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ABSTRACT

The collection of vignettes in this book provide science teachers with a multitude of source materials and useful alternatives for incorporation into their curricula and teaching. Teachers may select topics as brief issues for casual reflection or as a means for promoting deeper investigation and analysis. Most of the vignettes can be extended and adapted into a repertoire of classroom strategies which will promote the integration of content and societal issues. Considerations to be aware of in the process of creating moral dilemmas and conducting classroom discussions are included. General biology, the environment, populations, destruction of species, bioethics, general chemistry, waste, pollution, natural resources, mechanics, heat, light, sound, electricity, radiation, nuclear energy, energy conservation, earth and space science, computers, misconceptions, history of science, government policy, economics, and desirable inventions are topics included. A list of quotations, a sample moral dilemma, questions, and student projects are appended. (KR)

VALUES IN SCHOOL SCIENCE

Some Practical Materials and Suggestions

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Foreword

A THEORY OF MORAL DEVELOPMENT

Eminent national organizations are acknowledging what science teachers have known for a long time: that today's science curricula are "overstuffed and undernourished" (AAAS, 1989; p. 14). Moreover, criticisms levelled at our present science textbooks, curricula, and teaching practices claim that traditional approaches have actually impeded growth toward scientific literacy by emphasizing memorization of isolated bits of information rather than fostering critical thought and the free exchange of different ideas. To meet such criticisms as these, the American Association for the Advancement of Science has recently initiated Project 2061, a task force designed to promote the goal of scientific literacy for all Americans as we move into the next millenium. While the idea of promoting scientific literacy is not new, the public recognition that needless redundancy in many school curricula preempts the teaching of other areas of greater societal and technological importance is rather novel.

For the necessary educational reforms to become effective the AAAS (1989, p. 5) advises that we must be willing to:

-reduce the sheer amount of material covered.
-weaken or eliminate rigid subject matter boundaries.
-pay more attention to the connections among science, mathematics, and technology.
-present the scientific endeavor as a social enterprise that strongly influences-- and is influenced by-- human thought and action.
-foster scientific ways of thinking.

The present book is intended to address all but the first of these goals and to foster reflective student thought and reasoning skills in a unique way.

Many conscientious teachers recognize these goals, and over the years numerous programs and modules have been developed which address them. It is very tempting to purchase and to use these intact units in our classes and to feel that we have done our part to remedy the problems. Welcome on another bandwagon!

The problem with many "prepackaged" programs is that when the novelty wears off, we are still confronted with the job of getting students into the habit of individually and collectively thinking and reasoning critically for themselves. Here is one reason many programs fall short of their mark. Even when we present a highly structured but nevertheless well thought out program we often only succeed in making a quick fix. The problem of getting students to deal with issues in a manner that will foster the development of individual reasoning skills and autonomous reflective thought still remains.

Perhaps more important, as science teachers move to incorporate more societal and ethical issues and to discuss their "value implications" they are prone to unwittingly convey the idea to their students that <u>any</u> value a given society derives for itself is appropriate for that society, and hence that any of the values students select for themselves from their own culture are fundamentally equivalent. Such a relativistic approach reflects an error in thinking referred to in the literature as the "psychologist's fallacy" or the "naturalistic fallacy" and arises when we try to form ethical imperatives (what <u>ought</u> to be) from factual observations of human and social nature (what <u>is</u> currently the case). Thus, we may observe that a society does X, or people tend to act in a certain way, and fail to ask ourselves, "But is this desirable?" Failure to ask this question slides over the distinction between "what is" and "what ought to be".

We must be very careful, then, of "quick fix" approaches and programs. As science teachers facing a new generation of goals and concerns we need to become better informed as to how we can effectively present value-laden social and technological issues. While the ideas presented later in this manual are sufficiently flexible that they can be adapted to the needs of most teachers of conventional introductory science courses, it is still true that teachers must use judgment and creativity in incorporating these ideas in a sensible manner, and the remainder of this introduction is devoted to presenting a "starter set" of teaching strategies to help them to do so.

<u>A Developmental Approach</u>

In contrast to doctrinaire approaches which define morality in terms of fixed rules and virtues

taught by inculcation and reinforcement, and in contrast to values clarification approaches that view values as completely relative, neither correct nor incorrect, the developmental approach to moral education is guided by the view that the child is an active constructor of knowledge who progresses through a succession of increasing psychologically and philosophically robust stages of moral reasoning. The developmental approach to moral education attempts to avoid the arbitrary norms of society and the naturalistic fallacy by coordinating philosophical principles of human actions and values with the stages of natural growth and moral development.

Arguably the most comprehensive theory of moral development to date that has contributed to useful classroom strategies is the work of Lawrence Kohlberg. Kohlberg has expanded the cognitive-developmental work of Piaget to build a stage theory of how children develop the capacity for moral reasoning. It is pedagogically important for science teachers to have an appreciation of the characteristics of these stages of moral reasoning to ensure that their teaching strategies (when discussing moral and ethics-related science topics) are consistent with the moral growth stages of their students, just as knowledge of cognitive development permits us to organize and present our science lessons in such a way as to facilitate the intellectual growth of our students. Therefore, a brief introduction to Kohlberg's moral development stage theory is warrented.

Kohlberg's Theory

Unlike other theories of moral growth which are dependent upon culture-specific experiences, Kohlberg has advanced the concept of a series of universal stages of children's development. By observing that children's reasoning about ethical problems follows predictable patterns of developmental growth he has shown that moral reasoning is based on specific features of thought processes throughout different stages of development, and reflects the child's interpretation of rules and principles in conflict situations. These stages progress in a sequential, invariant, and hierarchical fashion. Kohlberg advances the claim that each stage is more philosophically adequate than the previous stage. That is, each higher stage better fulfils such criteria as impersonality, ideality,

universalizability, and preemptiveness. Hence there is a parallelism between the developing psychological stages of a child's development and the formal philosophical justification for their evolving moral standards. It is this psychological and philosophical consistency that serves as a developmental framework for the teaching of moral and ethical issues in the classroom.

The table at the end of this Introduction outlines these stages of moral development. As can be seen there, the earliest, or preconventional, stages are dominated by egocentric reasoning. The child's focus is purely on advancing his or her own needs by directly self-serving actions. In the subsequent, conventional, stages (preadolescence-adolescence), a child's moral reasoning begins to shift toward others who are immediately important to his or her person (family, friends, teachers, etc.) and, based on stereotypical images of proper conduct, attempts to gain their approval. The latter part of the conventional level is marked by an orientation toward fulfilling fixed social rules and duties and to maintaining social order. Finally, the postconventional level of moral reasoning (adolescence-adulthood) is characterized by a change in reasoning ability that encompasses a contractual, legalistic view of due process, a utilitarian concern for social justice, and a respect for universal ethical principles.

It is important to note that Kohlberg's model is in alignment with the formal criteria of cognitive developmental theory (increasingly complex differentiation and integration of stages). Moral development, then, occurs along a parallel path in juxtaposition to but distinct from cognitive development. Research has revealed that cognitive development is a necessary but not sufficient condition for moral growth. For example, formal operations in the cognitive domain are needed by a child in order to function at the stage of postconventional <u>moral</u> reasoning; but the ability to do so does not ensure that postconventional <u>logic</u> will take root. Research also reveals that individuals tend to prefer the highest stages of reasoning available to them (although they are not likely to utilize those stages in most situations) and are inclined to align their reasoning with those individuals who are slightly more developmentally advanced. This implies that the

science teacher's role is to ensure that conditions conducive to moral growth are available to their students.

The following section addresses how these ideas may be incorporated into the science classroom through the use of carefully selected issues in science-technology-society (STS).

Strategies for using STS Vignettes

The collection of vignettes (or "items") in this book provide science teachers with a multitude of source materials and useful alternatives for incorporation into their curricula and teaching. Teachers may select topics as brief issues for casual reflection ("food for thought") or as a means for promoting deeper investigation and analysis. The latter will require a certain amount of forethought and planning, but the creative teacher will find that most of the vignettes (or "items") can be extended and adapted into a repertoire of classroom strategies which will promote the integration of content and societal issues. One example of this approach is presented in the Appendix, p. but in whatever way they happen to be used there are some important considerations to be aware of in the process of creating moral dilemmas and conducting classroom discussions.

Effective dilemmas have plausible but competing claims with no clear social norms governing their resolution nor any basis of content or context relevant to the students' lives. Ideally, the classroom climate should be constructed so as to provide the following elements of experience: role-taking opportunities, intellectual stimulation, responsibility, cognitive-moral conflict, peer interaction, and a democratic communicative environment.

Typically, teachers who successfully develop their own "tailor-made" dilemmas recognize the importance of including five main elements: (1) The dilemma should have a major focus which is related directly (or at least indirectly) to the course content, life experiences (present or future) of the students or some realm of social significance. (2) Ideally the dilemma should clearly delineate a central character(s) or a primary group(s) of people who are

confronted with two or more competing claims or conflicts. (3) The main characters have been placed in a situation that necessitates a choice. These characters are confronted with the problem of having to choose among competing claims, mutually exclusive decisions and conflicts of interest that have no clearly discernable socially acceptable answer. (4) Effective dilemmas usually center on one or more moral issues or common moral values that are important to persons resolving the problem. Moral issues commonly confronted include punishment, property, roles and concerns of affection, roles and concerns of authority, law, life, liberty, distributive justice, truth, and sex. (5) Finally, effective dilemmas should include probes which the teacher, as a facilitator, should be prepared to implement at various times. Some of these probes are (1) clarifying probes - to make sure what kind of reasoning is being conveyed; (2) general probes - used to elicit responses about the dilemma; (3) issue-specific probes - used to focus students' attention on a specific issue; (4) stage-higher probes - used to confront a student with a problem that cannot be adequately solved at his or her predominant stage of moral reasoning; (5) role-taking probes - used to encourage students to make claims based on the perspective from a different moral dilemma than the one at hand. It is important that many of the probes be aimed at eliciting prescriptive judgments from the students ("What should X do...?", rather than "What would X do...?) and require that students justify their responses so as to reveal the logic behind their reasoning.

These suggestions are illustrated to a degree in the cited example in the Appendix. Following its example, the vignettes provided in this book can be adapted in a variety of ways to provide a powerful tool for incorporating societally and ethically based issues into introductory science courses at all grade levels.

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TABLE OF MORAL STAGES OF REASONING

I. Preconventional level
At this level, the child is responsive to cultural rules and labels of good and bad, right or wrong, but interprets these labels either in terms of the physical or the hedonistic consequences of action (punishment, reward, exchange of favors) or in terms of the physical power of those who enunciate the rules and labels. The level is divided into the following two stages:

Stage 1: *The punishment-and-obedience orientation*. The physical consequences of action determine its goodness or badness, regardless of the human meaning or value of these consequences. Avoidance of punishment and unquestioning deference to power are valued in their own right, not in terms of respect for an underlying moral order supported by punishment and authority (the latter being Stage 4).

Stage 2: *The instrumental-relativist orientation*. Right action consists of that which instrumentally satisfies one's own needs and occasionally the needs of others. Human relations are viewed in terms like those of the marketplace. Elements of fairness, of reciprocity, and of equal sharing are present, but they are always interpreted in a physical, pragmatic way. Reciprocity is a matter of "you scratch my back and I'll scratch yours," not of loyalty, gratitude, or justice.

II. Conventional level
At this level, maintaining the expectations of the individual's family, group, or nation is perceived as valuable in its own right, regardless of immediate and obvious consequences. The attitude is not only one of *conformity* to personal expectations and social order, but of loyalty to it, of actively *maintaining*, supporting, and justifying the order, and of identifying with the persons or group involved in it. At this level, there are the following two stages:

Stage 3: *The interpersonal concordance or "good boy—nice girl" orientation*. Good behavior is that which pleases or helps others and is approved by them. There is much conformity to stereotypical images of what is majority or "natural" behavior. Behavior is frequently judged by intention—"he means well" becomes important for the first time. One earns approval by being "nice."

Stage 4: *The "law and order" orientation*. There is orientation toward authority, fixed rules, and the maintenance of the social order. Right behavior consists of doing one's duty, showing respect for authority, and maintaining the given social order for its own sake.

III. Postconventional, autonomous, or principled level
At this level, there is a clear effort to define moral values and principles that have validity and application apart from the authority of the groups or persons holding these principles and apart from the individual's own identification with these groups. This level also has two stages:

Stage 5: *The social-contract, legalistic orientation*, generally with utilitarian overtones. Right action tends to be defined in terms of general individual rights and standards which have been critically examined and agreed upon by the whole society. There is a clear awareness of the relativism of personal values and opinions and a corresponding emphasis upon procedural rules for reaching consensus. Aside from what is constitutionally and democratically agreed upon, the right is a matter of personal "values" and "opinion." The result is an emphasis upon the "legal point of view," but with an emphasis upon the possibility of changing law in terms of rational considerations of social utility (rather than freezing it in terms of Stage 4 "law and order"). Outside the legal realm, free agreement and contract is the binding element of obligation. This is the "official" morality of the American government and Constitution.

Stage 6: *The universal ethical-principle orientation*. Right is defined by the decision of conscience in accord with self-chosen *ethical principles* appealing to logical comprehensiveness, universality, and consistency. These principles are abstract and ethical (the Golden Rule, the categorical imperative); they are not concrete moral rules like the Ten Commandments. At heart, these are universal principles of *justice*, of the *reciprocity* and *equality* of human *rights*, and of respect for the dignity of human beings as *individual persons*.

(From Kohlberg, 1971, pp164-165)

Introduction

HOW TO USE THIS MATERIAL

There nas always been widespread desire among school science teachers to show the relevance of their course material to their students' daily lives and to the great social issues of the community and the world. Within the past decade, as the works of science have become a more integral part of society than ever before, the desire to show this relevance has grown more fervent, and numerous teaching units and courses have been devised to address the need. For the teacher of a conventional school course in chemistry, physics, or biology, however, nearly all of the material has a serious drawback: it consumes too much time in an already overcrowded syllabus or curriculum.

Besides the shortage of available time, teachers who wish to raise societal or ethical issues in their classes report additional reasons for failing to do so. Among them is their often-inadequate knowledge of the facts surrounding debatable issues and a lack of usable material in print.

The following collection of short vignettes or "items", is intended to overcome these objections. To the degree that it is successful it will enable a teacher, however hard-pressed and ill-informed, to add an undercurrent of concern for the societal and ethical aspects of many of the topics studied in even the most crowded courses in chemistry, physics, and biology. Moreover, showing how a topic affects their personal lives-- or great world issues-- as so much of the following material does. cannot help but motivate interest in many students.

These may seem to be ambitious goals. Yet, at somewhat greater expense of class time, additional objectives can be added. The questions at the end of most topics and the various activities questions toward the end of the collection are intended to press students to exercise their critical reasoning skills in assessing complex issues and, in doing so, to develop their ability to recognize and to make value judgments. If these activities excite the interest of some students, then, for them, even more time-consuming special projects are suggested which relate conventional topics in the course to issues and activities of social significance. But at this level of time consumption there are numerous excellent units already available elsewhere which aspire to the same

purpose. The essential feature of the the present material is its brevity in practical use.

The ideas in the collection are potentially useful to teachers of introductory science at any grade level from the elementary grades through college. The wording of the ideas is addressed to teachers and is intended to suggest a way in which they can present the ideas orally or in print. The questions, factual background, and reading references may be useful too, but a major goal has been to keep them all brief. It's the brief presentation of an idea by the teacher that is central to each "item" in the collection.

This very brevity helps to resolve the objection that the teacher is not trained in the subject matter of the item, for unlike the long modules presently in print which require careful teacher preparation and study, our short items require none whatever. The teacher is not the expert. Teachers and students are on a common footing in facing a question that has no right or wrong answer. Indeed most of the questions raised have no right or wrong answers, and even the choice of the least unpleasant resolution often requires more knowledge than a busy teacher or student can ever hope to master. This, we suggest, is as it should be, for it is precisely such open-ended "no right answer" questions which constantly confront us as adults, taxpayers, voters, and consumers; it is for that adult world full of ambiguity that we hereby prepare our students.

* * * *

The following material consists of a number of short "items" which require, then, little or no class time or teacher preparation. In preparing them we have been guided by several considerations.

For an item to be useful it must be relevant to a specific topic in a conventional first-year chemistry, physics, or biology course. While this excludes many issues of immense societal importance, the intent of our items is to enhance the teaching of our present conventional course topics, not to distract from them. As an ideal, one can imagine at least one item for every single topic.

For an item to be useful it should relate to a youngster's immediate world or to an issue which can claim appeal to his imagination. We avoid issues which, however important, elude immediate recognition, and we seek items which will provoke thought and stick

in the mind. They can be amusing, puzzling, startling, or paradoxical as well as serious.

For an item to be useful it should require thought leading to a choice or a decision. Merely to evoke a "gee whiz" is not enough. The question that is posed should be capable of being dealt with at the level of a high school student's background. Nor should an item merely identify the important societal effects of a scientific principle. There must be a value-laden problem or issue at stake demanding the intellectual as well as the emotional participation of the student.

Not all items manage to meet all three of these requirements, but they all meet at least two of them. The sources of some items are noted, but no effort has been made to document each one since we have tried to keep each statement brief and to limit to quoted sources to those most readily available. It's the idea that is important; follow-up is distinctly secondary.

* * * * *

There is a variety of ways of using this material in class.

Many of the items involve a statement, an interest "grabber", typically supported by more information than a teacher may care to use, and followed by suggestive questions that are intended to relate the "grabber" to the students' lives. Teachers hard-pressed for time-- and that includes most of us-- will look through the collection, identify an item appropriate to the coming lesson, and simply state it at the appropriate moment as a "motivator". Time required: rarely more than a minute. Stop there! The subsequent questions can be rhetorical in the interest of saving time or omitted altogether. Ideally we would wish for such a motivator for every topic and for every day. It is the repetition of provocative ideas and questions that counts.

Some critics object that such brevity, requiring no response from the student, means that the student will be unmoved and unaffected. Doubtless some, even many, will be unaffected at one time or another. But the contrary is also surely true, or else the entire multi-billion dollar American advertising industry-- which operates on this same basis-- is badly misconceived. While advertising is not education in the best sense, it does create awareness and shape attitudes. Surely, at the hands

of experienced teachers a comparable technique can do at least that.

Field-trial teachers report that they often used this quick-reference approach but found it helpful to allow class discussion occasionally. They report that 5 to 15 minutes, perhaps once a week, is effective in reinforcing the effect of the quick references and in giving additional motivation to a new topic. Typically, they report that they have to resist the class desire to devote excessive time to such discussions. Not surprisingly, they also noticed a pronounced increase in the sophistication of response of students in the upper grade levels and an increasing inclination to react to the material even when stated in its briefest form.

Teachers also report that as successful alternatives to class discussion they have:

-offered students extra credit for an essay or brief report on a topic
-predicted an extra-credit question on the next quiz
-formed small groups to role-play opposing views on a question.

In addition to these more time-consuming procedures we offer in the latter part of this collection a variety of student activities that derive directly from some of the preceding items in the collection. In no sense are they complete. They are intended to suggest ways the teacher can extend the usefulness of the items that have proved to be effective.

In its present state much of the material becomes out-of-date with dismaying rapidity. Thus, by its very nature its usefulness will be determined not only by the items that are used from this book but also by the number and effectiveness of items improvised by teachers and their students attentive to small and to timely local issues as well as to the larger questions addressed in this collection.

The collection has already been immeasurably improved by the advice and support of a number of people. Particularly C. Arthur Compton, Dudley S. Taft, Andrew A. Polychronis, and David Walker, my colleagues in the Phillips Exeter Academy Science Department have been unfailingly helpful in countless ways; Dr. James T. Heyl of Exeter Family Medicine gave advice on medical matters. Clarke Brinckerhoff, lawyer/engineer,Avon, Conn. read the material on legal

questions; Prof. Channing B. Richardson, Department of Politics, Hamilton College gave advice on questions involving public and international affairs, and David P. Herron of Stanford Research Institute made helpful suggestions on the material on industry and risk. Irma Jarcho at the Walden-New Lincoln School in New York City was an inspired and unfailing source of cartoons and "item" material. To all of them and to those numerous teachers who responded helpfully to the Second Edition goes my warmest thanks for authoritative counsel and support cheerfully given. Blame for any errors goes to none of them. That must be mine.

The author hereby exhorts all users of this collection to send him copies of items they consider to be successful and to report on their classroom experience so that the collection can be improved and become still more useful to hard pressed teachers of introductory science at all levels.

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BIOLOGY

Definition of "life"

Biologically, when does a cat's life begin? At conception? At birth? Somewhere between? Biologically, at what moment did your life begin? At the same stage as a cat's? Legally, at what moment did your life begin? Does such a legal definition establish a parent's right to the abortion of (a) a healthy but unwanted child? (b) a child proved to have a serious incurable defect? When do parents' moral obligations begin-- at the beginning of life as defined by biology or by the law?

Consider the recent case of an anencephalic child. The doctors (with the parents' consent) removed the heart for another child in critical condition awaiting a heart transplant. Even though the child with anencephaly still had brain wave patterns (and was therefore still alive?), no anencephalic child has ever lived beyond a few days. The question is: Was this murder or not?

Biologically , at what moment does death occur? When breathing stops? When the heart stops beating? When brain waves cease? Somewhere between? Legally, at what moment is someone considered to be dead? Is it the same moment? Does this legal definition establish a family's (or a doctor's) right to end the life of a victim dying slowly of a painful incurable disease?

If you had the power to do so would you completely destroy all (a) HIV (AIDS) virus?, (b) mosquitoes, (c) poisonous snakes, (d) weeds?

Mitochondria and human origins

Were Adam and Eve Chinese?

The mitochondria in the cells of your body have their own DNA which is simpler than the double-stranded DNA in the chromosomes. The strands of mitochondrial DNA can be broken into fragments by various enzymes. The fragments from a particular ethnic group of people are all the same, but fragments from different ethnic groups (e.g. Papago Indians, Western Europeans, Eskimos, African Bushmen) are demonstrably different as a result of mutations incurred by their many ancestors over long periods of time in the past. The longer the time elapsed, the more the DNA fragments of any two groups are found to differ from each other. Working backwards, it appears that all the ethnic groups studied so far have common ancestors who lived in Asia between 50,000 and 100,000 years ago. From the study of fossils, that period of time has been determined to be the time during which modern man, Homo sapiens sapiens, originated-- a time before diverse ethnic groups existed. (Scientific American, Science for the Citizen, May 1985, p. 84)

Thus, all of us are related! In addition to our all belonging to the same subspecies is there any other sense in which you can think of the term, "The Family of Man"?

Dollar value of a human life

In dollars, how much money is your life worth? Or your neighbor's? Is your answer determined by a human being's responsibilities? By their contribution to the economy or to society? By sentiment? This is not just a theoretical question.

In the process of transforming coal into coke for use in making iron and steel a mass of coal is heated to over 2000 degrees F for up to 16 hours. The coal gives off hydrocarbon gases known to cause lung cancer. The remedy is clear and effective-- engineering improvements and changes in work practices

that steel industry experts say would cost about $200 million every year. As nearly as can be estimated, the changes would save 109 lives a year plus untold human suffering.

At one of the hearings of the Occupational Health and Safety Administration considering such remedies it was argued that the remedies would cost between $1 million and $9 million per worker saved. Since each worker was destined to earn only $200,000 to $500,000 in his career the cost of the controls outweighed the benefits, and therefore, it was argued, nothing should be done.

For another example, if it would cost auto manufacturers $90 million to install improved bumpers which will save 100 lives per year, is it worth doing? If each life is valued at $1 million, that is a saving of $10 million, so on a strict cost-accounting basis it is worth it.

In theory such an approach helps industries, government agencies, and the courts decide issues affecting loss of human life. For example, the Environmental Protection Agency puts the value of life between $475,000 and $8.3 million. The Federal Aviation Agency assumes $1 million, while the Consumer Product Safety Commission puts it at $2 million.

If you are horrified by this, then how do you decide how much a human life is worth when health and safety legislation is being written or legal damages being determined? As a regulator or a judge you must decide even if your decision is to do nothing. As examples of cases requiring decisions, consider whether it would be cost effective:

-to maintain crash fire trucks at small airports.

-to prolong the expensive safety testing of a new drug.

-to pay for the regular inspection of the nation's 565,000 highway bridges, half of which (according to the National Highway Traffic Safety Administration) are potentially unsafe.

-to close a copper smelting factory (in Tacoma, Washington in 1983) with the certain loss of 800 jobs or to accept the uncertain but demonstrated risk of lung cancer from arsenic in the air resulting in about one death per year.

-for an airline to lower the age of retirement of the aging airliners in its fleet when one crash occurs.

Debating dissection

Should a biology student be required to take part in animal dissections?

In a recent case in New Jersey a 17-year-old high school student refused to dissect a cat in biology class. In defence of his stand he said, "I think dissection just reinforces the idea that animal life is cheap. I feel it's an inherently objectionable thing to do."

But a past president of the New Jersey Science Teachers Association held an opposite view. He argued that dissection has importance and value and that no textbook could compare with the hands-on experience dissection offers.

How would you have resolved this conflict?

(From "Debating Dissection", F.B. Orlans. The Science Teacher. Nov. 1988, p. 36).

Hypothermia

Would you accept the benefits of a murder?

During World War II Nazi concentration camp doctors mutilated and murdered hundreds of inmates in the name of science, for example, immersing people for extended times in ice water to study their body functions and chemistry as they died. Their research reports, published in German medical journals at the time, are still available in many medical libraries and are of possible use to doctors today who are studying hypothermia, the extreme lowering of body temperature. Is it right to use such data known to be accumulated in the course of deliberate murder?

Some scientists say we should remember those who died and not try to squeeze profit of any kind out of it. Others say it serves no purpose to ignore knowledge that could be used to help people. (New York Times, May 21, 1989, p. 34).

Iodine, thyroid cancer, and risk analysis

In the event of a nuclear power plant meltdown the emission of radioactive iodine, I-131, would be a major cause of thyroid cancer in the exposed population nearby. But ordinary non-radioactive iodine in the form of potassium iodide binds equally well to the thyroid gland, and, if eaten before exposure to I-131, it excludes the cancer-causing I-131 and therefore provides protection from it. Apart from skin rash and swollen mucous membranes KI is harmless, and it's cheap.

It is reasonable to expect if half the population exposed to I-131 gets thyroid cancer that only 5% will get it if the needed supply of KI is available and distributed beforehand to protect the public.

Moreover, if you distribute KI you reduce the panic and casualties to be expected during evacuation after a meltdown.

Do you think it is a good idea to distribute KI to the population around a nuclear plant and instruct people in its use? Here is a good place to exercise risk analysis, for in spite of arguments to do so, KI is <u>not</u> generally distributed. Why might this be so?

If you could have known in 1942 what the release of atomic energy was going to mean to the world since then, pro and con, would you have voted to unleash the first nuclear fission reaction in Chicago.

Let's explode a nuclear device on the moon or an asteroid to find out what is inside it. Good idea? Why?

Daily hazards to life and health

When you know some things can kill you, how do you choose among risks to your life and health?

The general public smokes billions of cigarettes a year while banning an artificial sweetener because of a one-in-a-million chance that it might cause cancer. The same public eats meals full of fat, flocks to cities prone to earthquakes, and goes hang gliding while it frets about pesticides in foods, avoids the ocean for fear of sharks, and breaks into a cold sweat on airline flights.

Do any of these actions make good sense?

By broad statistical measures Americans have never been safer. . Life expectancy at birth in 1986 was 74.8 years, up a full four years since 1970, largely because of a dramatic drop in deaths from heart disease and strokes.

Provably, coal-generated electricity costs thousands of lives a year through mining, transportation, and pollution, yet a majority of the public prefers it to nuclear-generated electricity. Should the American public have a say about the risk of nuclear power which has claimed, by one estimate, only three lives in accidents in the last 30 years and yet does not have the sense to wear seat belts in automobiles which regularly kill close to 45,000 Americans every year?

Do you base decisions on such matters solely on the number of deaths, injuries, and damage, or are there other important but hard-to-quantify feelings and values you need to consider in making a risk decision? If so, when should they prevail? (See item: Risk, p. 172.

Trying to measure the risks from various presumed hazards to daily life, Richard Wilson, a physicist and acting director (1980) of the Energy and Environmental Policy Center at Harvard used the best evidence available at that time to calculate the level

of exposure that increases your chance of death by one part in 1 million (which reduces your life expectancy by eight minutes).

From cancer:

Smoking 1.4 cigarettes
Living two months with a cigarette smoker
One X ray in a good hospital
Eating 100 charcoal broiled steaks
Eating 40 tablespoonsful of peanut butter
Living 20 years near a polyvinyl chloride plant
Living 150 years within 20 miles of a nuclear power plant
Crossing the ocean by air (from cosmic rays)
Visiting for two months in Denver (from cosmic rays).

From accidents:

Travelling 1000 miles by air
Travelling 150 miles by automobile
Working three hours in a coal mine
Rock-climbing for 1.5 minutes

(From "Staying Alive in the 20th Century", W.F. Allman, Science 85, October 1985, p. 29).

Tobacco

Nicotine, the drug in tobacco, is as addictive as cocaine or heroin. Tobacco claims four lives every minute in the U.S. (350,000 per year), which is more Americans than were killed in all of World War II. Illegal drugs, by contrast, kill only an estimated 10,000 annually, though the social costs are immeasurably higher. Worldwide, smoking kills roughly 2.5 million people each year.

Ironically, while the U.S. contemplates imposing sanctions on Latin American countries that export cocaine and heroin to us, our government and the cigarette industry are collaborating to increase exports of our own drug, tobacco, to them!

Should tobacco companies be free to advertise their wares without restriction here and abroad? Remember that cigarette sales abroad are a significant factor in reducing our trade deficit. Would you approve if it were shown that somehow tobacco was killing baby seals?

(See item: Pesticide Pollution, p. 37.
See also "Unhealthy Alliance", L. Heise. Worldwatch Magazine, Sept.-Oct. 1988).

Science is an important component of much of the legislation before the U.S. Congress each year. Why shouldn't congressmen be required to show that they have had (and passed) some high-school level science courses before they take office?

Should the deep ocean be considered an option for hazardous (radioactive or toxic) waste disposal? How about shooting it into space?

Drugs and sports technology

Is winning worth it?

As sports medicine and sports technology become more sophisticated they improve an athlete's performance. Do they also de-value it? Certainly they raise questions. For example:

-Is there a moral difference between taking energy-giving glucose pills and taking an anabolic steroid that increases muscle mass in order to improve performance?

-If drug use is immoral, how about taking a drug that deadens the pain of an injured foot? If that's O.K., how about taking a drug that does nothing but increase aggressiveness?

-If introducing foreign substances into the body is wrong, how about the Olympic cyclist who, in mid-race, had a reinfusion of his <u>own</u> blood that had been drawn several weeks earlier when he was "fresh", and his red cell count was much higher?

-If attempts to alter the body's chemistry are immoral, how about taking vitamins during training and invoking the science of nutrition to suggest special diets?

If it was wrong to try to alter the athlete's body chemistry, how about improving his equipment? For example:

-Graphite- and boron-based tennis racquets and fishing rods are far lighter and stronger than earlier styles.

-Lightweight body protection for football players has reduced the rate and severity of injuries.

-Nylon rope and new strong lightweight alloys are making rock climbing safer and making more difficult climbs possible.

How does your school athletic coach respond to these questions?

Note that people climbing Mt. Everest commonly use oxygen. And at least half of the 9000 athletes who competed at the 1988 Olympics in Seoul, Korea, used anabolic steroids in training, according to estimates by medical and legal experts.

Inherited disease

Do you really want to know what you are going to die of?

As scientists learn to identify ever more minute defects in your DNA it becomes increasingly practical to tell whether you have already inherited a debilitating (or even fatal) disease or tendency such as schizophrenia, heart or kidney disease, anemia, or Huntington's disease which may kill you.

20,000 Americans are afflicted with Huntington's disease, an incurable and particularly cruel genetic disease that only manifests itself when its victims have already produced children of their own. Since the gene for Huntington's is dominant, each child of an afflicted parent has a 50-50 chance of inheriting it. Recently DNA research has led to an ability to identify which children will be stricken and face a lingering early death and which children will not-- usually between the ages of 35 and 50.

If your parent had Huntington's, would you take the test? (Two thirds of a sample of 36 such people said they would).

If you find you have inherited the defective gene, should you have children?

If you already have children, should you tell them?

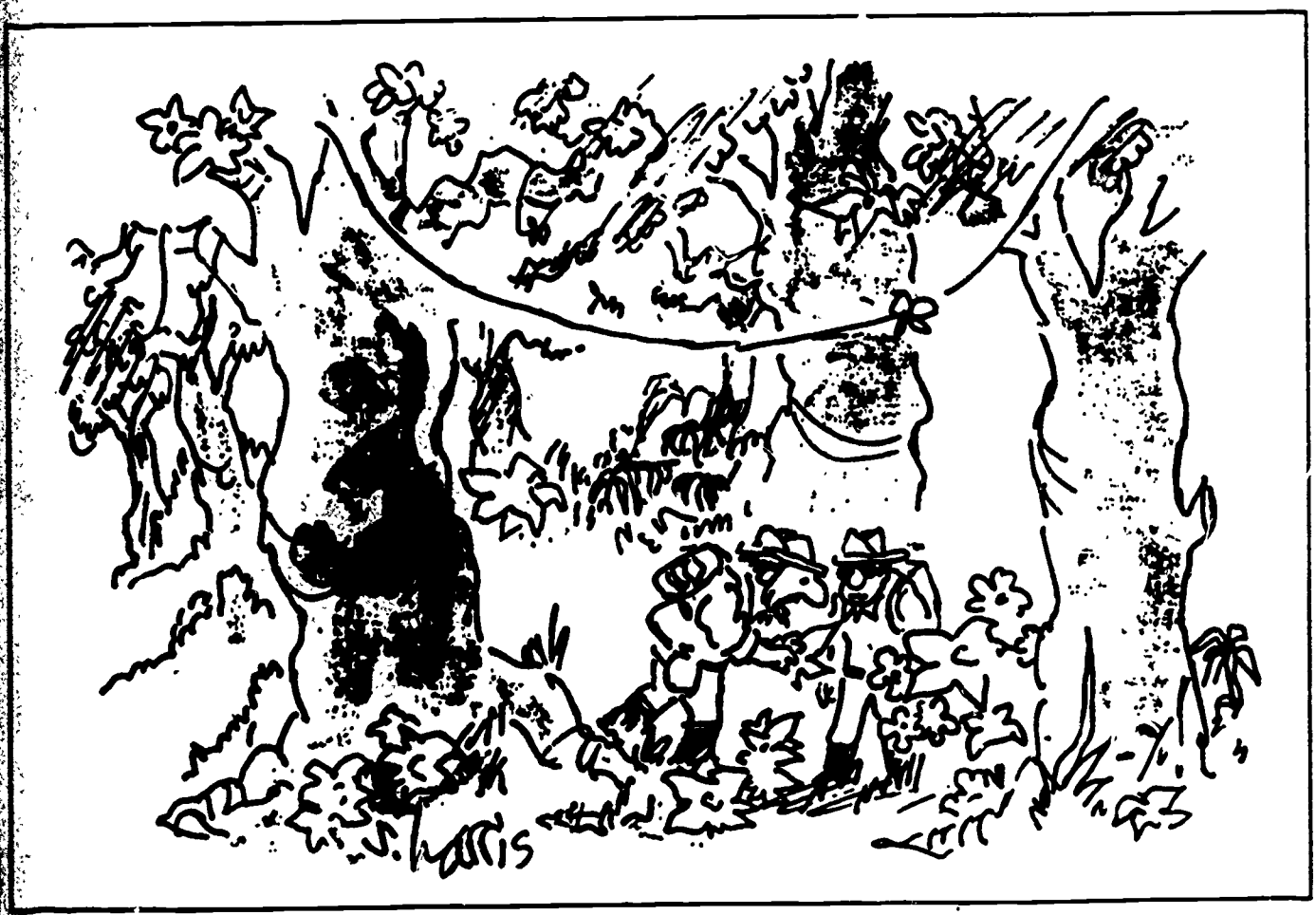
Should a severely retarded child with an incurable disease be treated when treatment will merely serve to prolong a painful life for a few months? How about 20 years?

Aging process

Given free choice, how long would you like to live?

Research now in progress may reveal why people age. If the aging process can be significantly slowed to allow people to live two or three centuries, would you want to live that long? If widely used, what effect would such a technique have on the job market for young people? On the age distribution of family members? On the financing of social security and health insurance? On the nation's (and the world's) population?

From 1970 to 1986 an American's life expectancy at birth rose by four years to 74.8 years, largely due to a drop in deaths due to heart disease and strokes. What will prevent this increase from continuing indefinitely?



"We're nearing civilization. This is genetically altered foliage."

Engineered bacteria

Life can be patented!

Genetic engineering, also called gene splicing or recombinant DNA technology, makes it possible to create entirely new species of micro-organisms specifically designed to serve very practical needs. In June 1980 the U.S. Supreme Court gave legal sanction to this new technology by making it legal to patent such newly created organisms. As a result there now exists:

-wheat with the soybean's ability to fix atmospheric nitrogen and convert it to fertilizer, thanks to newly engineered bacteria in its roots.

-bacteria that digest oil from spills.

-bacteria that create petroleum and alcohol.

-bacteria that raise the freezing point of water so that ski slope operators can make snow at warmer temperatures, and vegetables (e.g. tomatoes) gain frost resistance.

-micro-organisms whose metabolism creates interferon (an anti-cancer agent) and insulin (for treatment of diabetes), and vaccines against malaria and rabies.

Is it safe to release gene-altered micro-organisms outdoors where they can spread freely? And how can you make sure?

(See item: Patenting Plants and Animals, p. 15.

Why shouldn't people who carry antibodies to the AIDS virus but have not yet developed the disease be isolated or fired from their jobs?

Patenting plants and animals

It is possible now to invent and to patent new plants and animals-- if you can afford it.

In April 1988, eight years after the U.S. Supreme Court legalized the patenting of genetically altered micro-organisms the U.S. Patent Office ruled that genetic engineers may now patent higher life forms-- even mammals. One immediate result may be that with patents at stake and many millions of dollars invested in competitive research and development, the scientists developing new organisms for sale are unlikely to share information freely with colleagues, a subversion of one of the important characteristics of good science.

Another bad result, critics charge, is that competitive pressures to win profitable patents may encourage cruel animal experiments and may also wipe out small farmers who may not be able to afford genetically improved livestock. (See first following example). They worry, too, that escaped or mutant organisms might unleash a biological catastrophe of some sort on an unprepared world

On the other hand, supporters of genetic engineering insist that genetic manipulation may hasten a cure for AIDS and other diseases, may help to reduce chemical pollution of the environment, may produce new non-polluting substances that may replace fossil fuels as a source of energy and industrial raw materials, and may produce new agricultural food plants.

Support or disapproval of these conflicting positions must take account of unresolved ethical and safety questions. For example:

-Is it safe to release new gene-altered plants or animals into the environment?

-Is it ethical to alter the genetic structure of animals? Don't they have rights?

-By what rules or standards does our society decide whether a new technology should be pursued?

As Dorothy Nelkin, a professor in Cornell University's Program on Science, Technology and Society

points out, "The issues range from ethics within universities to the environment, to eugenics, to definitions of nature, to religious thought, to what it is to be human. The stake is tens of billions of dollars, hundreds of thousands of jobs, and America's ability to compete in the world's agricultural and pharmaceutical marketplace. Only the ability to obtain a patent justifies the immense expense of the necessary research".

As an example of what can happen, consider BGH, a synthetic protein identical to a hormone that is produced naturally in a cow's pituitary gland. Through genetic engineering, researchers have developed a bacterium that can produce the BGH protein in commercial quantities. Cows that were given the protein in daily injections increased their milk yields by 10 to 20 percent. The United States is already producing more milk than it knows what to do with. With no market for more milk, an increase in milk productivity will require a decrease in the number of cows in production-- which will result in a corresponding decrease in the number of dairy farms. If the federal Food and Drug Administration approves the use of BGH many small farms will be driven out of business.

This is only one example of how genetic engineering might well speed the elimination of small farmers and increase the size and industrialization of farms all over the world. Already the number of farms in the U.S. has been dropping from 4.8 million (in 1954) to 2.3 million (in 1985), and the average size of the survivors has more than doubled from 242 acres to about 445 acres. If this decline continues what effect will it have on <u>your</u> community? On local and state taxes and on food prices? On the social diversity of urban and rural society as ever more farmers go out of business? Should failing farmers receive financial assistance? Does the recent widespread failure of savings and loan banks in Texas bear on these questions? Should the use of BGH be made illegal?

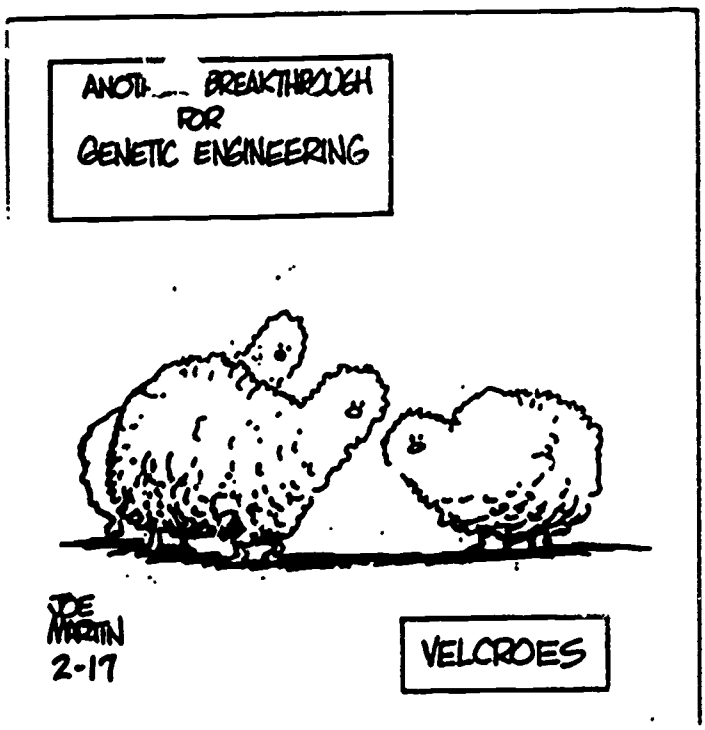
As a second example, fisheries biologists at Auburn University (Alabama) are isolating the gene in catfish which produces growth hormone, and their work shows promise of reducing the time needed for catfish to grow big enough to eat, thus improving the vitality of the South's $300 million aquaculture industry. A plausible next step is to genetically alter fish to survive in polluted lakes and rivers.

Yet another example is a genetically altered strain of rice with greater drought tolerance which has recently been created for use in arid countries.

Since 1986 researchers have altered 32 other species of plants including corn, cotton, and soybeans, and the number of field experiments has been doubling each year (1990). Among the goals is the desire to eliminate the need for pesticides to kill various worm parasites. The engineered genes become a permanent part of each plant cell, making every bite a lethal one for voracious worms.

It might be worth making a class collection of new examples of genetic engineering and posting them as they are noted from time to time in newspapers and magazines. Who benefits from the development? Who, if anyone, is hurt? How are are society or people's lives altered? What hazards are associated with each example? The preceding three examples may serve as a starter.

(See items: Engineered Bacteria, p. 14 ; The Geopolitics of Genes, p. 26 ; Citizens' Responsibility to Society, p. 178; Medical Research for Profit, p. 65; Society's Effect on the Goals of Science, p. 180 ; Animal Rights, p. 21 ; and Risk, p. 172 . See also "One Potato Patch That Is Making Genetic History", S.S. Hall. Smithsonian Magazine, August 1987).



Biological weapons or life savers?

Iranian researchers tried recently to buy a poison-producing wheat fungus in Canada and the Netherlands. U.S. officials, fearing Iran would turn this material into weapons, stymied the effort. But the Iranians could also have used it to design an antidote, and under American law as it stands at present any American citizen could have sold it to them. These are some of the contradictions facing the government as it works to stop the spread of biological weapons.

The problem is that biological materials and technology that can make weapons can also be put to legitimate uses like research on antidotes or the manufacture of pharmaceuricals.

If Congress is to strike a balance between curbing the spread of potentially dangerous substances and avoiding interference with legitimate commerce what considerations and provisions should its legislation contain?

In 1989 Senators Herbert Kohl and David Pryor introduced legislation to this end.. (From N.Y. Times editorial, August 29, 1989)

The last remaining smallpox virus in the world exists in only two high-security laboratories in Moscow and Atlanta, Georgia. Should it be destroyed?

Because of their knowledge, do some scientific researchers have a power that makes them dangerous?

Pets and high tech

How many dollars is your pet's health worth?

Veterinary medicine today is using procedures on animals that are far more sophisticated than were available for use on humans only a decade or so ago. Accordingly our attitudes toward our pets and other valuable animals is changing. Sick horses have had their hearts implanted with pacemakers, cats with cancer get radiation therapy, dogs with phobias are given psychotropic drugs, embryo transfer techniques have increased the value of prized cattle, dogs and cats receive cataract surgery, and birth control dog food may soon be on the market.

Knowledge is increasing so rapidly that entirely new high tech fields such as animal dermatology and cardiology are opening up, and some vets are beginning to specialize in them. These specialty procedures, and many more, are alternatives to euthanasia, but they can be very expensive. One 14-year-old Long Island cocker spaniel ran up bills for $100,000 for cancer surgery, radiation, and chemotherapy.

If money is no object you might want to take advantage of the growing movement toward pet health care insurance and be aware of one of the increasing number of vets who specialize in geriatric pet care. And when your pet finally dies there are now animal behaviourists who help the bereaved owner through the difficult process of grieving.

If veterinary technology is forcing you to equate your pet's welfare with money, is all this technology desirable? Despite their names, incidentally, CAT scanners and PET scanners are high technology medical devices whose names have nothing to do with cats or pets. It is worth noting that a majority of the graduates from veterinary schools now are women.

(See item: Animal Rights, p. 21)

Protein vs. cruelty to animals

Do chickens suffer?

Protein in your diet typically comes from bacon, pork, beef, eggs, or chicken, very little of which comes from traditional farms. Instead, pigs, cattle, and chickens are raised nowadays in factory-like conditions, confined in very small indoor spaces where they are mechanically fed a computer-formulated diet. Such confinement results in better animal health and higher production efficiency, and it lowers your meat bill. But it also denies the confined animals the chance for any kind of natural behaviour or social interaction.

How much more would you be willing to pay for that hamburger or egg in order to meet the psychological needs of those confined animals or to give them more nearly natural lives? 10 cents? 50 cents?

If you consider the extreme confinement of animals to be immoral or unnatural, isn't the confinement of people into tiny socially-isolated apartments in congested cities even more so?

(See items: Animal Rights, p. 21 and Pets and High Tech, p. 19)

"And that's the hand that fed me."

Animal rights

Do all animals have an unalienable right to life?

If they do, then consider the millions of rats, mice, rabbits, dogs, cats, and other animals sacrificed yearly in the U.S. in support of research of many kinds. Without their sacrifice the development of thousands of new vaccines, new surgical procedures and drug therapy, tests of potential carcinogens and new pharmaceuticals would be restricted or stopped.

Chimpanzees are the only adequate animals on which to test new vaccines against human virus diseases. Only infant chimpanzees can be imported successfully, and their mothers are usually killed during capture. The demand for chimpanzees is so great that the species is now badly depleted and in danger of extinction, yet no other species can serve the purpose.

Is the conquest of human disease worth the destruction of this (or any other) species? (See P. and A. Erlich, Extinction, Random House, 1980).

Unlike chimpanzees, baboons are monkeys, not apes, and are therefore less closely related to humans. But with humans they share similar organ architecture and several blood types-- A, B, and AB-- so they are important as a source of organ transplants requiring compatible blood types. A colony of baboons is being raised at the Southwest Foundation for Biomedical Research (P.O. Box 28147) in San Antonio, Texas, and it was the heart of one of these baboons that was transplanted into Baby Fae in 1984. (Newsweek, Nov. 12, 1984, p. 116).

Organizations opposed to such use of animals are proliferating, and legislation limiting it has already been passed in many states and localities and is even pending in Congress. In addition the treatment of research animals (except rats and mice) is federally regulated by the 1966 Animal Welfare Act, amended most recently in 1985. The trend is not so much concerned with the humane treatment of laboratory animals as it is with animal rights, asserting that all sentient beings have a moral right to life and

therefore deserve legal protection from harm regardless of possible benefits for human beings.

In a survey by the Boston Globe only a third of the respondents answered in the affirmative when asked, "Do you believe scientists should be allowed to experiment with live animals?"

59 percent of the respondents to a poll by Glamour magazine said they would be willing to use a drug that had not been tested on animals even if it might not be safe.

How would you have answered these two questions?

Are there moral differences between using animals for food or clothing and using them for research or for testing consumer products? What about research on a fatal human disease?

The Humane Society of the United States (2100 L St. NW, Washington, DC 20037) issues a booklet, Humane Shoppers Guide, which lists cosmetics and other products that have not been tested on animals, and names nearly 70 companies that do not test on animals.

Many people say zoos are cruel and should be banned, but others say zoos are a crucial last ditch refuge for the rescue of vanishing species. What do you think?

Americans love violent spectator sports. How do you feel about the Spaniards' and Mexicans attachment to bullfights? Would you like to watch one?

How do you feel about raising wild animals as pets? Suppose you come upon a nest of tiny, helpless baby squirrels (birds, rabbits, mice, etc.). Their mother is nowhere to be seen; they look abandoned. What should you do? The National Wildlife Federation (1412 16th St. NW, Washington, DC 20036 and the Sierra Club (Information Services, 530 Bush St., San Francisco, Calif. 94108) both issue free booklets explaining what you can or should do. In most cases, they say, you should do nothing. It is usually impossible to domesticate a wild animal or to rear it and return it to the wild successfully. Moreover, it is illegal for individuals to transport wild animals across state lines anywhere in the U.S.-- yes, even baby birds or mice. Do you think this is a good law?

If you feel strongly about the protection of animal rights, how do you justify killing cattle, chickens, pigs, fish, et al. for food? And if you are a convinced vegetarian, how do you justify the right of animals to kill plants by eating them?

Does a beautiful tree have rights? How about our much-abused planet, Earth? The Endangered Species Act affords legal rights to places by protecting the habitats of species threatened by extinction, and the Wilderness Act, passed 25 years ago, also preserves wilderness areas from permanent intrusion by human beings.

(See items: Pets and High Tech, p. 19 and Protein vs. Cruelty to Animals, p. 20. See also "Difficult Decisions: Animal Rights", J.S. Parakh and I.L. Slesnick. The Science Teacher, April 1989, p. 36 Contains a bibliography. Also "Alternatives to Animals in Toxicity Testing", A.M. Goldberg and J.M. Frazier. Scientific American, August 1989.)

Wasted protein

Why not eat insects?

"Honey bees are widely available in the U.S. Each fall many beekeepers in Canada and northern U.S. kill off their bee colonies with a view to buying new ones the following spring. As a result, one million pounds of bees are destroyed each year whose bodies contain about 170,000 pounds of protein."

"Termite bodies, ounce for ounce, contain twice the protein of sirloin steak, and termite protein contains more essential amino acids than almost any animal protein."

"A swarm of locusts in East Africa can easily blanket 600 square miles and contain about 400 billion insects, which equals nearly 100,000 tons of edible protein." (Science Digest, May 1982, p. 14).

Dried grasshoppers (Melanoplus sanguinipes) contain about 60 percent protein, 11 percent carbohydrate, and two percent fat. It is worth noting that as a source of energy they yield just over 1365 calories per pound whereas a pound of cooked medium-fat beef produces about 1240 calories and wheat flour about 1590).

Can you imagine practical ways of using this information to alleviate worldwide protein deficiency? Are the obvious objections (money, cultural habits, etc.) really insuperable?

Vitamin C and history

Certainly diet has consequences. It does today, and it must have been so five centuries ago. The question: Was Henry VIII malnourished? provides an example.

"His appetite for food and for women is legendary, but despite his royal girth, Henry VIII may have died from malnutrition. According to historian Susan Kybett, it was not syphilis, as once commonly believed, but a chronic lack of vitamin C that killed the king in 1547 at age 55".

"Henry's frequent colds, constipation, bloated body, collapsed nose, bad breath, ulcerated legs and wild mood swings are all symptoms of scurvy. The affliction was common in Tudor England, where fruits and vegetables were not only scarce but also shunned by the upper classes as unfit to eat. Kybett... contends that the deficiency also affected Henry's personality. If so, it could conceivably have affected his decision to marry six times-- having two of his wives beheaded-- and break with Rome to found the Church of England. Which raises the question, Might a few bottles of vitamin C on the king's table have changed the course of history?" (Time, Sept. 11, 1989)

Might diet be having any effect on events or on culture in parts of America? How do you know your diet is adequate?

Energy to produce food

A loaf of bread requires far more energy to produce than you gain by eating it. The energy output of a slice of white bread is about 75 Calories, but over 750 Calories went into its creation and transportation to you.

Thus, energy input is 10 times as great as energy output. The energy inputs include:

- solar energy falling on wheat fields
- gasoline for tractor for cultivation
- manufacture of all tools (e.g.,tractor) used in preparation
- work expended personally by farmers, bakers, transportation workers and you while shopping for it
- heat for the baker's oven

By contrast, consider a primitive farmer in New Guinea. Each Calorie of human energy he invests in raising sweet potatoes, taro, and cassava returns 16 Calories of food energy at harvest time. For him, input is only 1/16 as great as output. Thus, in at least a limited sense, his primitive agriculture is 160 times as efficient as American mechanized agriculture! (Current Energy and Ecology Mag., Dec. 1981, p. 15).

A second example: From May through October most of the lettuce eaten in New York (1983) is shipped 3000 miles by truck from California. The energy required for the trip costs 15 cents per head and adds up to six million gallons of diesel fuel per year just to transport the lettuce!

Are these sensible uses of energy? Identify the political, economic, and cultural pros and cons of any action you suggest. What are the long-term consequences of inaction?

(See "Food or Fuel: New Competition for the World's Cropland", L. Brown. Worldwatch Paper Series, noted in Bibliography. Also "Strategies for Agriculture", P.R. Crosson and N.J. Rosenberg. Scientific American, Sept. 1989, p. 128).

The geopolitics of genes

Who actually owns the genes of the hybrid tomato plants, corn, or potatoes on which so much of your diet depends?

The agriculture of the advanced industrialized nations of North America and northern Europe are based almost entirely on plants acquired decades or centuries ago from what are now developing nations of the Third World such as corn, soy beans, wheat, potatoes, alfalfa, barley, sorghum, tomatoes, cotton, tobacco, and flax.

Until recently such plant material and its germ plasm has been considered as the "common heritage" of humanity, free for the taking, worldwide. Over the years, however, plants gathered and transported as "common heritage" have become worth billions of dollars to the developed nations to which they were taken. As only one example, the genes from Turkish barley that gave it resistance to yellow dwarf disease is worth $150 million annually to U.S. farmers.

In contrast, the genetically perfected plant varieties bred by the commercial seed companies have been considered to be private property and therefore an article of commerce for which payment must be made--even by Third World countries who are impoverished and

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You may disapprove of South Africa's abuse of human rights, but it is the source of 81% of the world's supply of manganese, which is necessary for the hardening of steel. Should we buy from them?

Does a garden fertilized with synthetic chemical fertilizer grow as good a crop as one fertilized with natural plant and animal material?

Photosynthesis: Greenhouse effect

Trees counteract the greenhouse effect. If we plant enough of them they will ease the present threat of global warming caused by the buildup of carbon dioxide in the air.

Here is something you can do to help in a practical way.

Trees, crops, grass, and other green plants absorb carbon dioxide from the air and convert it to plant material (cellulose, starch, sugars, et al.) and oxygen by a process called photosynthesis. The reaction is energized by sunlight and catalyzed by green chlorophyll.

$$6CO_2 + 6H_2O = C_6H_{12}O_6 + 6O_2$$

Carbon dioxide is the gas chiefly responsible for the greenhouse effect. (See item: Absorption of Radiation: Greenhouse Effect, p. 154). Its removal from the atmosphere by the photosynthesis of green plants is being retarded by the massive destruction of forests and the desertification of agricultural land worldwide, and instead its concentration in the atmosphere is being steadily increased by the burning of fossil fuels like coal, oil ,and gasoline. (See items: Destruction of Tropical Forests, p. 46 , and Soil Erosion, p. 32).

To reduce the greenhouse effect we clearly must reduce the concentration of carbon dioxide in the air, which requires, in turn that we cut back on fossil fuel consumption and increase the effectiveness of photosynthesis.

These fundamental facts of nature have convinced a number of experts that the widespread planting of trees and conservation of existing forests is one of the surest, easiest, and least expensive ways to slow or even to reverse the buildup of carbon dioxide in the air.

In one of the first large-scale actions in this direction the American Forestry Association (1516 P Street N.W., Washington D.C. 20005), a citizens' conservation organization, has undertaken a national campaign aimed at planting 100 million new trees in

American cities and towns by 1992. The E.P.A. is presently considering the feasibility of planting 400 million trees, which could reforest 20 percent of the U.S. highway corridors and, planted strategically around buildings, would not only soak up carbon dioxide but would also provide shade to help reduce peoples' energy use in hot weather. The E.P.A. estimates that the total mass of American forests could be increased by 60 percent in this way.

Although it makes sense to develop large-scale tree planting programs on degraded land in the tropics, some of it denuded and abandoned after traditional slash-and-burn, it is also true that a reforested acre here in your home town in the U.S. is just as effective as a reforested acre in Brazil or Indonesia in helping to promote photosynthesis worldwide and counteracting the greenhouse effect. Thus, by planting trees, even in your own backyard, you can genuinely address a world-class environmental problem without having to travel overseas.

Over 100,000 children and adults in 42 states have planted and cultivated many thousands of trees for fruit or shade all over the U.S. through the agency Trees for Life, 1103 Jefferson, Wichita, Kansas 67203. Each tree removes an average of 13 pounds of carbon dioxide every year, converting it to oxygen, as shown in the above equation.

Here are a few more things you can do to fight global warming:

-Recycle newspapers. An entire printing of the Sunday New York Times consumes an average of 75,000 trees; preserving them by recycling could remove nearly one million pounds of carbon dioxide annually.

-Switch to natural gas. Burning coal and oil for energy are far greater culprits in global warming than natural gas.

-Insulate your space. Each year as much energy leaks through American windows as flows through the Alaskan oil pipeline.

-Ride the bus or subway whenever possible. Roughly one third of the global warming caused by the U.S. stems from transportation.

-Get better gas mileage. The average car driven in the U.S. emits nearly 60 tons of carbon dioxide during its lifetime Fuel-efficient cars available today emit less than half that amount.

-Put the heat on politicians. There are scores of actions our elected leaders should take at the national, state, and local levels to alleviate global warming.

Does it follow that because you are so small and the problem is so big that your effort will be worthless?

(See item: Trees vs. Desert, p. 33 and the booklet "Slowing Global Warming: A Worldwide Strategy", C. Flavin. Worldwatch Paper Series noted in Bibliography.)

Unpredictable costs of environmental protection

Is environmental cleanup worth undertaking when you don't know how much it will cost?

In many cases it is extremely difficult--probably impossible-- to predict the dollar costs of environmental protection even though supposedly precise scientific and engineering facts are available.

For example in 1965 the New York State voters approved a billion-dollar bond issue for, in the governor's words, "the elimination of water pollution in New York's lakes, streams, and rivers" within six years. Seven years later another 1.15 billion-dollar bond issue was approved for the same general purpose. After another three years had passed, it was estimated by a state spokesman that to meet federal EPA standards by 1983 would require an additional expenditure "on the order of 18 billion dollars". (The Existential Pleasures of Engineering, Samuel Florman. St. Martin's Press, 1976, p. 23.)

Similar unpredicted cost escalations have occurred in the course of providing environmental protection in the neighborhood of garbage incinerator plants and new nuclear power plants.

Some causes of rising costs are inflation, the imposition of increasingly high standards of performance, recognition of new hazards, and a steadily deteriorating environment during the years required for the construction of large projects.

Given competent and honest administration, why is it so difficult to be precise in estimating such costs? Does such imprecision in dealing with the taxpayers' dollars mean that environmental protection should not be attempted? Is "success" even possible?

Can you think of local examples of escalating costs? What was done-- or should have been done-- to contain them?

Does it make sense to strive for completely clean air or pure drinking water supplies? Does it make sense not to?

"All I know about him is that he's some sort of scientist doing research on cloning."

A 1978 estimate put the cost of dismantling a 1100-megawatt reactor at $33.8 million. By 1986 the Atomic Industrial Forum was quoting a figure four or five times higher, and in 1988 the U.S. Council on Energy Awareness pegged it at $180 million, not counting the cost of high-level waste disposal. Mothballing estimates rose from $10.1 million in 1978 to $225 million in 1988 and are now doubling every five years.

Nearly 340 reactors will have to be retired over the next 25 years., worldwide.

(See item: Nuclear Power Plant Disposal, p. 90. See also "Defusing the Toxics Threat: Controlling Pesticides and Industrial Wastes", S. Postel. Worldwatch Paper Series noted in Bibliography).

National parks

In Tanzania in Africa the local Masai cattle raisers annually burn the old withered grass so that fresh grass will sprout better in the spring rains in order to feed their herds. The fires also destroy bushes and woodlands, thus increasing the grassland area. As a consequence the population of grass-eating wild animals in the adjoining Serengeti National Park has expanded enormously. The 100,000 wildebeests there in 1960 have become two million in 1980, and the population of gazelles and zebras has also exploded so that in a drought overpopulation will result in mass starvation. One solution is to harvest a fraction of the population for their meat and hides and for export. This means the regular systematic slaughter of animals in one of Africa's most beautiful and unspoiled national parks.

Should this be done?

If oil were to be found beneath one of our national parks should it be drilled for? How about Alaska's Arctic National Wildlife Refuge, 19 million acres of fragile especially rich unspoiled coastal plain?

(See item: Minerals on Public Land, p. 100).

Soil erosion

It cannot go on, or we'll run out of land.

American farms grow enough food to feed the American population and enough grain to feed tens of millions of people in the rest of the world too. But 50,000 to 70,000 acres of America's land is being built over every week for highways, new housing, factories, etc. (1986). That's about 350 acres every hour. About one third of this is agricultural land.

Moreover , the topsoil on the remaining land, which averaged three feet thick two hundred years ago is blowing and washing away at the rate of five to seven billion tons a year so that today our fertile topsoil averages only about six inches deep. It's been calculated that in Iowa alone the soil being lost to erosion would fill a five ton truck every second of every day.

But soil erosion can be controlled. It's been done in China for 2000 years. In the U.S., however, except in such high yield areas as the corn and wheat belts, effective conservation can add $250 to $300 an acre to the cost of farming. For a farmer to stay in business he must exploit his soil; he cannot afford to build it. He is, in effect, borrowing from his children-- and from you.

Not incidentally, American homeowners spend $12 billion a year to maintain lawns whose product-- grass clippings-- they count as a nuisance. How many acres of farmland (at the price above) could be restored with $12 billion? Which use of the money is more important to you?

Worldwide, arable land is declining each year by an area the size of Colorado, forcing those who once tilled it to move into urban slums or other marginal or forested land. This process accelerates with population growth. (See item: World Population Explosion, p. 41) The deforestation caused by the expanding population who cut down trees for fuel or building supplies or clearing land for farming causes soil erosion and creates further pressure on the land-- an example of positive feedback.

Worldwide, we need to feed 86 million more people every year on 24 billion tons less topsoil (the equivalent of Australia's wheatlands), and something is going to have to give.

(See items: Feedback, p. 169 and Migration of Songbirds and Butterflies, p. 48 . See also "Soil Erosion: Quiet Crisis in the World Economy", L. Brown and E. Wolf. Worldwatch Paper Series noted in Bibliography).

Trees vs. desert: A project

Your school parking lot and possibly the playground may be barren, dry, sunbaked, and lifeless-- ecologically a desert. Like real deserts in Third World countries they are not apt to support useful forms of life.

Perhaps they can be made more attractive and even productive by using one of the techniques now being used abroad to combat desertification-- the planting of trees.

Species of trees are now known which have proved to be especially suited to very dry, barren developing countries where nothing else now grows, like your school parking lot or playground. Depending on the local conditions and needs trees can be chosen to provide windbreaks, shade, food for people, erosion and dust control, fodder for animals, fuelwood, industrial raw materials, pollen and nectar for honey bees. Some grow as much as 10 feet a year! For your school there may be all these benefits plus a saving of energy, because if there is sufficient shade, drivers do not have to turn on their air conditioners as they get into overheated parked cars. Moreover, there is almost always a big aesthetic improvement.

Perhaps the most valuable educational benefit of launching a tree-planting project will be the experience of dealing with all the necessary bureaucratic problems which are typical of efforts to convert sound scientific principles into practical reality! Here in the microcosm of your school community is a sample of what is happening in international politics and finance as developed nations help impoverished developing countries in their struggle to hold back encroaching deserts.

If you like the idea but think "nothing can grow" in the school parking lot (asphalt removed!) or playground, remember that's true of deserts too. Desert-tested varieties of carob, honey locust, prosopis, acacia, eucalyptus, and casuarina, among others, may be able to grow and stabilize infertile soil in your part of the country. Deserts, incidentally, cover 23% of the earth's surface and are increasing at the rate of 25,000 square miles every year.

For information on the care of desert-tested trees and where to obtain them write to the Desert Botanical Garden, 1201 N. Galvin Parkway, Papago Park, Phoenix, Ariz. 85008 or the Plant Dept., Arizona-Sonora Desert Museum, 2021 N. Kinney Rd., Tucson, Ariz. 85743.

(See items: Destruction of Tropical Forests, p. 46 and Photosynthesis: The Greenhouse Effect, p. 27. Also "Reforesting the Earth", S. Postel and L. House, Worldwatch Paper Series noted in the Bibliography. You should also note an article about Daniel Janzen, a University of Pennsylvania biologist who is attempting in Costa Rica to re-create a virtually extinct ecosystem known as a tropical dry forest. Costa Rica has set aside nearly 20% of its land for parks and nature preserves-- more than any other nation in the tropics. ("Growing a Forest from Scratch", Time Magazine, Dec. 29, 1986, p. 65)).

Why shouldn't cities and states confronted with a shortage of water pass legislation restricting growth?

Hazards of lawn care

Lawn care is important to many home owners as an investment and a source of pride, but lawn care chemicals include fungicides, pesticides, and weed killers, all of which are potentially harmful to the environment. How should their hazards be controlled, if at all? Choose one of the following:

a) ban all harmful chemicals (but you must define what "harmful" means)
b) require that only professionals apply them (like doctors administering drugs)
c) require users to attend classes and become licensed (like automobile drivers)
d) do nothing.

What is being done in your community?

Does a field or garden fertilized with synthetic chemical fertilizer grow as good a crop as one fertilized with natural plant and animal material?

(See item: Pesticide Pollution, p. 37. There is a PROJECT on lawn-care chemicals on p. 230).

No money should be spent trying to eradicate the Med fly (gypsy moth or other unusual insect infestation). Do you agree?

Blue-green algae and dinoflagellates

Fertile farm land can produce polluted reservoirs.

Some common species of blue-green algae are able to produce thick scums, called blooms, in fresh water lakes, rivers, and reservoirs. The blooms are so bulky and unattractive and smelly that fishing and boating become impractical, and shore property values are destroyed. Even worse, some cells of the common species (e.g. Aphanizemenon flos-aquae, Anabaena flos-aquae, and Microsystic aeruginosa) can create extremely poisonous nerve- and liver-damaging toxins that kill fish and make the water poisonous to drink, not only for people but for farm animals.

The blooms usually occur in water rich in phosphates and nitrates from natural sources, from urban sewage, and sewage treatment plant effluent, and from farm fertilizer run-off.

Similarly, in salt water, paralysis-producing toxins are produced by blooms of some species of dinoflagellates, a common form of phytoplankton eaten by shellfish which, in turn, are eaten by people. "Red tides" are an example of such blooms.

Either way, such naturally-occurring toxins are causing more and more legal, environmental, and health-related problems as we increase our dependency on marine and freshwater environments for food, drinking water, drugs, and chemicals.

The formation of toxins by freshwater or marine blooms is unpredictable and uncontrollable once the bloom begins. Nor do we understand how nature removes the toxins over a period of time or how man can do so.

Should a farmer have to stop fertilizing his field when a bloom has poisoned a nearby town's reservoir? Who should pay when property values along a lake shore are lost as a result of repeated blooms made possible by nitrates and phosphates from a town's sewage treatment plant effluent

In the 1960's and 1970's the New London, N.H. sewage treatment plant contributed such high

concentrations of itrates and phosphates to nearby Lake Kezar that algae blooms destroyed the lake's recreational value. Shorefront property values plummeted by 30%. Shorefront residents sued the town for damages. The town (taxpayers) paid.

(See items: Oil Pollution, p. 97 and Hazardous Chemicals, Dioxin, p. 80).

Pesticide pollution

Residents in expensive new housing developments on the west side of Denver, Colorado were severely troubled by mosquitoes (1984). Even heavy spraying did not eliminate the pests; it only killed off harmless wildlife and began to contaminate the ground water. Realistically, what should the residents do? Go on spraying? Stop spraying and suffer? Sell (if they can) and move out? Or-- ?

In Suffolk County, Long Island, the leading farm county in New York State, chemicals are losing the battle against the Colorado potato beetle. The beetle has acquired resistance to all major pesticides registered for use on potatoes. Growers spray up to 10 times per season, and pest control costs have climbed as high as $700 per hectare. Meanwhile heavy application of pesticides has caused extensive contamination of ground water, the region's sole source of drinking water.

Might the science of biotechnology (genetic engineering) offer a remedy to either of these problems?

* * * *

In developing countries pesticides poison people as well as insects. The U.S, annually exports 500 million pounds of pesticides abroad which are banned restricted, or not licensed for use in the U.S.

Overseas, typically in hot Third World countries the chemicals are put to work in the constant uphill fight against insects, plant diseases, and weeds that threaten the production of food. But in many countries it is so hot that the standard protective clothing designed for use in temperate climates is unbearable (Try working in an airtight rubber suit in the sun at 100°F for hours at a time!), and many of the workers are untrained and cannot read or understand the instructions anyway. (Rural Brazil, a major user of pesticides, is 40% illiterate) Is it surprising, then, that people use the empty pesticide containers to store drinking water and food?

Concerned about the 85 developing countries which urgently need to use the chemicals and at the same time suffer between 10,000 and 40,000 annual deaths and as many as a million cases of poisoning, the U.S. and the European Community are attempting to address the problem. If you were an official in the United Nations, where much of the negotiation takes place, how would you recommend that these two conflicting needs (use vs. poisoning) be reconciled?

Ironically, Americans remain exposed to some of the poisonous chemicals banned from use in the U.S. because we export them to developing countries for use in growing food which we then import and eat, completing a "circle of poison". Here in the U.S. tests show that more than a quarter of Iowans use drinking water contaminated with pesticides.

(See items: Hazardous Chemicals, p. 80 ; Patenting Plants and Animals, p. 15 , and Migration of Songbirds and Butterflies, p. 48. Also "Defusing the Toxics Threat: Controlling Pesticides and Industrial Waste", S Postel. Worldwatch Paper Series noted in Bibliography.)

Smoking kills and damages the health of more people than drugs do. Therefore, why shouldn't tobacco advertising be made illegal? Or legalize drugs?

Malaria, mosquitoes and DDT

The fragility of an ecosystem and its often-complex interconnections are illustrated by the following account of Operation Cat Drop, likely to brighten up any lesson on ecology.

This operation took place in the Dayak area of Borneo. The Dayaks are an early agricultural society who live in large communal huts called longhouses, each housing up to 500 people. In this region of Borneo malaria had been endemic until the World Health Organization (WHO) decided that the disease should be controlled by eradicating its mosquito vectors.

The WHO sprayed every longhouse with DDT, the number of mosquitoes diminished, and the incidence of malaria dropped dramatically. However, there were other consequences of this apparently successful venture.

The longhouses supported large populations of cockroaches which absorbed the DDT, which became concentrated in the lizards which ate the cockroaches. The lizards were in turn eaten by domestic cats in which the DDT became concentrated even further, but this time the dose was so high that it proved lethal to the cats. With the death of large numbers of Dayak cats the rat population began to increase, and there was a parallel increase in the number of rat parasites such as fleas and lice. Some of these parasites were vectors for sylvatic plague. Thus the Dayaks who were no longer suffering greatly from malaria became increasingly exposed to sylvatic plague. Operation Cat Drop was an attempt to restore the balance by parachuting in a new population of domestic cats. This proved quite effective. However, disturbance to the Dayak ecosystem was not so easily stopped.

The thatched roofs of the longhouses were subject to damage by caterpillars, the numbers of which were normally held in check by natural parasites and predators. The DDT killed caterpillars, parasites, and predators alike, but the caterpillars, as always in such cases, was the population to recover. A caterpillar explosion resulted, and when the rainy season started the roofs of the longhouses had been so ravaged they collapsed.

From Arthur Boughey, Man and the Environment, second edition, Macmillan Press, 1975.

Medfly

Hundreds of millions of dollars have been spent by the state of California on efforts to eliminate the Mediterranean fruit fly. Yet entomologists insist that the massive use of quarantine, trapping, stripping trees of their infected fruit, release of sterilized flies, and spraying with malathion are all demonstrably flawed in one way or another and cannot succeed. They say that eventually, because of the insect's biology, it will disappear of its own accord. Should the state officials heed the public and the fruit industry who understandably clamor for some kind of action? Or should they risk their political careers by heeding the entomologists, who should know more about the insects than anyone else--and do nothing?

If you were a responsible politician, what action would you take?

(Insects, Experts, and the Insecticide Crisis, J.H. Perkins, Plenum Press, 1983).

Any chemist who perfects a repellant for blackflies and mosquitoes could single-handedly alter the life style and the economy of large parts of rural Maine. For many years the biting insects have protected some of the most beautiful and underpopulated areas of the state from floods of vacationers and home builders, but a single effective use of chemistry could suddenly change all that and make it possible for many people to move in. Is this a change to be welcomed?

World population explosion

If the present human birthrate continues, by 2600 A.D. there will be only one square yard of dry land surface available for each inhabitant-- hardly more than the size of a telephone booth. Today, at the rate of 163 births per minute, a baby is born somewhere in the world every 1/3 second, and the world's population is growing at the net rate of 235,000 people per day (birth rate minus death rate). It has doubled since 1952 and is increasing at 1.7% per year. (See item: Exponential Growth, p. 167.

The world population, which stood at 1.5 billion in 1900, is 5.2 billion in mid-1989 and expected to grow to 6.2 billion in the year 2000 and to 8.5 billion in 2025. It may reach 10 billion before it levels off toward the end of the next century with nearly 9 out of 10 persons living in developing countries. (U.N. median projections)

No government, no academic expert, has the faintest idea how to provide adequate food, housing, health care, education, and gainful employment to such exploding numbers of people as they crowd into such mega-cities as Mexico City. Calcutta. and Cairo with their inadequate housing, health facilities, and overcrowded schools.

Moreover, the growing numbers of desperate poor implied in these figures will accelerate the ferocious assault on the environment already under way in Africa, Asia, and Latin America as they overgraze grasslands, chop down and burn forests, and overplow croplands in a desperate effort to produce more food.

Should the size or growth rate of the world's human population be curtailed to protect the global environment? If so, how? If not, what?

Has society the right to tell individuals (including you) how many children they can have? If your answer is "no", can population control be achieved by an appeal to conscience? What form of coercion or appeal would you respond to?

For free or inexpensive teaching materials and activities write to Zero Population Growth, Inc., 1601 Connecticut Avenue NW, Washington, D.C. 20009.

See also various titles in the Worldwatch Paper Series (noted in Bibliography) and "The Growing Human Population", N. Keyfitz, and Scientific Americar Sept. 1989, p. 118.) For counterarguments read "Fanisi's Choice", J. Tierney, Science 86, Jan/Feb 1986, p. 26, asking how many children a woman should have in Kenya, the fastest growing country in the world.

(See items: Tragedy of the Commons, p. 165 and Exponential Growth, p. 167).

Population paradox

Most people consider overpopulation to be one of the most serious threats to the quality of life and to world peace. Do you agree? Here is a list of things that make overpopulation even greater ard hence INCREASE the population problem; motherhood, medicine, public health, peace, law and order, scientific agriculture, accident prevention, and clean air.

And a list of things that REDUCE the population problem: disease, abortion, war, murder, famine, accidents, family planning, and sexual abstinence.

How do you resolve this paradox?

Given time and money, can science eventually solve our social problems such as crime, hunger, and mental illness?

U.S. birth rate

Every 8.5 seconds a new American is born. He is a disarming little thing, but he begins to scream loudly in a voice that will be heard for 70 years. He is screaming for 26 million tons of water, 21,000 gallons of gasoline, 10,150 pounds of meat, 28,000 pounds of milk and cream, 9,000 pounds of wheat, and great storehouses of other foods and drinks. These are his lifetime demands on his country and its economy.

The birth rate in the U.S. is now at about replacement level. That is, each couple produces on an average two children who will in turn survive and produce two children-- not more. Yet the population keeps growing, quite apart from immigration. Why? (Answer: Because of the population "hump" of parents at the child-bearing age). The net growth rate of the population is one additional American every 21 seconds. The 1990 population was close to 245 million.

What effect is this near-zero birth rate having on:

a) the public school system?
b) U.S. taxpayers' contributions to Social Security?
c) the average age of U.,S. citizens?

Suggest a program whereby the U.S. might achieve and maintain zero population growth. Would your program be politically practical? Who pays for it?

Is the U.S. immune from the effects-- and prospects-- of the worldwide population explosion? What do you think will be some of the effects upon you? What do you think should be done, if anything?

(See item: World Population Explosion, p. 41. Write to Zero Population Growth, Inc. noted in preceding item.)

Should science courses be required for high school (college) diplomas? Why?

Destruction of species

If you could destroy all the rattlesnakes in the U.S. would you do so? How about mosquitoes? Rats and mice? How would your life be affected if there were no cats and dogs? If all the birds were to disappear?

Has mankind an obligation to preserve the species of plants and animals we find on earth, or should they exist only as long as we find it convenient to have them around?

The California condor is an ugly bird, and only a few survive, so who cares if they become extinct? Warthogs, bats, and octopuses are considered by many people to be ugly, whereas the leopard is beautiful. Should beauty determine our sentiment toward conservation?

Wildlife officials are spending taxpayer's money to bring back from near extinction grizzly bears, timber wolves, alligators, bald eagles, and Florida panthers, all of them carnivorous. Does this make sense?

Worldwide the destruction of habitats is presently driving at least ten species of plants and animals to extinction every day. Of earth's five million or more species we could well lose one million more by the end of the century. We are in the midst of a mass extinction of plants and animals 1000 times more rapid than the pace of evolution that has prevailed since multicellular life appeared 600 million or more years ago, and it is well documented that this is the result of human activity. Should we care? Why?

The losses are especially severe in tropical forests which are, in effect, enormous gene pools, home to at least two million species of plants and animals--between 50% and 80% of the planet's species-- many of which have not yet even been identified. The genetic material being destroyed (some 4000 species a year) may contain secrets for improving food crops or fighting disease, and it is being lost forever.

As a result zoos are acquiring a new importance. No longer merely museum collections of

animals, many are becoming rescue centers where nearly extinct species can be bred and protected.

In 1960 a person with leukemia had one chance in five of survival; in 1980 the outlook was four chances in five. This change stems in part from the discovery that a tropical forest plant, the rosy periwinkle, contains alkaloidal material (vincristine and vinblastin) with powerful antileukemia properties. Of 32 such commonly used chemotherapy drugs 28 are plant products discovered by chance.

Antibiotics resulted from observations of a mold growing on a cantaloupe. Smallpox elimination resulted from observations of the effect of cowpox virus on the health of milkmaids. The peregrine falcon's fragile eggs warned us of excessive DDT in our environment, and the Devil's Hole pupfish warned of a falling water table in Nevada. Hamsters (medical science) and rubber trees (technology) have had immense effects on our lives.

When we buy medication at the local pharmacy there is a 50% chance that it derives from materials of natural origin. And scientists have systematically screened for usefulness of only one percent of the earth's species of plants and animals so far. How effective is the federal Endangered Species Act? (See Scientific American, March 1987, p. 65). And why are mining and utility companies often anxious to eliminate many of its most important provisions? In the U.S. alone 500 species of plants and animals are listed as endangered. Approximately one third of them are losing their battle for survival. Lack of money to protect their habitat is an important part of the reason. (See item: Destruction of American Forests, p. 49)

Endangered plants have received less attention than animals in this country and around the world. In the U.S. botanists have estimated that about 3000 plant species, more than 10% of the estimated 25,000 species of native U.S. plants, are in some danger of extinction. For information on endangered plants in the U.S. write to the Center for Plant Conservation, Inc., Arnold Arboretum, Arborway, Jamaica, Mass. 02130.

A project: identify endangered species of plants and animals in your state or local area. Find what the threats are to their survival and what is being done about them. Can you help?

ince many of the genetic resources on which U.S. agriculture is based come from overseas, and since it is so important to prevent the loss of wild varieties of grain or ancient lines of livestock that could be valuable some day for breeding, couldn't Congress be encouraged to help by tying the conservation of genetic resources to its international aid programs?

See items: Destruction of Forests, p. 46 & 49 and Worthless Species, p. 50. See also Extinction, P. and A. Erlich, Random House 1980; A Wealth of Wild Species, N. Myers, Westview Press 1983; and The Sinking Ark, also by N. Myers, Pergamon Press 1979. In the Worldwatch Paper Series (noted in the Bibliography) see "On the Brink of Extinction: Conserving Biological Diversity" and "Diversity". Also "Threats to Biodiversity, E.O. Wilson. Scientific American, Sept. 1989, p. 108, and "Searching for Medicinal Wealth in Amazonia", D.D. Jackson. Smithsonian, Feb. 1989.

Destruction of tropical forests

Worldwide, an area of tropical forests the size of Pennsylvania (45,000 square miles) is being cut down every year (1989). That is almost five square miles every hour, day and night. The Amazonian forests of Brazil, largest remaining forests on earth, were being cut (in 1987) at 120 square miles every day. The reason; fuel wood, timber, cattle ranching, and space for exploding populations to grow food.

Forest clearing removes most of the nutrients in the soil, destroying its fertility to such an extent that large areas of pasture and crop land that replaced tropical forest have in Brazil, for example, already become useless wasteland and been abandoned.

The effects include (1) undoubtedly major but unpredictable changes in world weather patterns, including enhancement of the greenhouse effect, which may, in turn, affect agriculture and create unpredictable changes in the world's food supply-- and your food bill. and (2) the destruction of thousands of species of plants and animals.

It is worth noting that increasing reforestation worldwide between now and 2000 A.D. by an area just twice the size of Texas would return the world's supply of wood for fuel and industry to a sustainable level and also capture and store considerable carbon, which would reduce the rate of carbon dioxide build-up and global greenhouse warming. (See "Reforesting the Earth", S. Postel and L. Heise. Worldwatch Paper Series).

Should anyone be doing something about this? If so, what, and by who? Perhaps a social studies teacher can make some suggestions.

Bear in mind that in many poor tropical countries, where the destruction is most rapid, if you set aside a large area of forest for conservation you are taking it out of the economy of the poorest and least fertile agricultural region where the poorest people must try to make a living. How can you use a rain forest productively without destroying it?

For one answer see the article, "Tropical Deforestation", P.H. Raven, in The Science Teacher, Sept. 1988. (bibliography and classroom activities).

(See also"Unravelling Another Mayan Mystery", A. Chen, Discover Magazine, June 1987, p. 40, and see also items: "Trees vs. Desert" (p. 33 , ("The Tragedy of the Commons" (p. 165, "Destruction of American Forests" p. 49 and "Destruction of Species" p 44.

Question: Do you think it is right to buy imported products made from tropical woods such as rosewood, mahogany, teak, or cocabola? On the one hand you help the economy of a poor developing country today, but on the other hand your purchase contributes to its long-term impoverishment. Do you approve of the consumer boycott of Burger King which, in the summer of 1987 forced the company to stop importing beef from Costa Rica where cattle ranches were expanding on land being cut from rain forest?

If a fetus has rights, isn't a crack- or cocaine-using pregnant mother guilty of drug pushing?

Migration of songbirds and butterflies: Threats

Many songbirds of the northern U.S. are being threatened with extinction. Latin American forests to which they migrate for the winter are being cut down to make room for the rapidly expanding human population. Not only will the world be poorer for their loss, but these birds eat an immense number of insects which are harmful to food and garden crops or are nuisances like mosquitoes and flies. Purple martins, those prodigious feeders on mosquitoes, winter in Brazil whose forests are particularly threatened and whose cleared land is heavily treated with pesticides.

In addition to songbirds, the monarch butterflies that migrate up and down the East Coast spend winters in only about 15 sites of one to 10 acres each in the mountains of central Mexico. Even careful selective logging of those tiny areas would presumably destroy most if not all of the East Coast monarchs forever.

Can you imagine a practical solution?

(See items: Destruction of Tropical Forests, p. 46 , Destruction of American Forests, p. 49 , and Pesticide Pollution, p. 37).

Is there a moral difference between killing animals (mammals) in the course of (a) testing consumer products, (b) medical research, and (c) producing food and clothing?

Destruction of American forests

In Oregon, where lumbering is a major industry, the discovery of a few spotted owls (a threatened species) created a widespread popular demand to halt lumbering in a national forest on which thousands of Oregonians depended for their jobs. Only a few hundred of the owls survive.

Whose interests should prevail-- the owls or the Oregon lumber industry? If you were responsible for making the decision, what further information would you seek?

Is it right for this country to urge Brazil and other tropical countries to slow the destruction of their rain forests while we continue to cut down the trees in much of our own remaining temperate rain forest in southeast Alaska (the Tongass National Forest)? There, as much as 50 percent of the most productive forest land has been logged since 1950, and in the U.S. as a whole some 60,000 acres of ancient forests are being cut down each year, mostly for lumber that is exported to Japan.

The U.S. Forest Service owns half the softwood timber in the United States. Should there be a connection between their sale of trees for harvesting and the nationwide recycling of waste paper? If so, what?

Worthless species?

Thanks to biotechnology we are learning how to create new forms of life tailored to specific purposes. (See items: Engineered Bacteria, p. 14 , and Patenting Plants and Animals, p. 15) If it is all right to create desirable new species, why isn't it all right to destroy undesirable or useless species? After all, we already are spending immense amounts of money to destroy or control such organisms as insects that kill crops and spread disease. If you had the power to do so would you destroy

-the AIDS virus

-the tuberculosis bacterium (which kills three million people worldwide per year)

-mosquitoes (they spread malaria) and tsetse flies (they spread sleeping sickness)

-cockroaches, poisonous snakes, or alligators

-weeds

Where do you draw the line? Why there?

Without affecting mankind, species of plants and animals have come and gone since life began on earth. The dinosaurs are an example. Why should we be concerned about the extinctions occurring today?

(See items: Destruction of Forests, p. 46,49, and Destruction of Species, p. 44).

To reduce roadside litter why shouldn't state laws be passed that ban the use of throwaway containers for beverages such as beer and soda pop-- or require a refundable deposit?

Human gene manipulation

At the present time (1989) human gene manipulation can only be performed on tissue cells (such as bone marrow cells) so the altered cells die with the patient. The day may come, however, when it will be possible to alter germ cells, whereupon the altered genes-- good or bad-- will be transmitted from one generation to the next. Here lies cause for serious concern, for medical scientists, like doctors everywhere, have a responsibility to protect the public against diseases of all kinds. When it becomes possible to alter human germ cells so as to prevent defective genes from passing from parents to children it may become criminal <u>not</u> to do so.

Many ethicists see nothing wrong with experiments that genetically alter microorganisms or plants or even large animals, but they express doubts about experiments to modify the genes of human beings. They foresee a series of progressively more difficult ethical questions. For example:

-Do you allow alteration of the genes of an individual with a previously incurable genetic disease such as Huntington's disease or Tay-Sachs disease?

-Do you allow alteration in that individual's germ cells so that his/her children will not inherit the disease? If asthma proves to be a genetic disease, should that be cured genetically? What about baldness?

-If it should ever become possible to do so, do you allow alteration in any <u>healthy</u> individual's germ cells to "improve" his/her children by making them taller, stronger, or smarter?

-What if people want to use the technology to improve genes that are not defective but merely mediocre? Could genetic engineering become the cosmetic surgery of the next century?

In June 1983 a group of about 40 religious leaders issued a statement calling for a complete ban on human genetic engineering, or gene transplants,

arguing that "humans should not assume the prerogatives of the Creator", and that "no individual, group, or institution can legitimately claim the right or authority to make such decisions on behalf of the rest of the species."

On the other hand, many people contend that the chance to reduce suffering or enhance human well-being far outweighs the risks of genetic tampering. Who do you think is right?

Just before and during World War II, using political action and physical force the Nazis tried to promote what they considered to be "pure Aryan" German citizens and set about destroying all the Jews they could (about 6,000,000). Does this fact alter your answers to the question above?

(See items: The 1000-Year-Old Baby, p. 62; Animal Rights, p. 21 ; and Patenting Plants and Animals, p. 15. See also "Biotech's Stalled Revolution", New York Times Magazine, Nov. 16, 1986, and The Nazi Doctors, R.J. Liften, Basic Books, 1986. For an extensive overview see the monograph: "Biotechnology, Genetic Engineering, and Society", G.H. Kieffer. National Association of Biology Teachers, 11250 Roger Bacon Drive, #19, Reston, Va. 22090.)

In vitro fertilization

Among sexually active adolescent avoiding pregnancy is a major consideration. Yet among adults 15 percent of all married couples in this country are unable to have any children, according to an American Medical Association estimate. The causes may originate in either the male or the female partner. In females one of the most common causes is blockage of the fallopian tubes or oviducts, but it is now possible to circumvent such a blockage by fertilizing the ovum outside the body using a technique known as in vitro fertilization (IVF). The fertilized ovum is then reimplanted in the uterus, where development of the embryo takes place normally.

The fertilized ovum can be implanted in the same female whose ovum was fertilized, or it can be implanted in the uterus of a second woman who agrees to carry the baby to term. The baby may then, by prior agreement, belong to either the genetic mother or to the surrogate mother who gave it birth.

The first such "test tube baby" was born to its genetic mother in England in 1978. Since then more than 5000 such births have been reported here in the U.S. (1989) and about 15,000 worldwide. Until there is a statistically significant number of in vitro people living out their lives the procedure must still be considered as being experimental and the people themselves as guinea pigs, for there are risks in any procedure which, like the thalidomide disaster, may not become apparent until later. On the other hand, for the infertile parents desiring a pregnancy the procedure is certainly desirable.

So far, no U.S. state has passed any law governing surrogate motherhood or IVF, but the technology of IVF raises serious ethical questions. For example:

-Does the government have a responsibility to prevent people from taking risks that are still undefined or to regulate who who may become IVF parents?

-Do IVF parents have a right to subject the developing human embryo to the risks of the procedure?

-In the case of a surrogate mother, who should be entered in the official records as the child's legal mother-- the genetic mother or the surrogate mother?

-What are the legal rights of the embryo?

-The IVF procedure costs upward of $3000 per attempt, and often several attempts are necessary for success. This cost is prohibitive for a great many deserving people. Is this fair?

(See item: The 1000-Year-Old Baby, p. 62. A module that deals with prenatal diagnosis, genetic screening, and recombinant DNA is Biomedical Technology, one of several in the Biological Sciences Curriculum Study series: "Innovations" noted in (Bibliography).

Ongoing experiments with the technology of IVF may rescue the Florida panther from its threatened extinction. Biologists are seeking (1989) to produce panther embryos from gametes of one of the 30 to 50 surviving wild panthers, gestate those embryos in more common cougars, rear the young in large enclosures stocked with deer as prey, and thus expand the panther

population for release into the wild. Might this work for other endangered species?

Should such experimentation be acceptable with animals but not with humans?

Should prenatal diagnosis for sex choice be prohibited by law?

Shouldn't underdeveloped nations which are overpopulated use compulsory sterilization to control their population?

Can a fetus be a tissue farm?

Fetal tissue is particularly valuable for transplants in treating a variety of serious diseases such as diabetes, leukemia, radiation sickness, Parkinson's and Alzheimer's diseases and spinal cord injuries because it grows faster and causes less immunological rejection than adult tissues does. Most people concerned with the use of fetal tissue for use in transplants agree that it is morally wrong but not illegal to become pregnant for the sole purpose of aborting a fetus to obtain tissue.

Dr. Robert Gale of the Univ. of California, L.A., says, "All of us who work in fetal research feel that if someone has decided to have an abortion and gives permission, it is all right to use that tissue to help someone else" (N.Y. Times, Aug. 16, 1987, p. 30), but Dr. John C. Willke of the National Right to Life Committee says (same reference) "People who kill these tiny babies, by virtue of the fact that they have done the killing, lose any moral right to use these tissues."

Although the sale of human organs was banned in 1984 by an act of Congress there is a market for renewable body tissues such as blood, bone marrow, and sperm. But should fetuses be treated as renewable body tissue that can be sold or as organs such as hearts, livers, eyes, and kidneys that cannot be? As a society we still have no public policy for deciding such issues as these.

Currently (1989) the federal Biomedical Ethics Board is attempting to define policies on fetal research as well as on experiments on human genetics and on nutrition for the dying. Conclusions and legislation on these difficult matters is still pending, and currently there remains a moratorium on federally supported fetal research.

(See item: Do You Own Your Body?. p. 58)

Fetal medical examination

Should parents be able to learn-- or to choose-- the sex of their unborn child?

A number of techniques now provide increasingly reliable identification of the sex of an unborn child as well as a diagnosis of physical deformities and genetic diseases such as sickle-cell anemia, hypothyroidism, and Huntington's disease. They include biochemical and hormonal tests, ultrasound, amniocentesis, chorionic villi biopsy, and even fetoscopy. But the use of such procedures raises such questions as:

-the fetus' right to privacy-- a right that may invoke the U.S. Constitution
-when does human-ness begin?
-the right of the fetus to life
-protection of the defenseless
-the rights of society with respect to the welfare of its citizenry.

With the dramatic rise in teen-age pregnancy these are more than theoretical issues. For example, should a doctor perform an amniocentesis for an expectant mother to determine the sex of her unborn child if he thinks the mother, who is strenuously opposed to its being a boy, will have an abortion if it is to be a boy?

Should prenatal diagnosis of sex be prohibited by law? Currently about 15,000 amniocenteses are done annually in the U.S. (1987).

I desperately overpopulated China (one fourth of the entire world's population) parents are penalized by the state if they have more than two children, yet traditionally in both China and India, where there is no such thing as life insurance as we know it, parents are supported in their old age by their sons, not by their daughters. What would be the effect in both China and India of widespread, easily accessible, amniocentesis?

If a fetus has rights then isn't its cocaine-using mother guilty of drug pushing? See item: Fetal Death, p. 57.

Fetal death

Recently a drunken driver crossed the center line and ran into a car driven by a woman who was 7 1/2 months pregnant. The woman survived the impact, but the fetus she was carrying did not. She and her husband sued the drunk driver for murder. If you were the judge, what would you decide?

How would you rule in the case of a woman who has an abortion done? Is she guilty of murder then?

The technology of fetal medical examination has made it possible for the law to intervene in the relationship between a negligent mother and her unborn child. A pregnant girl who smoked and used drugs and alcohol was found by fetal examination to have a high risk of giving birth to a defective child. Several doctors ordered her to give up her vices, but she did not. Her child was born dead, and amphetamines and barbiturates were found its blood. Is she guilty of murder? In at least one similar case in 1989 the mother was charged with manslaughter. (Time, May 22, 1989, p. 104 and New York Times, Nov. 16, 1986 editorial section, p. 24).

In 1989 a woman was convicted in Florida of having delivered drugs to a minor-- via the umbilical cord. This is a felony drug charge usually used against dealers carrying a possible 30-year sentence.

Florida estimates it must spend $700 million to get the 17,500 crack babies born in 1987 ready for kindergarten. Nationwide, intensive care for damaged babies born to crack-addicted women already costs $2.5 billion a year. (N.Y. Times, Sept. 25, 1989)

All these women failed in their legal obligation to care for their unborn children. How could they at the same time have the right to abort them?

Should people have unlimited rights to have a child? Society requires a license for people who cut hair but requires no training whatever to have a child. Is a bad haircut more important that a permanently damaged child?

Does society really want to jail women for having drug problems when they are pregnant?

Do you own your own body?

John Moore had been a cancer patient with hairy-cell leukemia. There was no treatment for it except to remove his dangerously enlarged spleen. So they had plucked it out, and some scientists at UCLA had managed to grow Moore's cells in the laboratory; an immortal cell line, they called it, because unlike most cells from mammals, Moore's cancerous spleen cells didn't stop replicating after a few dozen divisions. None of that was so new; immortal cell lines have contributed vastly to medical research. What made the case noteworthy was that UCLA and the scientists patented the line-- and then John Moore sued them for a share in any resulting profits.

Following its removal was John Moore's spleen his personal property? (Our laws and culture allow the sale of such things as hair, sperm, and blood). Or was it surplus like your hair on the barbershop floor or an extracted appendix? Or was it a gift, as when you donate a kidney to save another person's life?

The rights and wrongs of John Moore's suit illustrate the ambiguities and unsettled ethics surrounding your ownership of your body as an economic asset. See the cited articles for a discussion.

(Adapted from "The Gift of Life Must Always Remain a Gift", T. Murray, Discover Magazine, March 1986. See also "Cells for Sale", J. Stone, ibid, August 1988, and also items: Can a Fetus Be a Tissue Farm?, p. 55 and The Geopolitics of Genes, p. 26).

Because it unquestionably saves lives, why shouldn't the original 55 mi/hr speed limit on interstate highways be retained and enforced more rigidly?

AIDS and society's responsibility

Both for doctors and for society AIDS raises problems unlike those of any other disease.

For society the problems turn on the fact that most AIDS patients cannot afford their long-drawn-out (six months to two years) terminal care. Hence insurance companies try to screen out applicants for insurance and to deny policies to applicants who may be carrying the disease. To the degree that they are unsuccessful, the company's funds for terminal care are being consumed at the expense of other policy holders, whose premiums must therefore be increased. Hospital budgets are likewise being strained and broken to the detriment of patients whose illnesses are fundamentally more manageable.

Some day (if not now) you will probably be an applicant for medical insurance. How can insurance companies and hospitals be fair to you and at the same time do justice to the needs of AIDS sufferers?

For doctors one of the problems posed by AIDS was expressed by Dr. C. Everett Koop when he was the U.S.Surgeon General speaking to the President's AIDS Commission (N.Y. Times, Sept. 13, 1987):

> "Health care in this country has always been predicated on the assumption that somehow everyone will be cared for and that no one will be turned away... that care will not be abandoned for the sick and the disabled, whoever they are. Hence, the reports of a few physicians and others witholding care from persons with AIDS are extremely serious, in my opinion. Such conduct threatens the very fabric of health care in this country."

Remembering that however unlikely it may be for a physician or a dentist to acquire AIDS in treating a patient, and remembering that the disease is invariably fatal, what are the responsibilities of a doctor who may have a family of his own to consider as well as an AIDS patient?

(For questions and student thinking activities to provoke discussion and analysis of the public fear of AIDS see "Difficult Decisions: AIDS". I. L. Slesnick, The Science Teacher, Jan. 1988, pp. 34-5.)

AIDS vaccine

There is great doubt that a vaccine for AIDS will ever be practical. Nonetheless, the need is so great that a major worldwide effort is under way. If a promising vaccine is found its creation will raise difficult questions. For example:

When, in the course of research, does it become morally acceptable to conduct experiments on live subjects? Chimpanzees, the animals clinically nearest to humans do not seem to get AIDS from the wild strain of the disease, so they would not be appropriate test subjects. Sooner or later any promising vaccine will have to be tried on human beings. Like who? The research scientists themselves? Drug addicts? Prison inmate volunteers? People already infected? Since human experimental subjects must be protected against exposing themselves to infection from the AIDS virus (which is always fatal), how can such a human experiment be designed to prove that a vaccine works?

It will take years for the necessary large-scale testing to ensure the efficacy of a new vaccine. For example, serious side effects that occur rarely from measles, swine flu, and other vaccines did not show up until years after they had been marketed and injected into people.

And if such a vaccine is finally developed for marketing, how can it be distributed equitably worldwide, given that the demand will be urgent and enormous, much of it from third-world countries that won't be able to afford it?

(See item: AIDS and Society's Responsibility, p. 59).

Organ transplants

Many parts of your body can be replaced by artificial parts (prostheses). Plastic hips, hearing aids, pacemakers for your heart, wigs, dental structures, and artificial arms and legs are only a few of the more familiar ones.

Many more parts of your body can be replaced by transplanting living healthy organs from someone else. Eye (cornea) and kidney transplants, skin grafts, and of course blood transfusions are common, and entire hearts are now being transplanted from animals and from healthy accident victims into people with terminal heart disorders, but the need for transplant organs now far exceeds the number of donors becoming available. This raises tough questions.

As a first example, given two desperately needy patients, both about to die, how do you decide which one is to be saved by the one available heart from an accident victim? Would you be willing to donate one of your two kidneys to save the life of a stranger? Of a family member?

Second, fresh transplant organs are typically acquired from the body of someone who has just died or been killed in an accident. Speed is important in performing the transplant, but how do you know the donor is truly dead? Brain waves? Heart beat? Breathing? And who has the right to grant the use of a donor's organs? Relatives (often unavailable)? The surgeon (a heavy responsibility for one person who is a stranger)? A committee (hard to assemble quickly)? Although delay can cost the life of the recipient, haste can cost the life and rights of the donor.

Third, in France a law was passed recently that decrees that at death <u>all</u> the organs and tissues of a person's body may be used for transplant purposes unless they object in writing before their death. This measure makes available a copious supply of organs for transplant purposes-- hearts, lungs, livers, kidneys, eyes-- and will undoubtedly save numerous lives. Do you think a government has the right to decide the use of your body at death, even for humanitarian purposes? On the other hand, isn't it

selfish, if not almost criminal, to refuse the use of your dead body for humanitarian purposes?

Fourth, It is becoming practical to implant an entire artificial heart into an ailing human. (Barney Clark, 1983; William Schroeder, 1984) 50,000 people a year stand to gain added years of life from the operation which costs $100,000 (1988). But that same total investment of $5 billion would save many more than 50,000 lives if it were invested in measures to prevent heart disease in the first place. (See item: Tobacco, p. 9)

In 1983 172 transplants of natural hearts were actually performed in the U.S.; as many as 5000 people could have benefited from the operation. The available organs often go to those who can pay. Should people be allowed to die for lack of money to pay for medical treatment?

A new and practical use for a transplant: Perhaps in jest, it has been proposed that people liable to be kidnapped (e.g., important business men or public figures) have tiny radio transmitters implanted somewhere in their bodies so they and their kidnappers can be tracked!

The 1000-year-old baby

Scientists in England have invented a way to freeze male sperm and female egg cells and keep them viable for (they believe) as much as 1000 years. Using in vitro fertilization (See item: In Vitro Fertilization, p. , it may therefore become possible with the help of a surrogate mother to produce a child both of whose parents were supremely talented or otherwise unusual men and women even though they have lived many miles or years (even centuries!) apart and never known each other. Some people think this is a great invention giving hope of improving the human race, just as it is now being done with race horses. Others believe no one can take responsibility for having a son/daughter 1000 years from now, and the idea is scary.

If this possibility were to become a reality how do you think the sperm and egg donors should be chosen? How would you go about identifying the people responsible for doing the choosing?

(See item: Human Gene Manipulation, p. 51)

Medical technology for all?

When medical care becomes really expensive, who pays?

For example, Jane's premature baby girl was born blind. For three weeks in an oxygen tent and incubator, fed intravenously and tended continuously by the care of specialists and the machines and chemicals of modern technology, the baby survived and went home condemned to a life of darkness. Her teen-age parents had no job, no money, no child-care training.

Pregnant teen agers often have defective or premature babies-- babies that can be saved by technology but only at a staggering expense. Who pays for them now? Who should pay? Should access to unlimited medical technology regardless of cost be considered as a right of all American citizens?

Health insurance alone cannot solve the problem, for 37 million Americans have no health insurance whatever.

The National Research Council reports that in 1987 about a million U.S. teen agers became pregnant, resulting in 470,000 births, 400,000 abortions and 130,000 miscarriages. That's about 1300 live babies of teen-age parents per day. Since teen-age parents have severely limited career prospects they are likely to become dependent on public assistance, and the cost to society is high. $17 billion in federal assistance (Aid to Families With Dependent Children, Medicaid, and food stamps) went in 1985 to families begun by births to teen-age mothers.

As a second example, should Congress fund the design of an artificial heart? If fully perfected, as it probably would be, it might benefit 17,000 to 35,000 heart disease patients whose lives would otherwise be cut short. (1985 report by the N.I.H. Heart, Lung, and Blood Institute). How can you say "no" to that?

Cost for the operations: $2.5 to $5 billion annually, which must add to presently spiralling public health care costs (included in your taxes). Of course the patient's quality of life presents problems too-- a prediction of 2.3 hospitalizations, a drug maintenance

regimen, and need for constant medical supervision which has to be paid for somehow, with an expected life extension of only 54 months. Couldn't that money be more effectively spent on prevention of heart disease in the first place?

Situations like these are making it impossible to argue that we must save all life at any cost. We simply can't afford to do so. If we were to try, then the federal government should pay not only for these thousands of heart transplants annually but the $300,000 bill for a single liver transplant or the care of a 60-year-old alcoholic as well as for the care of a defective new-born child.

Where do you draw the line? And who pays for Jane?

(See items: Fetal Medical Examination, p. 56, Medical Tests for Health Insurability, p. 59 and Dollar Value of a Human Life, p. 4. See also a feature article on how economic forces and politics are changing American medicine: "The Revolution in Medicine", a Newsweek special report, January 26, 1987 and Hard Choices, The Mixed Blessings of Modern Medical Technology, B.D. Colen. G.P. Putnam Sons, 1986. Also "Infant Mortality and the Health of Societies", K. Newland. Worldwatch Paper Series, noted in Bibliography)

Putting fluorine in the public drinking water supply reduces cavities in your teeth, but it is medication without your consent. Shouldn't it therefore be stopped?

Medical research for profit

Is it proper for a hospital to be in the business of saving lives for a profit?

Current research in molecular biology may presently make possible the controlled replacement of defective human genes, and already the replacement of entire human hearts and ears are undergoing clinical trials. All three of these new forms of treatment are being developed in corporate medical institutions for profit, unlike earlier such forms of treatment. This raises questions of right and wrong.

Critics argue that the preliminary work done so far was brought to its present stage of perfection with taxpayers' money in not-for-profit research institutions and that the widely publicized clinical trials of entire artificial hearts (Barney Clark and William Schroeder) are an exploitation for commercial purposes. Undoubtedly private hospitals intent on making a profit face strong conflicts of interest in promoting their services and carrying out clinical trials.

How can medical research institutions such as hospitals work toward the goal of extending scientific knowledge and at the same time pursue a commercial self-interest? And yet, after all, the U.S. is a free-enterprise society.

If hospitals are to become profit-making businesses should they be required to accept indigent and uninsured patients-- as they do at present?

Is the dramatic increase in milk production made possible with genetically engineered growth hormones worth the unknown risk to children's health?

Medical tests for health insurability

Should a test that may predict a serious illness in the future be a condition for getting health insurance or a job?

For example, a positive test for HIV (human immunodeficiency virus) in a person's blood means a 25 to 50 percent chance of their coming down with AIDS within five to ten years of infection, followed by certain death. That, in turn, may make an otherwise healthy person uninsurable.

Insurance companies in some states are demanding proof that an applicant is not at risk for AIDS, and since the number of people at risk for AIDS is rising to epidemic proportions so also is the number of people who are unable to obtain health or life insurance and are therefore destined to become wards of the state when they become ill. If blood tests are legally prohibited as a condition for obtaining health insurance then insurance companies will be unable to screen out people who are at particularly high risk, with the result that the increasing number of AIDS victims will raise the price of policies for all insured individuals. In effect, the enormous costs of the AIDS epidemic will be increasingly borne by the uninfected public.

Should blood tests be made mandatory for insurance applicants? If you say "No", then who should pay the costs of hospitalizing people who later come down with AIDS? If you say "Yes", you should recognize that a tiny minority of people who do not have HIV in their blood nonetheless test positive for it. To exclude them from insurance or jobs clearly would work a great injustice to these very few.

AIDS victims are not the only people at risk. Progress in mapping human genes makes it possible that in the near future patterns of genes associated with a predisposition to heart attacks, diabetes, Alzheimer's disease and certain cancers can be identified quickly and simply. When they are perfected these tests will make it possible to identify a person even in the womb who may later in life face a long and costly battle for health-- and in the eyes of health and life insurance companies be uninsurable. This means that healthy

people pay the medical expenses of the unfortunate people who are sick. Is this right? If not, then what is your solution?

If it becomes legal for companies to withold insurance from people whose life and health are found to be at risk at some indefinite time in the future, it is probable that prospective employers will likewise make negative blood tests a condition of employment. Why should a company hire and go to the expense of training someone who will probably (or certainly) come down with AIDS or the consequences of some congenital gene deficiency in a few years?

Is it fair to forbid employers to make a blood test a condition for getting a job?

Is it fair to the AIDS carrier to be denied a job while he/she is still physically fit and otherwise qualified?

Should blood tests as a condition for employment-- or insurance coverage-- be legal? Aren't they an infringement on an individual's right to privacy? What do you think?

(See also items: Fetal Medical Examination, p. 56 and Inherited Disease, p. 12)

Every day there are 235,000 more people in the world than there were the day before. In what ways is this affecting you personally?

CHEMISTRY

Beginning
on page:

Law of Conservation of Matter

Where is all the trash and waste material for which you were personally responsible during the past month?

The Law of Conservation of Matter is one of the cornerstones of chemistry. Just about all of the atoms of which you are made have been around since the formation of the earth-- and earlier--and used over and over again by living organisms down through history. And they will persist into the indefinite future.

The atoms of wastes (if they are not radioactive) are also indestructable. While some waste compounds decompose into simpler compounds (e.g., sewage and kitchen garbage) other compounds often do not. Whenever it rains our lakes, rivers, and shorelines are dosed with oil, lead, and bacteria from city streets, sediments and pesticides from eroding farm lands, soil from construction sites, and acids from mines.

An example of the latter is the "acid mi· drainage" associated with coal deposits. contaminates streams in coal mining areas with sulfuric acid. A typical reaction is

$$4FeS + 9O_2 + 4H_2O = 2Fe_2O_3 + 4H_2SO_4$$

The FeS is from left-over deposits, and the O_2 is from the air.

Another example: "Rubber dust is an awful mess in cities, towns, or near freeways. Just think of all those millions of car tires wearing down as they drive by. Where do you think that rubber goes? Well, a lot of it goes up and sticks onto our windows. But only up to about the third floor. Most of it cuts out at about the seventh floor, which is one reason that more important people have higher offices. Us lesser folks use 135,000 gallons of Windex every day to remove rubber dust from our windows." (From Discover Magazine, Nov. 1986, p. 112).

Flushing the toilet, pouring chemicals down the sink, throwing old tires into the river are familiar examples. But the Law of Conservation of

Matter rephrased says, "Everything has to go somewhere". The law decrees that those undesirable polluting molecules cannot be destroyed; they can only be moved somewhere else (like where?) or expensively converted into less polluting material.

Who should pay for all that?

If industrial firms cannot afford to clean up and still stay in business then jobs are lost, and an entire community may decline. And if taxpayers cannot afford to clean up old chemical waste dumps community health is endangered. The problems of pollution in our environment are one consequence of the Law of Conservation of Matter.

(See: "Mining Urban Wastes: The Potential for Recycling", C. Pollock. Worldwatch Paper Series noted in Bibliography. See also item: Waste Disposal, p. 85)

Rich coal beds underlie some of the most fertile wheat-growing land in the American west. As oil grows increasingly scarce and expensive shouldn't the coal beds (which lie near the surface) be strip-mined?

Randomness: Entropy

"Things fall apart; the center cannot hold.
Mere anarchy is loosed upon the land."
(W.B. Yeats, "The Second Coming")

Work must be done (energy expended) to create order out of disorder. Left to themselves, orderly arrangements of matter tend to become disorderly or random. Disorder (measured by scientists by a quantity called entropy) tends to increase. Thus:

-a pack of cards arranged in order becomes disordered when it is shuffled. It is extremely unlikely that shuffling would arrange the cards in numerical order again. An effort (work) would be required to arrange them in order.

-a box of sugar cubes or an egg are orderly structures. Dropped on the floor they become disordered. Humpty Dumpty.

-a plant or animal body is highly ordered when it is alive. Metabolic work during life maintains the order. At death randomness ensues.

-environmental pollutants of all kinds (chemicals, heat, solid waste) may be tightly confined in various containers (ordered), but if not cared for the containers fail, and disorder follows. Work is then required to restore order, which is usually expensive, sometimes impractical.

-it is very expensive to extract fresh water from the ocean.

For further examples consider what happens to the orderliness of:

a) soda pop and beer bottles, once in factory containers, ending up alongside highways.

b) the energy of a lump of coal being dissipated in the atmosphere.

c) your disorderly bedroom unless you perform work to pick it up.

d) a discarded automobile rusting in the town dump.

e) an abandoned building.

f) PCB's and other industrial wastes disposed of in the river, in waste land above the water table, or as flue gases up the smokestack.

g) radioactive waste from the spent fuel rods of nuclear power plants.

h) information transmitted by word of mouth

Can you name some other examples?

Collect and post appropriate news clippings that illustrate the increase or decrease of entropy in the environment. Note environmental degradation of all kinds, collisions, wear and obsolescence vs. repairing, building, publishing, and growth.

The federal General Accounting Office estimates that there are over 130,000 hazardous waste sites in the U.S. Only a few hundred of them have been cleaned up so far. Is this a good example of how entropy behaves? In what ways do you increase the disorder of your own world during an average day? Can you name ten?

(See PROJECT on roadside litter, p. 229)

Where are the 1300 pounds of waste material that you were responsible for last year?

Nitrogen

Free nitrogen in the atmosphere is hard to "fix".

Nitrogen-rich fertilizer is essential to the intensive agriculture of most kinds of food, but it is becoming ever more expensive. To "fix" the chemically inert nitrogen in the atmosphere into molecules of fertilizer requires a great deal of energy in the form of heat or electricity and also huge amounts of petroleum or natural gas, a non-renewable natural resource. The spiraling price of fertilizer therefore poses the threat of famine in many poor developing countries.

Thus both humanitarian and economic urgency spur biologists to study the exciting possibility of creating varieties of major cereal crops such as wheat, rice, and corn that can perform their own nitrogen fixation from the atmosphere, just as legumes like peas, alfalfa, and clover do now. The work now in progress requires a combination of the new recombinant DNA technology (called genetic engineering) with classical plant breeding.

Try to identify the effects that success will have on (a) world hunger. (b) population, (c) the American economy, and (d) your food bill. Are all these effects likely to be good?

In answering these questions bear in mind that when the market value of new strains of a genetically engineered cereal crop becomes insufficient to pay steadily increasing fertilizer costs, the expense and the high promise of the development effort will be in vain, no matter how many people starve. Thus the solutions to world food problems are inevitably enslaved by economic forces-- Third World debt and balance of trade considerations among them.

(See items: Engineered Bacteria, p. 14 and Patenting Plants and Animals, p. 15. See also "Beyond Green Revolution: New Approaches for Third World Agriculture", E.C. Wolf, Worldwatch Paper Series noted in bibliography).

Methane, fermentation. Developing countries

How well can you eat when a fuel for cooking is scarce?

In the countryside of developing countries wood is often in very short supply because trees have already been cut off. Dried cattle dung is often burned, but that means it cannot be used as a badly needed fertilizer.

However, the daily dung from just three cattle is enough to generate methane gas whose calorific value is equivalent to four or five liters (about a gallon) of diesel fuel. This is enough for an average family's domestic use, and the fermentation equipment for producing and using it is very simple and can often be made locally from discarded oil drums.

Cellulose and other plant matter, $n(CH_2O)$, is broken down by anaerobic bacteria into CO_2 and methane, CH_4 as follows:

$$n(CH_2O) = \frac{n}{2} CO_2 + \frac{n}{2} CH_4$$

Or the methane can be used for the manufacture of caustic soda, NaOH, which is of great value in many small village industries for the production of soap, dyes, and the processing of cloth. NaOH is typically bought from larger centers, where it is prepared by electrolysis, a process impractical locally. But using methane gas to heat a mixture of slaked lime and sodium carbonate in water you get NaOH in quantity.

$$Na_2CO_3 + Ca(OH)_2 = CaCO_3 + 2NaOH$$

The raw materials are often cheaply available, and cast-off oil drums can be used for the reaction and for filtering off the NaOH solution from the solid calcium carbonate.

Reactions like these using simple equipment and local raw materials were abandoned long ago in technically advanced countries like the U.S. because they required too much labor and cannot be operated continuously. (They are "batch" processes). But these are both advantages in many developing countries.

Americans and people from other developed countries working in Third World countries overseas use

elementary chemistry in a similar way to help impoverished rural areas process basic raw materials such as wood, beet sugar, plant fibers, seaweed, and animal products for either local benefit or to sell elsewhere for money. In many parts of the world such simple village processes now create employment and produce previously unavailable materials. Each developing country has different needs and different solutions. Perhaps you will become interested in using your knowledge of chemistry in this practical way abroad some day.

For information on low-input agriculture and community resource management write Agricenter International, 7777 Walnut Grove Road, Box 17, Memphis, Tenn. 38119.

(See item: Energy Conversion: Developing Countries, p. 145. Note also Small Is Beautiful: Economics As If People Mattered, E.F. Schumacher. Harper and Row, 1973).

Coal

The cost of coal is greatly increased by the cost of transporting it. Loaded coal cars take the coal from the mines but have to return empty. Why couldn't the empty cars be used to carry trash and garbage which could be used to fill in and to repair land scarred by the coal mining? Arguments pro and con?

(See item: Waste Disposal, p. 85)

Ozone catalysis: Destruction of our atmosphere

Though too much ozone in ground-level smog is a health hazard, too <u>little</u> ozone in the upper atmosphere is a health hazard too!

The ozone layer in the upper atmosphere (12-50 km up) filters out all the ultraviolet light from the sun shorter than 3000 A. Any significant destruction of the ozone layer will therefore result in an increase in cancer-causing and plant-killing ultraviolet radiation at ground level.

Ozone (O_3) is highly reactive and is destroyed by the nitrous oxide (N_2O) and carbon dioxide (CC_2) emitted by stratosphere-flying planes (for example $3N_2O + O_3 = 6NO$) and by chlorine from freon spray-can propellants and refrigerants such as $CFCl_3$ and CF_2Cl_2 (called chlorofluorocarbons or CFC's for short). In sunlight the freon breaks down to release chlorine which catalyzes the reaction $2O_3 = 3O_2$. Since each chlorine atom acts as a catalyst and is therefore not used up it can go on wreaking havoc in the ozone layer for as long as 70 to 100 years. Continuing destruction of ozone will result in an increase in serious skin cancers and birth defects, will kill plankton in the oceans, reduce the yield of many crops, and may even destroy forests and alter climate. The effects will probably take years, perhaps decades, to be fully apparent, and by then the damage will be irreversible.

Nuclear explosions high in the atmosphere (not banned by international treaty) can deplete the ozone layer in additional ways, and the widespread use of nitrogen fertilizers may also be having the same effect.

There is no agreement even among experts on how much destruction of ozone results in how much increase in ground-level ultraviolet light nor how destructive any given increase in ultraviolet light would be, so extensive study of the problem is urgently in order. But any agreed-upon actions will take years-- even decades-- to have an effect. It may already be too late to avert serious consequences.

In view of these facts, what do you think should be done-- and by who? International treaties? Unilateral restraint by freon producers? Nothing?

(See items: Absorption of Radiation: Greenhouse Effect, p. 154 and Condensation: Jet Contrails, p. 124.

Fluoridated water: Teeth

Most peoples' teeth are very durable But given time and a diet rich in sugar and in starch (especially refined flour), the enzymes in your mouth degrade the starch to glucose which in turn, along with the sugar, is converted by bacteria to lactic acid and other organic acids which slowly dissolve holes in the surface of the enamel.

Before the Seventeenth Century and again during World War II in the occupied countries of Europe and today in many underdeveloped countries dental cavities are much less of a problem than they are in the U.S. today. It's a matter of diet-- and chemistry.

Cavities can be safely reduced by 40-75% by fluoridation of the public water supply in a concentration of about one part of F- ions per million. But only half of all Americans consume fluoridated water. Public referenda proposing fluoridation of drinking water lose more often than they win despite the support of fluoridation by nearly every major scientific government and public-interest group in the country. The voters who oppose fluoridation claim that adding the chemical to their drinking water is medication without consent.

What is your response to this argument? Of course acid rain is being added to many public drinking water supplies all the time and is demonstrably harmful. And chlorine is routinely added to city water supplies to destroy bacteria (which killed 50 percent of all the children born during the Nineteenth Century). Neither one has the voters' consent!

Meanwhile we drink vitamin-D fortified milk and eat iodized salt and may soon be eating food sterilized by gamma radiation.

Hazardous chemicals, dioxin, Molecular formula

Currently about 50,000 different chemicals are being produced by U.S. industry. It takes the Environmental Protection Agency three years and $1/4 million to study thoroughly the possible long-term toxicological effects of just one of them. At this rate it will take 150,000 years to study the chemicals we have now-- and a new chemical is being introduced into the biosphere every 20 minutes (1988).

Drugs and pesticides are the most fully tested of all chemical products coming onto the market, yet toxocologists have relatively complete information on the health hazards created by only about 10% of those in use today. Food additives and cosmetics are even less well tested (two percent), and no tests at all are performed on the toxicity of nearly 80% of general chemicals such as solvents, paints, and plastics.

Meanwhile, the Consumer Product Safety Commission reports that even some chemicals found on the school chemistry laboratory shelf may be carcinogenic (cancer-causing) if used in sufficient quantities over a period of time. That includes benzene, cadmium nitrate, carbolic acid, carbon tetrachloride, ferric oxide, chloroform, chromium nitrate, formaldehyde, kerosene, phenol, propanol, and tannic acid, among others. (For full details see the NIOSH Pocket Guide to Chemical Hazards, a booklet prepared by the National Institute for Occupational Safety and Health and available from the U.S. Sup't. of Documents, U.S. Gov't. Printing Office, Washington, D.C. 20402.)

Particularly dangerous is dioxin, the general name for a class of molecules which are created by reactions between oxygen and cyclic chlorinated hydrocarbons at high temperatures. Dioxin, a by-product, is an unwanted by-product in the manufacture of various herbicides (e.g., 2,4,5-T). It is, as well, one of the most toxic substances known after the botulism toxin. As an accidental contaminent on oil sprayed on roads by a waste hauler a few years ago, it forced the evacuation of hundreds of people permanently from their homes in Times Beach, Missouri. Analyzed, dioxin produces, in part, the following information:

1.000 gm yields 0.4410 gm chlorine
0.4472 gm carbon
0.0994 gm oxygen
0.0124 gm hydrogen.

When vaporized and its vapor density compared with the vapor density of a known gas, the molar mass of dioxin is found to be 322. What is the molecular formula of dioxin?

As long as society lawfully sanctions the manufacture of toxic chemicals there must, logically, be dumps created in which to dispose of them, yet fewer and fewer communities acknowledge any responsibility to share this burden nor is there any public ethic that imposes it upon them. Instead, the NIMBY ("Not in my backyard") attitude determines the response of voters in nearly every candidate community. For this reason, nationwide, no major new hazardous waste dump has been sited in the U.S. since 1980.

To avoid future tragedies, who should be responsible for the future disposal of such substances? the producer of the substance? the waste hauler? a state agency? a federal agency? How should the cost be handled? Give reasons for your answer.

(See items: Oil Pollution, p. 97 ; Blue-green Algae and Dinoflagellates, p. 36 ; Underground Toxic Wastes, p. 88 ; and Waste Disposal, p. 85)

Road salt, Raoult's Law, friction

A needed invention: About 1/10 of all the salt (sodium chloride) produced in the world is spread on U.S. roads each winter to melt ice and snow. Thanks to Raoult's Law and the depression of the freezing point of water, highway safety is increased and countless lives are saved as a result of the increase of friction between tires and bare asphalt. But the run-off from the salted highways kills fish in rivers, contaminates water wells, kills roadside trees, and rusts out the bodies of automobiles.

How else might highway accidents be averted without the use of so much salt?

(See item: Blackbody Absorption, p. 133)

Manganese, platinum, chromium, and foreign policy

The chemistry of these elements bears directly on our national policy towards South Africa.

Our opposition to that government's suppression of civil rights is inevitably complicated by the fact that we do not know how to harden steel without manganese, and South Africa has 71% of the world's supply. (The Soviet Union has 21%). South Africa has 81% of the world's platinum ore. It has 84% of all the world's chromium too, which is an essential component of superalloys used to resist corrosion (in ships) and high temperatures (in aircraft engine turbine blades). Platinum is an active ingredient in catalytic converters which remove polluting gases from automobile exhausts. (See item: Catalysis and City Air Pollution, p. 94)

Should these scientific facts be allowed to affect our policy toward South Africa? If so, how?

Aluminum

Throwing away an aluminum beverage container wastes as much energy as filling the same container half full of gasoline and pouring it out on the ground.

This is another way of saying that the fabrication of aluminum from its ore, bauxite, requires a prodigious quantity of electrical energy. Moreover, bauxite and coal must be strip-mined in the process, and rivers are often dammed to generate the hydroelectric power needed for smelting. Then in the end discarded aluminum containers often litter the environment. Each year the United States throws away more aluminum beverage containers than are made in the entire continent of Africa.

Here, then, is an argument for recycling. Moreover, recycling aluminum requires only one-twentieth as much electricity as aluminum produced directly from bauxite. Americans now recycle 54% of the cans they use, and the countries and most individual states which have container deposit legislation achieve 90%. No state with a bottle bill has lost jobs on a net basis, and a nationwide beverage container law would, according to the U.S. General Accounting Office, create a net total of 100,000 jobs. Recycling aluminum in any form thus conserves energy, reduces the air pollution associated with aluminum production, creates jobs, and improves the outlook for the future of its resource.

Energy accounts for 20% of the cost of producing aluminum from virgin ore. As world oil prices rise why does Japan import less and less bauxite and increasing amounts of aluminum scrap? What parts of a Japanese-made car are made of aluminum? Where do you suppose the aluminum came from?

* * *

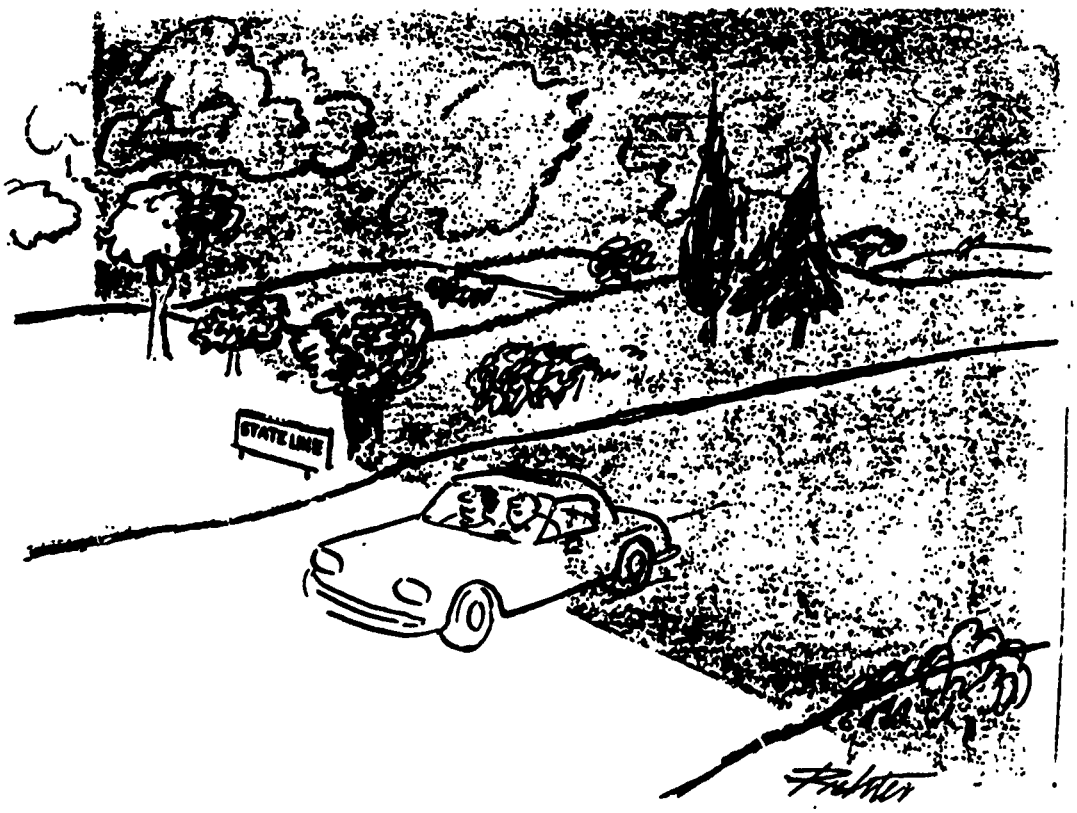
Despite its merits of relatively light weight (compared to iron and steel) and high electrical conductivity per unit weight (compared to copper) some uses of aluminum may be hazardous.

First, the surface of the metal is supposedly protected by an oxide coating, but aluminum pots may be attacked by acidic foods (fruit juices, curry), and the aluminum then dissolves into the food. Where is aluminum on the chemist's activity list of metals?

Food packaged in aluminum containers has been shown to have 10-20% more aluminum than the same food packaged in non-aluminum containers. Aluminum in the diet has been associated with Alzheimer's disease. Should aluminum containers therefore be banned? Who should enforce the ban?

Second, if aluminum wire is used in house wiring it can crack when bent during installation. This produces a localized point of high electrical resistance which can heat up and start a fire. Should aluminum be banned for these uses? (Ask an electrician or a house builder). If not, why not if its use may result in poisoning, fire, and even death? After all, other hazards such as smoking and the use of asbestos are hedged about by legislation intended to protect the unsuspecting public.

(See item: Declining Resources: Fe, Cu, Zn, Pb, Al. p. 105)



"They have very strict anti-pollution laws in this state."

Waste disposal

Each American discards, on the average, 1300 pounds of waste material each year. So far in your life how many tons have you been personally responsible for? Where is it now? Why not dump it in the deep ocean?

Close to half the nation's paper, 8% of the steel, 75% of the glass, and 30% of the plastics output is used only to wrap and decorate consumer products. And of course most of it is therefore thrown away. On your next visit to the supermarket see if you can find ways of reducing this "throwaway". Europeans have done so.

The Fresh Kills Landfill on Staten Island, New York City, is an imposing pile of garbage 140 feet high. It receives 22,000 tons of garbage daily and should reach a projected height of 500 feet by the year 2000, its scheduled closing date. When that time comes it will be the highest summit on the Atlantic Coast between Maine and the furthest tip of Florida. There is, indeed, a symbol of our nation's wastefulness!

(See items: Coal, p. 77 ; Hazardous Chemicals, p. 80 , and Underground Toxic Wastes, p. 88. Also see "Mining Urban Wastes: The Potential for Recycling", C. Pollock. Worldwatch Paper Series noted in Bibliography).

Trail bikes and dune buggies on public lands destroy fragile vegetation and the peace and quiet. Why shouldn't they be outlawed? And loud motorcycles on public highways too?

Degradable polymers: An answer to plastic trash?

17,000 tons of plastic disposable diapers were thrown away in 1986, and the amount is increasing year by year.

As garbage dumps bloat beyond their capacity to expand and our cities run out of landfill space, solutions to the trash problem are complicated by the unbelievably large volume of plastic objects which won't rust, rot, dissolve, or evaporate and increasingly clutters the earth. In 1986 we manufactured 20 billion plastic bottles. About eight percent of America's solid waste is plastic such as polyethylene, polyvinyl chloride, and polystyrene that takes up to five centuries to degrade. Less than one percent is recycled.

Typical polymer molecules such as these consist of chains as much as hundreds of thousands of atoms long. Bacteria (responsible for biodegradation) cannot attack such gigantic structures unless they are broken into pieces less than about 1000 atoms long, nor can sunlight do so in less than hundreds of years. Biodegradable and photodegradable plastic is made by inserting carbon monoxide molecules as weak links in the polymer chain, which is then easily broken by ultraviolet light or bacterial action.

Most of the plastic trash now accumulating worldwide is not degradable in this way; neither sun nor bacteria will get rid of it-- only time. Lots of it. Degradable plastic, which begins to crumble after only a month's exposure to sunlight, costs $2 a pound, however, while ordinary polyethylene costs only about 50 cents a pound so cost is a factor in any solution to the disposal problem. Burning is not a cheap solution either since some plastics when burned generate hydrochloric acid which requires expensive chemical scrubbers for its removal.

With no inexpensive technological solution in sight, what do you imagine is going to happen to the plastics in your trash 10 or 20 years from now? Bear in mind that as an average citizen you are the creator or are responsible for 1300 pounds of trash of various kinds every year. Bear in mind, too, the problems posed by nuclear reactor waste and atmospheric

carbon dioxide which are also indestructable products of human activity.

Can you suggest any solutions?

(See items: Radioactive Waste Disposal, p. 89; Nuclear Power Plant Disposal, p. 90; Underground Toxic Wastes, p. 88; and Catalysis and City Air Pollution, p. 94)

"The ground pollution won't be any worse if you take out one more bag of garbage."

Underground toxic wastes

Are you being poisoned by your drinking water?

From as many as 16,000 landfills around the U.S. pesticides, man-made organic chemicals, heavy metals, and other poisons are seeping into the earth and into the underground water table. Add buried gasoline tanks, septic systems, and farm fertilizer, and it may not be surprising that up to one-fourth of the nation's aquifers (underground natural fresh-water reservoirs) will be contaminated beyond use in coming years.

In California's Silicon Valley solvents used in making computer chips have seeped from buried storage tanks into the water supplies of several communities. Ethylene dibromide, a carcinogenic fumigant, has contaminated wells in Florida. It may cost up to $1.8 billion to completely clean up leaking pesticides and nerve gas residues at the Rocky Mountain Arsenal near Denver, Colo.

In 1986 26 companies were developing genetically engineered crops that resist herbicides so that farmers can clear their fields of weeds using herbicides, but the herbicides are already showing up in the aquifers of 10 farm states.

Price's Pit, a 22-acre dump for toxic wastes located six miles north of Atlantic City, N.J. was the repository for nine million gallons of toxic chemical wastes dumped there between 1971 and 1973. In nearby Egg Harbor Township the tap water blackened pots, turned laundry yellow, and at times fizzed like soda pop. The pollutants seep about seven inches a day or half a mile in ten years. Already they have reached the Cohansey Aquifer, which supplies Atlantic City with water. Last year over 33 million people visited Atlantic City.

What should be done? By whom? And who pays?

(See items: Hazardous Chemicals, p. 80 and Waste Disposal, p. 85)

Radioactive waste disposal

How do you feel about something that has to stay underground and be sealed off for 25,000 years before it is harmless?

The disposal of long-lived radioactive fuel rods and other waste products from the nation's nuclear reactors poses two serious problems. The first problem is how to protect people from the radiation during the thousands of years it remains dangerous? The solutions now being worked on involve forming the wastes into various forms of inert and insoluble glass or artificial rock and burying it deep in geologically stable regions of the earth.

The second problem is to decide on just where the burial sites are to be and how to pay for them over their long life times. In your town, perhaps? Why not?

In a democratic society like ours waste disposal is not only an engineering problem; it is a political problem too, requiring consideration by all segments of society. And this difficult problem has got to be solved before <u>anything</u> happens. Meanwhile the radioactive wastes continue to accumulate.

A thought question or class PROJECT: Where in your state is the most practical place for the disposal of the state's radioactive waste? Ideally, the answer must take into account the geology, politics, transportation routes, population density, jobs, water table, etc. and the volume of radioactive waste to be received and stored from the state's hospitals, industry, and nuclear power plants. Is your choice compatible with present state laws?

A related problem: 10,000 years from now when the wastes will still be dangerous the English language will have evolved beyond recognition. How do you record safety instructions and precautions for the people of that distant time <u>on the tanks</u>? Records on paper elsewhere might well be lost.

Should the deep ocean be considered an option for hazardous radioactive waste disposal?

(See item: Nuclear Power Plant Disposal, p. 90. See also "Radioactive Wastes", B.J. Skinner and C.A. Walker. American Scientist Magazine, Vol. 70, March-April 1982.)

Nuclear power plant disposal

By the year 2010 about 70 of the nation's 105 existing nuclear power plants (1987) will be reaching the end of their useful lives. There are about 340 nuclear power plants worldwide (1985).

The useful life of a nuclear power plant is about 40 years. After that the reactor itself is so unreliable and so radioactive that it can no longer function safely and economically, and it must be shut down. But what happens then? Dismantle it? But much of its steel and concrete is by now radioactive. Mothball it? But then it must be guarded indefinitely. Bury it? Convert it to other uses?

Today it could cost $700 million to retire just one reactor. The safer the disposal method that you choose the more expensive it becomes. Should we pay for the most expensive method of all in order to protect people thousands of years in the future, or should we save our money and let future generations worry about leakage of our radioactive wastes? Very few reactors have reached the end of their working lives yet so there is little or no experience in solving this problem.

What is our moral obligation to our children and their descendants?

(See items: 'Unpredictable Costs of Environmental Protection, p. 29 ; and "Radioactive Waste Disposal", p. 89 . See also "Nuclear Power: The Dilemma of Decommissioning", S. Shulman. Smithsonian, Oct. 1989; and "Fission Reactors", M.M. Levine, a module in the AAPT Issue-Oriented Modules Series noted in the Bibliography; and "Decommissioning: Nuclear Power's Missing Link", C. Pollock. Worldwatch Paper Series, noted in Bibliography.)

Acid rain

Rain may be bad for you!

Factory and power plant smokestacks emit a variety of chemicals, particularly nitrogen oxides and sulfur dioxide, that make the down-wind rain acidic. For example (simplified):

$SO_2 + O_2 = 2SO_3$ and then $SO_3 + H_2O = H_2SO_4$

The rain, turned into sulfuric acid (H_2SO_4), nitric, and hydrochloric acid which may be as concentrated as the acetic acid in vinegar, falls on lakes, farms, cities, and people, killing fish, creating lung disorders, and damaging buildings made of limestone and marble, ($H_2SO_4 + CaCO_3 = H_2CO_3 + CaSO_4$), rusting autos and stunting plant growth.

The Parthenon in Athens and the architectural treasures of Venice as well as numerous stone buildings in the U.S. are being steadily destroyed by acid rain from up-wind factories. The factories employ many people. Should the factories be allowed to expand in order to remain economically competitive?

Some corrosion products of acid rain also contaminate drinking water because copper, lead, and zinc pipes all dissolve slowly in acid rain. ($Zn + H_2SO_4 = ZnSO_4 + H_2$)

In Latin America many people's houses have galvanized sheet iron roofs from which rain is collected for drinking water. In areas of active volcanoes the rain is made acidic by the volcano gases, dissolves the zinc coating on the sheet iron, and poisons the drinking water. Zinc poisoning is common in some such areas.

In the Netherlands corrosion by acid rain has thinned the walls of bronze church bells. Since the thickness of a bell's wall determines its tone, its pitch is irreversibly altered. Carillon bells normally in tune for three or four hundred years are completely out of tune in 25 to 50 years. (The Physics Teacher Mag., May 1989, p. 408).

An epidemic of green-tinted hair among blond and white-haired residents of Columbia, Md. was traced to their drinking water. Their well was so highly acidic that it was dissolving copper from the pipes, which they then ingested. (Omni Magazine, October 1979).

Lakes and forests are severely affected by acid rain too. Hundreds of lakes in Ontario and the Adirondack Mts. are devoid of all fish, and thousands are damaged. 9000 are threatened east of the Mississippi. Acid rain has destroyed all aquatic life in 10,000 lakes in Sweden, and in Europe 22 percent of the forests are showing signs of damage, some totally destroyed.

1988 President Reagan agreed to freeze U.S. nitrogen oxide emissions at the 1987 levels until 1996, and an international acid rain treaty is now (1989) being negotiated. However, any laws that may be passed requiring factories to install expensive scrubbers in their smokestacks will take ten or fifteen years to have an appreciable effect on the acidity of rain in the Northeast and cost many jobs.

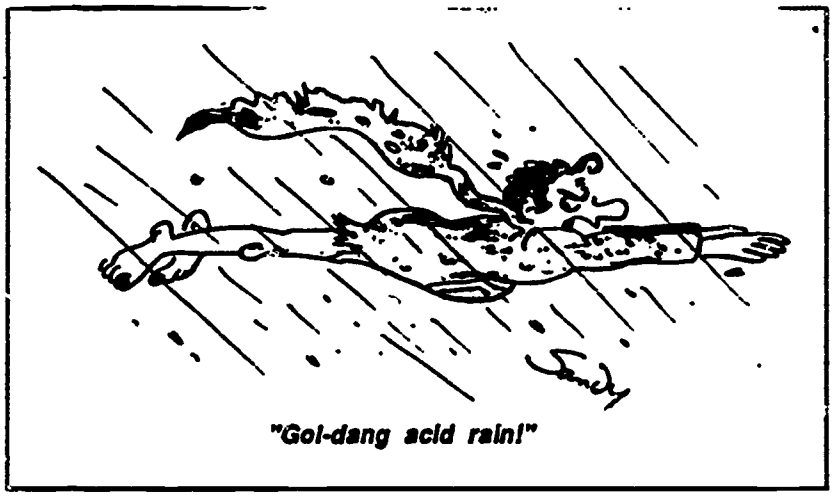
Who should pay for any clean-up required by legislation? What consequences (political, economic, environmental) do you think will follow if (a) corrective action is taken promptly?, (b) if action is not undertaken promptly? Should the people living around a mid-western American power plant have to pay to clean up the rain in eastern Canada?

Is it right that pollution control laws should force a company to go bankrupt or cause workers to lose wages or jobs? Should the U.S. replace its coal-burning plants with nuclear power plants? Should you be restricted from driving your air-polluting car into the nearby city?

If you are a congressman for a state in which much of the pollution originates, and immense numbers of jobs and dollars are at stake, what are you going to do?

(For teaching materials, activities, and free periodic updates on acid rain news and legislation write to the Acid Rain Foundation, Inc., 1410 Varsity Drive, Raleigh, N.C. 27606. See also Troubled Skies, Troubled Waters. The Story of Acid Rain, T.R. Lucoma. Viking Press, 1984, and "Air Pollution, Acid Rain, and the Future of Forests", S. Postel, Worldwatch Paper Series noted in Bibliography. "The Acid Rain Debate", R. Bybee, M. Hibbs, and E. Johnson in The Science Teacher Magazine, April 1984, p. 50 describes a class role-playing activity.).

A PROJECT on acid rain is suggested on p. 230.



"Gol-dang acid rain!"

If a few aging aircraft suffer explosive decompressions should all old airliners be grounded?

Catalysis and city air pollution

In traffic congested large cities even non-smokers suffer lung damage from air pollution. Occasionally the damage may be equivalent to a rural dweller who smokes a pack of cigarettes a day. Joggers are especially at risk.

The pollutants come mainly from automobile exhausts. For example:

$$\underset{\text{octane}}{C_8H_{18}} \rightarrow 2\underset{\text{ethylene}}{C_2H_4} + \underset{\text{propylene}}{C_3H_6} + \underset{\text{methane}}{CH_4}$$

and also

$$C_8H_{18} + 11\ 1/2\ O_2 = 6CO_2 + 2CO + 9H_2O$$

When these and other hydrocarbons and nitrogen oxides mix in the presence of ultraviolet radiation in sunlight they form ozone and other noxious compounds collectively called smog. Smog may contain 100 different compounds, many of them irritant, toxic, or carcinogenic.

The principal method of reducing the emission of these noxious products is by means of catalytic converters in the exhaust systems of cars. A converter contains one to three grams of a mixture of platinum and palladium metals embedded in a base of aluminum oxide. This mixture catalyzes the conversion of the polluting CO and hydrocarbons to CO_2 and water. But platinum (up to $600 an ounce, mainly from South Africa) and palladium are very expensive, and the necessary unleaded gasoline is more expensive than ordinary gasoline. Also the use of the catalytic converter reduces the car's gas mileage. Some people disconnect the converter in their car.

Should they do so? Would you do so? Why?

The nearly 400 million automobiles in the world today emit about 547 million tons of carbon into the atmosphere annually. At the present rate, if nothing is done, these emissions will nearly double by 2010, increasing global warming and city smog. The increased American demand for gas-guzzling cars in 1988 was clearly of no help.

(See items: Manganese, Platinum, Chromium, and Foreign Policy, p. 82 and Lead Poisoning, p. 96.

While gasoline engines are the major source of smog in cities, there are other sources of gases of various kinds which solar ultraviolet catalyzes to ozone and smog. Gasoline stations, hamburger restaurants (the smell of sizzling steak!), paints and varnishes, bakeries, dry cleaners, breweries, lawn mowers, and backyard barbecues are all sources of smog, and their uses are all deeply embedded in the habits of Americans. Officials of the Environmental Protection Agency say as many as 75 or 80 areas of the country fail to meet federal Clean Air Act standards, and their compliance will require a slash in offending emissions by at least 50 percent.

If your life style or your livlihood depends on any of these industries or activities, how would you react to such severe regulation? Would you fight it? How? Evade or ignore it? Move away? Or what?

How much right of protest have you? Is this an issue on which to exercise it?

* * * *

Note that ozone in the upper atmosphere is created in a different way than ground-level smog although man-made chemicals-- and life style-- play an essential part in its destruction there. See item: Ozone Catalysis: Destruction of Our Atmosphere, p. 78.

It has been suggested (N. Y. Times, Feb. 28, 1989, p. C4) that smog may be protecting people from the increased solar ultraviolet radiation that results from the destruction of upper-atmosphere ozone. If so, one source of pollution has offset the bad effects of another! Should this be cause for rejoicing or complacency?

Lead poisoning

Lead poisoning has been proposed as one of the causes of the collapse of the Roman Empire. The wealthy ruling class drank regularly from containers made of lead and sweetened their wine with lead acetate ("sugar of lead"), and so they may very well have poisoned themselves. A fluke? But today lead water pipes and solder in old plumbing systems is contaminating school and home water supplies, and lead-oxide-based paint in old housing with its associated dust and soil is a threat to public health. The use of lead solder was banned by the Clean Water Act in 1986. Now eliminated for use in gasoline for automobiles, lead (in the form of lead bromide) is still permitted in gasoline for use in farm machinery and construction equipment and for export.

Infants and small children are particularly susceptible to lead poisoning, and those with low to moderate exposure to lead in their environment are found to suffer a median drop of 4 to 5 points in I.Q. The U.S. Public Health Service reports that over 17 percent of all children in the U.S. (1984) have blood lead levels exceeding safe standards.

About 200 children die each year of lead poisoning in the U.S., and over 12,000 are treated and survive. Why should residents in an old building avoid consuming water from the hot-water tap, especially when preparing baby formula? And how can they most simply reduce the hazard?

(The EPA and the Office of Drinking Water publish Lead in School's Drinking Water, a 58-page manual outlining the procedure for sampling and reducing lead in your home and school's water supply. Write to Dept. 36-ES, Superintendent of Documents, Washington, D.C. 20402, citing stock number 055-000-00281-9).

Over a million ducks, geese, and swans were poisoned annually (1982) by eating some of the 6 million pounds of lead shot deposited every year by hunters in shallow lakes and marshes. The solution is to use steel shot, which is not poisonous, but both federal and state laws to require its use have met with opposition and mixed success. (For further information write to the Office of Migratory Bird

Management, Fish and Wildlife Service, U.S. Dept. of the Interior, Washington, D.C. 20240.)

Oil pollution

Should an oil company, negligent of legal safety precautions, be charged for criminal damage if an oil spill pollutes a public park or wildlife refuge or harbor? (e.g. the Exxon Valdez spill in Alaska in 1989).

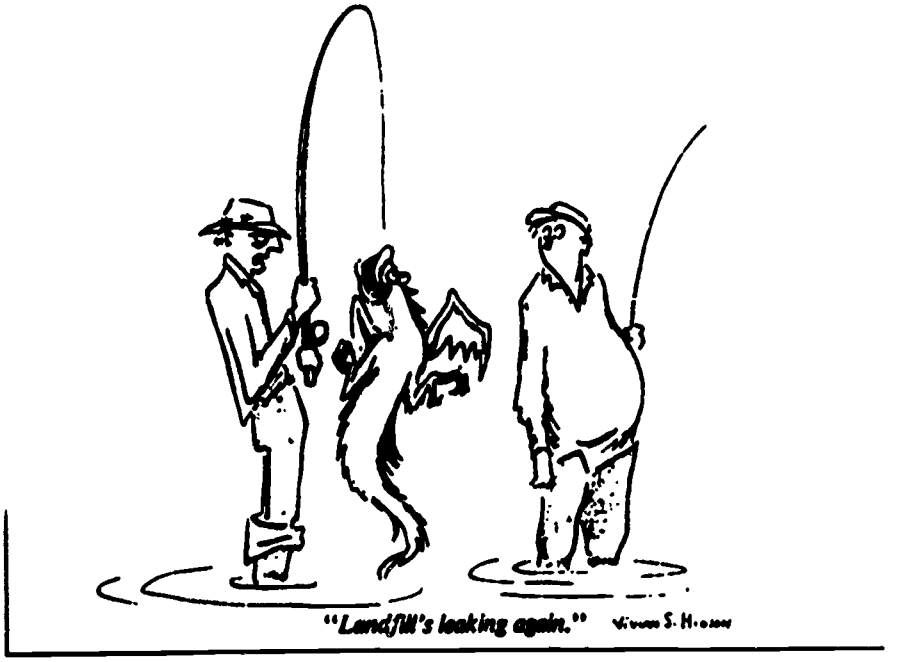
How about the individual company employees whose negligence was responsible? (e.g. the captain of the Exxon Valdez.

Should you be charged with a criminal offense if you dispose of polluting material (oil, detergents, old paint, et al.) into a park or a waterway?

Is your answer the same if you simply pour the polluting material down the sink?

Is there a moral distinction between you and the oil company?

(See items: Blue-green Algae and Dinoflagellates, p. 36 and Hazardous Chemicals, Dioxin, Molecular Formulas, p. 80).



Home air pollution

Even indoors, breathing can be bad for you!

For joggers in crowded cities the concentration of automobile exhaust fumes at street level sometimes becomes dangerously high. But even staying in bed may have its hazards because as energy-conscious home owners insulate their houses more and more tightly to prevent the escape of heat in winter they manage to prevent also the escape of a variety of polluting gases. Potentially fatal carbon monoxide builds up from badly ventilated stoves; radon gas, whose low-level radioactivity can induce cancer, seeps in from some kinds of rock and cinder block foundation walls, and formaldehyde fumes emitted by some urea foam insulation inside the walls can cause severe illness. Children and the elderly are the first and most severely affected.

(See "Radon: Reducible Risks, Rational Remedies", J. Texley. The Science Teacher, Jan. 1989).

"Walter's solution is to pump a lot of fresh air into the atmosphere."

Petroleum depletion

Within the next 10 or 15 years the decreasing supply of petroleum will start to fall short of the world's demand for it. As our petroleum reserves decline, alternatives to gasoline become more attractive and interesting. One of them is methyl alcohol (methanol) made synthetically from hydrogen and any carbonaceous material that can yield carbon monoxide

$$CO + 2H_2 = CH_3OH \text{ (with catalyst)}$$

Any present gasoline engine, including diesel, will run on it, and it's already cheaper than gasoline. Problems: greater engine wear, and exhaust pollutants such as formaldehyde, CH_2O. Mixed with gasoline it's called "gasohol".

Other processes are the extraction of petroleum from a form of shale and the Lurgi process (steam and oxygen over hot coal makes octane, among other things), but they are both expensive and polluting.

It is not very widely appreciated that we need petroleum to make plastics, synthetic rubber, and artificial fertilizer. For these important processes there are no very satisfactory substitutes. A good case can be made for trying to preserve the world's remaining petroleum for these important uses by finding alternatives to petroleum (such as those mentioned above) or developing alternative energy sources-- or conservation.

The complex interactions of geology, politics, and economics is going to dictate a drop in petroleum production in the next two decades. Can you write a scenario for the sequence of events as this begins to happen?

(See item: Oil from Rock, p. 100. Also see "World Oil: Coping with the Dangers of Success", C. Flavin. Worldwatch Paper Series noted in Bibliography).

Oil from rock

To reduce our dependence on imported oil we can extract oil from a kind of shale rock abundant in the West.

Within about a decade we could be producing from rock about 10 percent of the nation's present demand for oil. But each barrel of oil produced in this way will require one to four barrels of fresh water to produce it and result in as much as 1.5 tons of rock wastes. Should we do it? Arguments pro and con?

(See items: Water Shortage: U.S.A., p. 103 and Petroleum Depletion. p. 99)

Minerals on public land

Use it or lose it?

Rich coal beds underlie some of the most fertile wheat-growing land in the American West. Should it be strip mined?

Federal lands contain 40% of the nation's salable timber, 50% of its coal, 80% of its shale oil, and most of its copper, silver, asbestos, lead, beryllium, molybdenum, phosphate, and potash. As federal land it belongs to all American's, including you, just as the national parks do.

Should any of it be put into commercial production? Under what circumstances? How much should be saved for future generations or preserved just as it is?

(See item: National Parks, p. 31)

Ocean-bottom minerals

Vast wealth for the taking?

In the deep ocean far out beyond national boundaries large areas of the sea floor are covered with marble-to-baseball sized lumps rich in the valuable metals copper, manganese, nickel, and cobalt. No one nation owns the oceans; they are international. But only the developed industrial nations have the money and the technology to harvest this wealth which belongs to all nations. Should it be harvested? How are the poorer nations' rights to be protected?

The U.S. has refused to ratify the 1982 U.N. Convention of the Law of the Sea, which sought to regulate mining and other commercial development. The Administration argued (in 1988) that the treaty, which assigned ownership of the resources on the deep-sea bottom to all nations, interferes with private exploitation. Nor has the U.S. Senate yet ratified a similar treaty of 1979 concerning resources on the moon and other celestial bodies.

Thus, all those resources are available for you or anyone else to take who can afford to exploit them.

But why should minerals on the bottom of the ocean beyond the 20-mile limit be any different than the fish in the same ocean merely closer to the surface? Persons with resources for big fishing operations take more fish than the hook-and-line fishermen, and so it has been for ages.

Consider in this same discussion the use of 40-mile-long drift nets which snare not only all the fish to a depth of a hundred feet or more but also ensnare dolphins, sea turtles, and whales, killing them and sweeping an immense volume of the sea clean of all organisms larger than the mesh size of the nets.

By what means can destructive exploitation of this common heritage of mankind be brought under control? Is it possible to do so and still have it freely available? See particularly the item, Tragedy of the Commons, p. 165 for which all the above resources provide examples.

(See items: The Geopolitics of Genes, p. 26 and Crowded Communication Satellites, p. 157)

Fresh water for desert lands: Icebergs

Needed invention: Icebergs for hot countries.

Most icebergs are made of fresh water , and because some of them are so very large they can drift for months without significant melting. It's been proposed that icebergs be towed by ship from the Antarctic (where the biggest ones are found) to countries where fresh drinking water (or even water for irrigation) is in short supply. Candidates might be Israel or the Persian Gulf where water shortages are a major source of political tension. Or possibly southern California. There, in a lagoon prepared with appropriate pumps and piping, it would melt. Why not?

An alternative: Many of the Middle East countries are rich in oil but very short of water for irrigation and drinking. Supertankers that have delivered oil to developed countries such as the U.S. return to the Middle East empty-- and thus profitless. Why not fill them up with fresh water on their way back? Periodically tankers are idle, fresh water (such as from rivers) near the tanker routes is ample, and the oil-rich countries of the Middle East are both needy and well able to pay.

(See: "The Fresh Connection", B. Rice, Audubon Magazine, Jan. 1986, p. 104).

Water shortage: U.S.A.

Your drinking water supply may be at risk.

Only about 10% of the water used in the U.S. is for domestic use. By far the largest users are industry (about 60%) and farmers (about 30 %), who need 175 billion gallons a day just for crop irrigation. The water level in wells in many parts of the U.S. is steadily dropping. Major legal conflicts over access to available water in rivers are before the courts in several western states and in Washington.

Consider Tucson, Arizona, whose population is expected to triple by the year 2025. That projected growth will explode the demand for water for green lawns, golf courses, swimming pools, car washes, and water-intensive home appliances. Entirely dependent on groundwater, the city is even now meeting half its present demand by mining its aquifers. More than 307 million cubic meters of groundwater pumped each year are not replaced by recharge.

Elsewhere in the U.S. densely populated Long Island, N Y., and metropolitan Los Angeles face comparable pressures, as do many smaller communities.

Can you think of workable ways of meeting these demands? Can the need for irrigation water be reduced as it has been, for example, in Israel? Where does your drinking water come from? Is the supply secure and uncontaminated?

"One way to solve many of North America's water problems would be to trap some of the fresh water now flowing uselessly into the Arctic Ocean and send it south into the Great Lakes, which could then act as a giant reservoir supplying water as far away as the U.S. Southwest or even Mexico", says T.W. Kierans in "Thinking Big in North America: The Grand Canal Concept", The Futurist Magazine, Dec. 1980.

Does this sound like a reasonable idea to you? What problems do you see with it?

(See "Conserving Water: The Untapped Alternative", S. Postel. Worldwatch Paper Series noted in Bibliography and "Threats to the World's Water", J.W. Maurits la Riviere, Scientific American, Sept. 1989, p. 80).

Precipitation: Cloud seeding

Sprinkled into some kinds of clouds, dry ice (solid carbon dioxide) or crystals of silver iodide create immense numbers of ice crystals and often rain. This may be good for parched farm lands and depleted city reservoirs, but such cloud seeding can be a disaster for recreation areas and may even lead to damage by flash floods.

On Buffalo, New York, downwind from Lake Erie, over 100 inches of snow are often dumped each winter. Cloud seeding over the lake should result in the snow being deposited in the lake before reaching the city-- or at least spread over a larger area. Would you vote for an experiment in cloud seeding if you were:

a) the mayor of Buffalo?

b) the owner of a big ski resort a few miles north of Buffalo?

c) manager of the Buffalo airport?

d) superintendent of Buffalo city schools?

e) Erie County roads commissioner?

Who should decide where and when to seed? Will it work on hurricanes? If serious damage is caused by a "seeded" storm should the people doing the seeding be held responsible?

(See items: Concave Mirrors in Space, p. 133 and Weather Forecasters in Court, p. 153)

Declining resources: Fe, Cu, Zn, Pb, and Al

Over seven million cars are put into junk yards in this country each year. In a car weighing about 1650 kg (3600 pounds) there are:

	kg	lbs
steel	1125	2500
cast iron	225	500
copper	14	32
zinc	24	54
lead	10	22
aluminum	23	51
nonmetals	225	500

Three-quarters of the junked cars are compressed and sold as scrap metal, but such scrap is of low quality. It is expensive to reclaim the various metals for re-use. (See item: Randomness: Entropy, p. 73 and Aluminum, p. 83. The rest (over 1.5 million cars) are abandoned.

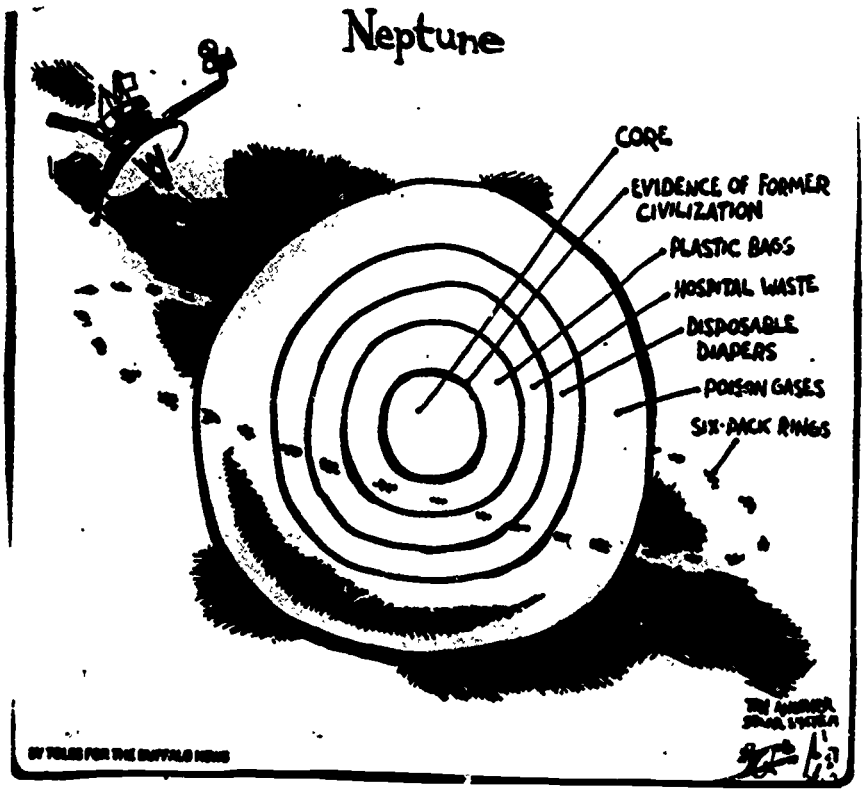
By the year 2000 we shall be nearing the end of the easily-mined world reserves of lead, copper, and zinc (and also uranium, tungsten, tin, gold, silver, and platinum) though the U.S. will still have sufficient reserves of coal, iron, and imported aluminum ore. (See item: Exponential Growth, p. ( )). What steps can you imagine to alleviate these approaching shortages? Do you think your solutions are realistic?

What are the pros and cons of burying people in lead, bronze, or other long-lasting metal coffins instead of wooden ones?

As the age of cheap energy recedes and as inflation, joblessness, and pollution intensify, it becomes steadily more difficult to sustain material living standards in rich countries and to satisfy basic material needs in poor countries. Recycling yields back much of the energy and capital originally invested in materials.

Wherever recycling the above materials is an option to consider, iron, aluminum, (and wood) should take priority because their initial production requires such immense quantities of energy and causes major environmental problems.

(See items: Petroleum Depletion, p. 99 ; Oil from Rock, p. 100 ; and Aluminum, p. 83 See also "Materials Recycling: The Virtue of Necessity", W.U. Chandler, Worldwatch Paper Series noted in Bibliography.)



If a major oil deposit were found beneath one of our national parks should it be drilled for?

PHYSICS

Beginning on page:

Newton's laws and the existence of God

In the 13th Century St. Thomas Aquinas proposed five proofs for the existence of God in his Summa Theologiae. His first proof begins with the observation that no object can be made to move except by the action of another. But there cannot be an infinite series of successive movers, he says, and therefore there must be a first or prime mover that is not moved by anything else-- and this is God.

Is St. Thomas' argument consistent with Newton's (17th Century) laws of motion? If not, why not?

Newton's First Law

Should an automobile passenger's hospital insurance be voided in the event of injury if they were not wearing their seat belt at the time of the crash?

People in cars who were wearing their seat belts at the time of an accident had 66% fewer injuries and paid 82% less for medical care than those who had not fastened their seat belts. This is reported in a study of 1984 Colorado highway accident data by Dr. William Marine of the University of Colorado School of Medicine and noted in The Physics Teacher, Sept. 1986, p. 381. Added comment: "The lesson would seem to be that it doesn't pay to try to fool around with Mother Nature."

(See item: Accelerated Motion Equations and Highway Safety, p. 113)

Newton's Second Law in athletics

Without protective padding a prize fighter's wallop or a collision on a football field can exert a force of 1000 pounds for a very brief time. Such a force, F, can deform bones, and the acceleration, a, it produces in limbs, trunk, or skull can twist, stretch, or rupture nerves and blood vessels. $F = ma$ can be written as

$$F = \frac{mv}{t} \quad \text{or} \quad Ft = mv$$

where m and v describe the fighter's fist or the football player's body as the collision takes place. Newton's Second Law!

Protective clothing spreads the action of the force over a longer period of time, t. In the product Ft, if t is increased by padding, the average force, F, must decrease (since the product Ft equals the unchanged and therefore constant mv), thereby reducing the resulting bodily damage.

Cyclists, motorcyclists, construction workers, football players, and hockey players are protected by helmets because $F = ma$.

But professional boxers do not wear helmets, and their padded gloves weigh only eight ounces. Should laws require them to wear gloves heavier than eight ounces? (See "Boxing and the Brain", Discover Magazine, January 1983).

Are jogging shoes designed with $Ft = mv$ in mind? In what ways? (See item: Physics and Running Shoes, p. ( )).

Why do elastic poles permit higher pole vaults than the older rigid poles?

Why do automobile seat belts reduce injuries? A passenger's mv is the same in a collision with or without a seat belt.

A majority of states now have mandatory child restraint laws for automobiles. See "Seat Belt Safety", National Highway Traffic Safety Administration, U.S. Department of Transportation, 400 Seventh St. S.W., Washington, D.C. 20590.

Elementary mechanics and woman's lib

Women's liberation has its roots in applications of elementary mechanics and electricity-- notably in the invention of the sewing machine, the typewriter, and the telephone.

"Before the sewing machine was invented, a little over a hundred years ago, sewing was the hardest, most time-consuming job of the housewife. Only the very rich could afford to have their clothes made by a tailor. The rest had to make and mend their own clothes. The farm wife or worker's wife of 1860 spent four to six hours a day plying a needle."

"The sewing machine cut this time to approximately 30 minutes a day. It also made clothes so cheap-- cutting prices by more than three-quarters-- that even ordinary people could afford "store- bought" clothes."

"The typewriter and the telephone, by creating middle-class employment opportunities outside the home, made it possible for "respectable" women to earn their living without being dependent upon a male. Even in Dickens' last novel, written around 1870, there are only male clerks in offices. "Respectable" women did not go out without an escort."

"Twenty-five years later an advertisement for a "clerk" generally meant a woman rather than a man, and "respectable" women were going to work by themselves, travelling by themselves, and altogether leading lives of their own. Higher education for women, considered a luxury or an ornament in Victorian times, soon became a necessity. The demand for the vote, for equality before the law, and for equality in careers inevitably followed." (Peter F. Drucker, Prof. of Social Science and Management, Claremont Graduate School, Calif.)

If simple applications of science can have such profound effects on the lives of so many people, what effect do you suppose the invention of the computer is having on your life and your job future this very day? See, for example, the items: Computers and the Job Market, p. 195 and Current Electricity and American History, p. 129.

AFTER UTAMARO

For what reasons is human survival going to depend on a willingness of people to accept a lower standard living?

Accelerated motion equations and highway safety

During the 1973 energy crisis federal law mandated a reduction of the speed limit to 55 mi/hr on the nation's highways to save gasoline. The accelerated motion equation $v^2 = 2as$ provides one of the reasons why the annual death toll went down by 27%.

The equation says that if you go twice as fast (v doubles) it takes your car four times as much distance (s) in which to stop. Conversely, if you slow down from 65 mi/hr to 55 mi/hr (0.85 times as fast) you can stop in 0.72 (or less than three quarters) as great a distance. The difference saves lives.

In April 1987 the Federal Government gave each individual state the power to raise the speed limit from 55 mi/hr to 65 mi/hr on its rural interstate highways. The National Research Council reports that if this increase takes place nationwide it will annually cost 2000-3000 additional lives.

Imagine that you are a member of your state legislature voting on whether to raise the speed limit. Knowing the cost in lives, which way would you vote?

Note that approximately 45,000 Americans are killed every year in automobile-related accidents. That is roughly equivalent to one fully loaded passenger airliner crashing each day.

Do you approve of motorists using radar detectors ("fuzz busters") to frustrate highway police speed control?

Should the use of automobile seat belts be mandatory? (For full information on all of the above write to the National Highway Traffic Safety Administration, U.S. Department of Transportation, 400 Seventh St. S.W., Washington, D.C. 20590.)

While lower speeds save lives, seat belts save lives too. When a car going 50 mi/hr hits a wall, the car stops in about 0.16 sec. But the humans inside it (if they are not wearing seat belts) keep going at 50 mi/hr and collide with the inside of the car 0.03 sec later. This second collision is equivalent to diving from a third floor window head

first with only your arms available to stop your fall. Is it true that "speed kills"?

Experience with airliner crashes shows that lives could have been saved if the seats, instead of facing forward, faced the rear of the plane. This would make maximum use of seat padding and head support. The view out the window at 10,000 feet would hardly be changed. In what ways would this change be good or bad physics? Good or bad for business?

The kinetic energy equation, K.E. = $mv^2/2$, says that at 10 times the speed a collision can do one hundred times the damage. Compare the damage from a collision when jogging at 6 mi/hr with the damage when driving at 60 mi/hr.

(See item: Newton's Second Law in Athletics, p. 110)

Projectile motion

The aiming and guidance of intercontinental ballistic nuclear missiles is becoming increasingly accurate. Do you think this increase in accuracy increases or decreases United States security?

Has this increase in accuracy had an effect on U.S.-U.S.S.R. disarmament treaties?

Wealthy people can afford to pay for heart transplants so Medicare or Medicaid funds should be available to pay for heart transplants for those who are poor? Do you agree?

Centripetal force and nuclear proliferation

Improved high-speed centrifuges give even poor countries access to bomb-grade uranium.

In nature just one in every 140 uranium atoms is an atom of U-235, which is fissionable and can be used to make atomic bombs. The remaining 139 uranium atoms are non-fissionable U-238. Separating the two kinds of atoms (isotopes) has been enormously expensive and technically difficult until now, whence access to bomb-grade U-235 has been limited to wealthy countries with advanced technology. In recent years, however, very-high-speed centrifuges, called ultracentrifuges, have been improved so greatly that when they are filled with uranium hexafluoride (UF_6) they can separate the molecules of uranium hexafluoride containing the lighter U-235 from those containing the heavier U-238. Run in great numbers for a long time they can produce enough U-235 to make a workable bomb.

This application of the idea of centripetal force, $F = mv^2/R$, is making it possible for poor countries like Peru and Vietnam and Algeria to take the difficult first step toward acquiring nuclear weapons. The source of the uranium would be (and in some cases already is) used fuel from nuclear power plants built in third-world countries.

In what way can American foreign policy be brought to bear on this threat to world peace? Is there anything you can do?

(See item: Nuclear Winter, 141)

Does science tend to break down people's ideas of right and wrong?

Physics and running shoes

If you are a serious runner you depend on good running shoes to avoid injuries and to win races.

When you run each foot hits the ground about 750 times a mile with a force about five times your weight. If your shoes don't absorb the shock your ankles, knees, and shins will have to do so, which is why roughly one third of all marathon runners suffer injured knees, shin splints, blisters, and inflamed tendons every year. To reduce this damage good running shoes depend on a good deal of physics.

The foam midsole acts as a shock absorber, an action that depends on the work, Fd, which the foam padding must do to reduce to zero the kinetic energy of your foot and body hitting the ground, $mv^2/2$. The thicker the padding, d, the less the average impact force, F.

The padding raising the heel reduces the tension that your Achilles tendon must exert to lever you up onto your toes. The principle of moments measures the effect of this.

The sock liner absorbs sweat, reducing the blister-causing force of friction inside the shoes, whereas cleated soles increase the friction with the track.

The upper should be made of a fabric that allows the shoe to "breathe" (leak air) to keep your foot cool by evaporation (loss of latent heat) and still repel water. No material available can do both these well at the same time.

And the shoe must have the smallest possible mass, m, in order to keep F small (in F = ma), or you will wear yourself out merely accelerating a massive shoe back and forth.

All of these features can still stand improvement, given time, research, and imagination. In the U.S. alone $3 billion dollars worth of athletic shoes are sold annually (1989). For example, a running shoe has been marketed that contains a tiny computer that keeps track of the runner's stride length, speed, and calorie consumption.

Do these refinements affect the pleasure you get from running?

(See item: Newton's Second Law in Athletics, p. ( ). See also The Running Shoe Book, P. Cavanagh. Anderson World, Inc. 1980 and Newton At the Bat: The Science of Sports, E.W. Schrier and W.F. Allman, Scribners, 1984, p. 55 et seq. See also "Athletic Clothing", R. Kyle, Scientific American, March 1986, and "The Race to Make a Perfect Shoe Starts in the Laboratory", R. Wolkomir. Smithsonian, September 1989.)

Gravity: Hole through the earth

Theoretically, if a hole were bored all the way through the earth and you fell into it you would arrive at the earth's surface at the other end in just 42 minutes If you could eliminate air resistance and friction with the walls of the hole (and the effects of high temperature at the center), no energy would have been consumed. Moreover, between any two points on earth, however close together or far apart, the time through a straight hole would be 42 minutes. No gasoline, no jet fuel, a reliable time table, non-polluting! Worth considering?

For a less whimsical proposal for a supersonic transport through evacuated underground tubes see "Macroengineering", F.P. Davidson, The Futurist Magazine, Dec. 1980.

Would you vote to outlaw the sale of irradiated food in food markets-- or eat it? Compare with iodized salt and fluoridated drinking water.

Science and athletic records

The laws of science have always had a lot to do with athletics. Our understanding of those laws continues to result in improved performances and steadily breaking world records. Consider the idea of force. The study of how forces act makes it clear that:

-the dimples on a golf ball make it travel more than four times as far as if it were smooth.
-a running track with a springy surface about twice as stiff as a runner's legs is the ideal for improving speed.
-the best path for a swimmer's hand through the water is an S-curve, not a straight line.
-the best way to keep an Indy-500 race car firmly on the track is with the help of stubby boxes shaped like airplane wings turned upside down.
-ski jumpers travel farther if they stretch their bodies low over their skis to gain lift like an airplane wing.
-floor oil on the first ten or fifteen feet of a bowling alley reduces the force of friction and hence preserves the ball's spin until it is close to the pins, thus improving the bowler's control.
-a properly shaped and thrown boomerang can stay in the air as long as 33 seconds (world record).
-tennis racquets made of graphite, which is ten times stiffer than wood, result in more powerful shots, and fiber glass poles resulted in an immediate increase of nine inches in the world's pole vaulting record.
-skin-tight clothing that reduces a runner's air resistance can mean a difference of as much as four inches in the 100-meter dash and 30 yards in a marathon. And of course it improves a cyclist's performance too.

Compare the structure of the human body with that of (a) an antelope for speed, (b) an elephant for carrying weight, (c) a bird for flying, (d) a monkey for climbing. Each of these four-limbed animals is superior to us in a very specific way. Being so badly outclassed by them, how is it that mankind is the most successful large animal on earth?

Furthur use of the various laws of physics, chemistry, and biology continues to push human performance to still greater limits.

(See item: Physics and Running Shoes, p. 116. See also Newton At the Bat: The Science of Sports, E.W. Schrier and W.F. Allman. Scribners, 1984, and The Physics of Sports, D.F. Griffen. Mohican Publ. Co., 1983. See also "Athletic Clothing", C.R. Kyle, Scientific American. March 1986, and "Physics of Sports", Ed. by C. Frohlich in the AAPT Issue-Oriented Modules Series noted in the Bibliography.)

Heat light, and sound

Is your home entirely your own?

Now that solar house heating and solar hot water heating have become economically practical in many parts of the country, imagine that your house (or apartment' has been equipped with one or both of them. Now a tall apartment building is put up next door, blocking half the sunlight. Should you have any legal recourse? (For half the sunlight substitute one quarter-- or all).

The apartment building has tennis courts alongside it. Since modern outdoor lighting is so efficient, the courts are lit at night, lighting your bedroom brilliantly and making it hard for you to sleep. Should you have any legal recourse? (For tennis courts substitute a shopping center or a trailer park.) See item: Scattering of Light: Light Pollution, p. 134.

Now the nearby airport adds a runway that leads planes directly over your house at take-off, making conversation and sleep very difficult. The maximum loudness is 100 decibels, ten times a day. (See item: Loud Sounds, p. 126. Should you have any legal recourse?

Finally, close to the other side of your house oil (or a valuable mineral) is discovered on your neighbor's land. The deposit presumably extends underneath your home at a depth of 10 feet (100 feet, half a mile), but you do not want it mined. How deep down in the earth does your ownership extend?

If you argue that the homeowner has a right to stop each of the four above threats to his/her comfort, consider each of the situations from the opposite point of view. Should your plans to build a big apartment house be blocked by the existence of one neighbor's modest solar panel? Or your plans to play tennis at night be blocked by his desire to have his bedroom on the same side of his house? Should the airport of an entire town be thwarted by one family's dislike of noise?

In resolving any of these questions the measuremert of heat, light, or sound is important.

Winston Churchill once said: We shape our buildings and then they shape us.

(See item: High-Voltage Power Lines, p. 130)

Heat insulation

It has been found that large glass-walled office buildings are very expensive to heat in winter (glass windows are poor insulation) and to cool in summer (the greenhouse effect). What can the owner of such a building do to reduce its heating and cooling bills?

Knowing these problems, why does anyone put up a glass-walled building in the first place?

(See item: Air Conditioning, p. 122. Also "Energy and Solar Heating", F.C. Bason, a module in the AAPT Issue-Oriented Module Series noted in Bibliography and "Energy and Architecture: The Solar Conservation Potential", C. Flavin, in Worldwatch Paper Series, also noted in Bibliography).

Heat of earth's interior

There are roughly 10^{52} Btu of heat energy waiting white hot beneath where you are sitting. As a source of energy it is environmentally ideal: no smoke, no acid rain, no radiation, no need for supertankers or worry about another war to defend its source. The heat of the earth's interior may be the ultimate energy source. Moreover, it is effectively endless in quantity.

The difficulties of extracting it are great-- but perhaps not entirely insuperable. The first problem is to locate sources within drilling distance of the earth's surface; the second problem is to drill down to it (the record well in the U.S. is 30,000 feet deep); and the third problem is to obtain the financing (perhaps $10 million a year) for the decade or two that the job will require.

But the U.S. consumes about 10^{17} Btu of energy annually, and many such year's-worth of energy are stored down there for the taking if we can get to it. A test well is already being drilled at Mammoth Lakes, Calif.

Once reached, how do you bring the heat energy to the surface? And how do you distribute 500^{0} hot steam or magma to the users without destroying the pipes and machinery?

Finally, who <u>owns</u> the heat: the drilling company? the State of California?, the U.S. Government (meaning you, the taxpayer? or the stockholders who invested their money in the well?

The National Geophysical Data Center (NOAA, Code E/CC4, Dept. 427, 325 Broadway, Boulder, Colo. 80303 distributes a variety of publications on thermal springs (with maps), data on temperatures in 1700 deep wells nationwide, data on the users of geothermal resources, and other geothermal publications.

(See "Geothermal Energy", V.T. Nguyen, a module in the AAPT Issue-Oriented Module Series noted in the Bibliography, and Newsweek, August 28, 1989, p. 55).

Air conditioning

After World War II engineers developed techniques for cooling large volumes of air below its dew point to condense and to remove its water vapor inexpensively. Mechanical air conditioning was born, and it revolutionized life in the South. In the 1960's, for the first time since the Civil War, the South experienced a net in-migration, and the prosperity associated with the Sun Belt began. But along with prosperity has come a loss of regional flavor and isolation. It can be argued that along with other manufacturers of air conditioners General Electric Company has had a more unsettling effect on the South than General Sherman did during the Civil War.

In what ways is an electric fan better than an air conditioner? How do people elsewhere in hot humid climates manage to stay comfortably cool?

If it were in your power to air-condition our entire planet, would you do so?

(See item: Heat Insulation, p. 120.

In the course of the year more energy flows through the windows of buildings in the U.S. than flows through the Alaska pipeline.

Cryogenics

Many lower animals can be quick-frozen into a solid block and maintained alive at very low temperatures until they are restored to good health by thawing them out, (e.g. goldfish dropped into liquid air, about -195^0C). Suppose some day it becomes possible to do this to human beings. If you have an incurable disease, might you have yourself frozen until a cure has been found?

Already, human tissue such as blood, corneas, bone marrow, sperm, and even embryos can also be frozen and thawed again later. So far, however, transplant surgeons have been unable to make use of frozen organs such as kidneys, the pancreas, or the heart, which therefore makes it impractical to freeze and then thaw entire people, though at least five people are known to be frozen in liquid nitrogen right now and possibly as many as 12 or more (1988). They face a very uncertain future, for when they are thoroughly frozen their heartbeat and their brainwaves stop. By definition they are legally dead for as long as they remain frozen. That could be for years or centuries!

If you have been frozen and it takes 100 years for a treatment for your disease to be found, should your great-great-great grandchildren have to be responsible for you when you are thawed out? If you left a will disposing of your worldly possessions, could you reclaim them? Would you still love your spouse who will have aged during your absence? Would this practice be ethical to perform on astronauts making space flights for many years? Or depressed people as an alternative to suicide? Or the curious who simply want to see what the future will be like without growing older while waiting?

If a person who had been frozen in 1800 were successfully revived today, what problems do you think they would face? What would their age be when they are thawed out? For that matter, how old is the thawed-out goldfish? Consult an English teacher on the fate of Rip Van Winkel.

(See "On Ice", C. Kahn. Health Magazine, March 1987; "Cold Storage", S. Vogel. Discover Magazine, Feb. 1988, and "Difficult Decisions: Human Cryonics", J.A. Miller and I.L. Slesnick. The Science Teacher, March 1988).

Condensation: Jet contrails

There are 17,000 scheduled commercial flights in the U.S. every day (1987). Many of them are high-flying jet planes whose trails of condensed water vapor (contrails) may be having an effect on the weather in parts of the Mid-west. In the area defined by St. Louis, Cincinnati, Detroit, and Des Moines the number of cloudy days has unquestionably increased by about 53% since 1900, much of it coming since the area has acquired the most heavily travelled air routes in the country. Elsewhere in the Mid-west where fewer planes travel the increase in cloudiness has been much smaller. Cloud cover has the effect of moderating temperature extremes. Can you imagine any effects this trend may eventually have on people's lives and on the economy of the area?

(See item: Precipitation: Cloud Seeding, p. 104. See also "The Physics of Weather Modification", J.E. Jiusto. A module in the AAPT Issue-Oriented Module Series noted in Bibliography).

"You don't know when you're well off. If it wasn't for all this gunk, some damn fool could be drawing a bead on us right now."

Convection

Hundreds of years ago in primitive societies in cold climates people kept warm by huddling together around an open fire in the center of their living quarters. Above the fire a hole in the roof let out some of the smoke and a good deal of the heat. In the ninth century in Europe it was found that a properly designed fireplace and chimney created a convection current which carried away all the smoke and, by radiation from the fireplace walls, increased the heat to the room. Now small fires could be built anywhere in a multi-storied building, which encouraged the subdivision of living quarters. Privacy and social divisions were enhanced. It has been said that the invention of the chimney may have affected the art of love in medieval Europe more than the troubadors did. It certainly isolated a lord and his lady in their "withdrawing room" (now "drawing room") from the rest of the household, increasing class divisions.

In Langland's Piers Plowman (14th century):

"Woe is in the hall each day of the week.
There the lord and lady like not to sit.
Now every rich man eats by himself
In a private chamber to be rid of poor men,
Or in a chamber with a chimney
And leaves the great hall."

Has modern central heating reversed the fragmentation of a family household? Is television a modern parallel?

(Lynn White, Jr. in an untitled review article in Isis (75) 1:276 (1984) p. 172 et seq.)

The family refrigerator is another application of technology that has had profound effects on family life. Its invention made it unnecessary to make daily trips to the corner market as our grandparents did and keeps us from having to make contact with our neighbors. Taking away a common ground on which people used to meet daily, it helps to isolate us even more from one another-- as television already does.

Loud sounds

With the exception of thunderclaps, most loud sounds are man made, and many of them damage your hearing permanently in a rather short time. For example, a jet engine close up, rock concerts, and some stereo headsets at 135 decibels do it instantly. A big motorcycle with no muffler or an average chainsaw at 110 decibels takes 10 or 15 minutes. A jackhammer or a big power mower at 100 decibels will do it in one to two hours. At 90 decibels a convertible ride along a busy freeway takes four hours-- and a screaming child takes eight. Alarm clocks and vacuum cleaners down around 75 decibels have no limit. Not surprisingly, by the age of 40 most Americans have lost some hearing in the top two octaves of their hearing range.

The Rocky Mountain News reported on Jan. 18, 1988 that when the Denver Broncos played Cleveland in the play- off game in Denver a sound level meter read a peak of 112 decibels when the Broncos recovered a Cleveland fumble. For a news note on a $27,000 "boom car" system that topped 150 decibels see Time Magazine, March 6, 1989, p. 52.

Even when it is not deafening, prolonged noise exposure causes stress and is linked to headaches, ulcers, and high blood pressure. An unborn child responds to sudden loud noises with increased heartbeat or by kicking.

In a New York City classroom adjacent to elevated train tracks the reading ability of a class of sixth graders was found to be a year behind that of sixth graders on the quiet side of the school building. Reading scores became the same on both sides after remedial steps were taken.

What is noise? How is it different from music? Can music ever be considered noise?

Are there noise regulations in your community? If so, how is the noise level measured? What are the penalties for excessive noise? Do you consider them to be reasonable?

Literature on loud sounds and their effect on hearing is available from the Better Hearing Institute, 1430 K St., N.W., Suite 600, Washington, D.C. 20005 and from the Council on the Environment of New York City, 51 Chambers St., Room 228, N.Y., N.Y. 10007. For a PROJECT on this see p. 229.

Supersonic passenger plane

Should the U.S. develop a supersonic passenger transport plane (SST)? We do not now have one.

Arguments in favor of it:

a) Maintenance of America's pre-eminence in air transport technology. Both the Europeans and the USSR have SST's of their own.
b) Stimulus of our passenger plane manufacturing industry and jobs.
c) It's the next logical advance in commercial aviation.
d) Its sales abroad will improve our international balance of payments position.

Arguments against it:

a) Much noisier than the noisiest conventional planes.
b) Sonic boom, leading to many lawsuits for damages.
c) Pollution of the upper atmosphere, particularly its effect on ozone, with unpredictable effects on weather and climate.
d) Extravagent expense to American taxpayers.

But the British-French SST, the Concorde, is now flying routinely into East Coast cities from Europe. Can't American scientific research solve the objections above? And in that case shouldn't we build an SST for the reasons listed?

Why not go further and design a rocket propelled craft which will travel from San Francisco to Tokyo in about four hours, as proposed during the Reagan administration?

Electric generators

Some years ago a group of well-meaning citizens planning a celebration in honor of the late Thomas A. Edison proposed that the high point of the nationwide ceremonies would be the simultaneous stopping of the generators in all the electric power stations of the country for one minute-- an appropriate monument to his many electrical inventions.

The suggestion was promptly vetoed by the engineers. Even if it were technically possible it would be calamitous to shut off the nation's electric power, so many are the electrical services which require electricity continuously. The celebration was observed, but the electric power was kept right on. It had to be, for what Edison started back in 1882 cannot be stopped for any reason, now or ever, without disaster. You might care to look up the many consequences of the great New York City electric power failure on November 9-10, 1965.

What are some of the things that happen to you when the electric power fails for even one minute? For eight hours? Could our society as we know it function without any electric power at all?

("The Biggest Two Percent", J.A. Waring, Public Utilities Magazine, Dec. 22, 1955. See also "Coping With Blackout: What Happens When the Lights Go Out?", M. Parfit. Smithsonian, Feb. 1987).

Where is the best area in you state on which to "go back to the land", raising your own food, living simply, and becoming as nearly independent as possible from the tools, amusements, and energy sources of twentieth-century America? If the pioneers did it, why couldn't you do it today?

Current electricity and American history

It has been suggested that if the telegraph had not been invented in 1844 (by the American painter, Samuel Morse) and rapidly deployed across the continent, the continental United States might have ended up as several independent nations. Prior to 1844 messages to and from the Far West had to be carried on horseback (Pony Express), a process so slow that California (3000 miles) took much longer to reach from Washington than the Apollo astronauts took to reach the moon (238,000 miles). Effective central government under such a condition would have been very difficult if not impossible. The telegraph, activated by storage batteries, may well have saved the nation!

Certainly the fact that it took a sailing ship six to eight weeks to carry messages across the Atlantic eastbound (and longer westbound) contributed to England's difficulty in ruling the American colonies at the time of the Revolution.

What do you suppose were some of the effects of the installation of the first transatlantic cable in 1866? During the War of 1812 the Battle of New Orleans was fought on January 8, 1815 after the peace treaty had been signed in Europe between the U.S. and Great Britain (Dec. 24, 1814). The news of the treaty was still on the way by sailing ship.

(See item: Electromagnetic Radiation: Radio, p. 136)

If we establish radio communication with an extra-terrestrial civilization (ETI) elsewhere in the universe, what do you think we should say to it?

High voltage power lines

High-voltage power transmission lines serve essential human needs and make modern cities possible. But they create human problems too. Powerline (by B.M. Casper and D. Wellstone, Univ. of Massachusetts Press, 1981) describes in vivid detail the reasonableness of the plans for an 800,000-volt power plant (d.c., incidentally, not a.c.) and transmission line to carry energy from a coal field in North Dakota across 430 miles of Minnesota farmland to Minneapolis and St. Paul. But the farmers whose fields lay in the path of the power line also had reasonable objections. The strenuous-- and violent-- conflict that resulted is a vivid example of citizen protest against what was perceived as the unreasonable encroachment of technology upon private property and voters' rights.

How would you react to a high-voltage power line being built a hundred yards or less from your home? On what grounds might you object? To whom?

For a further strong view on power transmission lines see the quotation by Thomas A. Edison in the Quotations section at the back of this book.

* * * *

A related issue is the perceived hazard of the electromagnetic fields surrounding power lines and electrical appliances in the home and their possible adverse effects upon the health of people living near them. Of the two, home wiring circuits, lighting fixtures, and appliances such as TV and electric blankets may play a greater role than transmission lines in posing a public health problem. Laboratory experiments on living cells and animals have shown a statistical association-- but no cause-and-effect relationship-- between cancer and exposure to electromagnetic fields from wires that carry electricity through neighborhoods and throughout homes. With no risk standards for avoiding exposure or proof that any are necessary, how should you proceed? Do you avoid the television set? Or an electric blanket (which is particularly close to you for an extended time)? Or other electrical appliances? Recent attempts to address this issue are described in "The Hazards of Electromagnetic Radiation: Power Lines", P. Brodeur. The New Yorker, June 12, 1989.

Photovoltaic highway pavement

If highway pavement could be impregnated with a material, Compound X, that makes the surface act as a photovoltaic cell, generating electricity from sunlight, the resulting current created by the immense surface of the nation's interstate highway system ought to produce an important fraction of the nation's electrical energy. Transmission problems would be simplified by the fact that the current would be at a low voltage, and hence the power lines could be laid cheaply along and under roadside drainage ditches along highways that are already in place. The buried wires would not mar the landscape, require new rights-of-way, or expensive towers. The installation could be done over a period of time as the highways are routinely re-paved. And think of all those new streets and parking lots being black-topped!

Now go invent Compound X!

Sound of music: the electron

In Mozart's and Beethoven's time what we know as classical music was for kings and nobles only. It had to be performed "live" by privately-hired musicians. Only with the discovery of the electron (1895), Edison's invention of the phonograph (1877), and the more recent development of electronics did classical music become available to everyone.

While electronics has made music <u>accessible</u> to nearly everyone in the developed world it has made "real" music ("live music") practically extinct. People listen to recordings, to stereo, to radios. And if you go to a rock concert you don't hear the original sound; it's all amplified by electronic means.

Of all the music you listen to in a week, how much of it do you hear with the help of electrons (electric current)?

Which do you prefer?

Current electricity and the telephone

In July 1986 a disc jockey in a light-hearted mood announced that the next afternoon the telephone company was preparing to blow the dust out of the telephone lines and recommended that his listeners put plastic bags over their telephones to protect themselves against the dust. There was a "run" on plastic bags in the local markets as many people hurried to comply.

What does this say about people's schooling? Their gullability? Could this have happened to listeners who had studied current electricity in a physics course? Could it happen in your community? (The Daily Iowan, July 11, 1986, p. 4).

Electromagnetic induction

On his discovery of electromagnetic induction in 1831 Michael Faraday was asked, "What is the good of this discovery?" His reply was, "What good is a newborn baby?" How could he have known the importance of his discovery when so little was known about electricity at that time?

Can you identify a few particularly important scientific discoveries made in recent years? For what reasons are they judged to be important? (A number of the quotations beginning on page 213 are appropriate to this question).

Do you approve of motorists using radar detectors ("fuzz busters") to frustrate highway police speed controls? Why?

Blackbody absorption

It has been proposed that coal dust sprinkled on the ice jams on the Mississippi River would absorb solar energy and help melt the ice and open the river to navigation earlier in the spring. Do you see any problems with environmental pollution? With the cost of the coal dust and its distribution?

Do you think it would work on icy winter highways as an alternative to salt, which pollutes groundwater and kills roadside trees?

(See items: Road Salt, Raoult's Law, and Friction, p. 82 and Heat Insulation, p. 120.

Concave mirrors in space

A very large concave mirror in space, nearly motionless at the distance of communications satellites, might focus so much solar energy on a limited area of the earth that it could dissipate hurricanes and bring moisture to deserts and drought areas. Assuming that it could be made sufficiently large and manoeuvrable (both of which are technically possible), would such a mirror be a good idea or not? Why?.

Can you suggest questions that would bear on such matters as hazards, economics, and control?

(See item: Precipitation: Cloud Seeding, p. 104)

Scattering of light: Light pollution

Have you ever seen the Milky Way?

Like the Milky Way, Halley's Comet, when it returned in 1985 and 1986, was invisible or badly dimmed for many people because of light interference from our brightly lit cities and suburbs.

The scattering of city lights by overlying "smog" particles gives the night sky a milky color against which even the brightest stars are often invisible. Because of such "light pollution" many high school students now grow up having never seen the Milky Way spanning the night sky. Already the usefulness of the nation's largest optical telescope, the 200-inch instrument on Mt. Palomar, is being seriously threatened by the the increasing glare of the lights of San Diego, and some of the telescopes on Kitt Peak are being limited by the lights of Tucson, Ariz. The famous 100-inch telescope on Mt. Wilson is now useless and is being retired because of the lights of Pasadena, Calif.

Even amateur astronomers looking at the night sky through small telescopes are having more and more difficulty finding places and times where the sky is dark enough to see planets, comets, stars, and nebulae. The moon, at least, is almost always easy to see.

If nothing is done, what do you think will be some of the long-range consequences?

For an up-date on the problem and numerous concrete suggestions on what can be (and is being) done write to Tim B. Hunter, International Dark Sky Association, 3545 N. Stewart. Tucson, Ariz. 85716.

P.S. Palomar astronomers named a newly-discovered asteroid "San Diego" as a "thank you" to the city for its cooperation in shielding its street lights.

(See item: Outer Space: The Infinite Dump, p. 159. For a PROJECT on this see p. 231)

Electromagnetic spectrum

Here are a few applications of the regions of the electromagnetic spectrum which affect you, the citizen-consumer-- and raise some problems:

Radio waves and shorter TV waves have an effect on your choice of political candidates to vote for; they enlarge (and distort) your view of world issues, raise issues of censorship of excessive violence and sex and the values you care to impart to your children.

Radar raises the issues of highway safety, the legality of speed detectors and "fuzz busters".

Microwaves. Used in ovens create the responsibility to warn people with heart pacemakers of possible hazards. Particularly high intensity microwaves raise questions of their hazard to the health of all people nearby. (Recent attempts to address this issue are described in "The Hazards of Electromagnetic Radiation: Video-Display Terminals, P. Brodeur. The New Yorker, June 26, 1989).

Infrared makes possible the photographic detection of forest fires and some forms of cancer and the measurement of heat losses from houses and other buildings.

Visible light now makes possible highly efficient long distance telephone transmission via optical glass fibers, which affects your telephone bill.

Ultraviolet light is used in the sterilization of food and glassware and surgical instruments. Because it gives many people a tan, suntanning parlors are popular in the northern U.S. and Canada, especially in winter. But exposure to their ultraviolet radiation is not always accurately measured (it should be longer than 3000 A), and over a period of time it easily leads to skin cancer. (See item: Destruction of Our Atmosphere: Ozone Catalysis, p. 78)

X rays are used in medicine and dentistry. Knowing that X rays can be harmful even in small doses, should you submit to a medical X ray? But

you may suffer harm if you do 't submit to the X ray. How should you choose wh.ch to do? What precaut' ons are usually taken?

Gamma rays are used in treating cancer and in steriliizing food. The storage and use of radioactive gamma ray sources requires elaborate care. (See: "Radioactive Radiations and Their Biological Effects", P. Lindenfield. A module in the AAPT Issue-Oriented Module Series noted in the Bibliography.)

Electromagnetic radiation: Radio

With the enormous increase in transatlantic commerce after the Civil War the number of ships lost at sea steadily increased. The maritime nations promoted a variety of schemes to cut down on the loss of life: ships with double and triple hulls, ships bridged together in pairs (catamarans), and convoys, among others, none of them very practical. But the final solution, improbably, had its origin in Henry's and Faraday's studies of electromagnetic induction (1831), Maxwell's electromagnetic theory (1867), Hertz's discovery of electromagnetic waves (1887-1890), and finally Marconi's use of electromagnetic waves to send a radio message across the Atlantic (1896). The newly invented radio summoned help and made possible the saving of 804 lives when the Titanic struck an iceberg and sank in 1912.

Note that this sequence includes an American, two Englishmen, a German, and an Italian. Science and technology are international.

A century after Columbus discovered America there were people in Europe who had not heard of it. But thanks to the discovery of the electron and the subsequent development of radio (Faraday, Maxwell, Hertz, Marconi) over a billion people knew of man's first landing on the moon as it was happening.

(Note the quotation on Lee deForest in Quotations near the end of this book).

(See items: Electromagnetic Induction, p. 132 and Current Electricity and American History. p. 129)

Television: The third parent

"Boob tube" or "window on the world"?

Television profoundly affects many people's daily habits and their attitudes toward the world around them. From kindergarten through grade 12 the average American student spends a total of 11,000 hours in a classroom and 16,000 hours in front of a television set. If you fit the average you can add 10,000 hours more for each decade after the age of 20.

Think what you can do with that kind of time! 5000 hours is what a typical college undergraduate spends working on a bachelor's degree. In 10,000 hours you could learn enough to become a doctor, a lawyer, or an astronomer. You could have learned to speak and to read several languages fluently. Or you could have walked around the world and written a book about it.

Do you think you will want your children to watch this much TV? Why? Do you think you should? Why?

For many people television is:
- -the most relied on source of news
- -a creator of political events
- -a primary source of entertainment
- -a way to structure time
- -a national marketplace
- -a major force in bringing up children.

A connection exists between the viewing of violence on TV and aggressive and violent behaviour in some young people. (National Institute of Mental Health report, 1983, and the U.S. Attorney General's Task Force on Family Violence, Sept. 1984). George Gerbner, dean of the Annenberg School of Communications at the Univ. of Pennsylvania, reports an average of five or six violent acts per hour on prime time television over the past 17 years of his study (1985).

When you have children of your own are you going to control the programs they watch? If not, why not?

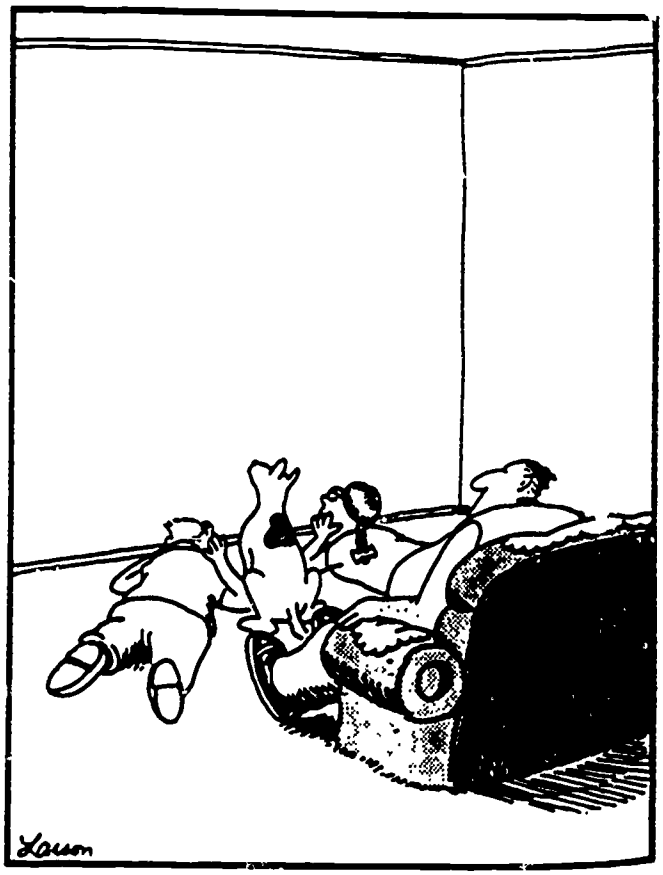
Computers can be as attractive as television for some students; in extreme cases we see "withdrawal

symptoms" a little like those associated with drug addiction. It seems ironic that the more computers are used in business, home, and school for communication purposes the less some people communicate.

What has been the effect of the development of national television networks upon:

a) regional customs and accents?
b) family reading habits?
c) awareness of national and international events?
d) merchandising of commercial products?
e) presidential election campaigns?
f) public safety?

(See: Television. A module in the BSCS Series, "Innovations", noted in the Bibliography.)



In the days before television

Would two-way television threaten your constitutional right to privacy?

Nuclear power: Risk assessment

Some of the pro's and con's for using nuclear reactors as a source of power are as follows:

PROS:

1. In a few years known reserves of coal will be depleted. In energy one pound of uranium is equivalent to 2,000,000 pounds of coal. The pressures in favor of nuclear power will become enormous despite the risks.

2. Breeder reactors never run out of fuel.

3. Nuclear reactors produce no significant emission of greenhouse gases, while coal and oil produce many pollutants dangerous to health and cause acid rain.

4. The problems of spent fuel and waste disposal are being solved.

5. Standardized safer and cheaper reactors are being developed.

CONS:

1. Radioactive poisoning and radiation are deadly.

2. There is no safe and effective way to get rid of radioactive wastes.

3. Uranium and plutonium can be used for weapons if stolen.

4. Many nuclear plants are near big cities where an accident will have particularly severe consequences.

5. Human error was the cause of the Three Mile Island and Chernobyl accidents. Can we ever prevent people from making errors?

6. The impending worldwide uranium shortage will provide strong pressures to reprocess spent nuclear fuel into plutonium, easily diverted into nuclear weapons.

7. Despite the efforts of the International Atomic Energy Agency, Israel and India have already evaded safeguards and joined the nuclear weapons "club". Several other nations are probably close to doing so. Such diversion and proliferation may be impossible to prevent.

(See "Reassessing Nuclear Power: The Fallout from Chernobyl", C. Flavin. Worldwatch Paper Series noted in Bibliography.)

Breeder reactor

Breeder reactors create more nuclear fuel than they consume, and therefore they extend our limited world supply of uranium indefinitely. In a world increasingly short of easily available energy breeder reactors may become our only practical alternative for generating the bulk of our electricity. But their plutonium fuel is exceedingly dangerous, the reactor creates environmental and safety hazards more serious than those of conventional reactors, and they are much more expensive. Yet if we do not build breeder reactors until uranium becomes scarce a generation from now the engineering and operating experience accumulating today will have been lost.

Should we build them? The French have already built one that is operating commercially.

("To Breed or Not to Breed", M. Gold. Science 82, May 1982; "Showdown For French Fast Breeders?", D. Dickson. Science, Oct. 23, 1987; and "Are Breeder Reactors Still Necessary?", A.M. Weinberg. Science, May 9, 1986)

"Men have become the tools of their tools". H. Thoreau, Walden. True?

Nuclear winter

The immense clouds of smoke and dust raised by even a medium-scale nuclear war would reduce the intensity of sunlight reaching the ground by as much as 95 percent for a period of weeks or months, reversing the "greenhouse effect" and leading to a rapid cooling of the earth's surface and lower atmosphere by as much as 40°C. Further effects would include the immediate destruction from nuclear blast, fires, radioactive fallout, and an increase in solar ultraviolet radiation reaching the ground as a result of ozone depletion.

If sufficiently intense, these effects would trigger a worldwide climatic catastrophe called "nuclear winter" that could destroy all the human survivors and many species of animals and plants as well.

Does the prospect of a nuclear winter reduce or enhance the threat of a nuclear war?

Even if a nuclear war were limited so that it did not result in a worldwide nuclear winter the use of nuclear weapons would have a devastating effect on whichever superpower fired them. In the event of a nuclear war in Europe the fallout of radioactivity carried eastward by prevailing winds would devastate life in the Soviet Union. Likewise any militarily effective nuclear strike from the U.S. against the Soviet Union would boomerang a cloud of death-dealing radioactivity over the U.S. In 1986 the radioactivity released into the air from the relatively picayune meltdown of the Soviet's Chernobyl reactor poisoned food supplies in Western Europe as well as in the Soviet Union. What does this say about the prospects of "success" in any use of nuclear weapons?

(See "The Environmental Consequences of Nuclear Winter" Environment Magazine, special issue, June 1988; and "Nuclear Winter Status Report", Science News, April 19, 1986).

Energy: U.S. consumption

In the course of the year more energy passes through the windows of buildings in the U.S. than flows through the Alaska pipeline.

The United States has only 4.7% of the world's population, but it uses annually 31% of the world's energy. This is equivalent to 59.3 barrels of oil per year per American. Does this rate of consumption carry with it any obligation (a) to the rest of the world's population or (b) to conservation of the sources of energy? What should be done, if anything? What should you do, if anything?

Amory B. Lovins, energy conservation advocate and author of The Energy Controversy: Soft Path Questions and Answers, (Brick House Publ. Co., 1978) has observed that civilization in this country, according to some, would be inconceivable if we used only half as much energy as now. But that is just what we did use in 1963 when we were at least half as civilized as we are now.

See how many forms and sources of energy you can identify that flow into and out of your house or apartment in various forms in the course of a day. Do you see any ways to reduce your net use of energy (inflow minus outflow)? Could you conceivably live comfortably with only half your present use, as Lovins mentions?

(See item: Electric Generators, p. 128.
See also "Strategies for Energy Use", J.H. Gibbons, P.D. Blair, and H.L. Gwin. Scientific American, Sept. 1989, p. 136.)

Would it save energy to extend daylight saving time throughout the year? If so, should we-- or should we not-- do so? Why do we use it now?

Solar energy

The energy of the sunlight falling on the roof and sides of your car on a sunny day is almost as great as the energy delivered by the engine! And it's free!

The yearly average sunlight on a horizontal surface when the sun is shining is:

Connecticut	0.2 hp/meter^2
New Mexico	0.3 hp/meter^2

At 60 mi/hr an ordinary automobile engine doing 30 mi/gallon consumes energy at the rate of 100,000 watts (134 horsepower) turning 80,000 watts (107 hp) into wasted heat and 20,000 watts into mechanical work (27 hp).

What are the prospects of a gasless car running successfully in New Mexico? In Connecticut? If it could run, why isn't such a car in general use?

(A car that drove all the way across Australia on solar energy is described in "Fill 'er Up With Sunlight", W.E. Jordan, Smithsonian Magazine, Feb. 1988 and "The Lessons of Sunraycer", H.G. Wilson, P.B. MacCready, and C.R. Kyle, Scientific American, March 1989. A solar energy teaching package based on Sunraycer and published by QUE Corporation is available from Softswap, PO Box 271704, Concord, Calif. 94527-7289.)

Should our nation's space program include plans to establish a manned base on the Moon or Mars? Why?

Cooking with sunlight: A physics project

Two billion people by the year 2000 will be cooking with animal dung as their only fuel or with wood which has taken them hours to collect from deforested and depleted land. As the world's population rises their present fuel shortage can only go on getting worse unless peoples' habits and technology can be changed.

A simple insulated box-within-a-box large enough to capture about three square feet of sunshine can cook food for an entire family in two to four hours at 200° to 275° with no fuel whatever! Made in a few hours out of only cardboard, wood, glass, shiny foil, and glue, an adjustable reflector- lid directs sunlight through a snug-fitting glass top into the box and cooks meals year-round in the tropics and for six to eight months of the year in most temperate zone areas. For more construction details see COOKING WITH SUNLIGHT in Student Projects, p. 231.

Consider the societal consequences if such solar box cookers could be put into general use in impoverished Third World countries! Better yet, build one as a physics project, and try it out. For complete plans write to Solar Box Cookers International, 1724 Eleventh St., Sacramento, Calif. 95814 or devise one yourself.

"For profit" hospitals are basically businesses. Should they be required to accept indigent and uninsured patients?

Energy conversion: Developing countries

In the farming areas of developing countries human muscle power is often the most practical source of energy for producing electricity. To operate radios and television sets battery packs and solar cells are prohibitively expensive, and small gasoline engines driving generators are unreliable and hard to maintain. But a person pedalling a bicycle can easily generate 35 watts or about 0.05 horsepower (746 watts = one horsepower), and a dynamo driven by someone pedalling a jacked-up bicycle is fairly easy for untrained people to fix.

If your input from food is 2400 kilocalories per day or 100 kcal per hour, your input from food averaged over the day turns out to be 420,000 joules per hour, which is 117 joules per second or 117 watts. Hence your efficiency at pedalling a simple electric generator is

$$\frac{\text{output}}{\text{input}} = \frac{35 \text{ watts}}{117 \text{ watts}} = 0.30 \text{ or } 30\%$$

which is better than a gasoline engine for the length of time that you or a farmer can keep it up--presumably for hours.

The same pedal-power applied to a stationary (jacked-up) bicycle can be rigged to pump water out of a well or drag a plow across a field with a winch or to operate winnowing or grinding machines.

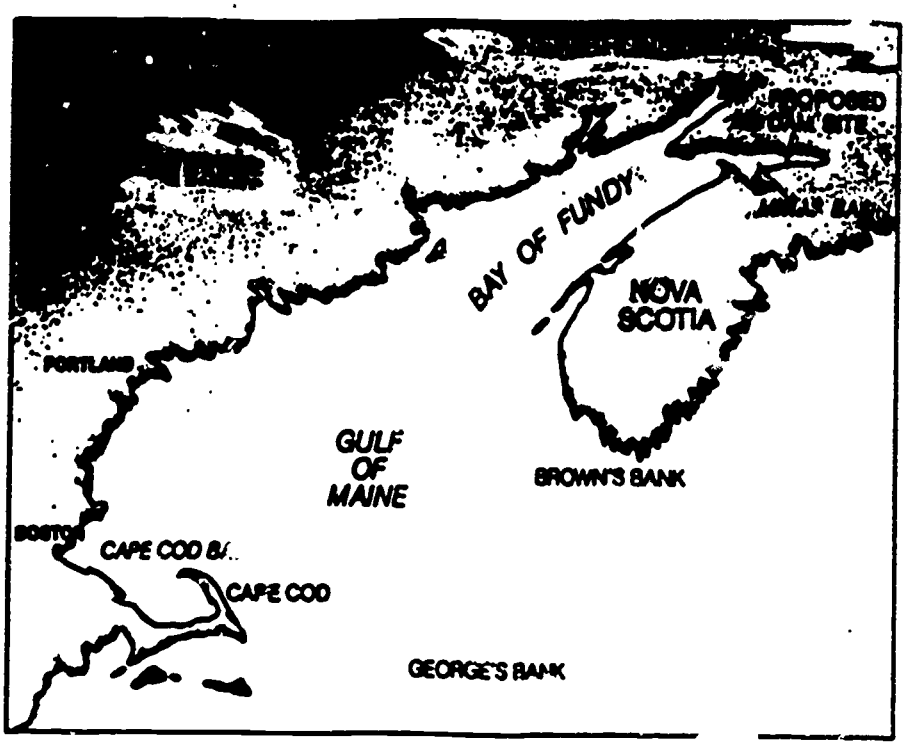
Sending powerful labor-saving machinery from developed countries like the U.S. may seem like a good idea, but it usually is not. 18,000 tractors shipped to Pakistan increased no crop yields there but simply put thousands of people out of work. Considerations like these guide the development of what is called "appropriate technology" for helping people in developing countries which have little or no access to

Western technology but have a large under-used labor force.

Americans and other people from developed countries working overseas use elementary physics in a similar way to improve pumps for getting clean water from deep underground, for building small cement plants and brick-making plants, designing simple metal-working machinery, and inventing more efficient windmills and more effective farming tools, all using locally available materials. Each developing country has different needs and different solutions-- different appropriate technology.

Suppose it takes 10,000 laborers two years to build an earthen dam in India using shovels and wheelbarrows whereas half a dozen American bulldozers could do the job in three months. If you had to make the decision (and some person has to) would you send the bulldozers to India as part of our ongoing foreign aid? If not, why not? Is your answer an argument against giving American technical aid to developing countries? How about sending bicycles instead of gasoline-driven vehicles?

Perhaps you will become interested in using your knowledge of science in this practical way abroad. For free information booklets write to the National Center for Appropriate Technology, Box 3838, Butte, Montana 59701. See also Small Is Beautiful: Economics As If People Mattered, E.F. Schumacher, Harper and Row, 1973.



A power plant in Minas Basin could raise tides in Cape Cod Bay,

Resonance and tidal power

Some of the world's highest tides flow in and out of the Minas Basin, the easternmost tip of Canada's Bay of Fundy between Nova Scotia and Maine. (see map) Canada has plans to build a dam across the basin in such a way that water trapped at high tide must flow out through power-generating turbines to escape as the tide falls. It would be a rare example of pollution-free energy from a renewable fuel source-- the tides. But there's a catch! The North Atlantic Ocean tide has a period of about 12 hours, 25 minutes. The natural period of water in the Bay of Fundy and Gulf of Maine, if it were free to wash back and forth between Minas Basin and Cape Cod, is about 13 hours. The proposed tidal-power dam would shorten the latter period, bringing it closer to that of the Atlantic Ocean and creating almost perfect resonance between them. The height of the tides along the coast north of Cape Cod would be be increased by about 10 percent, making some harbors unnavigable, flooding salt marshes, coastal roads, bridges, and waterfront property and contaminating some town wells with salt water.

Such a beautiful idea, probably defeated by the phenomenon of resonance! (See map preceding page.)

(Scientific American, Dec. 1984, p. 70, and "Tidal Energy", G.D.F. Duff, a module in the AAPT Issue-Oriented Modules Series noted in Bibliography.)

EARTH AND SPACE

Earthquakes

Scientists are slowly increasing their ability to predict earthquakes. If you are a scientist who has just determined that there is a 90 percent chance of a major earthquake destroying a town in the next 24 hours, what should you do? What should the public safety authorities do? But what if it was only a 50 percent chance? What do you and the public authorities do if there is a 90 percent chance of the earthquake occurring sometime during the next month?

If you evacuate the town and nothing happens to it, what consequences do you anticipate? But if you fail to evacuate, and the earthquake occurs, what then? Where is the "break even" point?

In 1980, when Mt. St. Helens was becoming active the immediate area was evacuated, but normal sawmill and lumbering activities involving approximately 10,000 people continued at what was considered to be a safe distance from the volcano. On Sunday, May 18 at 8:32 A.M. an explosive eruption blew off three cubic miles of earth and created a 5.1 earthquake on the Richter scale, obliterating a large fraction of the area of lumbering and sawmills. Many of the work force would have been killed-- except that it was a Sunday so they were not at work. A judgment call that "lucked in"!

San Francisco has been built on top of an earthquake fault along which two underlying plates in the earth's crust meet. As the plates move, the force between them builds up, and an earthquake becomes more and more likely-- and more severe when it finally comes. It has been suggested that if a small nuclear explosion could be detonated deep within the earth the force between the plates could be relieved, thus saving the city and its people from a future great catastrophe.

Would you advocate doing this? Why?

Who should make the decision to have this done? The city, state, or federal government? Popular vote?

Coriolis force

If the earth did not rotate we might not speak English in this country, according to a whimsical argument advanced by M.M. Payne in "Does the Earth Rotate?" (The Physics Teacher, Feb. 1987, p.86). Rotation is responsible for the Coriolis force that deflects moving weather patterns and ocean currents into curved paths. Thus, "were it not for the fact that the warm Gulf Stream northbound along our East Coast unexpectedly veers off to the right and ends up bathing the British Isles with its heat those islanders would probably have been kept too busy staying warm to worry about exploring the world. England is at the same latitude as Labrador and without the warmth of the Gulf Stream would have been nearly uninhabitable in early times!"

"One can show that the water on the right side of the Gulf Stream is about one meter higher than the water on the left side-- dramatic evidence for the Coriolis force".

Do you agree with M.M. Payne's argument? Can you cite another example or two of large climatic and cultural consequences of the action of the Coriolis force?

Weather forecasters in court

Are weather forecasters responsible for a faulty forecast when death or injury result?

When a defective wind-sensing anemometer on an ocean buoy off the coast of New England failed to provide accurate data, and the National Weather Service failed to predict a sudden severe storm four Gloucester lobstermen were swamped and drowned on Nov. 22, 1980. Relatives of the dead fishermen sued the National Weather Service for negligence in having failed to repair the buoy for two and a half months after the buoy had been hit by a ship. They won their case.

Although the science of predicting the weather is steadily improving, and weather forecasts for 48 hours ahead are now as accurate as 24-hour forecasts were 15 years ago, major lapses are still possible, and sometimes, as in the case of tornado forecasting, enormous damage and loss of life can result from inadequate warning.

If the weather forecasters were not held responsible for the deaths, who was responsible: the instrument repairmen? The fishermen? An act of God? Have weather forecasters any responsibility at all for massive loss of life to a tornado or hurric as a result of an inaccurate forecast?

(See items: Precipitation: Cloud Seeding, p. 104 and Medical Diagnosis by Computer, p. 199)

Absorption of radiation: Greenhouse effect

Just by breathing you add to the greenhouse effect!

As people burn wood, coal, oil, and gasoline ($C + O_2 = CO_2$ + heat) the CO_2 is released into the atmosphere. Like the glass panes of a greenhouse, the CO_2 molecules are transparent to sunlight, allowing it through to warm the earth's atmosphere. But when it is warmed the surface gives off its heat as infrared radiation to which the CO_2 molecules are not transparent. Thus blocked from radiating its accumulating warmth into space, the earth's surface heats up. As a result of this "greenhouse effect" the surface averages a comfortable $59^{o}F$. In the absence of all CO_2 it would be below 40^{o}, perhaps even below freezing.

The planet Venus is an excellent example of the greenhouse effect. Venus' $455^{o}C$ average surface temperature is largely due to its CO_2-laden atmosphere.

Methane (CH_4) emitted by decaying organic material, garbage, and bacteria is 20 times as effective as CO_2, molecule for molecule, and chlorofluorocarbons (CFS's) are 10,000 times as effective in blocking the passage of infrared radiation. Ozone and nitrogen oxides from automobiles are also important contibutors to the effect. Yet another is the accelerating destruction of trees (cutting down forests) and other green ground cover (overgrazing), since their photosynthesis would have absorbed CO_2 from the atmosphere and thus reduced the greenhouse effect. ($6CO_2 = 6H_2O$ + sunlight = $C_6H_{12}O_6 + 6O_2$).

Even the best scientists disagree on whether the effect has already begun (though they do agree that the warming is inevitable in the near future). Their disagreement arises largely because of the complexity of the feedbacks involved (See item: Feedback: Positive and Negative, p.( ), which are not yet well understood. It has thus become clear that we are altering our environment faster that we can predict the consequences. This is bound to lead to surprises, mostly catastrophic. Unfortunately, planners can use this lack of unanimity as an excuse to postpone the very unpleasant political and economic actions that

must soon be required of them. (See item: Long-Term Effects of Technology, p. 186)

If the warming trend is immanent, Canada and the Soviet Union may one day own most of the world's fertile land. Can you imagine the effect that will have on the world's economy and on international politics?

Another consequence of the greenhouse effect would be the melting of the Antarctic ice cap, which would raise ocean levels worldwide as much as five feet. The Environmental Protection Agency predicts a one foot rise in just the next 30 to 40 years. In parts of Florida one vertical foot can mean 1000 feet of land lost to the sea. Louisiana is already losing 50 square miles of wet lands a year. It has been pointed out that wet lands and salt marshes are the nurseries of the sea, and with their loss worldwide the entire ocean food chain may be broken.

At its extreme this will also flood seaport cities (e.g. Hong Kong, New York, Amsterdam) and make them uninhabitable.

As marginal lands are rendered totally uninhabitable because of diminishing water supplies, political conflicts will intensify (e.g. Egypt vs. Sudan over the shrinking Nile River, and between our western states along the Colorado River). As poverty spurs further depletion of forests and topsoil, hastening the effect, hordes of refugees will be forced to flee Dust Bowl conditions-- to where?

And yet China plans to double its coal production in the next 15 years to spur development!

Another concern is that as temperature and humidity climb parasitic and infectious tropical diseases such as yellow fever, dengue fever, and Chagus disease may migrate northward.

What can be done?

Consider the pros and cons of each of the following possibilities (from Time article, op. cit.):

1. Impose special taxes on carbon dioxide emission to encourage energy conservation.

2. Increase funding for research on alternative energy sources including safer nuclear reactors and solar power.

3. Provide developing countries with financial aid to build high-efficiency power plants.

4. Launch a world-wide tree planting program.

5. Develop techniques for recovering part of the methane given off by landfills.

6. Require all new cars, worldwide, to achieve an average of at least 40 miles per gallon of gasoline and to install catalytic convertors to reduce tailpipe emissions.

7. End all industrial production of chlorofluorocarbons (CFC's).

(See item: Ozone catalysis: Destruction of our atmosphere, p. 78. See also: "Global Climate Change: Toward a Greenhouse Policy", J.T. Mathews. Issues in Science and Technology, Spring 1987, p. 60; "Endless Summer: Living With the Greenhouse Effect", A.C. Revkin, Discover Magazine, October 1988; "Feeling the Heat", M.D. Lemonick, Time Magazine, Jan. 2, 1989; and "The Changing Climate", S.H. Schneider. Scientific American, Sept. 1989, p. 70).

"We delayed and did nothing, in spite of one environmental warning after another—and now we're freezing over!"

Climate and invention

During the 13th Century the sonnet was invented by poets in Sicily, and the button was invented in northern Europe. Given the difference in climate and the resultant life styles, why is it unlikely that the chilly Northerners might have devised a new form of poetry or the natives of hot southern Europe might have invented an efficient way of fastening clothes?

(See item: Coriolis Force, p. 152)

Crowded communications satellites

Communication satellites are beginning to crowd the geostationary orbit 22,300 miles up above the equator. Approximately 200 of them relay telephone calls, television, and weather reports to nations all around the earth. Most of them belong to the developed industrialized nations. Many Third World countries fear that by the time they have the resources to launch satellites of their own the geostationary orbit where a satellite travels at the same rotational speed as the earth (and is therefore a fixed target for radio signals) will be crowded if not filled.

Satellites are in little danger of colliding; the problem is the overlapping of radio frequencies of radio messages to and from neighboring satellites or earth stations. The number of remaining available "slots" is distinctly limited.

Given the steadily increasing number of satellites being put up by the wealthy industrialized nations, how are the interests of the poorer nations to be protected? Do they deserve protection?

(See items: Ocean-Bottom Minerals, p. 101, The Geopolitics of Genes. p. 26, and Outer Space: The Infinite Dump, p. 159)

American space program

America's space program is bound to have important effects on the taxpayer (you), on science and industry, and on our foreign policy as well as on our collective imagination, energies, and national character. Here are some of the questions that must be settled along the way. They make use ful topics for classroom debate.

1. What should the goals of our space program be?

   a) Construction of a habitable Earth-orbiting space station.
   b) Construction of a permanent Moon base. (to do what?)
   c) Human exploration of Mars.
   d) Earth-orbiting satellites to monitor the earth-surface environment.
   e) Search for rare or valuable minerals on the Moon or asteroids.
   f) Other

2. Should the goal be international or exclusively American? Why?

3. If " international", should the U.S. and the U.S.S.R. cooperate?

4. Is our present radio astronomy "Search for Extraterrestrial Intelligence" (SETI) a worthwhile expense of taxpayers money?

5. Is it important for the United States to remain in the forefront as a space-faring nation?

6. Should taxpayer money now being spent on space projects be sharply reduced and put to "better" use here on earth?

7. Should we pursue military uses of space?

   a) "Star Wars" (SDI) is at best a practical shield against nuclear surprise attack or at worst an impractical "make work" project to create jobs and lucrative contracts at taxpayers' expense. Should it be continued? Slowed? Stopped?

b) Does the use of surveillance satellites provide stability to volatile international political situations? In 1961 satellite photographs of Soviet missiles and bomber facilities dispelled the idea of a "U.S.-Soviet missile gap and averted an expensive U.S. crash catch-up program.

c) Would U.S. nuclear missiles orbitting the world and available for instant call-down enhance our security or diminish it?

(See "Extraterrestrial Civilization", ed. by T.B.H. Kuiper and G.D. Brin. 1989. A module in the AAPT Issue-Oriented Modules Series noted in Bibliography.)

Outer space: Infinite dump

The universe is so vast that we could never fill it with garbage.

Therefore it might serve as a dump into which we could launch such inconvenient trash as spent nuclear power plant fuel rods, radioactive waste, and troublesome chemicals all of which now pose serious disposal problems and pollute the earth. Or we might shoot it all into the sun, the ultimate incinerator. Why not do this?

Expense and the hazards of a launching rocket failure are two reasons why not. Another is that there's already a lot of trash out there in earth orbit creating a problem.

It is estimated that there are at least 40,000 orbiting objects ranging from scattered paint flecks up to intact satellites flying endlessly overhead, 7100 of them bigger than a baseball (1988).

The space shuttle runs only a one-in-a-million chance of hitting something on each of its orbits, but if it hit an ordinary iron bolt at a typical collision velocity of about 10 km/sec the impact would be the same as being hit by an exploding hand grenade.

Much of the orbiting debris comes from military anti-satellite tests. There will be a great deal more debris up there if Strategic Defense Initiative (SDI or "Star Wars") experiments result in the fragmentation of a significant number of additional orbiting objects. Particularly vulnerable is the $1 billion Hubble Space Telescope whose fragile mirrors or computers could be destroyed by objects as small as a few millimeters across.

There are no worldwide rules about what you can or cannot send up in orbit.

What problems do you see in cleaning up all that space junk (like roadside litter)? Or restricting further launches of vulnerable spacecraft? Or using junk-free orbits farther out in space?

Orbiting debris is already responsible for false astronomical "discoveries". What were thought at first to be pulsing stars sending out powerful but rare optical flashes have turned out to be reflections of sunlight off the solar panels of dead tumbling satellites.

There are other serious threats to astronomy. Worried astronomers have already attempted to block a Melbourne, Florida, company from orbiting the compressed ashes of cremated humans aboard small but shiny space-age mausoleums, and it would cost only slightly over $8 million to orbit a reflective sail 1/3 the size of a football field that would exceed the brightness of the full moon and blot out many objects important to astronomers.

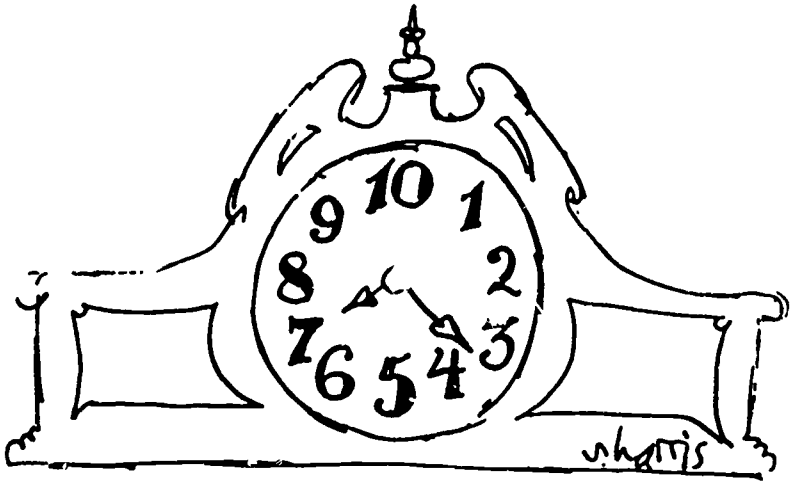
Seven-figure advertizing budgets that now capture a mere national audience could, if channeled into orbiting ads of various kinds in space, make the entire world a captive audience for years. The economic incentive to do so will be enormous, and the pressure on countries (and even religions) to colonize Heaven with their messages will likewise be great. There are presently no international agreements to prevent the orbiting of bright political or religious or commercial symbols, including luminous golden arches advertising McDonald's hamburgers.

(See items: Space Law: Justice on the High Frontier, p. 177 and Scattering of Light: Light Pollution, p. 134. See also New York Times, Aug. 4, 1987, p. C1 and Sky and Telescope Magazine, Jan. 1987, p. 31 and July 1987, p. 4).

Extra-terrestrial intelligence

If extra-terrestrial intelligence (ETI) is finally discovered elsewhere in space and we have established communication with it through our radio telescopes and receivers, what questions do you think we should ask of it? And what information do you think we should send out about ourselves? What about pictures? Music?

(See "A Quest for Contact: A Videotape on the Search for Extraterrestrial Intelligence" (32 min., color, VHS), Astronomical Society of the Pacific, 1290 24th Ave., San Francisco, Calif. 94122. See also "Extraterrestrial Civilization", T.B.H. Kuiper and G.D. Brin, a module in the AAPT Issue-Oriented Modules Series noted in the Bibliography.)



METRIC CLOCK

SCIENCE AND SOCIETY

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* Scattered throughout text. See table of contents.

Tragedy of the commons

When everyone looks out for their own interests and no one looks out for the interests of the entire community then eventually everyone suffers. For example, one family might discharge their sewage into an unpolluted river using the reasoning than "the little bit of pollution we contribute can't hurt that much". But if everyone in town did the same thing the general health and well-being of the public downstream would deteriorate.

Another example: The splendid sand dunes at the Cape Cod National Seashore are being destroyed by the ravages of human feet and tire treads. Efforts by the National Park Service to restrict climbers on them led one member of the Provincetown Board of Selectmen to exclaim, "It seems like every year they come up with more ways to deprive people of recreational activities. You can't take your dog out there; you can't pick the flowers. What are the dunes for? You can't admire them if you can't get on them."

Standards and laws are enacted in many situations to prevent nearly harmless individual acts from escalating to public disaster. For example:

-Factories creating air pollution
-Running in the school corridors
-Highway speed limits
-Throwing trash along the highways and in the school lunch room
-Exhaust emission standards for cars
-Toxic waste dumping
-Aircraft traffic control and highway traffic lights
-Hunting whales
-Fishing out of season in local streams and ponds.

Similar cases where few or no restrictive laws exist:

-Large-scale fishing on the Grand Banks and the North Sea and other productive ocean waters
-Having one more baby in the family
-Driving one more car into an air-polluted city
-Paving over one more acre of farmland for a housing development
-Cutting trees in the world's remaining tropical

forest. (See item: Destruction of Tropical Forests, p. 46)

Would you support laws restricting any of these activities? Which ones? (See the classic essay, "The Tragedy of the Commons", Garrett Hardin, Science 1968 (162) 1243-48 and reprinted frequently elsewhere.)

All goods and practices involving public or group ownership such as the atmosphere, the oceans, our parks, and our natural environment -- the commons-- are examples of resources that are vulnerable to being overspent in these ways. In a commons the gain to each individual user is exclusively a private gain in the short term whereas the resulting environmental degradation is spread out among all the users and only shows up as a community loss in the long term when the resource shows severe stress or signs of collapse.

How many examples of this can you identify in your home, in your community, in the U.S.A., and in the world? (Many are scattered throughout this book). As one example: Should dune buggies and other off-road vehicles be allowed in the dune or desert areas of national parks and other public lands where they destroy the fragile vegetation-- and the silence?

Garrett Hardin has said, "Freedom in a commons brings ruin to all." Do you agree?

(See items: Ocean-Bottom Minerals, p. 101, The Geopolitics of Genes, p. 26 and Crowded Communication Satellites, p. 157)

Exponential growth

Exponential growth is deceptive because nothing seems to happen for a long time, and then the situation explodes dramatically. Here are two examples.

The Sunday newspaper is one inch thick. Fold it in half, and it's two inches thick. Imagine you could go on folding it indefinitely. How many times would you have to fold it to make it become 93,000,000 miles thick, the distance to the sun? Answer: Just 43 times. The last fold would add half the total distance. By contrast, 43 steps of linear growth would make the paper only 44 inches thick.

Again, would you rather be paid a million dollars a day for a month or receive one penny the first day, two the second, four the third, eight the fourth day, and so on, doubling each day-- an exponential rate of increase? If you choose exponential growth you receive only $5.12 on the tenth day but on the 28th day you outstrip your million-dollar-a-day colleague. If you went on to day 44 you would receive all the money in stock in the entire U.S., and by day 50 you would own the entire wealth of the world.

In real life, population growth is exponential in many countries. The doubling time for a population growing at the rate of 2% a year is 70/2 = 35 years. In general, for any quantity growing exponentially, the doubling time in years = 70/percent growth per year. Thus, if electric power use is growing at 5% per year, a seemingly harmless rate of increase, it will have doubled in 70/5 = 14 years. So will your money earning 5% in a bank savings account.

World population is growing at the rate of 2% per year which means that we must double world food production in 70/2 = 35 years simply to hold constant the fraction of the world's population that is starving.

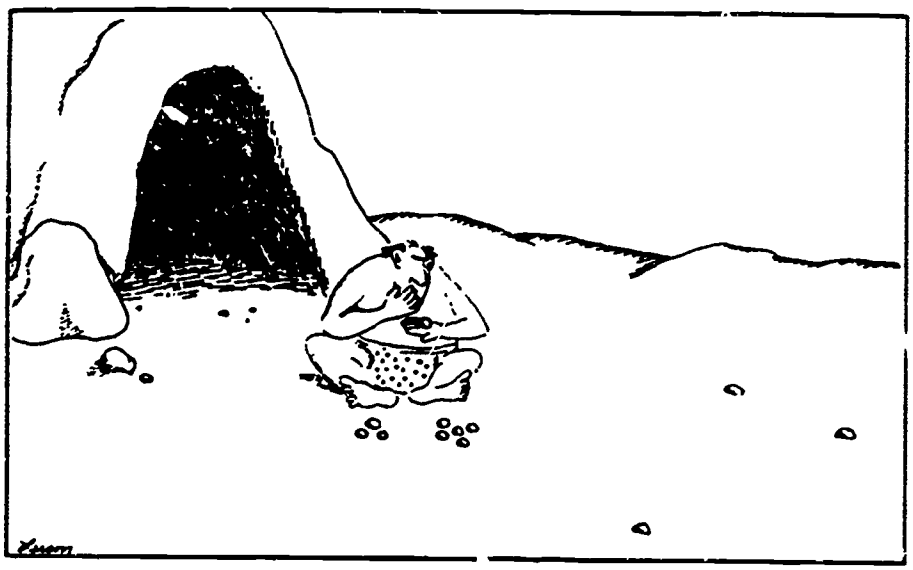
Modern agriculture is based on petroleum-derived fertilizers and petroleum-powered farm machinery. (In the U.S. we use 80 gallons of gasoline or its equivalent to raise one acre of corn). But world reserves of petroleum are being depleted--

exponentially. As exponentially exploding populations press against exponentially declining and unreplaceable natural resources the world is steadily losing its capacity to feed itself.

How much longer can our petroleum, coal, and iron resources last? How much longer can a community's underground water supply (yours?) keep up with an exponential growth of population? How much longer can commercial whaling continue? Whatever the answer, one thing is certain if the use of the resource is growing exponentially: whatever the limit is, half of the entire resource is used up in just one doubling time-- the last one. This mathematical certainty means that the depletion of a fixed natural resource will lead to a sudden crisis unless foresight and long-range planning are supported by political and economic action long before that painful last doubling.

Can you find examples of such foresight? Or examples of foresight that have led to effective planning?

(See "Forgotten Fundamentals of the Energy Crisis", A A. Bartlett, American Journal of Physics, Sept. 1978, or write to him at Dept. of Physics, Univ of Colorado, Boulder, Col. 80309 for a reprint. See also items: Steel, Copper, Zinc, Aluminum, Lead, p. 105 Petroleum Depletion, p. 99 and The Tragedy of the Commons, p. 165)



Early stages of math anxiety

Feedback: Positive and negative

We live in a world of constant change.

Up-and-down fluctuations of an animal population, economic cycles, and the varying temperature inside your house or apartment are a few examples. Some situations stabilize themselves and level out because the fluctuations set in motion some corrective action, called <u>feedback</u>, that reduces the fluctuations.

For example, the population of wild rabbits regularly fluctuates between scarcity and abundance. One reason this occurs is because rabbits are important in the diet of foxes. If there is an abundance of rabbits the foxes get lots to eat, and they multiply. But with more hungry foxes out hunting, the rabbit supply becomes depleted. Foxes begin to starve, With fewer foxes the rabbit population can increase once more. Thus an <u>increase</u> in the rabbit population leads to an increase in foxes which tends to <u>reduce</u> the rabbit population-- a self-correcting mechanism controlling the rabbit population called <u>negative</u> feedback.

Can you explain why the following are also examples of negative feedback?

A thermostat controls the temperature of a room.
Our economic system has slumps and booms (Take heart! No one has fully explained this one!)
A person can stand upright without falling over.
A passenger in a speeding car says, "Too fast, slow down!" whenever speed is too great.
A human heartbeat is controlled.

* * * * *

Some unstable situations fail to stabilize themselves naturally because any fluctuations that occur set in motion an action that <u>increases</u> the fluctuation.

You can demonstrate such a <u>positive</u> feedback situation by putting a microphone attached to an audio amplifier in front of the loudspeaker output. The faintest sound picked up by the microphone is

amplified, and the amplified sound coming out of the loudspeaker is picked up and amplified further, an inf. What limits the final loud noise?

As another example, when sunlight melts snow in the Northern Hemisphere the dark background exposed under the snow absorbs more heat, causing additional warming and heating. This positive feedback hastens the onset of spring in the snowbound North.

The spread of a forest fire is also a consequence of positive, not negative, feedback. So is the behaviour of a crowd in a theatre when someone shouts "Fire!"

Or again, when CFC's used as refrigerants escape to the atmosphere, they induce a climatic warming that increases the need for CFC-powered air conditioners, the use of which may further deplete the stratospheric ozone layer and increase further the need for the product. (M.C. MacCracken, Science, Oct. 30, 1987, p. 598).

Can you explain why an arms race may be yet another example of positive feedback?

Try to identify other examples of feedback, positive or negative, in your daily life.

Consider the more complicated feedbacks at work globally between energy consumption, agriculture, and the greenhouse effect.

Disease, abortion, wars, murder, famine, accidents, and pollution REDUCE the world's population; its INCREASE is promoted by motherhood, medicine, public health, peace, law and order, scientific agriculture, accident prevention, and clean air. Therefore why isn't the population explosion desirable?

Threats to human society

The fossil record contains a record of repeated wholesale catastrophes and extinctions of species-- the dinosaurs 60 million years ago are only one example-- and as we inquire into causes we realize that similar circumstances can recur. Asteroid collisions, ice ages, rising sea level, desertification, and predators are only a few among them.

Short of an asteroid collision or the sun becoming a nova it is hard to imagine the total extinction of Homo sapiens sapiens as a species, but it is easy to imagine events leading to a breakdown of organized human society. Consider the latter possibility:

a) What threats to the long-term survival of human society do you see at work today? (Possible answers include nuclear war, uncontrollable epidemics, and rising sea level aggrevating progressive overpopulation).

b) What steps do you see actually beginning to be taken today on a global or international scale to deal with your perceived threats to organized society? (Possible answers include widespread moves to abandon manufacture of CFC's which destroy atmospheric ozone, the elaboration of United Nations programs of food, health, et al., and treaties to confine and control nuclear proliferation.)

Examples of how nations cooperate on a global scale in dealing with science-laden issues may deserve particular attention. Questions of motives, financing, and leadership affect each nation's commitment. In what specific ways has the U.S. been active?

When astrology leads people to base serious economic and political decisions on its predictions it is no longer a game. Isn't it dangerous?

Risk

Is it possible to create a risk-free society? Identify risks you could eliminate from your own life by making personal choices.

Every day as a matter of habit people continue to kill themselves by smoking cigarettes and driving without seat belts while at the same time being afraid of the relatively smaller health risks of artificial sweeteners, salt, and cholesterol. Unthinking habit, perhaps, but in other cases the decision to act or not to act required a conscious weighing up of the consequences.

For example, in the spring of 1986 the European tourist trade collapsed due to the hijacking of the cruise ship, Achille Lauro , the bombing of a TWA jetliner over Greece, and the confrontation with Libya and peoples' consequent fear of travel abroad. But during the entire preceding year only 23 Americans had been killed anywhere overseas by terrorists-- not an unusual number-- while close to 45,000 Americans were killed in motor-vehicle-related accidents here in the United States. Would you have cancelled or postponed a trip to Europe or the Middle East in the spring of 1986? Why?

As another example, two independent teams of scientists agree that the southern third of the San Andreas fault extending past San Bernardino, California has a 25 per cent chance in the next 20-25 years of having an earthquake as severe as the one that devastated San Francisco in 1906. What effect might this announcement be expected to have on real estate values and insurance rates in the area? Would you be willing to accept a good job that required you to live in the area? (Boston Globe, Jan. 9, 1984, p. 31).

If you are a responsible public official who has just learned from reputable seismologists that there is a 50 percent chance of a major earthquake destroying your town in the next few days, what should you do? What are the consequences if you do not act, and the earthquake occurs? But what happens if you do act and the earthquake does not occur?

Another example: Radon, an invisible, odorless, radioactive gas is produced by the

radioactive decay of uranium in soil and rocks in scattered areas of the U.S. When it accumulates in ill-ventilated houses its radiation can result in lung cancer. It is generally accepted that radon is responsible for about 10,000 of the nation's 130,000 annual lung cancer deaths. If you find that your basement has an unusually high concentration of radon gas you or some other responsible person has to decide how much money to spend on renovation of your home. No one knows the probable cancer risk at a given level of radon exposure, but your failure to act will unquestionably increase your odds of getting lung cancer. And though you can reduce the risk, you can never eliminate it.

At what level of risk should the government subsidize corrective action in the homes of the needy?

How do you feel about the construction of a nuclear power plant upwind from your town? Or about the radioactive waste and hazardous industrial chemicals which pose a danger to the communities through which it must be transported by railroad or truck? Can you defend your opinion with reasons? (See items: Nuclear Power Plant Disposal, p. 90 and Radioactive Waste Disposal, p. 89)

We ourselves frequently put values on our own lives as when we choose a light-weight car instead of a more expensive gas guzzler or decide not to install an expensive safety device as protection against an unlikely category of accident. Which would you rather have: an entirely safe job at $200 per week or a job at $1000 per week with a 1-in-10 chance of coming down with cancer within 2 years?

Consider this example: The space craft Apollo 13 was launched from Cape Kennedy Space Center pad 39 (the third multiple of 13) at 1313 hours Central Time on its way to the moon. On the 13th of April, 1987 an explosion forced the craft to return, having barely escaped destruction. As the NASA official in charge of scheduling space craft and shuttle launches in the future, would you authorize a launch at 1313 hours on a Friday the 13th if the extreme pressures on the timing of launch made this the most appropriate moment? Why, or why not? Remember the Challenger disaster!

As a final example: Is it unethical for doctors or dentists to refuse to care for people infected with the AIDS virus for fear of contracting the disease themselves? Many doctors who do so argue that since the disease is <u>invariably</u> fatal <u>any</u> risk is

too high. Other doctors argue that many serious diseases are much more communicable.

Identify half a dozen of the hazards you consider to be the most threatening to your health or safety. Try to rank them by probability. Is it practical to reduce their probabilities to zero?

(See item: Daily Hazards to Life and Health, p. 8) See also Consuming Fears: The Politics of Product Risks, H.M. Sapolsky, ed., Basic Books, 1986, and Averting Catastrophe: Strategies for Regulating Risky Techniques, J.G. Morone and E.J. Woodhouse, Univ. of Calif. Press, 1986. The latter book contains detailed case studies of five technologies: toxic chemicals, nuclear power, recombinant DNA research, threats to the ozone layer, and the greenhouse effect. Also "Risky Business", M. Shodell. Science 85, Oct. 1985, p. 43.)

Science and congressmen

About half the bills presented to the U.S. Congress require some knowledge of science for their full understanding. Have your congressmen studied much science? If they have not, how do they go about deciding how to vote? Should your congressmen be required to show that they have had (and passed) some high-school level science courses before they take office?

Women as scientists and inventors

A National Inventors Hall of Fame near Washington in 1984 had 52 members. Not one was a woman. Not:

Marie Curie who discovered radium.

Lise Meitner who discovered and named nuclear fission.

Gladys Hobby for the development of terramycin.

Carrie Everson for her oil flotation system for separating gold and silver from rocky ore.

Eleanor Raymond and Maria Telkes for major contributions to modern domestic solar heating.

Jocelyn Bell who shared in the discovery of the first pulsar.

Bette Graham who invented Liquid Paper.

Rosalind Franklin who shared in the discovery of the double-helix structure of DNA.

Barbara McClintock who won a Nobel Prize for her demonstration of the transfer of genetic information among a single individual's chromosomes.

This deplorable state of affairs might justify a PROJECT (see p. ( )) to identify more women scientists and inventors and to examine their achievements.

(See Mothers of Invention. From the Bra to the Bomb: Forgotten Women and their Unforgettable Ideas, E.A. Vare and G. Ptacek. Wm. Morrow and Co., 1987; and "Making Contributions: An Historical Overview of Women's Role in Physics", ed. by B. Lotze. A module in the AAPT Issue-Oriented Modules Series noted in Bibliography.)

Political views of scientists and engineers

C.P. Snow observed that among pure scientists a higher proportion are politically left of center than any other profession. Not so for engineers, who are conservative almost to a man-- not reactionary in the extreme literary sense, but just conservative.

Can you confirm or refute this observation by talking to engineers and pure scientists?

Does it apply to members of your state legislature or the U.S. Congress who may have science or engineering degrees and whose political stance is usually well known?

If Snow's observation is correct, how do you explain it?

For a PROJECT on this see p. 176.

"Scientists should be on tap but not on top." Winston Churchill. Do you agree?

Space law: Justice on the high frontier

It may be only a question of time before we have our first murder in outer space, and if it occurred today there would be almost no laws to govern the crime. Since 1967 there have already been five international treaties to consider some of the eventualities that may occur as we project more and more men and objects into space, but many more eventualities still remain to be dealt with.

For example, if U.S. and Soviet astronauts jointly occupy a space station and a Soviet invents a new patentable gadget, would it be protected under U.S. or Soviet patent laws? Who would be liable for the bills if the astronaut were injured or killed in a jointly owned space station by the negligence of another U.S. astronaut? Or a Soviet astronaut? Under current law the family of the dead or injured astronaut could not claim damages from either the United States or any foreign country. Laws defining patent rights, personal liability, and criminal justice which work well for cases arising on the surface of the earth simply don't apply in space.

What obligation has the U.S. to assist in the rescue of Russians stranded in space-- or vice versa?

Had Canada any legal obligation to return the nuclear-powered Russian satellite that crashed and sprayed radioactive fragments over a large area in the far North in 1978? And who was legally bound to pay for its expensive ($14 million) retrieval?

Every country has legal command of the atmosphere above it in which airplanes fly, but above the atmosphere lies outer space in which overflying satellites are not similarly restricted. At what altitude does outer space-- and therefore a different set of laws-- begin? No one has yet decided.

And what laws apply if circumstances similar to those mentioned above were to occur on the moon? Since 1959 the United Nations has been the principal forum for the development of space law, and it is there that further work continues.

Perhaps Antarctica, which is an international territory, provides a standard for comparison.

Antarctica, like space, is not owned by any nation, thanks to a treaty signed in 1959 by all interested nations and due for review in 1991. The treaty holds all national claims in abeyance and bars military activities and nuclear testing. It limits national programs to scientific research and guarantees each nation's scientists unlimited access to the others' facilities.

(See item: Outer Space: The Infinite Dump, p. 159)

Citizen's responsibility to society

What responsibility, if any, do scientists have for anticipating or ameliorating the effects of their work on society? An important fraction of all the scientists in the U.S. are involved in military-related research. Does your answer apply equally to them?

Is the engineer responsible for the consequences when his product fails (e.g. automobile manufacturers for faulty design of your car's brakes or a chemical company for the carcinogenic effects of dioxin in its herbicide?)

Is the legislator responsible for his failure to legislate safety standards (e.g. not requiring seat belts when most other states do-- so you are killed in a collision-- or failing to fund the clean-up of a provably hazardous waste dump?

Is the voting citizen ever responsible for the consequences-- good or bad-- of his vote?

Are you responsible in any way for the consequences of your job? Suppose you find a well-paid job working on atomic weapons or building tanks for the military?

Many scientists and engineers have refused to take such military-related jobs. Would you do so? Do you approve of "whistle blowers"-- workers in government or industry who, as an act of conscience, report shoddy work or dishonest practices by their fellow workers?

Government duty vs. personal freedom

We permit people to smoke and to climb cliffs but make it a crime to ride a motorcycle without a helmet (in some states) or to use heroin or crack. If the government allows boxers, hockey players, football players, and other athletes to use their bodies to earn money despite the possibility of injury, why can't a female earn money as a surrogate mother?

Don't you have the right to risk your own health, or does the government have the duty to restrain you from becoming a burden on the rest of us? For example, should laws be enacted that:

a) require seat belts in cars?
b) prohibit smoking in certain public places?
c) ban the sale of junk food?
d) tighten up air and water pollution laws?
e) penalize overweight people?

Brain drain

For a century nearly a quarter of America's scientific leadership have been immigrants from abroad, including many of "our" Nobel Prize winners. And American industry would have difficulty functioning without the many foreign scientists and engineers it now employs. We need them.

Is it right that we take this much talent from other countries, many of which badly need them?

Yet if we send them back we are often depriving bright young people of career opportunities. Is <u>that</u> right?

How can we be fair to (a) the foreign student, (b) to their home country which may need their technical training, and (c) to the United States which gave it to them and needs it too-- all at once?

Society's effects on the goals of science

Science and technology have powerful effects on society. But the reverse may also be true.

During the 1940's and 1950's, well before Gorbachev's "perestroika" the Soviet biologist Trofim Lysenko argued that traits which a plant or animal acquired during its life were inheritable. The government backed him, believing the idea was not only consistent with Marxist ideology but could be used to increase crop yields. The first result was the arrest and imprisonment of most of the nation's top geneticists, followed by the complete destruction of what we regard as serious work in genetics, and a blow to agricultural production from which the nation has not yet fully recovered. Soviet genetics still lags well behind the West, not only in agricultural genetics but in the more recent developments in genetic engineering.

More recently in the Soviet Union, until the recent "openness" policy introduced by Gorbachov, computer education and the use of computers has been severely limited or non-existent. One important reason has been fear of the public gaining access to information of all sorts. Even copying machines were under lock and key; the production of video recorders was halted, and direct telephoning abroad came to an end soon after the 1980 Moscow Olympics. For years Moscow was forbidden to have telephone directories on the ground that it would provide too much information for those who shouldn't have it. Meanwhile, until recently immense sums of money were spent on jamming Western broadcasts.

What do you imagine will be the long-term effects of this policy of denying or limiting computer education and curbing communication technology in the Soviet Union?

In America society and its ideals clearly have an effect on the goals of scientific research (e.g. genetic engineering, the military, space, electronics)? Should it?

Today (1990) the U.S. Government provides more money for scientific research and development than

U.S. industry does, much of it aimed at helping the U.S. compete militarily with the U.S.S.R. and economically with Japan.

The total U.S. expenditure for research and development in 1989 was about $129 billion, according to a study by the Battelle Memorial Institute of Columbus, Ohio. Industry paid for about half. Federal money, about $60 billion, was dominated by military related R and D which accounted for 60 percent of the total.

Speaking a few years ago of a proposed increase of the National Science Foundation's budget, N.S.F. director Edward Knapp observed that the new budget would "strengthen and initiate programs... that would direct this country to a stronger position in international competitiveness and national security". Or, as a member of the Senate committee that oversees the N.S.F. put it, "Growth, jobs, national security--these are issues we feel very strongly about." ("Science and the Citizen", Scientific American, June 1984, p. 74.) Whether by persecution or by benign support (by stick or carrot), society's values affect what science does or does not do. Is this statement true for <u>all</u> science? Can you find other examples?

As one specific example, the Cambridge, Mass. City Council, in January 1977, forbade some kinds of research in recombinant genetics to take place within the city limits. (Science News, Jan. 29, 1977, p. 70 and Feb. 12, 1977, p. 103).

Should citizens who are not specially trained in science (e.g. voters, legislators) have the authority to vote to halt scientific research that they believe presents a hazard to human life? Or to fund it? Approximately half the bills before the U.S. Congress require some knowledge of science for their full understanding.

Should science courses be required for high school diplomas? Or to run for election?

Hazards of new technology

No one foresaw the bad effects of these technological changes:

a) Building the Welland Canal to open the St. Lawrence Seaway allowed lampreys to enter from the Atlantic Ocean and destroy a Great Lakes fishing industry.

b) Upon irrigating desert land in Arizona and California the land became salty and infertile. California's great Central Valley is in serious trouble.

c) The development of detergents containing phosphates in 1960 caused the degradation of waterways due to increased plant growth and the clogging of sewage disposal plants by foam.

d) Thalidomide was marketed in 1958-61 abroad as a drug for problems of pregnancy before the discovery that it was responsible for 8000 children being born with deformed or missing arms and legs.

e) When automobiles came into widespread use in American cities no one anticipated the resulting air pollution.

f) When nuclear weapons testing began in the air above Nevada in the 1950's no one anticipated the genetic effects of radioactive fallout.

g) When DDT came into widespread use against malarial mosquitoes and other insects in the 1940's no one anticipated its devastating effect on fish, birds, and the human food chain. It nearly exterminated the American eagle by destroying its eggs' resistance to breaking.

h) Because of the drilling of water wells in Venice, Italy, the city is sinking into the marsh.

i) Since World War II the increased number of power plants and factories emit such immense quantities of sulfur dioxide and oxides of nitrogen that they are almost certainly responsible for acid rain.

j) The use of freon gas (CFC's) as a propellant in spray cans causes the destruction of ozone in the upper atmosphere which, if continued, will permit a potentially serious increase in ground-level ultraviolet radiation from the sun.

k) If Louis Pasteur and those who followed him in the conquest of disease had not been so successful we would not now be faced with the problems of overpopulation.

l) Support for nuclear power eroded swiftly after serious nuclear accidents near Detroit, in Alabama, and at Three Mile Island (as well as Chernobyl in the U.S.S.R.). In 1989 there were no nuclear power reactors being planned or built. The current 107 reactors in service produced 18% of all U.S. electric power.

Questions:

-But how could greater care have been used to avoid these unexpected results? What should have been done?

-Can you think of any engineering projects in your own community that had unforeseen bad effects? Does this mean the project should not have been undertaken?

-Are major accidents likely to curtail or put a stop to the airline industry or the works of biotechnology, or chemical engineering?

(See The Demise of Nuclear Energy? Lessons for Democratic Control of Technology, J.G. Morone and E.J. Woodhouse. Yale Univ. Press, 1989)

Would you be willing to use a drug or cosmetic that you knew had been tested extensively on live animals? Would you use a drug or cosmetic that was guaranteed not to have been tested on live animals and might therefore be unsafe?

Didn't it violate animal rights to use a baboon heart for a human transplant (Baby Fae, 1984)? If so, how about the steer that provides your hamburger for lunch?

Large-scale scientific errors

Classic large-scale errors in the history of science shared by many scientists at the time include:

Phlogiston. An intangible substance whose escape from a flammable object explained burning, the change in appearance of a burned object, and the nature of flames. The idea was killed by the 18th Century experiments of Lavoisier.

Ether. The substance assumed necessary to carry waves of light through otherwise empty space. The idea was killed by the experiments of Michelson and Morley in 1887.

Caloric. A fluid-like substance which today we think of as heat. It gave way to the kinetic-molecular model of heat by the early 1800's.

Spontaneous generation of life. An idea current until the experiments of Louis Pasteur in the 1850's.

More recently we might include canals on Mars, purportedly seen by well-respected astronomers just prior to World War I, and room-temperature nuclear fusion that rose to prominence and abruptly faded in the spring of 1989.

Does this mean that "scientific theories are not to be trusted"? On what grounds do you base your confidence in such ideas as Newton's laws of motion, the germ theory of disease, the atomic theory, or the theory of evolution?

Consider items: Astrology, p. 203 and Dowsing, p. 205.

Might the alteration of human germ cells by genetic engineering become the cosmetic surgery of the next century?

Risks vs. benefits of science and technology

The use of science and technology has improved our standard of living, but it has also created an arms race, widened the gap between the rich and the poor nations, created a perilous dependence on imported oil, and led to widespread dissatisfaction in the workplace.

Some new fields of science and technology that have visibly <u>created</u> problems for human welfare:

recombinant genetics
nuclear fission
aerodynamics (airplanes)

Some new fields of science and technology that have visibly <u>alleviated</u> problems of human welfare:

medical instrumentation and drugs
nuclear fission and radioisotopes
recombinant genetics
semi-conductors (computers)
aerodynamics (airplanes)
plant breeding.

Consider the risks and benefits derived from the following applications of science and technology:

a. The Green Revolution has radically increased the food supply of underdeveloped nations. However, it also entails the expenditure of petroleum for fertilizer, insecticides, and herbicides which are expensive. Moreover, the necessary fertilizer increases the rate of eutrophication of lakes and streams.

b. Energy production creates pollutants from mining, transporting, and burning fuels. (e.g. oil spills, smog, acid rain, strip mines).

c. Irrigation will make most desert land productive but keeps needed water from downstream users and drains underground aquifers that may take thousands of years to refill.

d. The American economy depends to a great extent upon the automobile, but the manufacture and operation of these vehicles causes environmental damage while accidents result in 45,000 deaths per year.

Long-term effects of technology

Human activities are massively affecting the environment in ways we do not yet understand because a generation of human lives is too short a time for us to determine:

a) the effects on the atmosphere of carbon dioxide from automobiles, power plants, and factories (greenhouse effect).

b) the possible genetic effects of radiation from the burning of coal and from the use of nuclear power plants.

c) the effects on humans of drugs and chemicals of all kinds.

d) the long-term effects of birth control on populations.

e) the long-term consequences of our destruction of plant and animal species and our worldwide destruction of forests.

Whatever the effects may be, they will be shaped to a great extent by actions we take today. In each case, what actions do you see taking place, and what do you think our actions should be?

(See Scientific American, September 1989, a special issue devoted to "Managing Planet Earth". For additional human activities that may have profound effects in the future, see the PROJECT, "Technology Tomorrow" on p. 231)

If a woman has a legal obligation to provide prenatal care for her child how can she at the same time have the right to abort the fetus?

Obsolete technology

Obsolete within living memory: radio tubes, 78 rpm phonograph turntables, fountain pens, the telegraph, ice boxes filled with natural ice, bowling alley pin boys, transatlantic passenger liners, steam locomotives, slide rules, mechanical adding machines, many passenger trains, the Bessemer converter for making steel , castor oil.

Can you think of others? What's next?

(There is a PROJECT on "Technology Yesterday" on p. 230.

Independence from technology

Occasionally people who tire of the pace and pressures and values of modern life try to "go back to the land". raising their own food, living simply, and becoming as nearly independent as they can from the tools amusements, and energy sources of twentieth century America. The early American pioneers did it successfully. Could they do it today? Could you? If not, why not? Can you name some other people in history or literature or in modern life who have succeeded to some degree?

Henry Thoreau, the American philosopher who wrote Walden, said, "Men have become the tools of their tools", and Kurt Vonnegut, author of Player Piano, said, "Our machines are to practically everybody what the white men were to the Indians."

Do you disagree?

Why isn't the proven technology of cloud seeding used to produce rain in drought-stricken areas?

Effects of the automobile on American life

Some effects of the automobile on American life:

Economic effects

1. There are enormous numbers of workers in the auto industry itself.

2. Numerous industries serve as suppliers to the auto industry such as steel manufacturers , makers of tires, plastics, electronics, and, of course, the oil industry.

3. In addition to supplying the industry there are many businesses and industries that depend on the automobile such as garages, service stations, parking lots, car washes, auto races, toll booth operators, meter maids, highway construction and maintenance firms, roadside stands, motels, junk yards, driving schools, drive-in movies, trucking and farming.

4. Taxes on autos and gasoline are important sources of revenue for local, state, and federal governments.

5. Auto loans are important in the banking business.

6. Automobile advertising is important in the advertising business.

7. It is estimated that as much as 25% of the lifetime earnings of a worker and his family go to the cost and upkeep of his automobiles.

8. The huge industrial capacity of its automobile manufacturing plants served the U.S. in good stead in World War II. Automobiles, jeeps, tanks, trucks, etc. are essential to the modern army.

Environmental effects

1. A great deal of land has been paved over for parking lots, garages, etc., and an area exceeding that of Conn., Del., Mass., N.H., Rhode Island, and Vermont has now been paved over for motor traffic. It is estimated that 2/3 of the Los Angeles downtown area is given over to the automobile.

2. Ugly billboards and road signs constitute visual pollution of the highways.

3. Tankers which carry oil are a threat to the ocean's ecosystem.

4. Junking of cars wastes valuable resources, yet the entire industry is predicated on planned obsolescence.

5. The burning of fossil fuels in automobiles increases the heat in the atmosphere and contributes to the "greenhouse effect".

6. The automobile is the most important source of air pollution in many areas of the country.

7. Automobiles are an important source of noise pollution.

Effects on health

1. Automobiles are a major cause of death and injury. Deaths total about 45,000 a year and serious injuries about four million.

2. Lack of exercise and overuse of the automobile tend to keep many Americans in poor physical condition.

3. A health plus for the automobile is the many emergency vehicles that save lives-- ambulances, fire trucks, police cars.

Political effects

1. The huge automobile industry has considerable influence in government, and its lobby can influence legislation in the industry's best interest. For example, it has obtained delays in the implementation of various control laws.

2. Similarly, since many auto companies have foreign subsidiaries and large export sales they may affect or be affected by political events in foreign countries.

3. U.A.W., the automobile labor union, sets the pattern for many of the union contracts for other industries. It has pioneered in such things as escalator clauses in contracts for cost of living increases.

Effects on Society

1. The mobility given by the automobile has influenced leisure-time patterns of Americans. The auto also makes possible short vacations such as weekends, ski trips, etc. as well as extended travel.

2. The automobile allows people to live and work in widely separated places. Thus the auto is an important cause of the rise of the suburbs and, at the same time, a cause of the decline of the inner city.

3. The automobile has greatly affected the sexual mores of American society.

4. The automobile has enormous importance as a status symbol and a source of prestige in the community.

5. The emphasis on the car as a source of prestige leads many people to get into debt beyond their means.

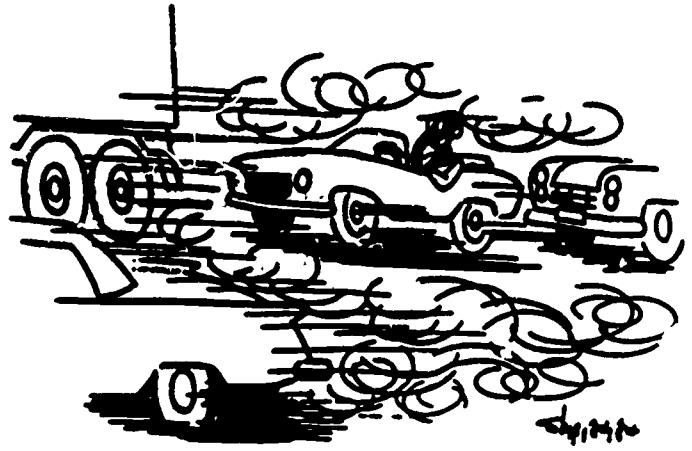
6. The automobile makes possible attendance at cultural and sports events, museums, libraries, etc.

7. The private auto has strangled public transportation. Railroads used to provide cheap and efficient passenger service; now many states have no passenger trains at all.

8. School and family join in making it easy for teenagers to drive. Three out of every four Americans of age are licensed drivers.

9. The speed and mobility given by cars have made Americans more <u>time</u> conscious-- always hurrying.

(See "Rethinking the Role of the Automobile", M. Renner. Worldwatch Paper Series, noted in Bibliography).



Metric system

Why bother changing over to the metric system?

Advantages:

It's much simpler to use. You change kilometers to centimeters by merely moving a decimal point. If you doubt this, try changing miles to inches!

It's used in every other nation in the world except Burma, South Yemen, and Brunei. Hence it's important that our industries use it in manufacturing for export and competition in the world marketplace. General Motors is almost entirely metric.

Disadvantages:

The public resists strongly, and some people have even organized to fight what they see as a troublesome, even impractical, move. For example, deeds, plats, and blueprints on record for hundreds of years back are all in inches and feet. Consumer advocates warn that a changeover to metric packaging in the marketplace will provide a smokescreen to hide steep price increases.

In September 1982, after six years of effort, the federal government gave up exhorting the country and abolished the U.S. Metric Board. The new, much smaller, Office of Metric Programs assumes that eventually, perhaps not in your lifetime, enough people will be used to metric measurements so that the change will take place slowly and all by itself.

What metric units do you feel comfortable with already? Kilograms?, meters? liters? Should stores selling consumer goods such as food, hardware, and clothing, be encouraged to use them?

Isn't it odd that people are so enthusiastic about learning to use computers, which is much more difficult than learning to use the metric system.

* * * *

While most measurements are being converted into metric units these days, the football field will probably always remain 100 yards long. Not that no one has tried to change it. Chemistry Magazine (Vol. 50, No. 9) reports an experiment at Carleton College in Minnesota with a field 100 meters long and 50 meters wide, which is 28 feet longer and 14 feet wider than usual. In the experimental game with its rival, St. Olaf, Carleton lost 43-0. It seems that the experiment was abandoned.

There is a metric-based index that relates your body mass to your health. You can calculate your own index by dividing your mass in kilograms by the square of your height in meters. For values of the index above 25 there is a steady decrease in your life expectancy and an increase in the likelihood of certain diseases. U.S. Metric Association Newsletter, July-August 1985, p. 7).

Time

All the clocks in China always read the same time-- the time in Beijing, the national capitol-- even though China is four times zones wide.

Why wouldn't that be a good idea for the U.S.? We could perfectly well have the entire contiguous U.S., three time zones wide, run on the time in Omaha, Nebraska, which is in the middle of the country.

Thus, when it is noon in Omaha it would be 1:30 PM in New York City and 10:30 in Los Angeles. With the entire country on a single time wouldn't half the country be saving energy half the time-- thus accomplishing more than Daylight Saving Time does during its short reign? Telephone rates would be the same all day, businesses would have the same hours and lunch breaks, and in national elections everyone would vote simultaneously so that television exit polls could not affect election results. We are already one hour off Sun Time between the edges of our present time zones, and we seem able to adjust readily enough to that extra hour of Daylight Time.

As an alternative proposal, would it save energy to extend Daylight Saving Time throughout the year? If so, should we-- or should we not-- do so? Why do we use it now?

Computers in an open society

Has electronics made our society too "open"?

Like it or not, your life now is an open book to many people you never see, and it will become even more so in your years ahead as an adult. Records you assume are confidential are available to many people and are stored, transferred to other people, and often transferred again without your ever knowing of it.

There are now or probably will be records covering nearly every aspect of your life from birth records to your death certificate. Your credit rating, your banking transactions, your complete school transcript, your medical history, your life style as you are investigated for insurance policies, your federal income tax information, your job history, and your criminal record if you acquire one are all encoded in computer memories somewhere.

Occasionally it is proposed that all the records on each American citizen be stored in a master system in the interests of efficient and cost-saving administration of the U.S. Government. So far, the idea has always been voted down. Are you in favor of the idea? Why?

Almost always the use of such data is perfectly legal, but when there are errors in its recording or transfer-- and sometimes there <u>are</u> errors-- the effects on you can be devastating. Moreover, computers can be mis-used; they can be used to invade confidential records of governments, businesses, hospitals, the military, schools, et al. and to falsify bank records and telephone calls and bills.

What protection have you against such errors or mis-use? What are your rights to privacy? To reduce or eliminate such hazards of error or mis-use should computer education be sharply reduced and access to computers severely controlled as in the Soviet Union?

(See items: Society's Effect on the Goals of Science, p. 180 and Computers and Privacy, p. 198. Also Computers and Privacy, a module in the BSCS Study Series noted in the Bibliography.)

Computers and the work place

Will the widespread use of computers of various kinds eliminate the need for central offices?

Workers whose jobs are entirely done with computer help might just as well have their terminals at home, tied into the company's central computer by a telephone link.

Think of the effects on our big cities if this were to take place: Fewer commuters, more relaxed rush-hour traffic, a decline in office real estate including the need for big central-city skyscrapers, an accelerated destruction of farmland as suburban commuters move farther out into the country, households where the breadwinner is home all day long, the isolation from gossip and office politics, and the loss of a sense of community with fellow workers.

Or will we find that the human need for society is so strong that these dispersals will be resisted?

Given these advantages and disadvantages, would you choose to spend your working life at such a "home work station"?

The athletes at many Olympic events could perhaps perform better without leaving home. There, timed and measured electronically, their performance could be communicated immediately to central headquarters, complete with pictures, from all over the world, eliminating immense expense and controversy. Wouldn't this be desirable?

(See items: Computers and the Job Market, p. 195 and Automation Costs Jobs, p. 197)

Computers and the job market

As computers and automation increasingly perform menial tasks they will change or eliminate nearly every kind of job that is familiar to you now--and create new ones. The greatest number of new jobs in the U.S. through 1995 will be for janitors (779,000), not computer programmers (53,000), followed by cashiers, secretaries, office clerks, then sales clerks.

Some careers on the way out or in decline include:

-factory workers. By the year 2000 many assembly line jobs will be done by robots, and even factory engineers will be giving way to design computers connected to the robots, thus eliminating blueprints.

-clerks. U.S. Dept. of Labor projections call for 66,000 fewer mail carriers and postal clerks to be replaced by electronic mail sorting.

-bank tellers, to be at least partially replaced by electronic banking, and telephone operators by automation.

-computer programmers. Computers will be able to program themselves.

-air traffic controllers. The space shuttle is already guided by computer.

-farm laborers. Centrally controlled robotized machinery will plow, plant, irrigate, cultivate, and harvest. (See item: Automation Costs Jobs, p. 197)

-lumberjacks. Tomorrow's house may be made of maintenance-free plastic composites.

Some careers on the rise include:

-data base managers

-aquaculturists. Fish farming is a potentially important source of protein in an increasingly hungry world.

-laser technologist as fiber optics replaces wires for information transmission.

-space technologists to design space stations and work in space and on ground facilities.

-educationists. The Labor Department predicts a need for a 37% increase in elementary school teachers by 1995.

-geriatricians. In 1979 there were 18.9 retirees for every 100 workers. By 2030 this number will double, creating jobs for 700,000 geriatric social workers and 300,000 technicians for hearing aids, wheelchairs, prostheses, et al.

This prospect challenges the 20-30 million young American adults who cannot at present read, write, or calculate well enough to function effectively at work. "The well educated face a future of expanding job opportunities and rising wages while those not well educated face a future of contracting opportunities and poverty", says Sue E. Berryman, director of the Institute on Education and the Economy at Columbia University. (N.Y. Times, Sept. 26, 1989, p. 1)

(See items: Computers and the Work Place, p. 194 and Elementary Mechanics and Women's Lib, p. 111. See also "Careers of the Future", R. Wolkomir. Omni Magazine, Sept. 1985).

Would you be willing to take a job working on a product (e.g. robots) which you knew would put people out of work? How about working in a gun factory?

Which would you rather have: an entirely safe job at $200 per week or a job at $1000 per week with a 1-in-5 chance of coming down with cancer within five years?

Automation costs jobs

Research at some American colleges and universities is leading to the development of labor-saving machinery for use on farms. In recent years huge machines that harvest tomatoes and other crops have eliminated tens of thousands of jobs and have contributed to the growth of ever-larger corporate farms and the elimination of small farmers.

Research in other laboratories has led to the development of the transistor and then the microchip which, in computers, has automated factories and offices and eliminated innumerable further jobs.

Robots are being used more and more in manufacturing industries (e.g. automobiles and refrigerators), both in the U.S. and abroad. Unfortunately they too replace people and therefore cost jobs. But highly automated plants raise productivity, thus offsetting cheaper labor costs in other countries, and their untiring precision makes possible a uniformly high quality of product which is economically competitive in world markets.

Developments such as these raise the specter of what has been called "jobless economic growth".

Would you be willing to take a job developing a machine or a device that you knew would, if successful, put people out of work? For example, how about a robot to drive farm machinery?

What if the displaced worker were a member of your own family?

If you had been a member of the California state legislature when a bill came before it to suspend state support for research and development of agricultural labor-saving machinery because their use would destroy farm workers' jobs, how would you have voted? (The measure failed).

(See items: Computers in the Job Market, p. 195 and Computers in the Work Place, p, 194 For an article that argues that technological change is essential to U.S. economic welfare see "Technology, Employment, and U.S. Competitiveness", R.M. Cyert and D.C. Mowery in Scientific American, May 1989).

Computers and privacy

"Big Brother" can watch you!

Two-way cable television technology allows a viewer to respond to questions or to initiate a variety of transactions by pushing buttons on a small hand-held console connected to his TV set and thence to the cable TV company headquarters. Early versions tried out in 1984 in some cities (e.g. Pittsburgh, Cincinnati, Knoxville, Syracuse) could be expanded to provide electronic banking, shopping, opinion polling, meter-reading, burglar, fire, and medical emergency protection, as well as education and entertainment.

Because it is now possible to store such enormous amounts of information in a tiny silicon computer chip it is easy to save information fed into a television company's headquarters by its cable subscribers. As a result, a subscriber's two-way television set becomes, in effect, a guest in his house which puts on file at headquarters his comings and goings, banking transactions, opinions on controversial issues, taste in consumer goods, and the viewing preferences of the household-- a goldmine of confidential information which the cable TV company can sell to advertisers, politicians, sociologists, or gossip columnists.

The right to privacy is one of the cornerstones of liberty. To the degree that subscribers choose to take advantage of this technology it can be argued that it places the liberty of its users in the hands of every two-way cable TV operator.

Does this technology indeed pose a serious danger to you? Should any action be taken? If so, what action? By whom?

Another example from a report on March 1, 1989 in The New York Times: The Nynex Corporation will offer customers a "caller identification system that would display the number from which an incoming call was originating before the call was answered." This system would allow customers the advantage of screening their calls or identifying the sources of obscene or crank calls. It would be disadvantageous to callers wishing to protect their unlisted telephone numbers or their identity from a crisis hotline. Should the use of such caller identification systems be regulated? If so, how?

(See item: Computers in an Open Society, p. 193)

Medical diagnosis by computer

Computers can be programmed to make decisions in many complicated situations and to make them much faster than people. They can play expert chess, control electric power plants, route long-distance telephone traffic, and direct the actions of robots. Fed all the symptoms of a health disorder, they can also be programmed to make a diagnosis and to advise physicians on treatment.

But if a computer recommends a treatment and the patient then dies, whose fault (or responsibility) is it? The programmer's. The original medical expert's? The computer manufacturer's? The presiding doctor's? Or, on the other hand, suppose the doctor ignores the computer's advice and the patient dies? Who is responsible now-- if anyone?

(See item: Weather Forecasters in Court, p. 153)

Alphabetization: Chinese

One of the reasons the Chinese Government in 1956 began to convert Chinese writing to our familiar 26 letters is the inefficiency of trying to alphabetize everything from telephone books and dictionaries to tax registers in terms of the 214 radicals used to write their complicated-looking characters or ideographs.

If we had 214 letters in our alphabet, how much longer would it take you to learn to write? Or to look up a word in a dictionary or a telephone book? Could we do with fewer letters in our own alphabet? Would the advantage of fewer letters outweigh the problems created by trying to eliminate some of them? Compare your answers with the present efforts to replace our British units of measurement by the metric system.

In the last few years word processors have been devised which can convert entire sentences written in Chinese characters into grammatically correct Japanese or Korean or vice versa. This invention will change the fabric of Asia's cultural and economic life in fundamental ways, bringing more women into the work force (who master the machines more quickly than their male counterparts), speeding communication in the business world, bringing together diverse cultures previously divided by language barriers, and promising to raise the level of literacy of Asian nations.

(See item: Metric System, p. 191. See also "Solving the Chinese Puzzle", Time Magazine, Aug. 18, 1986, p.43).

Popular ideas about science

To compare your attitude toward science with the views of 2000 American adults tested in 1985 by Jon D. Miller, head of the Public Opinion Laboratory at Northern Illinois University, answer the following questions (true or false).

1. Some numbers are especially lucky for some people. (40)

2. Because of their knowledge, scientific researchers have a power that makes them dangerous. (over 50)

3. The positions of the sun, moon, planets, and stars have at least some influence on human affairs (astrology). (40)

4. It is likely that some of the unidentified flying objects (UFO"s) that have been reported are really space vehicles from other civilizations. (43)

5. Space shots have caused changes in our weather. (over 40).

6. Science tends to break down people's ideas of right and wrong. (over 30)

Of the 2000 test takers, the percentage answering "true" is in parentheses after each question. Ideally the numbers should all be zero (0) since <u>all the statements are false</u>. Assuming the sample was a fair cross section of adult Americans, what do these numbers show about their attitudes toward science? Compared with them, how well did you do?

In another poll reported in The American Biology Teacher (editorial, May 1989) 34 percent of those polled thought psychic powers could be used to read people's thoughts, 29 percent felt we could communicate with the dead, and 22 percent believed in ghosts. The sample being polled consisted of high school life science and biology teachers!

For a PROJECT on this see p. 231.

Eclipse

In 1983 the Indonesian Government declared the total solar eclipse of June 11 to be a national disaster, urged the nation's 70 million Muslims to join in special prayers that they be spared blindness, and advised eclipse watchers to stay indoors and watch the event on television. (J. Gribbin and O. Sattaur, "The Schoolchildren's Eclipse". Science '84, April 1984, p. 51).

Was this excessive caution, or did it make sense?

Astronomers setting up their instruments in North Carolina to observe the total solar eclipse on March 7, 1970 found that many of the local farmers had been so frightened by the eclipse warnings of the local news services that they not only kept their TV sets turned off but also hid inside their houses to avoid the supposedly deadly radiation from the eclipsed sun.

Was this excessive caution, or did it make sense?

Among people being shown the physics facilities at Pennsylvania State University are some who are afraid to enter the building that houses the nuclear reactor used for teaching and research. The reactor has been in routine use for years. Was this excessive caution, or did it make sense? The damaged power reactor at Three Mile Island is only a few dozen miles away.

Astrology

A Gallup poll in 1984 indicated that 52 percent of American teen-agers believed that astrology works. Astrology columns appear in over 1200 newspapers in the United States. Does this mean that astrology should be taken seriously?

Consider some of the evidence and some pointed questions:

1. What is the likelihood that one-twelfth of the world's population is having the same kind of day?

2. Why is the moment of birth, not conception, crucial for casting a horoscope?

3. If astrologers are as good as they claim to be, why aren't they richer?

4. Are all horoscopes done before the discovery of the three outer planets incorrect?

5. Why do different schools of astrology so strongly disagree with one another?

6. If astrologers claim that your personality is dictated by the attraction of the planets at the moment of your birth, how do you account for the fact that the gravitational pull of the delivering obstetrician far outweighs that of the planets involved?

The following are a few of the many publications and articles dealing with the evidence for the credibility of astrology:

Astrology: True or False, R. Culver and P. Ianna. Prometheus Books, Buffalo, N.Y. 1988.

"Your Astrology Defense Kit", A. Franknoi, Sky and Telescope Magazine, August 1989.

The Skeptical Inquirer. A magazine published quarterly by the Committee for the Scientific Investigation of Claims of the Paranormal. P.O. Box 229, Buffalo, N.Y. 14215. An essential tool for keeping up with the claims, tests, and refutations in

astrology, the UFO debate, psychic prediction, and other fringe areas.

Astrology and Astronomy. An information packet prepared by the Astronomical Society of the Pacific, 390 Ashton Ave., San Francisco, Calif. 94112. Several articles on various aspects of astrology and accounts of tests of its validity. Extensive bibliography of further books and articles.

"The practice of astrology took a major step toward achieving credibility today when, as predicted, everyone born under the sign of Scorpio was run over by an egg truck."

Should people who believe in astrology be allowed to teach science in public schools, practice medicine, or hold public office? Would you vote for such a person if you had the choice?

the subject of creationism vs. evolution. The article also points out the journals where authoritative reviews of these books are obtainable.

6. National Academy of Sciences: Science and Creationism, National Academy Press. Washington, D.C., 1984, 28 pp. "A booklet dedicated to educators, parents, and others concerned with science education at the secondary level."

(Above references are from Irma Jarcho, Teachers Clearinghouse for Science and Society Education, Inc. 1 W. 88th St., New York, N.Y. 10024)

Single copies of "Why Scientists Believe in Evolution" are available from AAAS Marketing Office, Dept. NC, American Association for the Advancement of Science, 1333 H St. NW, Washington, DC 20005.

Science and non-science

Which of these is supported by scientific evidence? Which is supported by popular tradition with little or no scientific evidence? How do you tell the difference?

Bermuda triangle	extra-sensory perception (ESP)
acupuncture	homing instinct in pigeons
astrology	prediction of eclipses
astronomy	flat (or hollow) earth
biorhythms	continental drift
UFO's	pyramid power
creationism	evolution of species

(Fads and Fallacies in the Name of Science, M. Gardner. Dover Publications, 1957, and Science and Unreason, D. and M. Radner. Wadsworth Publishing Co., Belmont, Calif., 1982, and The Skeptical Inquirer Magazine, P.O. Box 229, Buffalo, N.Y. 14215.)

Dowsing

In the mid-1960's U.S. marines in Vietnam used dowsing (water-witching or divining) to locate underground Vietcong tunnels and booby traps. Dowsing for simulated land mines was part of their training at Camp Pendleton.

Dowsers have repeatedly failed to produce results in controlled studies, yet dowsing is frequently used to search for underground water despite the fact that in many areas it is difficult to drill and not to find water.

In 1989 the 20-year-old American Society of Dowsers, Inc. (Danville, Vermont 05828) hac 68 local chapters around the U.S. and links to groups in England, Canada, New Zealand, and Australia.. How could the U.S. Marines and the members of the Society of Dowsers take dowsing seriously if it doesn't work? Does dowsing defy the laws of modern science? How would you go about finding out?

(See "Water Witches", R. Wolkimer. Omni Magazine, Sept. 1985, p. 41; "Water Witching", C. Kraus. New Yorker Mag., Oct. 9, 1989, p. 97, and The Skeptical Inquirer Magazine, Box 229, Buffalo, N.Y. 14215. There is a PROJECT on this on p. 229.

Should citizens, although not specially trained in science, have the authority to vote to halt scientific research that is believed to present possible hazard to human life?

Why shouldn't scientists be forbidden to do research on some subjects such as nuclear explosions, powerful insect poisons, methods of altering human genetic material, and the means of warfare?

Science and creationism

In a recent poll of high school life science and biology teachers reported in The American Biology Teacher (editorial, May 1989) 43% felt that creationism should be given equal time in the classroom, and 30% indicated that if forced to choose, they would teach creationism instead of evolution in their biology classes. 43% believed the Great Flood to be an actual event. Clearly the issues debated by William Jennings Bryan and Clarence Darrow in the Tennessee "monkey trial" of 1925 are still alive. In 1989 some church groups opened a campaign to require the teaching of the biblical account of creation in California's public school science classes alongside the theory of evolution.

The articles and pamphlets listed below are only a few of those available on the subject of creationism. Several of them include additional references, however. All of them are chosen for their usefulness to teachers and parents in dealing with the scientific basis of evolution.

1. "Nobelists vs. Creation Science", W.J. Bennetta. The Science Teacher, Dec. 1986, pp. 37-38.

2. "Voyage of the Overloaded Ark", J. Diamond. Discover Magazine, June, 1985, pp. 82-91. A history and analysis of creationism including the diagrams for Noah's Ark proposed by one of the first creationists, Athanasius Kircher.

3. "Blunder in Their Footsteps", L.R. Godfrey, and J.R. Cole, Natural History, August, 1986, pp. 4-12. Discussion of why the so-called "human" tracks found in conjunction with dinosaur tracks are fakes.

4. "Darwinism Defined: The Difference Between Fact and Theory", S.J. Gould. Discover Magazine, Jan. 1987, pp. 64-70. Gould discusses attacks upon evolutionary theory by ill-informed laymen and amplifies this with further discussion of modern trends in evolutionary theory.

5. "Science and Creationism: An Annotated Bibliography of Recent Books", J.S. Wissler and T.R. Mertens, The American Biology Teacher, Nov./Dec. 1986, pp. 471-474. An annotated listing of 18 books on

Gibberish pays

How clearly do <u>you</u> speak?

"Dr. J. Scott Armstrong, an educator specializing in the psychology of marketing, carefully coached an actor on the delivery of a purportedly scientific lecture entitled "Mathematical Game Theory As Applied to Physical Education". The lecture consisted entirely of "double talk", meaningless words, false logic, contradictory statements, irrelevant humor, and meaningless references to unrelated topics."

"Dr. Armstrong's bogus scientist presented this lecture to three audiences of social workers, psychologists, psychiatrists, educators, and administrators, none of whom detected the hoax. In a poll requesting anonymous opinions most respondants described the lecture as 'clear and stimulating'". (Quoted from The New York Times, Jan. 6, 1987, page C3.)

This would seem to indicate that an audience will rate an author or speaker's competence more highly if he or she is unintelligible! Is this true in your experience?

High-school football, power mowers, and mountain climbing take more lives each year than nuclear power plants. Therefore shouldn't they be abolished before nuclear power plants are?

Taxpayers' money is presently being used to search for life elsewhere in the universe? Should this effort be stopped? Expanded? Left unchanged?

Murphy's Law

Murphy's 6th Law (apocryphally) states "The more complicated a device is, the less likely it is to work as planned, the more likely it will be to break down, and the more difficult or expensive it will be to repair." As examples, consider the following:

1. The nuclear reactor accidents at Three Mile Island and Chernobyl.

2. The Mariner I space probe was launched from Cape Kennedy, Florida on July 28, 1982 headed for Venus. It was planned that after 14 minutes of flight a booster engine would speed it up to 25,820 mi/hr; after 44 minutes 9800 solar cells would unfold; after 80 days a computer would compute the final course correction, and after 100 days the craft would begin its orbit around Venus. However, only four minutes after take-off Mariner I plunged into the Atlantic Ocean. Inquiries later revealed that a minus sign had been omitted from the instructions fed into its computer. "It was a human error", a launch spokesman said. That minus sign cost $4,280,000.

3. When a NASA technician accidentally tripped and bumped into a space rocket poised to ferry an important satellite into orbit he cracked the brittle heat-resistant carbon exhaust nozzle too seriously for it to be fixed. The entire first stage assembly of the rocket had to be replaced for about $6 million. (Time. Dec. 19, 1988.)

4. On January 28, 1986 the space shuttle Challenger exploded 73 seconds after its lift-off, killing its crew of seven. The cause was traced to a plastic ring made brittle by cold weather before lift-off which allowed a leak of liquid hydrogen.

Is there a common thread to all these incidents?

Can you cite examples from your own experience?

Do they confirm Murphy's Law?

Is Murphy's Law a scientific principle? Why?

APPENDIX

Quotations

Science as Foolishness

Q1 In debate, Feb. 21, 1861, on an item that would appropriate $6000 to the Smithsonian Institution Senator Simon Cameron said, "I am tired of all this thing called science here... We have spent millions on that sort of thing for the last few years, and it is time it should be stopped."

Q2 "We hope that Professor Langley will not put his substantial greatness as a scientist in further peril by continuing to waste his time, and the money involved, in further airship experiments. Life is short, and he is capable of services to humanity incomparably greater than can be expected to result from trying to fly... For students and investigators of the Langley type there are more useful employments." (The New York Times, Dec. 10, 1903, editorial page).

Q3 "The demonstration that no possible combination of known substances, known forms of machinery, and known forms of force can be united in a practical machine by which man shall fly long distances through the air, seems to the writer as complete as it is possible for the demonstration of any physical fact to be." (Simon Newcomb, eminent American astronomer (1835-1909) quoted by Arthur C. Clarke, Profiles of the Future, Harper and Row, 1962, pp. 2-3).

Q4 "I have always consistently opposed high-tension and alternating systems of electric lighting... not only on account of danger, but because of their general unreliability and unsuitability for any general system of distribution."

"There is no plea which will justify the use of high tension and alternating currents, either in a scientific or a commercial sense. They are employed solely to reduce investment in copper wire and real estate." (Thomas A. Edison, "The Dangers of Electric Lighting", North American Review, Nov. 1889, pp. 630-633.)

Q5 Aristotelian professors who were contemporaries of Galileo said, concerning his discovery: "Jupiter's moons are invisible to the naked eye, and therefore can have no influence on the earth,

and therefore would be useless, and therefore do not exist." (A. Williams-Ellis, Men Who Found Out, Coward-McCann 1930, p. 43.)

Q6 Criticizing Robert Goddard's pioneering rocket research, a New York Times editorial in 1921 said, "That Professor Goddard with his "chair" in Clark College and the countenancing of the Smithsonian Institution does not know the relation of action to reaction, and of the need to have something better than a vacuum against which to react-- to say that would be absurd. Of course he only seems to lack the knowledge ladled out daily in high schools." (M. Lehman, This High Man, The Life of Robert H. Goddard. Farrar, Straus, and Co., 1963, p. 111.)

Q7 In 1939 U.S. Rear-Admiral Clark Woodward said, "... As far as sinking a ship with a bomb is concerned, you just can't do it." (Ralph L. Woods, American Legion Magazine, October 1966, p. 29.)

Q8 In December 1945 Dr. Vannevar Bush said of intercontinental missiles, "There has been a great deal said about a 3000-mile high-angle rocket. In my opinion such a thing is impossible for many years. The people who have been writing these things that annoy me have been talking about a 3000-mile high-angle rocket shot from one continent to another, carrying an atomic bomb and so directed as to be a precise weapon which could land exactly on a certain target such as a city."

"I say, technically, I don't think anyone in the world knows how to do such a thing, and I feel confident that it will not be done for a very long period of time to come... I think we can leave that out of our thinking. I wish the American public would leave that out of their thinking." (Arthur C. Clarke, Profiles of the Future, Harper and Row, 1962, p. 9.)

Q9 In 1945 Admiral Leahy told President Truman that the atomic bomb "is the biggest fool thing we have ever done... The bomb will never go off, and I speak as an expert in explosives." (Harry S. Truman, Memoirs, Vol. I, p. 11, Doubleday and Co. 1955.)

Q10 Commenting on the proposal to drive a steamboat by a screw propellor, Sir William Symonds, Surveyor of the British Navy, commented in 1837, "...even if the propellor had the power of propelling a vessel, it would be found altogether useless in practice because, the power being applied in the stern, it would be absolutely impossible to make the vessel

steer.." ((W. C. Church, The Life of John Ericsson, Charles Scribner's Sons, 1890, p. 90.)

Q11 In 1913 Lee de Forest, inventor of the audion tube which made radio broadcasting possible, was brought to trial on charges of using the U.S. mails fraudulently to sell public stock in the Radio Telephone Company, purported to be a worthless enterprise. In court the district attorney charged that:

"De Forest has said in many newspapers and over his signature that it would be possible to transmit the human voice across the Atlantic before many years. Based on these absurd and deliberately misleading statements the misguided public... has been persuaded to purchase stock in his company..."

DeForest was acquitted, but the judge advised him "to get a common garden variety of job and stick to it." L. Archer, History of Radio, American Historical Society, 1938, p. 110.)

Q12 Aristotle maintained that women have fewer teeth than men; although he was married twice, it never occurred to him to verify this statement by examining his wives'mouths. Bertrand Russell on the importance of experiment.

Q13 When I was a boy of 14 my father was so ignorant I could hardly stand to have the old man around. But when I got to be 21, I was astonished at how much he had learnt in 7 years. Mark Twain.

Q14 The world was created on October 22, 4004 B.C. at 6 o"clock in the evening. Irish Archbishop James Usher in 1742.

QUOTATIONS II

Science in Our Culture

Q15 Science and technology will play the key role. They will be of decisive significance in the competition between the two systems. Leonid Brezhnev, Soviet ex-president and general secretary.

Q16 The splitting of the atom has changed <u>everything</u> save our mode of thinking, and thus we drift toward unparalleled catastrophe. Albert Einstein.

Q17 Scientists should be on tap but not on top. Winston Churchill.

Q18 One small step for a man, one big step for mankind. Neil Armstrong stepping on to the moon, July 1969.

Q19 Socialism is inconceivable without engineering based on the latest discoveries of modern science. V.I. Lenin, one of the major architects of Soviet communism died in 1924.

Q20 It is science alone that can solve the problems of hunger and poverty, insanitation and illiteracy, of superstition and deadening custom and tradition, of vast resources running to waste, of a rich country inhabited by starving people. J. Nehru, prime minister of India from the beginning of its independence in 1947, died in 1964.

Q21 The whole of science is nothing more than a refinement of everyday thinking. Albert Einstein.

Q22 I have one further observation to make, and that is that you scientists have gotten a long way ahead of human conduct, and until human conduct catches up with you, we are in a precarious way unless you scientists slow up a little and let us catch up. Senator Johnson of Colorado at hearings before the Special Committee on Atomic Energy. U.S. Senate, 79th Congress, first session.

A Sample Moral Dilemma

When selecting vignettes to foster the various types of critical analysis, personal reflection, and moral growth mentioned previously, it is useful to think how two or more vignettes may be incorporated into a common theme relevant to the course content. As an example, elements of the vignettes in this book entitled "Destruction of Species" (p. 44), "Worthless Species" (p. 50), "Underground Toxic Wastes" (p. 88), and "Hazardous Chemicals, Dioxin, and Molecular Formulas (p. 80) may be combined and incorporated into material appropriate for biology, chemistry or earth science classes (grades 10-12 for this example) in the following manner:

Moral Dilemma: USA Technologies, Inc.

Focus: To analyze an example of the consequences of chemical pollution and to identify our obligations to society and to other forms of life.

Central Character: Norm

Choice: Whether Norm should report hazardous industrial waste to the public and to the proper authorities (in order to protect the health of fellow workers or to save an endangered species), or whether to work under the guidelines of his contract, ensure fellow workers and himself of his livelihood, and protect national security interests.

Norm, a bright young college graduate who majored in chemical engineering , has been hired by a local company named USA Technologies, Inc., or USA Tech as it is known in the local community. USA Tech is one of the major sources of employment for Petersburg, a pleasant community that has suffered great financial hardships because of the closing of several mills over the past fifteen years. Before USA Tech located in Petersburg the town had not been growing, and many people have had to give up their homes and move away to search for employment in other areas. USA Tech has given "new life" and hopes to Petersburg.

USA Tech holds several large U.S. Government defense contracts. Norm was interviewed at the beginning of his senior year year in college and offered a position with USA Tech that would start him at a salary that would offset all his college bills. Norm knew that he would be required to sign a contract that swore him to secrecy because of the sensitive nature of USA Tech's research for the U.S. Department of Defense.

Norm, brimming with excitement over his new job, felt a sense of pride because he was putting his knowledge to practical use and aiding his country. He he began work by helping to develop a new fuel which was much more efficient than regular fuels and less expensive to manufacture. Norm realized that the development of this new fuel could save the country billions of dollars a year.

Norm's excitement was soon shattered when he found out that in the process of making the secret fuel there had been carcinogenic (cancer-causing) by-products released into the environment. He also found that the health records of people who worked in the department that produced this fuel showed more illnesses than any other department of the company. Norm immediately reported this to his supervisors who thanked him for pointing this out and promised to correct the apparent problem.

In the meantime a group of environmentalists known as Ecology Watch had discovered that a rare species of animal only found in that region of the country was producing deformed offspring because of some contamination in their food chain. Ecology Watch reported that they did not know the source of the contamination but the threatened animal was clearly in danger of extinction.

Norm immediately realizes that USA Tech is likely to be responsible for this problem too. Again he tells his supervisors, but he is surprised at their reactions. They remind him that he should be thankful to work for the company and have them paying his college expenses. They also point out that the government may be able to save its taxpayers billions of dollars a year with the development of the new fuel. They tell him that "going public" with this information could also force the closing of the company, causing many families to be out of work, and they remind him that his contract binds him to secrecy.

Should Norm go public with this information?

Yes . Can't decide No

Probe questions:

1) Should Norm tell only the workers in his department of the potential risks although one of them may go to the press with this news? Why/Why not?

2) Should Norm ever be trusted again if he decides to go public with the information? Why/Why not?

3) Should Norm feel responsible for the loss of jobs if the plant is forced to close because he has made the news public?

4) From the point of view of the workers in Norm's department, is it more important for him to keep his oath and contract or risk their livelihood and health? Why/Why not?

5) If some of the other workers in Norm's department were very close friends should this affect his decision? Explain.

6) Suppose Norm decides that the economic benefits outweigh the danger to the people in his department. Should he still report his information to the Ecology watch group? Why?/Why not?

7) Suppose the animal species in question is considered a "pest" or a "nuisance" such as a poisonous snake or a scorpion. Should this affect his decision? Explain.

8) Should the animal be saved at the expense of further economic hardships facing the people in Petersburg? Why/Why not?

9) Do we have the right, because we have the power, to decide the fate of another creature? Explain.

Multiple choice questions

Each question has only a limited number of possible answers. This makes it practical to have a debate between supporters of Answer A and those of Answer B or C. Or small groups can discuss a question until a majority agrees on one of the options. More simply and quickly, students can vote for each option by a show of hands after thinking about the questions overnight at home.

Note carefully that just because a majority check Option B, this does not make Option B correct. There is no right answer!

1. Who should decide whether cloud seeding should be carried out in order to end a prolonged drought? (See item: Precipitation: Cloud Seeding, p. 104)
   - A Only the farmers whose crops are dying.
   - B The farmers plus elected public officials.
   - C Everybody in the affected area, including resort operators, vacationers, public safety officials, retailers, etc.

2. A factory whose smokestacks emit highly polluting acid-rain-producing smoke proposes to locate in an economically impoverished area. The jobs it creates will rescue the local economy. To scrub the smokestack gases is impractical; it would be so expensive that the factory would be bankrupted. Should the factory be permitted if the only practical site
   - A is in your economically depressed home town?
   - B is up-wind from your prosperous home town?
   - C is in a big city? (See item: Acid Rain, p. 9;)

3. When do you think a fetus' legal rights as an American citizen (ethical rights as a human being) should begin?
   - A At the moment of conception?
   - B At 3 months pregnancy?
   - C At 6 months pregnancy?
   - D At birth, and not before? (See item: Fetal Medical Examination. p. 56)

4. It was a life-and-death matter when the prevalence of dioxin-contaminated soil forced the evacuation of

the residents of Times Beach, Missouri, from their homes in 1982. Who should have to pay the costs of evacuation, medical attention and clean-up? (See item: Hazardous Chemicals: Dioxin, p. 80)

A The U.S. government, which means all taxpayers, including you.
B The State of Missouri.
C All the residents of Times Beach.
D Only those residents of Times Beach who chose to move.

5. Atlantic City, unlike Times Beach, is larger, wealthier, and can anticipate the consequences of Price's Pit. Who should pay the enormous bill for protecting Atlantic City's water supply before pollution reaches it? (See item: Underground Toxic Wastes, p. 88)

A The U.S. government, which means all taxpayers, including you.
B The State of New Jersey.
C The residents and visitors to Atlantic City only.

6. If a major oil field were found under one of our national parks, should it be drilled for? Consider the precedent this sets for other minerals and other parks. (See item: National Parks, p. 31)

A No way. Period.
B Only in a national emergency.
C Yes, but.. (but what?)
D Of course. No problem.

Alternatives grid

Small discussion groups of three or four students address one of the questions identified below. The full text of each question consists of an item in the preceding book, identified by title. Each discussion group should be provided with a printed "alternatives grid" such as the following:

Consequences	Alternative #1	Alternative #2	Alternative #3
1			
2			
3			
4			

Each group is to invent as many answers or courses of action (alternatives) as they can think of and list under each alternative the foreseeable consequences. From the resulting grid they should then try to identify their "best alternative" before comparing it with the answers of other groups. A few examples of items that lend themselves to this procedure are:

Acid rain (p. 91) What should be done to alleviate the problem in the U.S.A. and Canada? Identify the consequences of each option.

Underground toxic wastes (p. 88) What should be done about them and by who? Consequences and objections to each option.

Radioactive waste disposal (p. 89) How should we exercise our responsibility to future generations?

Medfly (p. 40) To whom should the decision makers respond?

Off-road vehicles. Should they be allowed or not: (a) in wilderness areas? (b) in public parks?

Extra-terrestrial intelligence (p. 161) Should we remain silent? If not, what should we say?

Destruction of species (p. 44). Alternative #1: What happens if nothing is done to restrict it? Alternatives #2 and #3: What realistic means are

available to restrict it, and in each case what might happen?

Television (p. 137. Alternative #1: You let your children watch all the TV they want to. Alternative #2: You restrict them somewhat. (By what standard?). Alternative #3: You forbid them to watch it at all.

SCORECARD FROM PROPHECY QUIZ ON PAGE 226

Here are Arthur C. Clarke's answers. Count the number of your own answers that match his and compare it with that of your classmates.

1 (b)
2 (b)
3 (a)
4 (a)
5 (c)
6 (b)
7 (b)
8 (a) If you answered c or d, not only are you at odds with Clarke, but you're completely wrong; Jupiter and Saturn do not have solid surfaces!
9. (g)
10 (a)

11 (a, b)
12 (a)
13 (b, c)
14 (e)
15 (b)
16 (h)
17 (a)
18 (c)
19 (a)
20 (b)

Continuum questions

These questions can be handled in several different ways. The first procedure requires the least expense of time. The last procedure requires the most.

1. Post a long line (continuum) on the bulletin board. Write the options on it, identifying various responses to a question which is printed at the top. Over the course of a week have students write their names or initials along the line, identifying where they stand on the question. They might then be encouraged to defend their position in discussion with students elsewhere along the line and to change their positions if they choose to do so.

2. Several continuum questions can be printed and passed out to each class member. Students commit themselves to a position on each continuum before comparing their answers with others.

3. Three to five students debate among themselves, seeking a group consensus on a continuum question. Their position is then compared with the positions of other groups on the same question.

Items that lend themselves to this procedure include:

Metric system, p. 191. Range from "dead set against it" to "urgent to introduce it now".

World population explosion, p. 41. Range from "no restrictions on growth" to "quotas per family enforced by severe laws" as presently done in China.

Television: The Third Parent, p. 137. Range from "no restrictions on watching" to "no watching at all".

Risks and Benefits of Science and Technology, p. 185.

You are a congressman responsible for framing legislation on automobile safety. The best available evidence shows that a new safety device will save about 100 lives a year in collisions. Would you vote for its installation in all cars to be made mandatory if it:

adds nothing to the price of a car	adds 50% to price of car	is so complex it doubles the price of a car

Earthquakes, p. ( ). If you are the public safety official of a town that has just been informed by an expert that there is a 100% chance of a devastating earthquake (or storm) in the next 24 hours you would presumably order the evacuation of the town. But what if the probability is less?

100% Surely evacuate	80	60	40	20 Won't evacuate	0

At what % do you evacuate?

Reaction questions

The questions and short comments at the bottom of the pages of this book are intended to be used in either of two ways. (1) They can be tossed out verbally in the course of a class discussion or lecture or (2) they can be written and posted on the bulletin board in large letters in a prominent place. In either case no comment is immediately invited from the class. It is reasonable to hope that students will have had time and provocation to think about the question when the teacher invites a reaction at a later time in one way or another.

The virtue of these short questions is that they require no class time to pose. Of course entire "items" from the preceding collection, edited or entire, can also be used in this way, but they take more time.

Prophecy quiz

What will life be like for you and your children in the next century? Can you make reasonable predictions based on what you already know?

While of course no one knows the right answers, you might like to compare your predictions with those given by Arthur C. Clarke, one of the most distinguished visionaries of our time. His views, expressed in more than two dozen widely read books, are one of the most perceptive analyses of the future since H.G. Wells. (Condensed and with permission of Omni Magazine, July 1985, p. 40). Clarke's answers are printed at the end.

1. Will we establish extraterrestrial contact in the twenty-first century? (a) yes, (b) no.

2. Which of the following events will occur first in space? (a) a birth, (b) a marriage, (c) a murder, (d) a suicide.

3. If sex selection becomes reliable, which of these three alternatives will twenty-first century parents choose? (a) a majority of boys, (b) a majority of girls, (c) a 50/50 ratio.

4. In the coming years which one chore will people come to rely on mostly for their home robot to accomplish ?
   (a) housecleaning
   (b) cooking
   (c) laundering
   (d) serving as a burglar alarm
   (e) acting as a pet or companion

5. What percentage of the American labor force will work at home via computer modem in 2000? (a) 1 percent, (b) 5 percent, (c) 10 percent, (d) 25 percent, (e) 50 percent, (f) 75 percent.

6. Will there be World War III ? (a) yes, (b) no.

7. If World War III comes to pass, will we survive it? (a) yes, (b) no.

8. Which of the following planets will man have walked on by the year 2050? Check as many as seem realistic. (a) Mars, (b) Venus, (c) Jupiter, (d) Saturn, (e) none.

9. Which of these diseases will be eradicated before the year 2000? (More than one answer is acceptable). (a) lung cancer, (b) herpes, (c) leprosy, (d) AIDS, (e) Alzheimer's disease, (f) the common cold, (g) none of the above.

10. Name the most common global energy source in the next century. (a) oil, (b) coal, (c) fusion, (d) geothermal power, (e) fission.

11. Which of the following events will have occurred by 2010? (More than one answer is acceptable).
(a) A computer will defeat a grandmaster at chess.
(b) A major earthquake will ravage California.
(c) Terraforming will have begun on Mars.
(d) Genetically engineered foodstuffs will virtually eliminate hunger in Africa and the Third World.

12. What will be the primary use of orbiting satellites in the coming century?
(a) telecommunications
(b) solar-energy receivers/transmitters
(c) space weapons
(d) cargo holds and fueling stations for shuttles

13. Robots and computers will make which of the following jobs obsolete in the year 2010? (Check more than one if desired) . (a) bank clerks, (b) newspaper deliverers, (c) telephone operators, (d) short-order cooks.

14. What will be the average life expectancy at birth of an American born in the year 2000? It is 75 now (1990). (a) 66 to 69, (b) 70 to 73, (c) 74 to 77, (d) 78 to 81 (e) 82 or over.

15. By 2000, how many nations will possess workable nuclear weapons? (a) 8 to 10, (b) 11 to 13, (c) 14 to 18, (d) 19 to 24, (e) more than 25.

16. Which of these animals will be extinct by 2000? (More than one answer is acceptable). (a) grizzly bear, (b) sperm whale, (c) bald eagle, (d) giant panda, (e) whooping crane, (f) Indus dolphin, (g) snow leopard, (h) none of the above.

17. How will most cars be powered in the year 2010? (a) gasoline, (b) gasahol, (c) electricity, (d) steam.

18. There are approximately 5.0 billion people alive today. (1988) How many will there be in the year 2000? (a) 5.2 billion, (b) 5.6 billion, (c) 6.0 billion, (d) 8 billion, (e) 10 billion.

19. What would a twenty-first century man say is the single greatest invention or discovery of the twentieth century? (a) computers, (b) theory of relativity, (c) polio vaccine, (d) splitting the atom, (e) television, (f) satellites.

20. What is the most difficult, perhaps impossible, challenge facing man in the twenty-first century?
(a) alleviating world hunger
(b) reducing or eliminating nuclear weapons
(c) finding alternative energy sources to replenish depleted reserves
(d) colonizing outer space.

ARTHUR C. CLARKE'S ANSWERS ARE TO BE FOUND ON PAGE 223

Student Projects

With student projects we are going well beyond short and simple thought questions, but occasionally a project may useful after one of our items (or some other issue) has stimulated some background reading and discussion. A few examples and suggestive questions follow.

1. A LETTER to an editor or congressman. A major goal of such a letter should be to teach students to develop and to write a clearly stated argument that is based on carefully researched supporting evidence.

2. RADIOACTIVE WASTE DISPOSAL. Identify the best area in your state for the underground disposal of low-level radioactive wastes. Arguments for the choice Arguments against it. See item, p. 89.

3. Examine the various components of ROADSIDE LITTER. How much of it is biodegradable? What is the most realistic and practical remedy? Can the merchants who are the source of cans, bottles, and fast-food plastic containers be encouraged to help? See item: Waste Disposal, p. 85.

4. Does DOWSING really work? See item, p. 206. Write to the American Society of Dowsers, Inc., Danville, Vt. 05828 for further information. Devise and carry out an experiment to test it.

5. LOUD SOUNDS. Some students may believe that they can study better and learn more if a radio or television set is playing loudly nearby. Others will insist that silence is better for learning. Plan and carry out an experiment to test these two ideas. See item, p. 126.

6. PLANT TREES either on the school grounds or in the community. See items: Trees vs. Desert p. 33 and Photosynthesis: Greenhouse Effect, p. 27 for useful addresses.

7. Find out whether the use of LAWN CARE CHEMICALS is affecting your local community environment, including ground water, birds, insects, and weeds. Poll garden supply centers and home owners. See item: Hazards of Lawn Care, p. 35.

8. Sixty-six students at William Alexander Junior High School in the Park Slope section of Brooklyn, New York spent TWO PERIODS A WEEK HELPING OUT IN STORES along Brooklyn's Fifth Avenue. They sought practical applications of science in beauty salons, plumbing stores, ice-cream parlors, hardware stores, pharmacies, appliance repair shops and other businesses. The project was the idea of a sixth grade teacher, Barry Weinbrom. With the help of the store keepers, the students try to identify the scientific techniques and principles that apply to each business. They keep a record of their observations and present a written report on their findings. (N. Y. Times, Jan. 12, 1987).

9. ACID RAIN. Use a pH kit or the chemistry lab to measure the acidity of rainwater at various times and groundwater in various places. Compare the results with whatever official figures are available. Can you identify the source of the acidity? See item, p. 91.

10. Identify ENDANGERED AND THREATENED SPECIES of plants and animals in your state or local area. (There are 500 endangered species in the U.S.). Find what the threats are to its survival and what is being done about it. Can you help? See item: Destruction of Species, p. 44.

11. TECHNOLOGY YESTERDAY. INTERVIEW your grandparents or other elderly persons, possibly in a nursing home, to explore the following questions:

a) How was their house heated when they were young? How is it heated now?
b) How were their available foods different from today, especially in winter?
c) How were foods preserved? Freezing, canning, pickling, cold storage, drying?
d) What did they do for entertainment? Travel Communication?
e) What consumer products which are common today did they lack?
f) How did they get to school? Church? Errands? Long trips?
g) What important diseases did they have or particularly fear?

h) What did they consider to be a comfortable annual income? A comfortable family size?

It has been said that no one in his senses would choose to have been born in a previous age unless he could be certain that he would have been born into a prosperous family, that he would have enjoyed extremely good health, and that he could have accepted stoically the death of the majority of his children.

12. TECHNOLOGY TOMORROW. Discuss, comment on, or try to predict the possible future effects of the following uses of technology.

a) recombinant DNA
b) space stations
c) ocean mining
d) prolonging human life
e) limiting the population explosion
f) controlled nuclear fusion

13. In their POLITICAL VIEWS are pure scientists typically left of center and engineers to the right? See item: Political Views of Scientists and Engineers, p. 176.

14. POPULAR IDEAS ABOUT SCIENCE. Try out Miller's poll on your school mates. See item, p. 201.

15. Build a microphone-audio amplifier FEEDBACK demonstration in the physics lab, and use it to illustrate other examples of feedback. See item, p. 169.

16. How many of your state legislators or school board members have an academic or practical background knowledge of science? See item: SCIENCE AND CONGRESSMEN, p. 174.

17. Identify the faintest stars visible in your community. Compare city and country night sky. See item: Scattering of Light: LIGHT POLLUTION, p. 134.

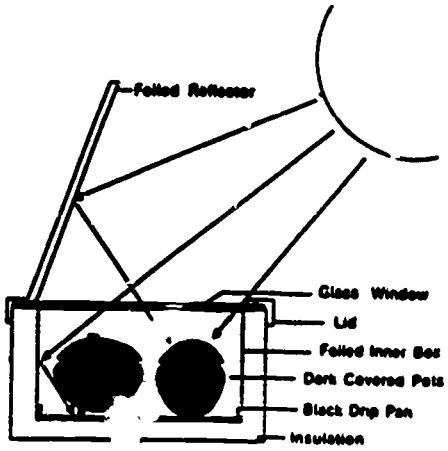
18. COOKING WITH SUNLIGHT. (See item, p. 144. Build a solar cooker, and use it to prepare a hot meal. Simple plans are on an adjoining page. For fuller details write to Solar Box Cooker International, 1724 Eleventh St., Sacramento, Calif. 95814.

19. WORLD POPULATION EXPLOSION. p. 41. Have small groups form opinions on the effects (social, economic, environmental, et al.) of population growth if the size of their school population doubled while the building and classroom sizes remained the same.

Hints for Making a Solar Box Cooker:

I. OVERVIEW: These instructions will make a solar box which cooks 10-15 lbs. of food on sunny days. Larger, deeper cookers will cook more food and hold larger pots. A solar box cooker is

A. a large inner box covered with aluminum foil on both sides
B. a larger outer box foiled one side only
C. insulation between boxes
D. toppers to seal space between boxes.
E. A tight-fitting lid with a glass window to let in sunlight and hold heat inside. As part of the lid a shiny flap, a reflector is propped up to bounce more sunlight into the box. When not in use it closes to cover and protect the glass.
F. a prop to hold up reflector.
G. Inside the box, heat from sunlight is absorbed by a black metal tray at the bottom and by
H. dark covered pots which heat and cook the food.



II. MATERIALS NEEDED: Those used for the inner box and insulation must withstand high temperatures, be non-toxic, and not conduct heat readily (as metal does).

- **Corrugated cardboard:** 2 large boxes, 19" x 23" x 8 1/2" and 24" x 28" x 10", (or cardboard to make them) and several extra pieces. (see p.2) If you don't have enough big card board pieces you can overlap and glue together smaller pieces.
- **Glass pane** at least (20" x 24") and slightly larger than inner box.
- **Glue** - a pint of water-based whiteglue or carpenter's glue.
- **Aluminum foil** - about 75 feet x 12" wide
- **Insulation** - crumpled newspaper or clean, dry straw, rice hulls, etc. Must withstand high temperatures.
- **Large tray** thin metal (or foil covered piece of cardboard) for inside bottom. Paint top side with black tempura or high-temperature black paint.
- **Dark cooking pots with dark lids.**
- **Stick or wire** to prop reflector; also string or cord.
- **Silicone caulk or papier mache** (shredded paper soaked in water, mixed with glue).

- **Tools needed:** scissors or knife; bowl or flat pan to mix glue, brush or roller to spread glue.

20. If you think that SONGBIRDS are declining in your community you can help to find out by joining in the Audubon Society's Christmas bird count which takes place annually in most states. For information write to Massachusetts Audubon Society, Lincoln, Mass. 01773. Or set up your own long-term census and try to relate changes year by year to habitat destruction and the local spread or decline in pesticides use and/or pollution. See item: MIGRATION OF SONGBIRDS AND BUTTERFLIES: THREATS. P. 48 .

21. (To teachers: The following STUDENT ESSAYS at the beginning of a course provides a particularly revealing insight into students' concerns that they would otherwise rarely state and facilitates the choice of additional societal and ethical items in this collection.) Describe your picture of the world 10 (or 25) years from now and its major differences from the world today. Consider such big issues as your hopes for the natural environment, America as a place to live, the use of outer space, peace vs. war, jobs, your probable recreations.

22 Identify as many women scientists as you can, and try to find ways in which the science you are studying relates to their work. Can you arrange to interview any women scientists of technicians working in nearby laboratories or technical projects? Does the interview lend itself to a theme in an English or social studies course? See item: WOMEN AS SCIENTISTS AND INVENTORS, p. 175 for a few famous examples.

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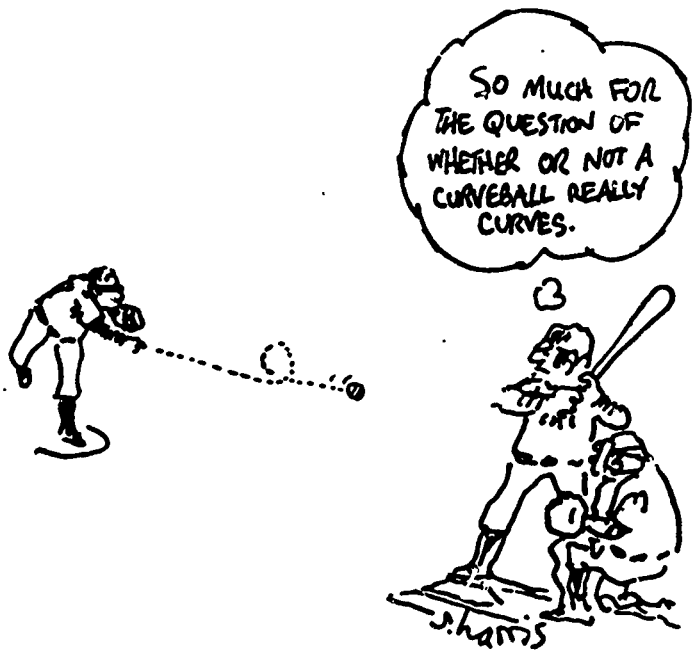

Appendix 16

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