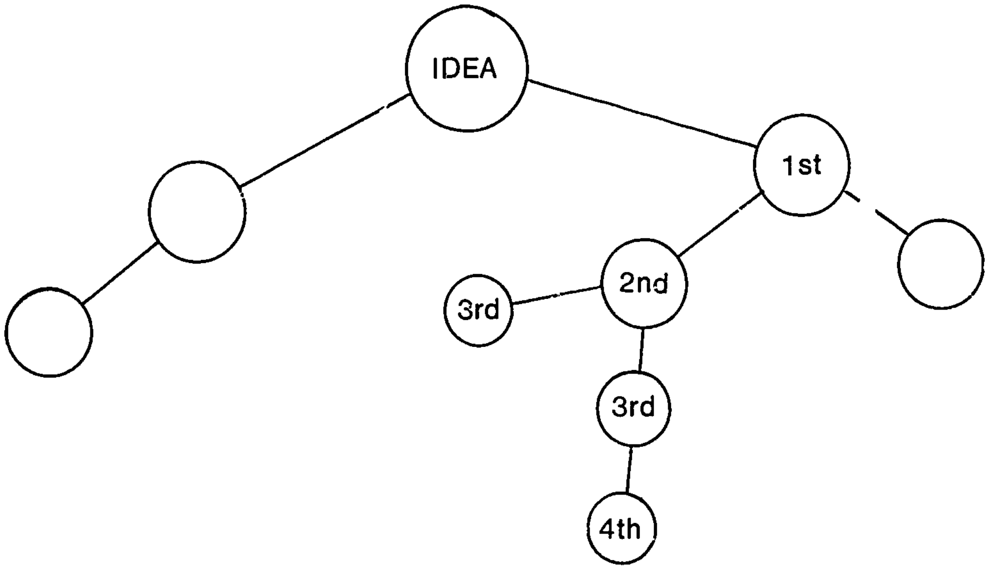


Figure 11-3. Example of a Futures wheel & factories employ robots.



— Follow the same procedure for third- and fourth-order effects. You may find that some effects can produce similar lower-order effects. Show this by connecting the appropriate circles.



— Figure 11-3 illustrates a futures wheel that examines the effects of using robots in factories. Study this example.

Some Suggested Ideas and Trends

Robots that respond to voice command.

Robots used as teachers in school.

Robots that can think.

Personal robots in every household.

Cashiers in food and department stores.

Robots that do office work.

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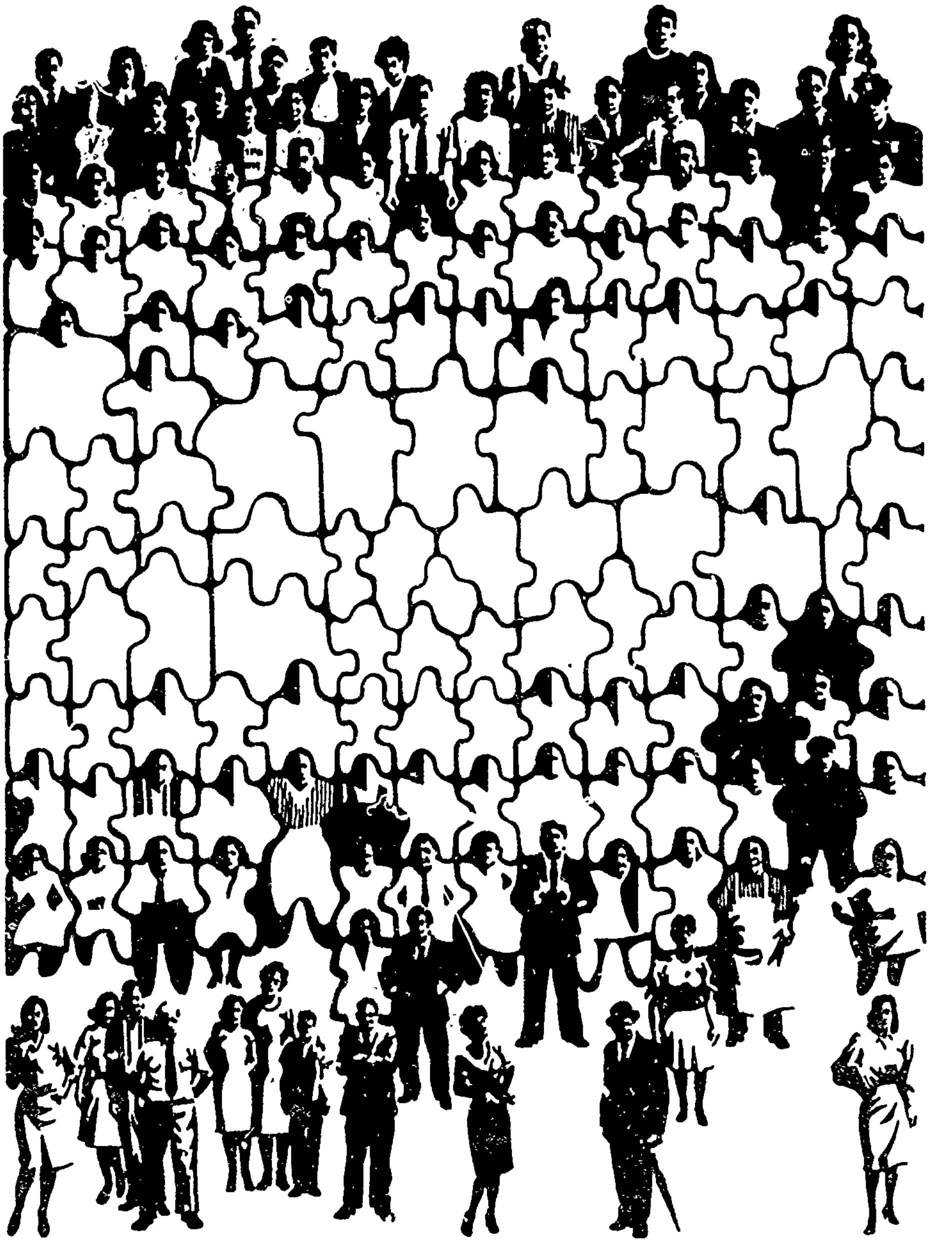
Chapter 12



Technology And Decision-Making

Technology and Decision-making *

- A Simulation -

In the previous readings and activities some of the complexities and unforeseen consequences of technological applications were illustrated. These examples point out the need for decision-makers to better understand the new technologies and their potential effects. However, the complex and sophisticated nature of new technologies makes it difficult for policy makers, such as members of Congress, to become experts in all aspects of the topic. In addition, it is not enough to know about the scientific and technological details, one needs to know about how the technology will affect people, their lives, and their environment. In recent years this need has been recognized, and systematic approaches for evaluating new developments have emerged. These approaches encompass a variety of information-gathering techniques and come under the heading of technology assessment.

The importance of technology assessment is best evidenced by the establishment of the Office of Technology Assessment to assist Congress and regulating agencies in making policy decisions and enacting legislation. You will now have an opportunity to apply some of your knowledge to a technological assessment activity.

In this activity you will assume the role of decision-makers who have the power, authority, and ability to direct the future development of new technologies. Members of the class will represent different interest groups and select technologies for the world of the future. The technologies will be presented to a World Review Court which will decide on their acceptability. The objective of each group is to select technologies that will promote and advance their desired goals.

Part I

- Group Preparation -

Procedures

— The class will form into four groups of similar size. Each group will represent one of the following:

Factory workers
Government officials
Industrialists
Preservationists

— Group members will assume the role of the group they represent. While in your groups, review and discuss your goals.

Goals of Factory Workers

1. To create safe conditions in the workplace.
2. To create more meaningful and challenging jobs.
3. To improve living conditions and the quality of life.

*Adapted from Iozzi, Louis A., et al. *Technology and Society, A Futuristic Perspective*. Sopris West, Longmont, Colorado, 1980.

Goals of Government Officials

1. To create a nation with a high standard of living.
2. To export more products than it imports.
3. To protect the country from outside aggression or terrorism and to reduce internal conflicts.

Goal of Industrialists

1. To increase production efficiency, and therefore, profitability.
2. To insure the continued availability of raw materials and energy at low cost

Goals of Preservationists

1. To protect the existence and survival of plant and animal life.
2. To maintain a high-quality environment.
3. To guard against any drastic changes that adversely affect the quality of life for plants, animals, and people.

While reviewing and discussing their goals, each group should also compile a list of issues or problems that must be solved or addressed in order to achieve their goals.

At this time, select a recorder to keep notes of the group discussions.

— Review Figure 12-1, "Technical Innovations Very Likely in the Next Twenty Years."

From the list, select approximately six technologies related to the goals of your group. Perhaps members of the group know of technologies that are not on the list, feel free to include them among the possibilities for your group.

You may also wish to acquire some additional insights into new technologies by reviewing current magazines that focus on future developments such as *The Futurists, Discovery, Next, Omni, Business Week, Time, Newsweek,* etc.

After making your selections, it is sometimes helpful to rank your selections in their order of importance and then evaluate each one to determine if it showed up in one of your final four. When your group agrees on four technologies, the remainder need not be considered.

In making your final selection of the technological innovations, however, you should keep the following points in mind:

1. *How important is the technology, especially to the group you are representing?*
2. *Will the technological innovation be readily accepted by the general public?*
3. *How well does the technology assist you in achieving your goals?*

Using the "Technology Assessment Worksheet" (Handout 9), evaluate each of the four selected technologies. You can do this by having each member of your group evaluate one of the four technologies or the entire group might evaluate each of the technologies in turn.

In completing the Technology Assessment Worksheet, you should realize that the effects of the new technology are often unknown even to the experts. Hence, there are no absolute answers. You will have to make your predictions based upon your knowledge and creative ideas. A good way to start is to "brainstorm" with the members of your group. For example, have each member of your group suggest an effect and continue going around the group until all ideas have been exhausted. In brainstorming, no judgments are made no matter how far fetched the idea.

When the session is complete, select those ideas you consider most appropriate.

As an example of how to complete the "Technology Assessment Worksheet", consider the first, second, and higher order consequences that might result from the introduction of "Ocean Farming" to the world.

Figure 12-1

Technological Innovations Very Likely in the Next Twenty Years

1. Many applications of lasers and masers for sensing, measuring, communications, cutting, heating, welding, power transmission, illumination, destruction (defensive), and other purposes.
2. New or improved materials for equipment and appliances (plastic, glasses, alloys, ceramics, intermetallics, and high heat-resistant compounds).
3. New airborne vehicles (ground-effect machines, vertical take-off and landing, super-helicopters, giant and/or supersonic jets).
4. More reliable and longer-range weather and earthquake forecasting.
5. Intensive and/or extensive expansion of tropical agriculture and forestry.
6. Extensive and intensive worldwide use of high altitude cameras for mapping, prospecting, census, land use, and geological investigations.
7. New methods of water transportation, such as large submarines, flexible and special-purpose "container ships", or more extensive use of large automated single-purpose bulk cargo ships.
8. Extensive use of cyborg techniques such as mechanical aids or substitutes for human organs, senses, limbs, or other components.
9. Genetic engineering to produce new and useful plant and animal species.
10. New or improved uses of the oceans, such as mining, extraction of minerals, controlled farming, tidal power.
11. Widespread use of nuclear power.
12. Use of nuclear explosives for excavation and mining, generation of power, creation of high-temperature, high-pressure environments, and/or as a source of neutrons or other radiation.
13. Extensive and intensive storage of current and past personal and business information in high-speed centralized computer data banks.
14. Some control of weather and/or climate such as rainmaking, changing courses of hurricanes, and suppressing lightning.
15. New and more reliable educational and propaganda techniques for affecting human behavior - public and private.
16. Practical use of direct electrochemical communication between the brain and a computing machine so that the brain can control machines and vice versa.
17. Cheap and widely available war weapons and weapon systems.
18. Other genetic control and/or influence over the "basic makeup" of an individual.
19. Prolonging of life, postponement of aging, and limited regeneration of organs and limbs.
20. Greater acceptance and consumption of artificial foods and beverages, such as carbohydrates, fats, proteins, enzymes. vitamins, coffee, tea, cocoa, and alcoholic beverages.
21. More extensive use of transplantation of human organs.
22. Permanent manned satellite and lunar installations-interplanetary travel.
23. Application of space life systems or similar techniques to terrestrial installations.
24. Permanent inhabited undersea installations and perhaps even colonies.
25. Extensive use of robots and machines "slaved" to human beings.

26. Underground tunnels for private and public transportation and other purposes, such as a tube-craft system that permits travel at speeds of 14,000 miles per hour.
27. Automated instantaneous credit, audit, and banking systems.
28. Chemical methods for improving memory and learning, such as "knowledge" pills that transfer learning.
29. Widespread deep freezing, supercooling techniques, especially for storing living tissue and organs.
30. Improved chemical control of some mental illnesses and some aspects of senility.
31. Mechanical and chemical methods for improving human thinking more or less directly.
32. Inexpensive and rapid techniques for making tunnels and underground cavities in earth and/or rock, using high-speed electrons from particle accelerator.
33. Inexpensive high-capacity, worldwide, regional and local (home and business) communication using satellites, lasers, and thin glass fibers.
34. Other widespread use of computers for research and professional work such as translation, teaching, literature search, medical diagnosis, traffic control, crime detection, computation, design, analysis, and to some degree, as intellectual collaborator generally.
35. Space defense systems.
36. Maintenance-free, long-life electronic and other equipment.
37. Home education via video and computerized and programmed learning.
38. Common use of (long-lived?) individual power source for lights, appliances, and machines.
39. Extensive genetic engineering of plants and animals.
40. New and possibly very simple methods for lethal biological and chemical warfare.
41. Extensive use of biological processes, such as microorganisms, in the extraction and processing of minerals and energ production.
42. New methods of producing electricity, such as from magnetohydrodynamic generators that blow hot gas through a magnetic field.
43. Computers that talk as well as understand and respond to human speech.
44. Production of food proteins from wastes.
45. Automated conveyor belts or robots to deliver messages and packages in large offices.
46. Entire books printed on a single card-size sheet of microfilm.
47. Use of algae to generate hydrogen fuel from water and sunlight.
48. Offshore floating platforms to house nuclear power plants, airports, apartment houses, etc.
49. Use of algae to purify wastewater and produce paper.
50. Use of gels and microorganisms to clean up oil spills.

- Effects of Ocean Farming -

First Order Consequences

The intended effect(s): increase world food production significantly.

Second Order Consequences

The effects related to the technology:

Recognized and acceptable impacts: reduce malnutrition; new types of food products.

Unanticipated or accidental impacts: population increase; eating habits change; inland nations at a disadvantage.

Abuses of the technology: none identified.

High Order Consequences

Broad changes: need for greater cooperation among nations regarding the use of the seas; formation of international companies to farm the oceans.

* * * *

It should be noted that sometimes it is helpful to break down the various consequences into groups as was done with the "Second Order Consequences" above. In this case, the effects related to the technology were grouped according to "Recognized and Acceptable Impacts", "Unanticipated or Indirect Impacts", "Abuse of the Technology", etc.

Figure 12-2 shows a completed Worksheet in which all blocks or boxes were filled in. This completed sheet does not represent the only way it could have been filled in. Others might have thought of different consequences which, in turn, would have led to other entries in the worksheet (e.g., "Impacts in other areas," etc.).

— When the worksheets are completed, the group members will review the consequences and impacts of each of the four technologies they selected. Based on the results of the assessment, does the group still consider the selected technology desirable?

If not, the group should select another alternative and conduct another technology assessment. Remember, it is important that your technology be accepted by the World Review Court. Therefore, if the consequences and impacts have severe negative effects, your technology will be rejected, and you will be unable to achieve your goal.

— When the group arrives at its final decision, it will prepare a report describing each of the selected technologies and the changes that will occur. This report is, essentially, an argument in support of the technology and should demonstrate the beneficial changes that will result if the technology is adopted. The "Technology Assessment Worksheet" will serve as your information base.

The report to be presented to the World Review Court for each technology should take no more than 5 minutes. It should include information about how you will bring the technology into use, how it will be used, and why the technology should be promoted.

— Elect a member of your group to present the report to the World Review Court. It is recommended that each member of the group has an opportunity to report on a technology.

Figure 12-2

TECHNOLOGY ASSESSMENT WORKSHEET

What needs influence the development of the technology?
- farm land decrease
- population increase

What are the components of the technology?
- advanced fishing gear
- underwater sensors
- new food processing techniques
- ocean factories, electronic traps

Who will control the technology and who will benefit from it?
- ocean farming companies control nations

Technology Ocean farming

Give an example of its use Cultivating plankton and other small plants and animals and raising fish under controlled conditions (fish farming)

First order consequence — What is the intended effect(s)?
Increase world food production significantly

Second order consequences — What effects are related to the technology?
- reduce malnutrition - population increase
- new types of food products - eating habits change
- inland nations are at a disadvantage

Higher order consequences — What broad changes will occur?
need for greater cooperation among nations regarding use of seas - world sea court to resolve disputes - form international companies to farm oceans.

Impacts on Other Areas

Individual Health and Safety
- less starvation
- improved diets

Family Life
- father spends months out at sea
- change in dinner menus

Government and Laws
- disputes among nations over who had rights to use the oceans

Community
- people move to coastal towns to be close to jobs

Natural Resources
- habitat of existing sealife may be disrupted
- some species become extinct

Waste Disposal
- waste from the factories need to be treated properly

Workplace
- more jobs for fisherman and marine biologists
- reduce unemployment
- dangers of violent storms

Business
greater demand for seafood products
- enlarge fishing fleets
- boom in boat building

Energy Needs
- reduce need for petroleum to produce fertilizer

Environment
- coast becomes more crowded
- natural food chain may be disrupted

Industry
floating factories at sea

Part II

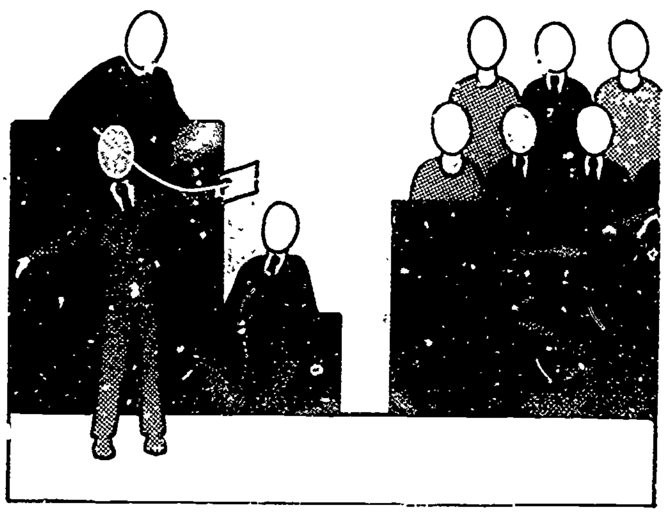
- World Review Court Hearing -

- The groups then present their selected technologies to the World Review Court. The Court will review the proposed technologies and make its judgments.

- The group with the greatest number of technologies accepted will have achieved its stated goals.

- The World Review Court will convene at its scheduled time. A chief judge is selected to preside over the proceedings. The entire class now assumes the role of World Court Judges. (The presentors of the technology assessment reports retain their group role when they give their report.)

The panel of World Court Judges is an impartial body charged with the task of evaluating the development of new technologies. As a World Court Judge you must now broaden your concerns from that of your interest group to that of the world-at-large. It is your responsibility that new technologies be developed wisely and justly. You must weigh each decision carefully after considering the benefits as well as disadvantages. A good question to ask yourself before making a decision is, "How will the new technology affect an individual's right to a safe and healthy environment?"



- The groups will rotate giving their reports. That is, a member of the first group will give one technology report and then a member of the second group will give one report and so on. The process continues until all 16 reports are heard.

- Each World Court Judge will receive an evaluation sheet, "World Review Court Evaluation Sheet" (Handout 10). This sheet contains the instructions for judging each technology and a record sheet. Review this form carefully before starting.

- After a report has been presented, the judges will decide whether or not that technology is acceptable. On the evaluation sheet are a list of objections. Review this list and decide if the technology is objectionable on any of these counts.

- **Raising an objection.** Any judge may raise an objection. When he/she is recognized by the Chief Judge, he/she will announce the objection and explain why the technology is undesirable. The panel of judges will vote on the objection:

  Yes for agreement; **No** for disagreement

- A proposed technology that receives two or more objections will not be accepted. If there are no objections, the technology is automatically judged as acceptable.

- The reports and evaluation will proceed as described until all 16 have been heard. At the conclusion of the hearing the list of accepted technologies will be read by the Presiding Judge.

— The interest group with the most technologies accepted is declared the group which has successfully accomplished its goal.

Discussion Questions

After completing the presentations and deciding which of the four groups has met its goals, discuss the following questions before proceeding on to Part III of the simulation.

— Which group was most successful in achieving its goals? Why do you suppose its technologies were accepted?

— Do you think that the technologies accepted were the most important ones? What are your reasons?

— How would you categorize the technologies that were accepted? Labor-saving devices? New materials? High-speed communication and travel? More powerful tools? Food production technologies? Others?

— What values were held as most important by the judges? Was there much disagreement between judges? In what areas was there greatest disagreement?

— Are there groups of people who will benefit more than others from the technologies?

— Are there technologies on the list you selected which are in conflict with others? That is, is it possible to promote all the technologies and not be counterproductive?

— How will life-styles change with the new technologies? What are your predictions?

— Is there any possibility that the selected technologies might be misused?

— Will society have to change dramatically in order to adapt to the new technologies? Is this desirable?

Part III

- Discussion of Results and Scenario of the Future -

The class will discuss the results and conclusions of the

simulation activity and write a scenario of the future.

Since you have devoted much effort and thought to this simulation, you will now have an additional opportunity to express your ideas and feelings about future technologies. The class discussion also serves to summarize some of the major ideas introduced during the course of the activity.

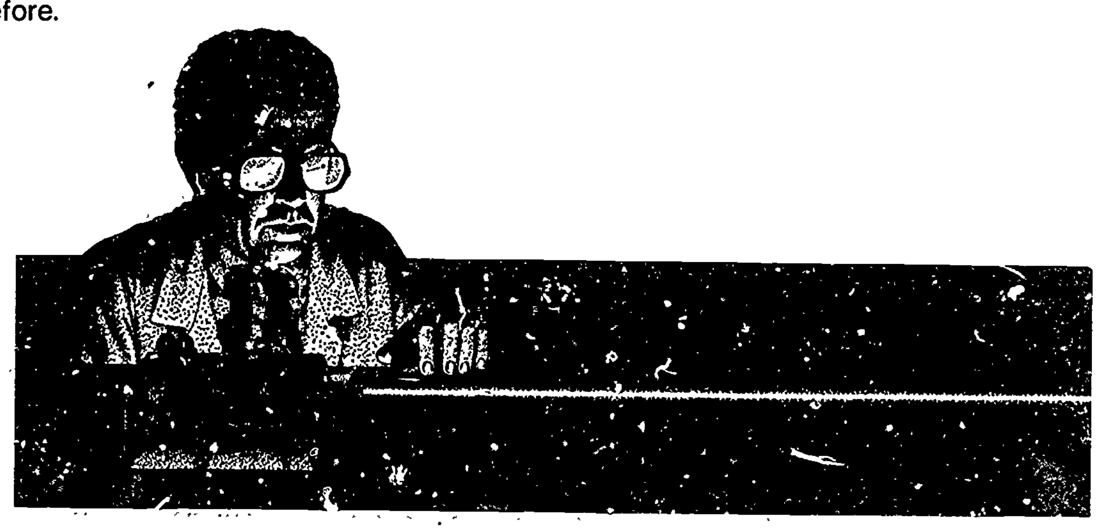
Scenario for the Future

In small groups or individually, write a scenario describing the future. That is, how do you envision the world of the future which has developed the technologies that you proposed? What major changes will occur and what are the effects?

Writing a Scenario

The term "scenario" was used to describe a type of comedy play developed by medieval Italian actors. The scenario was the written plot but contained no set dialogue. The actors simply improvised the dialogue when they acted out their roles as outlined. In the motion picture business scenarios have come to mean a plot, a screenplay or the script.

In more recent years the scenario has acquired a new meaning. It describes a tool/technique used by planners, futurists, businessmen and other types of decision-makers to help them examine a future possibility in greater detail. The scenario serves as an interesting, flexible and creative way to project into the future and explore possibilities and different alternatives. It is, in essence, a story describing a future event. Scenarios examine the series of steps leading to a future goal or investigate effects of different decisions. They help the writer or policymaker to make better decisions because they force him/her to consider how changes interact with other changes in a more dynamic manner, through descriptions of the effects and consequences of the future possibilities. By working out the details of the interaction, the future situation becomes clearer, and one can begin to identify relationships that have not been considered before.



When writing a scenario, one typically begins by asking the questions, "What if..?" One possible change leads to other changes and the scenario story unfolds. Your scenario can be presented in a number of different ways: a science fiction story, a short skit, a planning diagram, visionary drawings, a cartoon story, or even a simple outline of events. The main purpose is to explore alternative possibilities and show where they might lead. It allows you to test the different underlying assumptions and values of a future goal.

In this scenario-writing exercise you will expand upon the ideas that emerged from your technology assessment and speculate about the world of the future which has applied the technologies selected by the court.

- Will it be a world in which you will enjoy living?
- What are the many changes that will come about and what types of adjustment will you need to make?
- How does one technology affect other technologies?
- Will all the changes be beneficial?

Your scenario will help you evaluate the decisions you made as World Review Court Judges.

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