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The meager period of time we call "ours" in the vast continuum from creation to dissolution has but one constant and that constant is change; our time is one of unprecedented change. Man has been developing his ability to alter the face of the earth for centuries and now has arrived at a place in time when he can change the physical features of the earth by pushing parts of it around, he can change the physical features by adding and subtracting materials, as to the soil, air, and water, he can modify the genetic characteristics of the living things, he can repair living things, he can replace parts of living things, he can determine the behavior of living things including man, he can decide what things will survive and what will not, and he can escape from the planet.

The sources of these capabilities are knowledge of structures, knowledge of relationships between structures, knowledge of the interactions of matter and energy, knowledge of energy control, and knowledge of energy transduction. These kinds of knowledges you recogniże as coming from the study of natural objects and phenomena and from putting objects and energy together in a variety of ways. You classify these knowledges as science and technology. You classify the processes by which knowledge is added to the structure as research. Although most of these modifications affect people, there is no need for knowledge of the society in order to bring a change about.

The interaction of people with these scientific and technological developments and attitudes has, however, resulted in a unique society. A brief look at these two elements may make the result more understandable.

The citizens of the U.S. have attitudes and opinions that are something less than consistent because:

1. Our experiences with government have been that the individual is of paramount importance. The agencies of government are developed to serve man and man has not been a servant of the government. Governmental control is frowned upon.

2. The people have generally accepted the idea that "I am my brother's keeper." In times of difficulty the fortunate will assist the unfortunate.

3. The human life is highly prized regardless of its stage of maturity.

4. There is a desire to live more comfortably and to remove the human from the responsibility as a beast of burden.

5. Science and technology, until the time of the atom bomb, were considered to be good. This was reasonable because that was the nature of the message that reached the people.

With the atom bomb, people discovered that science could be applied in a bad way.

6. Within the last thirty years, the rate of growth of science and technology has been more rapid than the learning of this by the people.

7. Mass communication has become so extensive that secrets are difficult to keep. You now see the wars as they happen live or dead on your TV screen and in living color.

8. The teaching of science in the schools K-16 during recent years has had one main purpose—to make big scientists and little scientists. The interrelationships between science and society have never been explored by the students.

9. Scientists themselves have until recently ignored the people who make their studies possible; they have not bothered to interpret their developments or procedures to their benefactors. This has resulted in the public attitude that science is too difficult for the layman to understand. It has also contributed to the layman's feeling that sometimes what scientists do is valueless.

10. The knowledge of the successes of science and technology has given the consuming public a confidence that science can do anything. The trip to the moon and back increases this confidence. All the public needs is dissemination of such feats.

11. There is no understanding of pure science on the part of most of the public. This is true despite the fact that science courses they take in school are now most closely allied to pure science. The prevailing opinion seems to be based on the idea that everything must have immediate use. I'm sure you recognize the myopic character of this opinion.

Let us now look at science very briefly.

1. Science is sometimes characterized as a search for truth even by scientists. In interpreting this type of label we must remember that the term truth in science, if it should be there at all, is a relative term. It does not have the same meaning to the scientist as it does to the moralist. Science is probably more accurately characterized as the desire to make natural objects and phenomena comprehendable to man. The developments of the scientists are more precisely classified as approximations. You may now ask approximations of what. The best answer I have is an approximation of what can be understood by all.

2. Science is man-made and is based upon some assumptions and follows rules established by the practitioners. Some assumptions are: matter is real, space is real, nature is not capricious, and nature is understandable by man. A change in the basic assumptions would bring about a science with different characteristics.

3. Scientists do three things. a. They classify or describe, b. they correlate facts, and c. they develop theories. You must recognize that in doing these three types of things, the scientist is working with facts; you may call these data. In the processes of science the scientist collects facts, forms, ideas, and makes predictions of the facts to test his ideas. According to Einstein, "Science begins with facts and ends with facts no matter what

other structures he builds in between."

4. Scientists do not treat the data they gather as if these data were without error. In fact they recognize that an element of error exists in all data. For that reason they often idealize the data. Newton could not have come up with F = ma had he not idealized the data. You see he could not get away from gravity and friction.

5. Science, until recently, was viewed as not having a moral dimension. Knowledge developed was neither good nor bad. What made it good or bad was the way society used the knowledge. Recently this concept of the moral immunity of the scientist has been challenged.

We could continue with more of the factors that serve as bases for the message I hope you get, but this is adequate. Let us now look at some of the social consequences of living in a scientifically illiterate society. As you consider what is said here, use a careful frame of reference; that is, "The confidence in and mystery of science held by the present population is a consequence of a myth passed on from generation to generation, that this myth began when the developments were few in number and slow in coming, and when the population of the U.S. was probably about 100 million." As you now know, most people do not know much of science other than what they get from technology. What problems do we have now?

Overpopulation–This has had its origin in science and technology. There is still the feeling by a large segment of our population that we are still 100 million and the population can grow. The opinion is that you may have as many children as you can financially afford. Unfortunately, the rate of population growth is outdistancing food production and the supplies of potable water. In this decade we must ask: what population can the world support, and this not in terms of dollars. Diseases have been studied and cures for many were found. A baby at birth now has an excellent chance of growing up. The average length of life is now about 71 for men and 75 for women. Fortunately at the time the health practitioners were working in the U.S., the food producers were also active. The sewage disposal experts have also been active but not active enough. Every person in the U.S. now accumulates between 4 and 5 pounds of solid waste per day, and it is still disposed of in a primitive manner. It is being buried and the areas available for burial are rapidly disappearing.

With large populations comes demands for more consumer goods–paper, cloth, automobiles, houses, etc. Manufacturing plants, operating under the beliefs and procedures held at a time when we had 100 million people, pollute the air and the water. These, however, are probably not the greatest polluters. The greatest polluters–especially of the air–are the people themselves. Those self-propelled vehicles called automobiles really are a problem. This industry has only recently realized that we have more than 100 million people spewing waste into the air. They really should have been more conscious before because their sales have increased. The people should also have known that the population would get out of hand but

they did nothing; in fact they do very little right now.

We have a tendency to think that someone else will come along and solve the problems. That someone is the scientist or engineer. The people must recognize that there are limitations even if the money is unlimited. We do not attack problems that are related to each other together. We are reasonably fortunate in the U.S. where we have a shrewd sense of values; so let us use a moment to reflect upon the way to upset an ecological system through poor management. The outcomes of this were certainly known—were they ignored, or was this a part of our humanitarian heritage emerging?

We will take a quick brush with India but it would be the same in many other countries. I'll not bother you with statistics since these can always be confusing. In India prior to World War II, infant mortality was high: about one of six grew to the age of five. Mothers, and in fact all, had the prospect of dying young. The average length of life of a woman was only slightly above 30 years. This deplorable condition was recognized and work was initiated by the medical profession. Infant mortality dropped drastically and the life expectancy has increased to about 45 or 50 by now. Note what the results were: 1. More of the children grew up. 2. Women lived longer so they lived through the full period rather than half of the period during which they could reproduce. The only outcome possible was a growth in population. The irony of this was that the smaller population was underfed. What else was initated at the same time?—nothing. It was not until this population that was helped to live a longer time was living longer only to starve to death that the error was recognized.

If this problem had been attacked scientifically, the approach would have been different. A simple generalization became apparent to wildlife ecologists a long time ago. If one factor in an environment is modified this will influence all other factors. This failure to relate basic scientific knowledge to the world usually creates more problems than it solves.

What should have been the pattern of attack? This is not difficult and all of you know the answer. As you improve the health conditions, you must expand the food and water available. If the living things reproduce too rapidly for the food and water, the rate of reproduction must be controlled. The question of who controls is the problem. You may be surprised, but in many animal communities there seems to be a kind of automatic population control. When the density of the population in relation to food supplies passes a limit, the rate of reproduction decreases. This is not understood but exists among some forms of rodents.

It is apparent by now that we live in a science-dominated society. Permit me to use a technological device to illustrate a point. If our society is made analogous to an airplane, then science must assume the position of fuel for the craft. Science and technology are the fuel that keeps our society operating. Without the products of pure and applied science, our society would crash. The deposits we presently have in the form of pure sci-

ence upon which to draw are meager indeed. It is science and technology that provides our food, shelter, and clothing. This society is not able to return to the land and eke out an existence as is found occurring in many African villages. We do not know how and if our population is too large. How many people know how to bake bread let alone weave cloth? The population is so large that if the productivity of the land were allowed to decrease there would be famine. The grain breeders in colleges of agriculture must constantly develop new strains because diseases that consume the grain are always attacking. Our plant breeders are presently only a few years ahead of the diseases.

What would happen if the methods of making water potable were not available. The pollution caused by a half million people in a city would soon be a part of the awareness.

Now for some variety let us examine some serious social problems that could arise if science and technology interact with society in a peculiar way. Let us recognize that since man has been aware that his health is not in the hands of destiny, there has been the desire to have a population that is free of physical and mental defects so that each member can function productively. There are several ways this can be accomplished. Please do not think of the scientific capabilities to be the limiting factor. The capabilities are practically here.

Let us take the example of gene modification and selection first. Suppose you were married and you wanted to have a child in your house. One method of population quality control could be that the genetic makeup of both parents could be carefully examined. If there were defects the difficulty could be corrected after the fertilization of the egg. A child of high quality would then be born. A question arising here is who makes this decision and on what basis.

How about a next step? Would you like to be able to pick out the specifications for your children? Red hair; blue eyes; grow tall; bright; average; or dull; well coordinated; boy or girl. Would you need a chart of factors for your selection? Soon we would have different fads in children as we have with children's names today. There is another way to control the characteristics of the child, and this is not beyond realization since it has already been successfully carried out in other mammals. How would you like to be able to go to an embryo bank to select what you want. You could review the characteristics of each embryo prior to making a selection. I guess you could call this place you go a "baby factory." You would then have to select combinations of factors and make some concessions, but the baby quality would be specified by a group of experts as able to take its place in the society. The low-quality embryos would be eliminated. When your decision is made, the embryo is transplanted in the female, and it becomes your child. You must admit that this could be an effective population quality control measure. It would be especially effective if the embryos had been formed under laboratory conditions—life in a test tube or should we say synthetic life or homo-synthetica?

Now a more simple problem that

still involves children. Suppose you want a child; so you go to the local medical officer of your town to get his approval. He examines the genetic makeup of the potential father and potential mother and finds them okay, so that is simple. What if he finds one not genetically proper? The decision: no children. Now what would be your reaction. What if after one or two children in a family, other measures were taken to limit the population? Even the thought of such regulation is probably repulsive to some. Others of you, who are still living with the beliefs that the U.S. must guarantee you the right to do your "thing" regardless of how all others are influenced, are probably getting violent. Of course, there are many variations between the baby factory and the present method of populating the earth.

You may speculate that this cannot happen. You are right if we have a population that will not allow it to happen. If, however, you have a group of the socially and scientifically uninformed making all of the decisions for the masses, I'm not so sure. Notice that I did not say either science or society, I included both. You may say that these are social, ethical, or moral issues and are not the business of science anyway. If you do, you have failed to recognize that science reacts to a pressure from society to make some things possible. It reacts to society only if it can understand the wants. If science cannot communicate with the society, it may make some wrong interpretations. You know that the study of genetics has its purely scientific aspects, but it also has many aspects that are a response to the society. It has been asked to investigate such questions as the following: "Why some children are born with certain defects? How can the defects be prevented? Do you see the easy step to gene modification and even its desirability? Certainly you have heard of many genetic defects, especially with reference to monogolism, heart defects, blindness, etc.

I have mentioned some extreme cases, in your judgment. They are really not extreme. Doctors and their patients and scientists have these decisions daily. Suppose there are the following conditions: A family. Eldest child—mongoloid. Next two children —normal. Woman pregnant. Although this may be too many children, there are other problems.

Should a genetic study of the unborn child be completed? (This can be done simply with no real danger.) I'm sure you know there is more than one type of genetic defect that produces a mongoloid. One is rare and the other is not so rare. Now what would you recommend if the study revealed a mongoloid embryo? How would society or the mother and father view an abortion? When the knowledge was not available, chances were risked. With knowledge available, how will it be used?

Decisions, decisions, decisions—brain transplants—use of heart machines—kidney machines; the old, the care of the young, etc.

How about young DNA and old DNA? There is a difference. Should we all have a bank of young DNA so we can have it injected when we get old? In making requests to science, the

public should be able to ask and answer certain questions for itself. All of the questions involve both science and society. Yes, you can turn them all over to a group that is the scientifically elite for answering. You may then get a baby factory type of answer. What if the babies then live to be 125 years of age?

Science and technology are influenced by society. Industrial technology is vitally sensitive to the wishes of society. At present there is a somewhat slow but subtle transformation occurring in industrial technology. Until about 1950, industry was making studies of the desires of the consuming public and was attempting to satisfy these desires. What the public wanted the public was going to get. Contrast this with the last five to ten years. Industry now develops the bright ideas and proceeds to sell them to the public. How many housewives wanted a detergent with enzyme action? The approach now is to educate the public to want the product prepared.

This condition similarly exists in the society-science relationship. Scientists live in the society and are sensitive to its problems. They often tell us what we do not know and do not wish to hear. We must be well enough informed to make judgments relative to these things. The people, of course, often go to the scientist. Remember that the scientist is not an expert in the problems of society. Unfortunately most sociologists are as ill informed in science as the scientist is in sociology. This situation must be eliminated, so that scientists and sociologists are able to communicate with each other and with society.

The population of a republic must be in a position to know how to ask questions, know where to get information when decisions are necessary, must know how knowledge is generated, and must know how the society of which they are a part moves. It must be recognized that parts of every population exist as if they were living in different generations in terms of time and that each has different goals and different moral and ethical standards. Do you now see why we started this discussion as we did?

Today we are confronted with serious social problems that exist in a large part because of science and technology or that depend upon science and technology for solution.

a. We are confused as to our national goals. Do we want national security, world-wide political prestige, health and welfare at home, health and welfare world wide, economic growth, minimum subsistence for all, technological superiority, scientific superiority, population superiority, back to the land and caves, etc.?

b. When the goals are decided, there must be a plan for the place of man in the system. Will he assume a mechanistic position? Will there be intellectually elite and intellectually subservient groups? Who will make decisions?

Presently we are concerned with some of the social problems and the related science problems. Some concerns are: 1. "Whether the scientist is the best and last judge relative to the kinds of research that should receive maximum attention." 2. Should technology be controlled or allowed to continue relatively free? 3. Should

scientists be held responsible for the way their research is used? Where should the emphasis in pure research be placed? What is the place of educational institutions? What are the places of the central government, state governments, and local governments? What kinds of talents are needed to realize these goals?

Whatever decisions are made relative to goals, it is too late to form any society that is not science interacting with society centered in its source and solution of problems. There must be ways of keeping the supply of scientists coming and to keep the other people knowledgeable with reference to how science operates, some basic scientific concepts, how it relates with society, and its limitations. This will always mean a more efficient use of science manpower and facilities. This will always mean pursuits in both pure and applied science. Additional attention to the interrelationships of science and society will enable the goal setters to be more sensible in their decisions and priorities.

If this is not done, we will find ourselves suffocated by our own waste or poisoned by the organisms cultured in our wastes. We must quickly look at waste products as a natural resource to be exploited. We must increase our knowledge of the relationship of living organisms with social, psychological, organic, and inorganic factors of the environment. Our goal should not be "To conquer the natural world." Our goal should be "To live in harmony with the natural world." This can come only as a result of the development of knowledge. It is the irreversible changes that are the problem. Through science and technology, these irreversible changes can be predicted and avoided. If we do not preserve and protect the brain power of each generation as it emerges from egg to revolutionary to adult, there will be no opportunity to choose the kind of world they want to live in. We do not want to go down in history as the elegant technological society that was lost because of biological disintegration caused by lack of ecological understanding. To act requires confidence. To research requires doubt. Society requires that both activities be carried on by knowledgeable people. These must be literate in science as well as sociology. In researching and acting you must know that you are always standing on the shoulders of another even though that someone may be immersed to various depths in waste —real material and outdated knowledge make up the wastes. You should know that Johannes Kepler predicted much of the activity of man to the moon in 1609 in his book "The Geography of the Moon." It is also said that his mother was imprisoned because of her son's activities. She died after more than twenty years in jail. We can see far because there were some giants with broad and strong shoulders on which to stand. There were also those who in their own time and since were weaklings and standing on quicksand. These provide very little help. The problem you all have is How do we detect the "phony characters"? You must develop a good "phony detector" if you are to be a responsible citizen of the world.