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Theonetics

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Man Ventures into the Unknown



Fall Symposiums 1965 Sponsored by

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PREFACE

Man used to live in a world that did not change very fast. This is no longer true. Discoveries are now being made in the fields of medicine, science, electronics and sociology that are stirring the imagination of man to think on a new plane. They fire his imagination towards even more discoveries. They continually remind him that "new occasions teach new duties, time makes ancient good uncouth". The explosion of technology has given man a whole new set of tools which he never had before. Not only new materials, new methods and new machines but also new levels of education, new standards of living and new ways of thinking. This stampede of progress has made much of man's past experience obsolete.

What is happening inside the scientific community that ought to be better understood by the Christian community within the organized church? How can man remain human amidst the march of progress toward the planets? Should there not be creative dialogue between those who are <u>making</u> discoveries and those who are concerned with <u>using</u> discoveries?

To help the church better understand and meet the on-coming future the Christian Education Committees, the Church and Society Committees, and the Council of United Presbyterian Men, under the sponsorship of the Synod of California, Southern Area, held three symposiums presenting creative man in God's changing creation.

In the fall of 1965, 260 persons (mostly Presbyterian pastors but including pastors and laymen from other denominations) met for the five-day symposium at the Lafayette Hotel in Long Beach, California. The symposium was divided into two two-day sessions and a one-day session held a week apart. In Southern California in 1965 the three areas of greatest change seemed to be technology, urbanization and education. This determined the selection of the fourteen speakers who were best qualified to present data on these subjects. Each speaker is an acknowledged authority in his field. The speakers' objective was to:

1. <u>Motivate church leaders</u> to more knowledgeable involvement in what is <u>really</u> happening in the world.

2. <u>Share insights</u> concerning specialized subject matter.

3. Prepare church leaders to <u>work toward more creative solution</u> to problems in their vocation, and to do this more within the context of what the world is actually like <u>now</u>.

4. Stimulate a theological probing of the actions of God as they take place in accelerating technology, expanding urbanization and exploding education.

Following the conference, attendees were unanimous in their desire for printed copies of the proceedings. The rather huge task of editing thirty hours of tape recordings was then undertaken and the material transcribed for this publication. The reader's patience and understanding is requested in overlooking those places where direct tape transcription make the manuscript sound clumsy. In a number of places personal references, etc., have been removed.

A second theonetics symposium for ministers and laymen has been scheduled for October 31, November 1,7,14 and 15, 1966 covering Economics (Shaping a Worthy Economy), Communications (The Message in Mass Media), and The Systems Approach to Social Problems.

Introductory Remarks at the First Symposium on Theonetics,
Long Beach, California
October 25, 1965

THE SPIRIT'S INVOLVEMENT IN MATTER

by

Edward B. Lindaman

Alfred North Whitehead is credited with this famous quote, "The art of progress is to preserve order amid change....and to preserve change amid order."

So much is happening in our world today that all of us are hard pressed to keep abreast of even a small percentage of changes. The surface events of the last thirty years include the Great Depression, World War II, the Rise of Many New Nations, the Spread of Affluence and the Technological Revolution.

But beneath these obvious happenings there are more subtle changes and events. Today 25% of all human beings who ever lived are alive! We know four times as much as we did in 1935. During the next 15 years scientists will learn as much more as in all previous history. Last year 6,000 new products were introduced in the U.S. Just ten years ago that figure was 2,000 and in the early 1930's it was only a hundred.

We live in a time of unprecedented challenge. Of great promise and of deep menace. Religion cannot respond in a vacuum.

The background of the average minister is such that it is difficult for him to communicate with many of the things that are happening. And yet, as Harvey Cox puts it in his book "The Secular City", "When we know where and what God is doing, then we can ask about the appropriate shape and style of church life."

These next days of this Symposium are dedicated to learning more of what God is doing.

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In about 500 B.C. a little known Greek philosopher, named Heraclitus, lived. But he cast a long shadow before him. He contended (and at that point it was just philosophy) that one cannot step into the same river twice. He contended that no one thing is ever twice the same, and that reality is to be regarded as a process. One cannot step in the same river twice, he said, not only because the river flows and changes, but also because the one who steps into it changes too.

Heraclitus was 2,000 years ahead of his time. For this is the basic notion of science---though stated centuries before scientific thought. It is important to us because it, in a way, expresses an important view. It talks about the crucial character of reality. Man's possibilities of knowing reality---his total surrounding---also man's resources for adjusting to it.

No other fact so unrelentingly shapes and reshapes our lives, like the river of Heraclitus. And in recent years the river has been rising faster and faster. What we once thought was safe ground, has been abandoned to the flood. The dikes of civilization are watched with anxious eyes.

One simply CANNOT step into the same river twice. Physicists, chemists, geologists and all others who scrutinize physical phenomena; anthropologists, sociologists, psychologists and all others who study men, agree that what they find are processes, growth, movement, change, decay, energy, transformation, social changes, etc.,.....no event is ever exactly repeated.

We are living in a world that is different all the time!

Once we begin to look for differences instead of looking for similarities, creative things happen. It is impossible to remain intact. It is impossible not to get new ideas. The habit of asking, "How do these things differ?", or "How might this be different?", is one of the basic techniques of originality or creativeness.

The river of Heraclitus is on the rampage.*

The ultimate purpose of science is to predict and control processes... to, in effect, measure the rivers changes, certainly not to resist process, but rather to predict and thus control it. Why? In order that men may stay attuned to the great flux of nature by which they are surrounded and of which they themselves are a part.

*Preceeding is adapted from "People in Quandrys" by Wendall Johnsen

Paul says in Romans 8 (Phillips) "I have become absolutely convinced that neither death nor life, neither messenger of heaven, nor monarch of earth, neither what happens today nor what may happen tomorrow, neither a power from on high, nor a power from below, nor anything else in God's whole world has any power to separate us from the love of God in Jesus Christ our Lord."

What is meant is that by these "forces", about which we will learn much during this symposium do not have the power to determine man. Rather, man has the power and responsibility to rule over them in responsibility before God.

What happens now and what happens tomorrow in the laboratories of the world, is part of the world, to be dominated and utilized by man. But man's freedom is so complete that he keeps wanting to worship and serve the things and creatures instead of the Creator! He easily falls captive to forces over which he was intended to have "dominion". Things he was meant to control, are starting to control him!

It is God's action in Christ, (which goes on all the time in our lives) that has the capability of freeing men from the domination of what is happening and what will happen. The action of God in Christ is to summon man to responsibility over and for these forces, these principalities and powers.

Before meteorology, the gods handled the lightning. Before astronomy, mythical deities managed the planetary motions. Before psychology, the devil inflicted our psychoses. Now primitive beliefs are in retreat. Now Christianity must salute our expanding knowledge--- even if it spreads the possibility of organic life to the far ends of another solar system!

Scientific experiment permits us to now know God through a channel in addition to that of revelation and prayer...through a deepening understanding of the physical sciences. He will reveal himself in the laboratory even as he does in the sanctuary and the discoveries of scientists are as much discoveries of God as are the researches of theologians!

We have no need to look around for areas of life where we can still say "Here, at least, religion carries more power than science". This is, as Ernest Harrison says in, "Let God Go Free"...a sort of last ditch resistance and the God it sets up is known as "the God of the gaps". It declares that we see religion as that area of life about which science does, or can, make no firm pronouncements.

We are here today in this Theonetic Symposium to de-gap God!

The truth is, Harrison goes on, that science is a religious exercise in itself. It is of no importance whether or not the scientists recognizes this. So far as the church is concerned the scientist is seeking the truth--and seeking it, insofar as humanly possible, with a minimum of prejudice. He is therefore seeking God. Something else mighty significant: Scientists always expect that their theories will one day be superseded by more accurate ones.

The right and duty of the church is to be concerned with the whole of man's life, including all the forces that play upon him, and not alone his spirtual life.

In an era, such as now, the church could easily be tempted to retreat. It can retreat in two ways. The first is to resist the movements of history and try to live in the past...in a sort of medieval Christendom---in a biblical world where life was simple. Or the church could retreat into the inner life, which, if separated from the outer life, is stagnation.

We are now becoming conscious of our place---and our responsibility in relation to the universe. Men of today in all phases of management and labor act in the knowledge that the choices they make can and will have repercussions through countless centuries and upon countless human beings. To a man, those who will speak to us represent those whose actions will affect generation after generation of future human beings!

There are those who will argue about the spiritual value of matter. They will see nothing valid in our newly found terrestial consciousness. Let me quote Chardin here from "The Future of Man".....

> "Let us suppose, for example, that the strivings and the progress of civilization had come to an end at the time of Buddha, or in the first centuries of the Christian era. Can we believe that nothing essential, of vision and action and love, would have been lost to the spirit of earth? Clearly we cannot, and this simple observation alone suffices to guide our decision. So long as fruit continues to grow and ripen we refrain from picking it. In the same way, so long as the world around us continues, even in suffering and disorder, to yield a harvest of problems, ideas and new forces, it is a sign that we must continue to press forward in the conquest of matter."

The people of the world must prepare for an inundation of new knowledge, especially about the physical world around them. We must take measures to deal with it more intelligently. We have to continually separate the important from the unimportant...in new ways we have not yet thought of. We have to learn, yes, but we also have to learn how to unlearn and learn something new and something different which comes from our exploration of the universe of matter around us.

The thinking of civilized man has always been oriented to the past. He studies history to understand the present and to predict the future, but his thinking seldom reaches far enough out...even though the whole gospel is future oriented. Again Chardin say, "The whole future of the earth, as of religion, seems to me to depend on the awakening of our faith in the future." Henry George says about people who won't accept change and new things: "The first thing they say is that it isn't true. And when its truth can no longer be denied, they say it isn't important. And when its importance is firmly established, they say it isn't new."

Paul Tillich died last Friday. But his brilliance will live for generations in what he has written. My wife and I spent an entire weekend with him in March of this year, along with about a hundred other people, and my summarizing remarks are based upon an insight I received from him. To me it sets the stage for a creative thrust into Theonetics: Tillich says.....that which we have seen with our eyes (according to the Gospel) is the Word, the eternal Word in whom God speaks. But who can also be seen through the works of creation. And who is visible in the man Jesus. The Word can be seen.

Seeing is the most astonishing of our natural powers. It receives the light, the first of all that is created, and just as the light does, seeing conquers darkness and CHAOS. IT CREATES FOR US AN ORDERED WORLD, THINGS DISTINGUISHED FROM EACH OTHER AND FROM US. WHEREVER WE SEE (THAT IS, TRULY SEE IN THIS SYMPOSIUM!) A PIECE OF THE ORIGINAL CHAOS IS TRANSFORMED INTO CREATION. We distinguish, we recognize, we give a name, we know. We proceed to new understanding of creation!

Man ventured into the submicroscopic world of the filterable viruses, and saw! At the very same instant he reached out into space and saw the surface of Mars. Only the human eye is able to see in this way. To see a world in every small thing and to see a universe of all things. The human eye is infinite in reach and irresistible in power. It is says, Tillich, the correlate to the light of creation.

But truly seeing means more than just the creation of a physical world! And this is Theonetics! Listen carefully! Where we see

we unite with what we see. It becomes part of ourselves. It gives abundance to the poverty of our loneliness. (I think of the loneliness of pre-historic man and I thrill at what the discovery of fire must have meant to him. He is less lonely. He experiences something of God.) Seeing what unites means seeing into. A grasping and being grasped.

Not just seeing...but a seeing that is shaped by love! But what can I do with it? We never see only what we see. We always see something else with it, and through it. Seeing creates. Seeing unites. Seeing goes beyond itself. We always see beyond what we see. A computer technician sees a 7090 IBM computer. You see the same computer. What he sees in it and through it and with it far surpasses what you see.

If we look at a thoroughbred race horse we see directly the colors and forms of its skin. But with it and through it we are aware of the tension and power of its muscles. We are aware of its inner strivings to win. All of which is <u>covered</u> as well as <u>revealed by</u> the skin . (Tillich) If we look at a human face , we see lines and shades, but <u>with</u> it and <u>through</u> it, we see a unique, incomparable personality whose expressions are visible in his face. We see infinitely more than we see when we look into a human face. We see the mysterious powers which we call beauty and truth and goodness.

Here is the whole point....we cannot see beauty, truth, goodness, as such...we can see them ONLY in THINGS, PEOPLE and EVENTS. We see them WITH and THROUGH the shape of a rose, the beam of a laser in an eye operation, the wiggle of a microbe in a diagnostic lab under an electron microscope, the movements of the stars, the image of a friend, the deepness of the ocean, the sunless world. We CAN see them but it is not necessary that we see them. We CAN close our eyes. We CAN become blind <u>and some are blind to any truth which is not tradtitional</u>. And that is why we are here today.

Seeing gives us a world, the order and unity of much.

Only with and through can we truly see. Through <u>things</u> and <u>men</u> and <u>events</u> and <u>images.</u> This seeing and not seeing at the same time is what Tillich calls faith. NOBODY CAN SEE GOD. (Biblically speaking, everyone wanted to, however.) But oh how we CAN see Him WITH and THROUGH! !

So often we see things, discoveries -- satellites, oceanology, biochemistry, but are we blind? We do not see with and through them, so by default, they become idols and thereby hold us fast to themselves and DO NOT LEAD US BEYOND. When they should. And that's Theonetics!

We are asked to see with and through everything in God's creation, to the depth into which He shows the way.

And He did show the way.

The universe is to be interpreted not as a random conglomeration of elements, not as a strictly predetermined evolutionary process, not as a continuing dialectic of two eternally opposing principles. No!!

The model for the integration of the universe that which we, man, are made to see with and through...is to be found

not in a mystical formula
not in an impersonal rational principle
not in a machine
not even in some kind of servo-mechanism.

Rather, the Christian Gospel desperately tries to say, (and our words have become pebbles worn down by the waters of time)....that the universe and all that is within it, is to be interpreted in terms of personal values. The model for its "integration", (for having integrity) is to be found in a personal career!

The meaning (and I talk now mythologically and do so with my eyes wide open to it)....the meaning of the universe became incarnate and we saw, in and through Him:

His unmaskedness (some call it truth)
His humility (some call it humanness)
His integrity (some call it fullness)
His unrelenting compassion (some call it worldly involvement)
His sacrifice (some call it a gift)
His facing tomorrow (some call it faith)

The model of the universe was disclosed as a personal movement into our field of vision so that we might choose to see with and through the enrichment of spirit through involvement in matter and the enrichment of matter through the involvement of the Spirit! He, Jesus Christ, integrates man's imperial knowledge into a meaningful and triumphant wholeness.

I N T R O D U C T I O N

for

John R. Moore

John R. Moore is a graduate of Washington University, St. Louis, where he received his degree in Mechanical Engineering. He was Associate Professor of Engineering at UCLA, where he initiated and taught graduate courses in advanced servo theory and analysis of three-dimensional systems.

He was with General Electric for nine years,where he supervised development of gunfire computing and tracking devices, servo-mechanism and gyro stablized equipment.

He was also Associate Professor Mechanics and Director of the Dynamical Control Laboratory at Washington University, teaching graduate courses in guidance and control and precision automatic control systems.

In 1960 he received Washington University's "Outstanding Engineering Graduate Award" and again in 1963 received the Alumni Citation for his "exceptional career as scientist, engineer, and business executive in the field of electronics."

In 1957 he was elected Vice President of North American Aviation, Inc., and in 1960 President of NAA'S Autonetics Division. Here he pioneered the development of guidance and control, culminating in the most advanced system now used in 1,000 Minuteman ICBM's, defending our nation.

He holds many patents, authored numerous papers, served on the Air Force Scientific Advisory Board....and many,many other awards time won't permit me to talk about.

I worked in his Division for many years, pleasant years; it is a clean, sharp, motivated, well organized "outfit". Its principle outstanding feature, in my book, is its responsive, dynamic character to the needs of the Department of Defense as well as NASA....

John Moore is the kind of man who is continually giving of himself to provide work for 25,000 people....and that's a lot of mouths to feed. He travels all over the world continually.

The last time I introduced John was in 1962 on my CTTV in-plant program, when he talked to his people, which is now a commonplace thing with him.

He will speak now and open this Symposium with..."Technology of the Future".....John Moore....

INTRODUCTION

THE AGE OF COMPLEXITY

John R. Moore

Ladies and gentlemen, I consider it a real privilege and a challenge to be able to open this certainly unique exercise in the establishment of a better relation between man, nature, and environment; between science and religion. I am somewhat concerned because my primary background has been in a relatively narrow area of the physical sciences. I am used to dealing primarily with problems which can be reduced to numbers leading to tangible answers. These are the simpler problems of human existence. The clergy and the church and all of the constructive organizations of humanity that are trying to solve the imponderables of life are dealing with problems which are far more difficult and far more intangible. Yet, it is very significant that this conference has come into existence because science needs religion and religion needs science.

Science is here to stay, but its use for human happiness depends very much on the people who benefit from it and give it the direct and indirect support and direction which shapes its course and determines its future.

The church must adapt itself to an increasingly complex world in which science plays an ever more dominant role. The church must adapt to a world of science and scientists. People in the congregation are continually exposed to the new discoveries which are called the "wonders of science;" to the theories; and to the logic of the methods of thinking. On the part of the church, such a role in such a congregation demands flexibility, objectivity, courage, and an ability to keep pace with the apparent realities which experience and deduction reveal. The church has a God-given opportunity to provide an institution for improved communication; and let me say, where I use communication, I am using it in the broadest sense, the sense of a transfer of information among human beings. But communication involves not only transmitting but receiving. The church is one of the whitest hopes of the future in teaching people how to better communicate with one another. It also has the opportunity to provide motivation for the truly important activities of objective evaluation of many of the intangible factors which are so much a part of the fulfillment of man's mysterious role in the universe; and it is a base for the happiness which can come only from the recognition of the difference between false, transient standards, and the realities of individual values and accomplishments.

What is happiness? I am not a professional philosopher, and I cannot hope to pose answers to the questions which I assume the prerogative of asking. Some of these questions may evoke some thoughts among you and perhaps some answers that we can use. First of all, is not happiness the ultimate objective of most individual and joint human endeavor? Is it not irrevocably based in the individual? Are the happiest people today any happier than the happiest people a hundred years ago? I doubt that they are because happiness comes from within and without changing the "within," the passage of time will not make the happiest people happier. But is the average individual happier today than a hundred years ago? The chances are pretty good that he is. What part does physical pain, cold, fatigue, illness play in unhappiness? What part does

fear play in unhappiness—fear of pain, fear of failure, fear of ridicule, fear of decline? What part do physical possessions play in happiness? Not nearly so much after we have them as we thought they would before we got them. What part do fame and acclaim play in happiness? Or real or imagined ridicule in unhappiness? What part does frustration, that is, desire without fulfillment play in unhappiness?

Undoubtedly there are many more similar questions which bear upon the subject of what part science can play in human happiness. But, when all the questions are asked, there seems to be a basic thread running through them. To me, at least, the happy individual seems first of all to like himself, to consider that he is achieving or can achieve his goals of performance, conduct, improvement—goals which he has set for himself. He has self-respect in the most literal sense of the phrase. Second, he likes his prospects compared to the goals which he has set for himself. Thus, we might say that happiness is not determined so much by state of being but by rate of change of state of being. The sick man getting better is normally happier than the well man getting sicker. I think that most of us have had that experience.

Now science, government, and hard work can help with reduction of physical pain and the improvement of the physical state of human beings as a whole. But the church has an opportunity and a responsibility to help replace the false standards with true values that are the basis for each individual's evaluation of himself and his prospects. So with these items of importance for science and religion alike, we may start consideration of the several objects embraced by this conference on Theonetics.

The people who formulate catch phrases for popular consumption have called this era the "Space Age." But really, it is more accurately described as The Age of Complexity—brought on by quantities of people, things and knowledge continually increasing. It is brought on by inter-relations among several or many diverse people, factors, forces, materials, technologies, physical entities—by increasingly rapid obsolescence of information, material items, methods, customs, laws and even standards. Progress in individual disciplines (used in the educator's meaning of the word) is advancing by geometric progression. This gives us an expanding universe of scientific knowledge limited only by the ability to use and to coordinate diverse disciplines and quantities of information. Everything that man does leads to more knowledge, more experience—more basis for further advances, until the ultimate limitations are the limitations of man himself. For man is still limited by his capabilities to acquire information to be used as a basis for action or stored in his memory. His only means for acquiring information are seeing, hearing, feeling, tasting and smelling. He is also limited by his ability to add to his memory rapidly and accurately, to recall information from his memory rapidly and accurately, to synthesize and to recognize patterns.

In describing beauty, items themselves are important; but the real importance lies when they are placed in relation to other items ... patterns. The most advanced sort of intelligence tests involve pattern recognition. In short, man is limited by his ability to take information in, to think and to act on the basis of his thoughts; and finally, he is limited by time. There are only

24 hours in a day. This year, at least, we normally expect that he must use 6 to 8 hours in sleep. There are other things which he must do—work, or take a little time off, or spend time with his family. But this limits particularly the 'consecutive time' which he has to think. So these seem to be the ultimate limitations of the advance of science and knowledge; and if we can do something about these, then we can push back the frontier of complexity on our way into the future.

The problems of the Age of Complexity which we are just entering are far too numerous to discuss in detail. However, some of their major causes can be identified and discussed.

They are frightening, and they are challenging, for they include: The potential population increase (and I use the word potential advisedly). The potential increase in knowledge. Advances in the scientific disciplines or specialties. The changing character of dominant human activities. The increase in human choices required for decisions, and the increasing requirement for flexibility in methods, customs, laws, rules and all essential phases of human activity.

The most significant and overriding problems with which ours and future generations must cope arise from the potential population explosion on earth. The earth has about 200 million square miles of surface area, 140 million of which are covered by oceans. The earth's resources, or at least those which are presently available to us, lie within a few miles of this surface, and so far we have had to get them from the 60 million square miles above water. The earth's present population is a little over 3 billion people, plus all of the animals, plants and insects which share our planet with us and help keep its status in balance. Most people must live on dry ground; but after the aquanauts' recent experience off San Diego, perhaps the number who will live in the ocean is going to be increasing. About 52 people per square mile is the population density; and this includes all of the mountains and deserts, the farms, the rivers and lakes, as well as the places now inhabited by people. The United States has about 51 people per square mile.

The mathematics of population growth is simple and frightening. Our population is presently doubling at the rate of once every 37 years. This is equivalent to about 3-1/2 children born to a couple between the ages of say 25 and 35. If this had been the course of history in the past, Adam would have appeared on the scene about 1200 years ago. So you can see why things seem to have gotten more hectic recently. But if this growth were to continue, we would have an average of more than one person per acre by the year 2100; or one person per 12,000 square feet, which is about the size of a single house lot by 2170, and of one person per 100 square feet shortly after 2500 A.D. This is about 17 trillion people, or more than 5000 times as many as we have today. Of course, long before that, all or almost all animal life would have suffocated or starved. Indeed, it has been estimated that the earth's food supply is adequate for only about 25 billion people; and we will achieve, at the present rate, 25 billion people by the year 2075 A.D.

Can you think of any more difficult problem under today's ideas of control and morality than this one? But there are other problems having to do with

the population explosion. More important than the saturation of the surface of the earth, is the saturation of the atmosphere which we breathe by the products of combustion of the machines which man has made and which are continually poisoning the air we must breathe. I am certain you remember the U. C. L. A. professor who created a sensation by saying that if we didn't do something, our atmosphere would not be able to support life a hundred years from now.

With more people, we are also going to have a much more complex situation in government. In the first place, the number of people who can work together directly is limited, so we are going to have to generate more tiers of government, either on top or on the bottom or both. Also problems of laws and government will become increasingly complex because so many factors enter human activities, as well as so many more humans are involved. For example, a large part of our law books involve situations with automobiles, aircraft, radio, and radar transmission. Such items didn't even exist at the turn of the century and tomorrow our laws may have to further limit what we now consider to be the sacred human rights of individuals.

More people means more crowding of facilities for transportation. We can't build freeways fast enough. I am certain that all of you can see that even at our relatively slow rate of increase, we have tremendous problems of crowding in facilities for transportation. Most of this crowding has evidenced itself in the cities and in the intra-urban problem, but it will become more and more a problem for inter-urban travel as well.

More people create greater requirements for communication and for means of communication. We are not increasing the frequencies that are available for communication; so we will find that unless we can begin to use something like lasers, with their very much greater capacity (but other offsetting restrictions) we will have to use other means for carrying separate messages through the same space than we presently use, merely the difference in transmission frequencies that we now use.

More people generate increasingly massive amounts of information which can become useless if it is not related to other information and rendered easily accessible on call. I am certain that many of you know today the futility of trying to keep up with your profession and yet read all that you think you should. Imagine a situation where there is ten times as much literature being written, any of which may contain a jewel you can use.

Crowding will generate requirements for order, for scheduling, and for control not contemplated today at all. We are beginning to see some of that on our golf courses and in our parks and on the beaches and those areas where there are not unlimited areas by even present day standards.

The increase and magnitude of information available for alternative decisions can impose severe nervous tensions even when they involve noncritical items. I am sure most husbands have seen the nervous glint in their wive's eyes as they try to get advice regarding what dress to put on.

Unbridled population increase will require tremendous efforts even to maintain a given state of human physical welfare, much less provide the steady rate of improvement which seems so essential for continuing, maintaining, or increasing individual happiness.

Depletion of all the earth's natural riches will require discovery of new sources and massive efforts and advances in the industry and science of reclamation of water, air, minerals, organic compounds, and even energy.

The increase in the average age of the population is already affecting many of the things we do; how we govern ourselves (because the population has different aims and more mature judgement as time goes on); our facilities and requirements for leisure hours; the mix of our consumer goods. All of this is bound to increase as science gives man more active years to enjoy his life on this planet. The presence of many older people with their years of experience but with youthful vigor can be a tremendously important resource, but we must change rules and customs to tap this resource. I am certain all of you know what some of these rules and customs are.

Increase in communication and different rates of advance of standard of living permit the have-nots to learn what they are missing and to covet these things. This sometimes generates severe unhappiness which begets powerful pressures to achieve what others have, thereby sowing the seeds for wars, insurrections, riots and increased pressures to legislate more equality of status, as well as equality of opportunity. Increased complexity of factors affecting decision and action tends to produce oversimplifications, leading sometimes to very bad decisions and actions.

Although I will not attempt to judge the recent marches in favor of ending the fighting in Viet Nam, I am certain that the marchers do not have available to them the information which our heads of state are using to make their decisions; thereby causing us to lose more than we would if we had been able to present a patently solid front to an adventurous enemy.

Increased automation and easy availability of essentials and nonessentials of life can make for laziness and moral softness among large sections of the population. This can generate a variety of terrible social ills, ranging from individual self-generated unhappiness to unhappiness imposed by the encroachment of others seeking outlets for self expression and uses for free time. It seems that we are coming to an era when some people will have to work all of the time, and other people will be worried about not having enough self-satisfying work to keep them busy. This increased availability of leisure time, that is, time not spent working to achieve the means for comfortable existence and the selection of leisure activities, can be both a bane and boon. If challenging activities are not provided, people will become bored and unhappy because they are not maintaining the level of accomplishment necessary to insure the self-respect which they require for happiness. We have seen what can happen with some of the spoiled children of wealthy parents, as well as with the potential juvenile delinquents in slum areas. "The devil finds work for idle hands to do."

On the other hand, as problems and tasks become more complex, there is an increased requirement for intensive concentration and extensive mental gymnastics; that is, mental gymnastics spanning a large number of different subjects; of better communication; and of more time spent in these pursuits. These produce, among some, the requirement for continuing study, the requirement for long working hours, and the requirement for great skill in communication and team work. They reduce the time available for such people to relax, and they require sacrifices of their family and friends. Denial of such precious personal time is a great sacrifice; yet, it is the only way that increasingly complex activities can be carried out effectively. The number of these activities which will require more concentrated dedication and giving of time of individuals is bound to increase as we attempt to solve more and more complex problems. Therefore, mechanical, medical, and management aids must be called on if continually more complex problems are to be attacked successfully without destroying some of the most valuable human resources that we have.

I could go on and on listing problems of the Age of Complexity; however, such time would not accomplish my primary purpose here. Therefore, let me point out as a last example one which is happening around us, but one which we do not normally recognize as a potential problem. This is the simple fact that people seem to be getting larger. I am certain that all of you have seen your children and grandchildren as they reach maturity towering above you. A month ago I was in Viet Nam. One of the things which impressed me the most was the tininess of those people. I don't know how much the little girls weigh, but they seem to weigh no more than 85 pounds and be about five feet tall. In Japan, some years ago, we saw some of the same; yet now, when we go to Japan you can see a tremendous difference. When other areas of the world are given the same opportunities for adequate nutrition and rest, we will see dramatic increases in the size of individuals which will affect the local economies. But even here in America where a five-foot eleven-inch man like myself can have a six-foot five-inch boy, one may begin to worry about such things as the adequacy of the budget for food. Also, as people get larger they require more oxygen from ventilating systems, larger doors and closets, more room in cars, elevators, public transportation seats and furniture. The effect these can have upon long-time amortization of capital assets could also be of concern.

Now, fortunately, problems once identified are well on the way to being defined; and problems defined are well on the way to being solved. Therefore, despite all of the crepe which I may seem to have been hanging here this afternoon, I can look toward a really bright future, which will not only maintain the standard of living in the presence of such population expansion as may be allowed to occur, but actually will continue to increase it in a way which will make the people of the 21st century look back on us as being as primitive as we think the people of the 19th century are today. This is because science has far more than kept pace with the problems.

The industrial revolution began to supplement man's muscles and reduce his physical strain, while accomplishing things he could never ever accomplish with his muscles. Today, we see not only an acceleration of the augmentation of man's physical capacities; but what should be far more important, the

the beginning of rapid strides to relieve man's mental drudgery and augment his mental capacity.

I am certain you have seen some of the statistics which I will quote. Somebody has calculated that scientific knowledge has doubled in the fifteen years from 1945 to 1960, and 90 percent of all the scientists who ever lived are alive today. The reasons for this are ironic because it seems that fear (as contrasted with terror) has been and continues to be the strongest motivator for action (not necessarily for creativity). In this case, fear of national destruction by war or being second best in the eyes of the world in the space race has produced a driving force which has made us advance as much in twenty-five years as we would have in more than a century at the pace of the 1930's. For what board of directors would authorize the risk of 100's of millions or billions of dollars required to reduce to practice (not just invent) such things as radar, high-capacity electronic computers; (and, notice, I did not say giant electronic brains because those are obsolete, they are tiny high-capacity computers today); atomic energy, helicopters, jet aircraft, supersonic transports and space vehicles, to name only the most sensational. From them, have sprung a myriad of by-products in the form of improved materials, electronic devices, gadgets, manufacturing methods and machines, management techniques, mathematics, improved health science, new foods and many others which we wouldn't have today if they hadn't had to be developed in connection with this fear motivation that we have been living under since 1939.

Not only do we have the products and technology which have resulted from such activity, but also we have a backlog of scientists, technologists, skilled teams, organizations and the schools with which to maintain and expand our ability to attack complex problems.

The wonders of science cover the whole gamut of identifiable knowledge, from the macroscopic universe of interstellar space and the mighty engines which we are fashioning for this exploration, through the microscopic world of organic cells and viruses and micro-electronics; something which I hope to tell you a little bit more about later; to the infinitesimal realm of molecules, atoms, nuclei, mesons, protons and all of the things which we have named but don't really comprehend.

Those people here who enjoy the sensational can appreciate some of the startling evidence of our scientific progress and the prognosis at least for its relatively near future. At the beginning of World War II, the engines of our largest aircraft pushed them through the air with the force of about 5,000 pounds at speeds of 150 to 200 miles per hour. I just returned from the east on a jet liner which was pushed along the ground and into the air by four engines with a total thrust of almost 70,000 pounds and then proceeded to fly at 600 miles per hour. You all know about this. It is commonplace. But before 1970 we plan to send three astronauts to the moon in the Apollo moon rocket with a first stage thrust of 7-1/2 million pounds—more than a hundred times the thrust of that jet liner—achieving a speed of about 25,000 miles per hour! This is the near future!

Already scientists and engineers talk of atomic powered rockets with capabilities to launch spacecraft weighing tens of tons. Such engines are sensational for the force that they exert for a few minutes; but once in space, the job may ultimately be better done by microscopic forces measured in degrees, but applied for many years to achieve the fantastic velocities required to explore space at the outer reaches of the solar system, and beyond. Such microscopic force would be achieved by nuclear powered engines which emit small charged particles called ions at tremendous velocities; and although such ion engines could not free a usable space ship from the earth's gravity, they are a major present hope for achieving speeds of thousands of miles per minute.

In terms of energy, we have, from a man's known genesis, depended upon the sun, either directly or indirectly, for all of our energy. Wood, coal, petroleum, and water power all get their energy from the sun. Recently, we have begun to unlock some of the energy of atomic nuclei in the controlled fission or breakdown of heavy atoms into their lighter constituents. This is quite inefficient and requires special materials which are relatively rare. But we are already hard on the heels of almost limitless energy obtained by the fusion or combination of light atoms and the heavy ones—the energy source of the hydrogen bomb and of the sun. We are in a race to achieve such a limitless energy source before our supplies of combustible fuels and fissionable materials are exhausted; and, before, in the case of the combustible materials, they have made the air unbreathable in the process of their exhaustion.

We are beginning to develop the technology for exploiting the oceans and their bottoms, and I note that you are going to have one of the top oceanologists in the country, Dr. Rechnitzer, talk to you on this subject later this afternoon. I will not say anything more about this, except that many of us feel that the potentialities of "inner space"—the ocean and its bottom—will pay far more dividends to investors in the next half century than the exploration of outer space.

Now I will discuss an area that is more close to home. I have mentioned micro-electronics. Many of us are used to thinking of electronic advances in terms of something made in Japan which we can buy for a few dollars called transistor radios. Transistors did make possible the first reliable electronics with anything like the complexity which engineers have had the capability to design for many years. However, the same principles which produced transistors are now being applied to produce whole circuits no larger than the transistors themselves. These circuits are being called first-generation micro-electronics. They are relatively large, they are one tenth by two tenths of an inch, and they contain the equivalent of 15 to 30 elements which you will find in a radio; resistors, capacitors, diodes and transistors. But before the first-generation micro-electronics is even in operational use, the second gener..tion is making its appearance and is giving promise of being far more sensational compared to the first generation than that generation was compared to the transistor.

Micro-electronics is based on the science of solid-state physics, semiconductors, and super-pure materials. It is primarily useful for amplifiers, and amplifiers are useful for almost anything, particularly computers. It is

a white hope for medical electronics. We already have implants which require no wires which can make simple measurements and broadcast from a tiny radio transmitter powered by a battery the size of an aspirin tablet. These are measurements of what is going on continually in the living, human body. The second generation of micro-electronics already permits us to build 200,000 equivalent components into a piece of material one inch square by one sixty-fourth of an inch thick, and we have in our laboratories means for increasing this by a factor of twenty-five to one.

To give you some idea of what this means, we could store five, 350-page novels in one cubic inch. If we assume that the library of a minister contains between 500 and 1000 volumes, we could store that whole library in 100 cubic inches and call for any passage in less than a second. We could put all the circuits of a television, except for the picture tube, the controls and the power supply on a chip one tenth of an inch by two tenths of an inch by fifteen thousandths of an inch thick; that is, we could put the control and amplifying circuits for 3300 TV sets in a cubic inch.

We already have computers with great capability, but we are proposing those with fantastic capability, using the second generation micro-electronics. The ones with good capability could, for example, compute the income tax returns of all Presbyterians in the United States in 30 seconds.

The use of computers is boundless. It will be a tremendous help in government and in all of the service industries; that is, the industries such as insurance, law, medicine, entertainment and education. It will be an important tool of management, for banking, for engineers, for ground- and air-traffic control, for complex process control, machine control, equipment trouble shooting, communication switching, coding and decoding, and that one that I always come back to, accessible storage; making it possible to justify and use the information which we are generating and which the future generation will develop.

But more sensationally, computers are beginning to be adapted to machines which seem to think and to learn. These machines can be "taught" to be experts in many narrow fields. For example, certain specialized law, specialized medicine, specialized engineering, physics and chemistry. They will have infallible memories with tremendous capacity, a capacity which begins to approach that of the human brain. They are ideal for language translation, and it is by no means unreasonable to expect that within the next twenty years, perhaps even sooner, we will be able to pick up a telephone and speak to a friend in Japan in English, have it translated into Japanese by a device, have him talk back in Japanese, and have it translated to us in English, all by a sentence-by-sentence learned basis instead of the totally inadequate word-to-word dictionary method which people have proposed but have not found to work so well.

We can look for a tremendous growth in the field of communications. We think we have a lot of radios, TV, and telephones now. We can certainly look for telephones with television attached. We can look for automatic printers to associate with these telephones. We can look for telephones with no wires, telephones mounted on automobiles; and if the law will permit, televisions and certainly teleprinters in automobiles; and finally, even pocket models to be

carried around by individuals. At the present, it looks as if communications has the largest immediate nonmilitary potential for expansion of any of the fields of application of electronics because it begins to hit the consumer.

In the field of mass transportation, there has been much talk about monorails and subways. These modes of mass rapid transit may be very important in center-to-center runs; but, high speed doesn't pay unless it saves appreciable amounts of time. Therefore, we must balance time to load and unload and get to and from the station, with time between stations. For high speed, we should have block times of at least 5 and preferably 10 minutes.

Vertical take-off aircraft are a considerably more flexible means of providing rapid mass transportation. From the financial point of view, there is a smaller fixed investment in roads, with an immeasurably more flexible and versatile system. The science of propulsion electronic control and fail safe features should make vast improvements during the capital writeoff period of right-of-way investment. Regardless of the form or the routing of this vehicle, the problem of dispersal of combustion by-products and noise must still ultimately be solved.

At the present time, I foresee no substitute for buses until everyone has an individual "power pogo stick." One of the greatest improvements needed will be the automatic control of autos to allow rapid acceleration and deceleration and automatic car-to-car spacing at high speeds. A computer-augmented control system would eliminate traffic jams by adjustment of uniform automobile velocity and alternate route selection. I have often felt that the space used by our freeways can basically handle several times the amount of traffic which now causes them to degenerate into frustrated parking lots. But this requires changes in laws, improvements in all cars to eliminate delays in acceleration and deceleration plus more attention to the problems of on and off ramp traffic.

Living may very well become more and more concentrated into decentralized complexes—perhaps, nearly self-sufficient high rise buildings with services and stores within each for, at least, all ordinary requirements. This will reduce the requirements of routine transportation to the capabilities of elevators. Work may be either concentrated in other large, high rise complexes or, ultimately, for jobs not involving manual dexterity or transportation and delivery, in an office attached to each home, with completely effective communication by television, teleprinting and telephone.

Long distance transportation will be subsonic or supersonic, depending on the distance. More important, time from point of origin to airport—time to emplane and deplane, and time to destination will be greatly reduced by the use of helicopters and channeled ground effect machines. Very likely the "Pullman" system will be used for supersonic transport. Local cells will be boarded at various centers and transported with people and baggage to be installed in the supersonic aircraft like Pullmans attached to a train. For shorter hauls, like Los Angeles to San Diego or Los Angeles to San Francisco, vertical take-off and landing aircraft or compound helicopters will be used, at least until rocket ships are available for runs of all lengths.

Perhaps the greatest challenge and the greatest payoff lies in the study, repair and improvement of the physical and mental functioning of human organisms. I cannot speak with detailed authority in this area; nor, if I could, would it be appropriate here to compete with such articles as have recently appeared in LIFE magazine. These articles give a glimpse of the future which is frightening to the timid and exhilarating to the bold. Whatever our reaction, we cannot fail to recognize the tremendous social, moral, physical and religious significance of the potential synthesis and control of human life and the physical and mental characteristics of human beings.

Medico-physiological science has already established its ability to protect life against the ravages of disease, abuse and accident. We can look for startling advances here within the next 25 years. Certainly the advances made during this period will cause the 21st Century to be populated with large numbers of active, useful centigenarians.

Medical science has already produced simple mass means for birth control and now appears to be heading toward correspondingly simple means for greatly increasing the probability of multiple births. Also imminent, seems to be the prenatal control of sex of the children, as well as other of their characteristics. Again, the period of parent fertility seems destined for very great increase.

Such radical control of birth is both a hope and a challenge. On the one hand, it provides a non-cataclysmic solution to the problem of over-population. On the other hand, it will require radical changes in laws, customs, morals, habits and conscience. If the average couple lives 100 years and has two children at the age of 25, the population will undergo an initial increase and then remain static. In this connection it is significant to note that increase of life span increases the total population but not its rate of growth. But, if every couple has only one set of triplets, the population will reach a condition where it increases by 50 percent every 25 years or by a factor of more than 5 every hundred years! Clearly, we are facing a time in the foreseeable future when the whole world must face control of birth by legislation or by the natural consequences of overcrowding and shortages.

Medico-physiology has lagged the so-called physical sciences because of the extreme complexity of human organisms and the difficulty of performing experiments. This difficulty involves both measurement and data reduction, since so many measurements must be dynamical and chemical. However, the combination of microelectronics and high-speed, high-capability computers gives promise of providing the means for reducing our understanding of human physiology, and disease and treatment, to quantitative theories leading to early diagnosis and quantitative prescription of cures. The combination of such quantitative knowledge with the ability to make continued measurements of physical and chemical precursors of malfunction and the utilization of nutrients and medicines can lead to optimum control of health and treatment of maladies.

Techniques developed to integrate many disciplines for complex military and space systems are the starting point for systems engineering at the ultimate complexity which is the human body and brain.

In the nearer term, we are already witnessing the replacement and augmentation of organs including their nerve control. A fine example of the augmentation principle is the "Pacemaker," which provides synthetic excitation to the heart to permit regular and reliable heart pumping action for the patient with an "excitation" or nerve deficiency

In our research laboratories, we have developed, under the auspices of the National Institutes of Health, manmade artificial heart pumps. These devices have been successfully applied to a calf in laboratory experiments and demonstrated the capability of keeping the animal alive for extended periods of time.

Artificial aids to sharpen senses, take over routine body functions, and increase capacity for work have been developed and are now in everyday use.

The ultimate objective of science involves understanding and improvement of the human brain, sensory apparatus and nervous system. Not only does this seem to be the greatest challenge, but it certainly has the greatest payoff. Anything we can do to help increase the human brain's capacity to think clearly, accurately, rapidly and on complex subjects, can produce the wellspring that stimulates and accelerates all other progress—physical, social, and spiritual—towards the maintenance and increase of human happiness. This improvement in mental capacity is the activity which regenerates itself, as well as every other human endeavor. How can we do this?

Physical science helps by taking over routine activities of measurement, data storage, data retrieval and complex calculations. Medical science can help by reducing anxieties, sharpening mental processes, improving ability to concentrate and by reducing requirements for sleep. Sleep-machine experiments have indicated that we can add 4 to 6 hours to each work day by using machine-induced sleep. Chemical and electronic means can be found to increase concentration, improve memory and speed up mental processes.

Management, education, laws, customs and conscience all help by providing accurate basic information and reducing the disruptive anxieties and diversions which interfere with thinking. Psychology can help by providing better understanding of the physical manifestations of functioning of the brain. improving concentration, preventing disturbance, improving communications to the brain by means of motivation and getting the brain's attention. Application of techniques of systems engineering and complex program management is a must for welding together in a concerted effort the widely diverse disciplines required to attack this problem; such disciplines as psychology, physiology, chemistry, physics, mathematics, medicine and management.

Progress in the physical and medical sciences can help us solve the problems of the age of complexity, but these in themselves are not enough. We need to discover and to develop people, who for lack of a better word, we are calling these days "Generalists." The generalist is the opposite of the "Specialist." He is the jack of many trades and master of several. He is characterized by an ability to switch rapidly from one to another of widely diverse problems and widely diverse disciplines, but it is important to note that he

must be able to concentrate; he must be objective; he must be an expert in communication both in transmitting and receiving; and he must be able to evaluate the credibility of information which he receives. He must be a man of unusual physical stamina and dedication, and he must be possessed of very understanding family and group of friends. The capabilities and numbers of such generalists will establish the ultimate limit of all of our progress in the Age of Complexity.

Advances in the science of managing complex programs have been a necessary, albeit unsensational, ingredient in our well-publicized military and space programs. The requirement for team effort involving specialists in diverse activity will continue and expand. Our programs have and are continuing to build the management resources to go with our scientific advances. These resources are being generated just in time to give us the tools to cope with the many problems of the Age of Complexity—problems of government, world, national, local and family—problems of economic forecasting and protection of the world's and nation's economy—problems of scheduling of limited physical and service resources; of land reclamation; of air and water purification; of industrial organizations to produce complex goods and services with the flexibility to abandon the traditional production line and produce for local consumption an article which is needed and then shift over to produce a different article—problems of transportation, inter- and intra-urban—problems of communication and retrieval of data—problems of better education; of replacement of the depleted mineral and power resources; of the improvement of health through better hospitals, diagnosis and understanding of the human body and augmentation of its functions—problems of understanding, improvement and augmentation of the human brain and problems of understanding of man and man's spirit's place in the universe.

And so, we see the Age of Complexity has many problems and much opportunity. Human happiness is the objective and the stake. Science can help; but alone, at least for the foreseeable time to come, it will fall far short of being able even to communicate with the largest factors of the population. Science must be the servant, humanity the master. Through all the problems and all the potential solutions, there run the common themes applicable, regardless of the turn which history may take. Human progress and all the laws and shibboleths with which it finds itself cloaked must be measured against and dependent upon the external standards of objectivity, dedication and faith in the immortality of its destiny, and in the God in whose almighty presence we are permitted and privileged to face the challenge of the future.

P A N E L

TECHNOLOGY OF THE FUTURE

by

John R. Moore

Question: One of the statements that you made was about the place of happiness as a basis of man's being. I think you raised it in the form of a question, "Is not happiness the ultimate objective of human endeavor?" I suppose because we are working on the Confession of 1967 and worrying with a shorter catechism in the process, I keep coming back to the chief end of man as we in the Christian faith would conceive of it. I am wondering, if happiness is not defined anymore specifically than that, is it an adequate statement of the ultimate objective of human endeavor? Now perhaps this is something that you would like to say just a word about. I am not quite satisfied with that as being the ultimate objective of human endeavor.

J.R. Moore: I think that we have a little problem in semantics and possibly a problem in elocution. I said, or meant to say, "endeavors", and there is a difference between endeavor in the large, and endeavors as we look around us and see what most people do most of the time. That is what I meant, I don't wish to get involved with this thing of happiness because I am such an amateur at it.

Question: The impact of our technological age seems to inevitably also bring not only the problems but the disintegration of personality both for those that are involved in it, and then are affected by it indirectly, just as you saw in Viet Nam. Is there any way that science itself is helping redeem this situation where science tends to destroy the very thing and the very objective of life, the untimate endeavors of life?

J.R. Moore: This is a complicated question. Again, I wish you were asking questions about electronics or management. Fortunately I mentioned Viet Nam only twice. Once in terms of the size of the people in connection with the fact that they seem so small and yet look what would happen if we make them larger. The other was in connection with the student demonstrations. I raised a question of whether the happiest people today are any happier than the happiest people a hundred years ago. I think I stated it was my feeling that they aren't. Man can "like" himself either by achieving his standards, or by getting a different set of standards and they have a different set of standards in Viet Nam, and who are we to say that they are not as happy. They don't know they are unhappy; they don't get unhappy until they learn what else there is! That does not say however, that in the presence

of people like the communist who are trying to exploit the situation where they don't have things, which they now can be told about, that they are not perhaps less happy now than they would be if they had known about more things. I do believe, however, that the anguish that a mother feels for a sick child or a dying husband cannot be called happiness and yet we are not doing a lot to aleviate that. We are doing a lot to show them how to produce more to eat and not have to work so hard, so that they do have more time. I do believe that in the long run we can raise the average level of happiness.

Question: Dr. Moore, as you began talking about the age of complexity and one of its chief problems being the expansion of man's knowledge and the limitations upon that expansion you talked about the potential population explosion. It sounded good and I wonder if perhaps you could go back and just pick this up again for us.

J.R. Moore: I talked about the limitations in this area because this is perhaps the most dramatic way to emphasize the problem. Actually the problem becomes acute long before this ever becomes a fact. There are all sorts of statistics which are put together by people who like to deal in terms of startling statistics. However, without going over those statistics again if you will grant me that there is a problem there.

I did't memtion another problem which is much more immediate. The contamination of the atmosphere. I think that we must take this as a real challenge of the immediate future. I don't know what the answers to it are, in total, but I don't think they are smog devices in automobiles although these might help some. I think we must ultimately get to some kind of power generation source which doesn't emit gases into the atmosphere. You can imagine such things as fuel cells, or even little atomic engines or batteries running electric drives. That will certainly be one of the ways to help. Of course, another way is to find ways to filter out the products in question which are in the atmosphere without upsetting the balance of nature.

Another thing I mentioned is that with more people and more ;things to control and legislate we're going to have increased complexity in government and laws. We have seen much happen since the turn of the century that we now consider to be common place regarding the laws affecting automobiles, radio transmission and aircraft. I pointed out that with the more people we get the more crowded our means of transportation are going to become. There is a question of whether or not we can build highways fast enough to cope with the situation which continues to progress as it has in the last few years.

I feel that it is fairly significant to note that just a small overcrowding of a highway will produce a traffic jam. In other words, I believe you can maybe add 5% additional cars to a freely flowing highway and you can produce a traffic jam. I believe that with this kind of information and with other things, such as controls of starts and stops, we can do quite a bit. But ultimately we're going to have to not use the highways so much as we're doing now for going back and forth to work. I think that has to be the answer. We have to use something else.

I pointed out that with more people there are going to be greater requirements for communication. This means both electronic communication and communication in the broader sense, of being able to discuss one's ideas and understand someone else's ideas because there are going to be more ideas than there were before. I am continually impressed with the tremendous difficulties just using information which we generate. This is known in the industry as data retrieval. Certainly there is going to be a tremendous requirement placed upon the elimination of unnecessary information, both in texts and in titles. We're going to have to make further advances than we already have made. Some substantial ones will have to be made in the field of indexing so that we can call for it.

I mentioned that crowding will require additional steps to maintain order, to maintain scheduling and to control on a timely basis the use of rare facilities such as beaches, parks and golf courses. One thing that continually impresses me is that the more complex we find the information available, the more difficult becomes the problem of decision making, and the more likely we are to generate neurosis if we don't have either better brains to think with, or better means to tell what is important and what is not. Some of us in management, and I am sure other places, in order to get on with the job, have often come up with the over simplification that if you can't determine which is the right decision it doesn't make much difference. This is not always the case. Sometimes it just means that you don't have enough information and it might make a lot of difference.

Next I talked about the problem of depleting the earth's natural resources which requires that we develop new sources by exploration. Here I had in mind exploration of the oceans and perhaps deeper penetration of the earth's crust, although I don't have much hope there. More importantly we must have reclamation of things which we now discard. Of course, we have had reclamation in the steel industry for many, many years and we are having it in other metal industries, and it is primarily a matter of economics, but we are going to have to expand it into other areas.

In reclamation we also talked about water. We are definitely going to have to reclaim water.We are going to have to keep our streams and lakes from becoming polluted. We are going to definitely have to get water from the oceans. We're going to have to see what we can do about controlling the weather, which I didn't mention. We are going to have to reclaim organic materials. Even if we reach a static population state we will continue to be depleted, unless we can reclaim it. About the only thing that we don't know how to reclaim in the ultimate is energy. I pointed out the significance of the increased average age of the population. How it will affect government. It will make more people of voting age for example. How it will affect leisure. How it will affect the bills which are up for legislation and the judgment which elects our electors, and which rush to the chosen agents, the people, the congressman and the members of the local government. I also pointed out what a great benefit it will be to have people with both experience and youthful vigor. We obviously are going to have to change some of the customs such as company rules which require retirement at a certain age and other things which discriminate on the basis of age.

There is another very definite problem that our state department is concerned with, and that is the difference in the rate of growth of the standard of living in the United States and Europe. At the present, only the United States and Russia have the gross national product required to maintain the kind of growth, the attack on scientific problems that we talked about and the mounting of major complex programs that we are now doing. Smaller countries in Europe just can't do it and the only way they can is to get together. Now this is a very important problem, and of course whenever there are differences at one time or another there is a tendency to try to eliminate the difference, and this is the thing that wars and insurrections and riots make up. I don't know that I need to go on.

Question: You've mentioned, sir, the complexities the human being will have to deal with and intimated that the decision making processes of the individual are going to be strained almost to capacity and perhaps beyond capacity. Do you have any suggestions as to how the technical advance, wuch as micro-miniaturization of the ability to recall, the ability to remember, to help us as individuals to make the decisions that are going to be required in this world that you have outlined for us?

J.R. Moore: This is one of the white hopes of the immediate future. The use of electronics -- the general information processing technology to help manage large routine activities. One reason we have trouble in making decisions is

because we have to consider a certain number of factors in a given amount of time, and so if we can get more time then that's one way we can do a better job of making a decision, or least not become neurotic and frustrated, because we're not sure we made the right one. Another thing, of course, is to use the additional capabilities of the data processing equipment to distill the information and to extract from it that which is needed for making decisions, so that we are not continually faced with large masses of information that we can't use. We have seen errors of over information made time and time again to the point where I have attempted to establish a policy in Autonetics that managers and other people ask the question, "What happens if I don't?" What happens if I don't send a copy of a letter? What happens if I don't call someone on the telephone? What happens if I don't call a meeting or go to a meeting? What happens if I don't spend time? What happens if I don't go on a trip? I think the distilling of information in accordance with some of the things which we have had to learn to do in managing the large space and missile programs, can be more widely applied. One of the biggest problems that most people have in making decisions is that they start with all the information and then work and try to get the answer instead of starting with what they desire and working backwards. It's like the traditional problem of how many tennis balls are used in a tennis match when there were 64 initial contestants. Start from that end you have trouble, but if you start from the last two and work backwards pretty soon it becomes an easy problem.

Question: I am concerned about the sound of all this that makes man more the slave of the machine than the master, You spoke of the ideal for a manager would be to be a generalist, who would be jack-of-all-trades and master of several. Who would be dedicated and would have to have a family that could put up with their being away for these long hours. Presumably they could get along on few hours sleep with the help of these instruments and so on. Where does the goal of training man to be more human come into all this?

J.R. Moore: I am very glad that you asked this question because it points up a problem that I have had in communicating with you. The generalist that I am speaking of is relatively rare. The requirement for them is relatively rare. They probably do not spend their time working on machinery, either developing it or running it. Most of the problems which a generalist will have to solve are intangibles and the intangible problems can go into all walks of life. Government is certainly one. The various systems probelms that I mentioned, such as the land reclamation, the anti-poverty program, the urban renewal, city planning. All these are major systems problems that are extremely complex. The

large part of the people will not be working on these problems simply because problems of this size are characterized by being small in number and high in value, with large numbers of components. You simply cannot get all of the people who might even want to work on a problem like that even talking to each other. There isn't enough time. So we are developing two types of people. We are developing one, and I speak from sad experience of both having had to act as a generalist and try to find some, who spend nights and weekends and holidays away from their family wrestling with complex problems. Many of these problems are human. Another kind of people, who because they are not in those positions of responsibility, are able to partake of the benefits and labors of those who are generalists and have the other kind of a problem. The problem of what do they do with the extra time which the labors of generalists have given them.

Question: Do you see, sir, a lessening of the place of the "common man" or the average man, the usual man in society, if this generalist becomes more important, or if the common man's decisions begin to be made for him? To see that he may not be as necessary as he is at the moment?

J.R. Moore: Of course, I don't quite know what the common man will be. One thing we can hope is that all men and women will get smarter all of the time. If they do, they are going to be important. I consider that the generalist is more the slave than the so-called common man. As long as we have a democratic society then most of the people are going to call the turns, and the best thing that the generalist can do is to get them information. The best thing that the experts (that I hope will be solving some of the problems of communication and improvement of mental ability) can do is to get the common man this improved mental ability so he can make better decisions in those areas where he is the only one that can, under our form of government.

Question: Then you don't foresee Orwells "1984" position in this?

J.R. Moore: I don't want to predict anything specific but I certainly don't foresee anything like that!
I think the big problem is to try to find ways to use the capabilities of everybody in the optimum fashion. It would be nice if we could get a thousand men around one man's desk so the one man wouldn't have to work all the time. You might be able to parcel a job out, particularly if there were some way of communicating more accurately and more rapidly with all the people. That isn't beyond the realm. We're already talking of

by-passing the eyes and the ears and going directly into the brain.

Question: In regard to the decision making. Is the research that is going on in the field of science making as startling a contribution to this field, as it is in space ships? That is, the whole question of decision making and accepting responsibility; communication and all? What is being done in this area?

J.R. Moore: There is a very large activity in this area and it is so complex. It is difficult even to write about. It is easy to write about space ships. We can see them take off on television and we can see spacemen floating around in space. we can sort of have a curious experience with these. But it is much more difficult in dealing with the problems of management and program direction. Yet without the solution of at least some of these problems we would have no space ships to see on television; we would have no Minuteman ICBM'S standing guard. We could not look forward to the application of this management technology in the solution of the complex systems problems of the age of complexity. So the answer is that there is a large effort. There has been success. Without this success we would not be where we are today in the things which we see as being sensational.

Question: I don't want to go against your wishes and ask primarily a philosophical question, but I am still troubled with what seems to me to be a kind of an assumption that has run through your presentation: that human happiness seems to be more or less identified with increased human productivity to the limit and beyond. We will soon break through new barriers of limits, such as increasing longevity of man in the face of population explosion. We are fighting ways to increase his length of life. There are all kinds of medical and scientific techniques that can be employed in doing these things. I am just wondering whether we are necessarily achieving the ends for the welfare of mankind by artificially seeing to control these things to the degree that we are, or whether we may be actually accentuating the problem.

J.R. Moore: I think you had better seek a wiser head than mine for that answer. The point of that is if we don't take steps to control the population explosion and some of the other consequences of it, the laws of nature which have exerted control before will come into being and exert control again. Maybe it's better this way because certainly we are on a treadmill. We have a momentum that seems to be increasing.

Question: I have a question about the extension of our sensory apparatus. I just wonder what kind of things are currently going on that will extend this part of our world. You said something a little bit ago about just picking up knowledge and going around one's ears for example. Could you elaborate on this?

J.R. Moore: It doesn't happen to be in my field and I really should't say anything more about it except that even we have programs in bionics. One of the things in bionics is a combination of biology and electronics. Study is going on concerning similarity between biological phenomena and electronics and the relationship between them. Also an attempt is being made to substitute electronic or other mechanical means toward the biological phenomena, and I do happen to know that there is work of this sort going on. I have no idea how successful it is or when it will be successful. I'll say "when" not "if" because the wheel, the cotton gin and the steam boat, and other things seemed equally ridiculous at the time.

Question: We are at the end of our panel time and we express our appreciation to you. I would express the appreciation of the panel with one more question. You spoke of a white hope for the future. I am wondering if you could help those of us who are here, who are vitally concerned in the hope of the church and the future of the church, if you'd care to. Would you dare to give us what you feel the white hope, as far as the church is concerned, in its place in this society which you have intimated is coming?

J.R. Moore: Again, I am beyond my field, but I think that certainly the church has the opportunity to communicate and motivate people in a way which cannot be approached any other way. I think that this communication and motivation is important. I also think that the church can be extremely helpful in salvaging people with real values. It always has the faith to survive things which are beyond comprehension and sometimes, without the faith, would be beyond endurance. I don't think there is anything that I can see that is going to change this requirement. The church also is practicing brotherhood. Again extremely important when there are so many people and so many pressures that tend to drive people apart.

I N T R O D U C T I O N

for

William F. Bakemeyer

William F. Bakemeyer is Assistant Manager, Advanced Systems Laboratory, Hughes Aircraft Company.

The laboratory is responsible for studies and development of advanced systems in the communication satellite field. Advanced Systems is part of the Hughes Space Systems Division and was responsible for the development of SYNCOM and Early Bird communication satellites.

Hughes Aircraft Company is a development and manufacturing firm in aerospace and electronics. The company, which employs over 20,000 persons, is located in numerous cities in California and Arizona and is also well known for its airborne fire control and missile systems.

Speaking on the subject of "Synchronous Communication Satellites", I present to you....William F. Bakemeyer.....

SYNCHRONOUS COMMUNICATION SATELLITES

by

William F. Bakemeyer

I hope to concentrate today, not so much technically on how these satellites work, but rather what they can do. I will discuss some of the superficial affects on mankind that these satellites might offer in the near future. I doubt that I will touch in any great way upon the very fundamental affects upon mankind. I think the technical man very rarely appreciates the impact of the work he does in the long pull. We were discussing earlier that the man working on the jet transport probably appreciated what I will call the so-called superficial affect of being able to lift someone out of Los Angeles and deposit him in New York in four short hours. What he probably didn't anticipate was the effect, in my opinion at least, that that transportation capability had on the population of Los Angeles. I think it ushered in an explosion in transportation. Many people in the United States that never thought of leaving home (and that includes myself in Indiana) were exposed to various parts of the United States which caused some to settle in Southern California (and I include myself in that group). So this would be sort of a secondary effect of the technology.

You are certainly aware that the space systems programs are a very recent innovation. It was not until 1958 or 1959 that any significant funding or activities occurred in these fields, and there is great controversy still being raised as to the practical benefits of this large investment that we are making in space. I think, however, that the active communications satellite portion of this research, (that portion which I will discuss) has in a very short period of time demonstrated both its feasibility in accomplishing communications over great distances, and proven that it is economically a very attractive output of the space technology this country has invested in. I think we stand today at the very threshold of realizing this potential.

I would like to describe for you some of the short history that has brought us to this point and what we might expect to see in the next five years. It has been said that one would be extremely foolish to attempt to predict beyond that time. It is very difficult to see in this rapidly developing technology, I think, more than five years into the future. Certainly there are not many in this room who, five years ago, would have appreciated the current status of the space program of the United States, and I include myself in that.

(You will find that like most technical people I rely heavily on illustrations. It's perhaps part of our training to think in terms of graphs and charts so you'll find my talk heavily illustrated this way.) Shown here, essentially, is the history of the free world's active communication satellite program. There have been some satellites launched by MIT which are not listed here, and as you are well aware from the paper, our friends in Russia have also quite recently become interested in this field, perhaps belatedly recognizing the social impact that this may have upon the world. You see that in 1962 the first active communication satellite was launched; Telestar by the Bell System. It operated for a short period of time and failed. It has not operated since that time. Next was the relay satellite launched by NASA. It operated intermittently and up to the date of this chart, at least, it was still operating satisfactorily. Our first endeavor in a synchronous communication satellite, called Syncom I, was launched in the early part of 1963 and suffered a failure, (sounds somewhat similar to this morning's effort with the Agena vehicle for the Gemini flight, namely, when the booster motor was ignited nothing further was heard from the satellite). We suspect, although it has never been clearly proven, that there was a catastrophic failure in the propulsion system. However, after that time Synchom technology got off its knees and you see that there have been a number of satellites launched, all of which are continuing to operate successfully, despite the fact that they were never designed for any real lifetime. You will also note that certain of these spacecraft have had an extremely high amount of operating time in terms of hours, namely the synchronous satellites, Syncom II and Syncom III. We will admit to being quite prejudice to Syncom satellites and we feel that their utility is very great compared to other types, as borne out by the chart.

The two Syncoms are currently in use by our armed forces in the Viet Nam area at the present time, continuing to operate 23 hours a day since launch. On many occasions it is the only communication we have to that area. Perhaps you are well aware that about the time we were readying the Syncom III for launch the Communication Satellite Corporation was formed by the Congress of the United States as a commercial venture to exploit satellite communications in conjunction with the International Consortium, of which it is a part. The executive and administrative agent decided to initiate commercial communications across the North Atlantic via a synchronous satellite, which came to be known as Early Bird Satellite. The Early Bird is very similar to the earlier Syncom satellites, weighs approximately the same and uses the same booster. It has a little more power in its solar cells and in its transmit capability. It currently sits over the Atlantic, as it has since April of this year. (1965). It, too, has been operating some 23 hours a day since its launch, about 14 or 15 of these hours are available to public use. The lines are leased by the common carriers in the United States and Europe. The satellite has a capacity for 240

simultaneous voice channels across the North Atlantic and as such it contributes 50% more channels than were heretofore available via all the cables combined. Now there is an economic reason for going to satellites as well as being a thrilling adventure into space, and this is best illustrated by a recent full page add in Wall Street Journal which announced that the new cable had been completed across the Atlantic at a cost of 50 million dollars and it would carry 138 voice channels. It didn't say that it didn't have a capability for television, but it did not. Compared to that, the Early Bird Satellite on its station has a capability of 240 channels, as well as television. In fact television may be relayed both directions simultaneously, pictures from the United States going to Europe and those from Europe going to the United States, and its cost in orbit is less than ten million dollars! So this is about a ten to one economy, and our world is still run on the basis of what it costs to do things. There is a great economic reason for going to satellites to handle increased communication requirements, and we expect to see this occurring in ever great proliferation.

The next system that will be put up will be to support the man space flights, such as Gemini, which was attempted this morning. As you well know from listening to the Gemini flights over the radio, there are periods when no one is in touch with the space-craft. It is very difficult, and sometimes impossible, to retrieve the information from the far reaches of the world back here to the United States where decisions can be made affecting the safety of the astronauts. So in an effort to eliminate this problem a system will be put up in the next year. The final decisions are now being made to do so. (Two satellites covering the areas illustrated are to retrieve the data from the overseas locations that are in touch with the astronauts.) I don't think it will be a great step beyond that to have direct communications from the astronaut's spacecraft via the satellite and back. We will eliminate the long periods of anxiety of not hearing from them due to the limitations of present communications.

Also next year a satellite having from 10 to 15 times the communi-cations capacity of Early Bird is programmed to be launched. It is not really designed to be a communications satellite, but designed to be a bus to carry experiments. It is called the Applications Technology Satellite. However, as I say, it will have a great increase in capability beyond the Early Bird's factors. We will also have on board (there is a spidery-looking antennas on the bottom) a capability to operate very high frequency (VHF) and communicate directly with aircraft in flight. We have already done this using the earlier syncoms.

The equipment that will be required to operate with this satellite is shown on the right, and has already been built and delivered. Pan American and Trans World Airlines will be testing this capability next year. (1966) This may not have any great significance to many

of you, but aircraft is largely out of touch with land, once over the ocean's of the world. They have high frequency radios, the difficulties of which are best appreciated by those who use them. The airlines have decided they would like to go to satellite communications. Great effort is being made to provide communications to aircraft at all times during their flight around the world. This, of course, will be an international venture. The Comsat Corporation that I spoke of earlier, have also requested proposals from companies around the world. Our satellite proposed for this operation is shown with a built model and tested in our laboratory. When the go ahead is given the system can be put into operation within two years. So within the next two years you can look forward to a complete global capacity. I might add that the satellite for the Apollo and Gemini flights will also be used partly for commercial use and we will have the global communications within a year for them. This satellite will have a capability of a thousand voice channels, in addition to television simultaneously, which in our minds respresents a modest step forward. If we took the satellite shown earlier and modified it completely for a communications mission, one could have a satellite that has perhaps 5000 times as much capability as the earlier Syncoms, or again 100 or more, times the capability of the Early Bird Satellites.

One of the capabilities of such a satellite is that it will no longer be necessary to go to a cable, or a terminal, as we do in the Early Bird and bring all the communications in Europeto one point, and send it out to satellite and receive it in the United States. It will be possible for any point within the view of the satellite to radiate its energy and its communications to the satellite. The satellite merely repeats what it hears in the strictest sense of the word and this is received at all points on the earth. So it will be possible to connect in a way, heretofore, impossible every point on earth with every other point on the earth, without going through these communications centers.

You may be aware that if you are on the east coast of Africa, and wish to talk to the west coast, your conversation is relayed via Europe, because the communications have been set up by European concerns and also all the cables and links are north-south direction. This sort of difficulty will be eliminated by the satellite. I think the only impact upon the average man will be a tremendous cost saving in communications. The chart shows that the satellite will cost about $20,000 a year per channel, when all other means of communication are saturated. Now you can currently lease a channel across the Atlantic for a quarter of a million dollars a year. To the man on the street who puts his dime in the slot, the cost per minute to call anywhere within the range of the satellite starts off at about 50¢. This compares to $4.00 a minute to call Europe at the present time. Things don't do anything but get better after that, as the capacity increases, so the requirements increase. You see that you get down to the point where "please deposit your dime, your call to Africa is ready" is not so far fetched. I think one of

our scientist said the other day, we shouldn't really attempt to determine the communications requirements by conventional means, we should analyze postal interchange, because that really defines who wants to talk to whom. With communications of this type you will almost be able to talk to someone as cheaply as you can mail a letter. What this will do to the communications requirements is hard to visualize.

You may also be aware that the major networks of the United States have expressed an interest in relaying their programs around the United States by means of satellite. Currently these programs are relayed by a net of microwave cables. The program material originating in New York and Los Angeles is distributed to perhaps 200 affliates around the United States. Because of the time zones, and the fact that you want to sell snow tires in Main and bathing suits in Los Angeles, there are four or five channels required for the different commercials. The current cost to a network of leasing it from the existing facilities is about 12 million dollars a year for this type of service. Our evaluations indicate that this would cost about one half the current cost to these networks by substituting a single satellite hovering over United States. Some of the things you might see appearing around the country in such a circumstance would look like this picture. On the left are the originating stations, perhaps one in Los Angeles and one in New York, depending on the individual networks. Down at the affliates a smaller stationary antenna would be pointed at the satellite. These would be the type of terminals that would be involved and they are available at a surprisingly modest cost due to the fact that they can just sit there, like your home TV antenna, pointing at the station requiring no one to move it. Now with this possibility in a country which is as rich in communications as the United States is, it is not surprising that in some of the lesser developed nations of the world, a great interest has been expressed in using satellites for their internal communications.

We spoke this morning of the overcrowding of the world. One thing that these nations have found is, that despite the fact that there is a lot of land available, people will not migrate to points where there is no communication. Canada is typical of this. People will not go northward. (Perhaps weather has a lot to do with it too,) but people will not go out of range of communications. They have gotten used to telephones and television and they will not go to these remote areas without them. I think this is the case in Australia, Brazil and many other nations of the world. We are crowding into areas where there is communication and there has not been any migration to areas without communication. A number of governments are studying the possibility of installing very modest size terminals in these far reaches of the world to tie them together communication-wise with the rest of the world or even within one nation.

I am sure that many of you who have been in missionary work in various parts of the world recognize the inadequacy of our present communication system. Those of us who live here in the United States do not really appreciate how much communication we really have. Another interesting idea being discussed very seriously is the possibility of providing educational television to the under developed areas of the world via satellites. What this chart attempts to show are the two satellites that can cover something like two billion or two and a half billion people in the world. They could provide to all those areas, five hours of educational television during the day. The equipment that is required on the ground can be made very modest. The type of antenna required at any location in view of the satellite is just a small six foot dish mounted permanently on top of the building, or what have you, providing television to the students in that area.

I don't profess to know the fundamental benefits of educational television. I don't think it has been especially successful here in the United States since we do have quite a population of teachers. The problem of the under developed countries is having enough teachers to educate their population. With such a system a single teacher , say in Mexico City, could be the best linguist in Spanish and talk to virtually every student in Mexico; or the best lecturer in mathematics can be made available to the humblest school in the country. One of the difficulties in getting good teachers is that once they are trained, they tend to stay in the city. It is hard to get them to go back out. I was talking to a fellow about the U.S. Student Exchange program and he said, "We have a lot of students coming into the United States, they settle here and they don't go back." They come to the United States and don't want to go back to their home country, so in a sense, it has depleted the resources of their country more than if they hadn't come at all. So this could be alleviated in that the best instruction could be provided in these remote areas. It seemed to us that this holds a tremendous potential.

Another thought has been to put these in the hands of our Peace Corps people overseas as an addition to their other capabilities. Going beyond their own personal knowledge, they could then draw upon the best resources of the United States during the day for specialized courses. Since these satellites do cover a large area, time and lingual difficulties are present. It will be necessary (and indeed is possible) to have multiple languages inserted so that those in different countries can listen in their own language. I think we see very quickly that the language problem can be a limitation in communications.

I was interested in the optimism expressed previously on translating elements as I think this is about the first limitation that we will come to; the people's inability to talk to one another. They will have the means, but language will be a great difficulty.

I think you can also visualize that there are many other uses that I haven't touched upon. We heard this morning of the ability to store 500 books in a small storage device. Well, you can also transmit 500 books in about the same length of time, or 5000 books, or have data retrieval from a central library available to anyone without the cost of storing them, through communications of this type. The possibility of relaying data to central computers has also been discussed. I think you can see that we have been very conservative today in projecting what can be done. We have not talked about anything that we could not initiate at this time and have available within two years. Perhaps next year we will have a whole host of new ideas to present. One does not have to project very far to see that the Early Bird and the satellites are but a small peeping voice telling you of the communications explosion that is possible in the very near future.

P A N E L

SYNCHRONOUS COMMUNICATION SATELLITES

by

William F. Bakemeyer

Question: What kind of problems are associated with having large numbers of people work together to try to solve the fantastic technical problems that are associated with this kind of undertaking?

W.F. Bakemeyer: There is a tremendous problem of communicating amongst the various technical people required to make up such systems. I am proud of the fact that our system is a simple one. That's the reason it's so successful, but even under that circumstance there are a tremendous number of specialities required, each requiring a man of very high motivation to keep abreast of his technology. Not only must he do that but he must also be able to communicate with others interested in putting all these special capabilities together. I guess I would be the generalist (although I don't mean to have the attributes described this morning by J.R. Moore) but there must be a mix between the specialist and someone of a more general capability who is looking to the outside world and beyond his own technology to ascertain what problems are there that need to be solved. It is very easy to solve a problem. But it is also very likely that you can solve a problem that doesn't need to be solved. One of the problems in an engineering society is doing just that. There are many people who will solve problems that you don't need to have solved and will spend a lot of time doing it. We try to control this to an extent but you can't do it to a very great extent.

Hughes has been called one of the largest corporate democracies in the United States and I certainly think that is the case. The individual is given a tremenous amount of freedom to think of the new areas of his technology. The synchronous satellite we have been discussing was conceived in the minds of one or two people, You saw their photographs, Dr. Rosen and some others and they had tremendous difficulty,even within our company, convincing the management that this was a worthwhile project to work on. In fact it got to one point where one of these individuals, a young fellow, went to the general manager of the Hughes Aircraft Company with a certified check for $10,000 which represented his life's savings and he said, "I have been unable to convince you to work on this program, so I would like to make the first contribution to such a program." Well, needless to say his contribution was not accepted, but it brought home the dedication of these individuals in belief of their ideas. Shortly after that

the company did apply some of its own private capital to this venture.

I guess to generalize, the people that work on these programs are some of the most highly motivated people that I have run across. They are not adverse to working long hours. They go far beyond the financial remuneration that is given to them and I think that Dr. Rosen in particular has a great public spirit. He is interested in this educational television not because of the financial rewards that might come to him or to his company. He thinks it would be a great boon to society.

Question: This is perhaps an obvious question: How do <u>you</u> define a "systems approach" to a problem?

W.F. Bakemeyer: Well, I'm sure better heads than mine have attempted to prepare a difinition of this nature. To me the systems approach to these problems is to first grasp all aspects of the problem. It's surprising that this must be grasped in generally a few heads, a few people, and I think heretofore most of these technical advances have been accomplished by very few people. Now the difficulty, and the reason why there is so much emphasis on a systems approach to these complex systems, is that the system becomes more complex. One man's ability to comprehend all this fails him and so there have been elaborate managerial plans drawn up. I think the Air Force's plan as we mentioned earlier is the most documented plan. It is sort of an orderly process by which each of these specialty technical areas will document their views in relation to the remainder of the problem. I think this is one of the largest management problems in technology today. It is the ability to take these very large teams of people, very large spectrum of capabilities that are required, and get them to function as a team together, communicating with one another.

The systems approach to me is the perfect conception of the problem, conception of a potential solution, modeling of such a solution, the interplay between all of these specialists who must contribute to the solution and the administration and management of that operation.

Question: You spoke of the satellite for military communication. Yet the possibility of using this for such an operation as the Peace Corps is still in the future. What do you see as the principle barriers that have to be overcome in order to make it as easily used for this kind of thing as it is for military operations now?

W.F. Bakemeyer: There are many factors brought about by the regulations in our society. For example: What agencies should do this? Should this be the government? Should this be a private commercial venture? Should this be done by an international body? Or should this be done by a single nation? Well, apparently there are only two single nations that could undertake such a program, ourselves and the Russians. One of our concerns has been that they will regiment a potential and implement it while we are fumbling at the gate, so to speak, deciding how to do it. How to do it administratively and within our political and social, moral standards? We give them such questions as "Is it truly international?" "Should the United States take part with other nations?" "Should the United States attempt to go out and provide this aid program to the foreign countries?" "Does it get the taste of propaganda under such a method?" "How much authority over the satellite should be vested in the using country?" "Should the using country originate the programs that go to to its own students?" Certainly I think most nations would want to control the program material that went to their own students. Someone else might control the satellite, turn it off and on and so on. Largely we are not deterred from doing this on technical grounds. It's a question of political and administrative nature as to who should do it. What does this imply in the future? Big brother looking over you could be the satellite telling you what to think and eat and so on and that's the fear of many people. The nations which need satellite educational services, of course, are the ones that can leap before it happens. The United States can put an educational television satellite over us and use it for educational television in California. There would be no international ramifications at all. But we are not the ones that need it the most. It's needed by those countries that really cannot afford it. Do you give this to them? Do you sell it to them? How do you handle that? Whereas in the military case it's pretty clear that we want to have our own communication capability in our own hands and under our own control. It's just a matter of deciding what to do and when to do it.

Question: The previous speaker made a comment that the strongest motivation that we have to do things, apparently, is the fear motivation. That we really have invested money in all these things largely for our national defense. I think you mentioned that the Department of Defense is heavily involved in the underlying expense in so much of this. You spoke and illustrated very beautifully in these last statements concerning the potential for peace, international accord and goodwill. We in the church are particularly concerned about this. My basic question along this line would be this: As long as the Department of Defense (I am not opposing this, and am not critizing this) is so heavily and necessarily involved in providing the funds for

these programs, even with commercial institutions like Hughes Aircraft doing what they do, is it conceivable that we will ever move to the point where we don't have to look to government financing that's concerned with military affairs, in order to release this thing from primarily military or defense considerations so that it could be fundamentally an instrument of peace?

W.F. Bakemeyer: The Thor booster, used to launch the satellite, is now obsolete from the military point of view but you continue to use it in the space program. The Department of Defense, as such, contributed none of the satellite costs. The technology that was discussed here today has been through NASA. Now that may be a subtle distinction. It's still government, but the technology I have spoken of here has been through the NASA rather than the Air Force. The ground stations (and you saw the military people running the ground stations) are owned and operated by the Department of Defense, as least those which were used in the early Sycoms. But getting on to your former question, you are raising the same questions that were raised at the time of the Communication Satellite Act and when the Comsat Corporation was formed. It was decided at that time that this should be privately owned and pursued with private funds. The Comsat Corporation is 6% owned by the general public. Perhaps many in this room; 6% owned by the common carriers of the United States. Now, that entity then went to overseas governments, with the help and assistance of the State Department in seeking further funding. Now, because of the varying political beliefs of the other foreign governments, some of that private funding is coming from overseas and from foreign governments and some are from commercial entities in those governments. At this time these things are done by private funding. The only hinderance to that at the moment is that there is only one capability for launching spacecraft and that's owned by the U.S. Government, the United States. And even the Comsat Corporation must go to NASA to have its boosters launched.

There have been studies done by commercial booster manufacturers who were ready, willing and eager to establish their own privately owned booster facilities at their own expense and deliver any purchaser wanting it, a satellite in space. It would underwrite the risk of failure as well as the rewards of success. You are bringing up what is currently being tested in the courts at this time. The American Broadcasting Corporation has filed with the FCC to establish a TV distribution system of the type that I described and this is currently being debated as to whether it will be allowable that a private concern be permitted to establish a communication system covering the United States. I heard last week the chief engineer of the FCC discussing this problem and he raised such questions: "Is it in the public interest to have this vested in a commercial concern or shouldn't this be better done by the government?" I think there is plenty of capital available. Certainly the Comsat stock was bought up awfully quick and jumped up shortly thereafter. There is a lot of technical feasibility. What will control this will be the

regulations passed down by the FCC and the United States Government as to what extent this will be privately owned versus government owned.

Question: You used the word capability like some of us preachers use some theological terms. We would like to have you expand upon the word capability.

W.F. Bakemeyer: Well, the best proof is in the execution. I must have an over-simplified impression of what you are asking because my reaction is perhaps too simple. Every man is more or less his own island, as far as proving his inherent capability to those about him. I suppose you would say that by demonstrated aptitude and ability to either perform analysis on paper, which prove later to be correct in practice, or to devise experiements in the laboratory which prove later to have been properly conceived. This judgment is constantly going on. There is a far greater emphasis upon the ability of the individual than there is to his seniority or his age. The ability, I think you would say, comes first. It is measured, not by the individual supervisor alone, but by the consensus of all those that work with him.

Question: Is there a means whereby the various ones that are specializing know what the total objective is?

W.F. Bakemeyer: Well, that varys from individual to individual and from group to group. It's very difficult to make a generalization about a large organization. The means by which the individual is acquainted with the overall problem is generally through what we call a program organization. It has this interest first to develop the system of the spacecraft or the complete effort. It is their job to communicate to the other people what the overall mission is. This is done by internal talks similar to this one or by written materials. But mostly by technical specifications of what is required for the complete job.

Question: Just a moment ago you mentioned some of the court discussions on the legal aspects of the Comsat Corporation. I wonder if you could help us to understand some of the laws that may have to do with the satellites that we are putting up, or some of the explorations that we are making?

W.F. Bakemeyer: There are space laws in effect today requiring international agreement on the frequencies that you will transmit at. To date this is a voluntary cooperation

among nations, not enforceable except by social or equivalent authorization of the nation. I don't know of any other than the efforts of the United Nations and the treaties that have been reached between nations of any body of space law that has been established to date.

Question: Could some other nation get the Syncom satellite out of orbit?

W.F. Bakemeyer: Yes, they could and this has worried us. In fact a ham radio operator could do it and we have been greatly concerned about that.

Question: Tell us how?

W.F. Bakemeyer: This was an unclassified program. There was no attempt to preserve secrecy as to any of the methods of control of the satellite. In fact, they exist in many books which we and NASA have long ago lost control over. Some energetic individual, even if he didn't have the books, could probably cut and try a little bit and learn how to maneuver or turn off our satellite, or do all sorts of nasty things. In fact he could even transmit his own messages through it, and by and large, we wouldn't know where it came from or where it was going. Thus far there has been no evidence of anyone attempting to tamper with any of the satellites. It's a tribute to real cooperation between peoples on a voluntary basis.

Question: An implication seems to be coming out of all that we have heard so far today. A good bit of what John Moore was talking about and what we have heard with respect to this communication satellite and also your definition of a systems approach: all of these things are telling us that these are ways in which the capacities of one single individual man can be extended. Our brains can be extended. Our sensory apparatus, our thinking, our decision making process. All of this I find very interesting, also a little bit disturbing. It's something I hadn't thought about much before.

My question is this. Do satellites like Syncom now only transmit, in other words is there any holding capability in a satellite so that a program could be put into one and then held for a length of time and transmitted later?

W.F. Bakemeyer: Certainly it can be done. It is being done in military applications today. The satellites of the type that I

spoke of here today, however, have been wnat we call repeaters. We transmit to it and it merely repeats back out. Such as a little radio, you might say, and is transmitted at the other side of it. There is no appreciable delay and there is no storing of information or intelligence within the satellite itself. This is very possible to do this but it has not been considered very seriously for communications purposes.

Question: You were talking about time differences in the world with respect to educational television. Would you comment on this?

W.F. Bakemeyer: The satellite program might be shown here at dawn, in West Africa that evening, and so forth, so if those two areas of the earth want to look at the same program you would have a time difference problem. Someone is just getting up while the other fellow is getting ready for bed.

I N T R O D U C T I O N

for

Dr. Andreas D.Rechnitzer

Dr. Rechnizter received his B.S. in 1947 from Michigan State, his M.A. in 1951 from the University of California and his Ph.D. from the University of California, Scripps Institution of Oceanography.

He joined North American Aviation, Inc., Autonetics Division, in 1961 and is now the Chief Scientist Deep Submergence Systems. In this position he holds a key responsibility in directing the company's expansion into the whole field of oceanology.

As scientist in charge and coordinator of the U.S. Navy Bathyscaph program,he was awarded the Navy Department's Distinguished Civilian Service Award by President Eisenhower in February, 1960 at the White House. This was for his significant contribution to the field of oceanography. In 1961 he also received the International Underwater Film Festival Award for Outstanding Contributions to Underwater Photography.

In 1961, in Chicago, he was presented the Gold Medal for scientific accomplishments in geography, by the Geographical Society of Chicago.

We recall that the bathyscaph Trieste conquered inner space only as recently as January of 1960, we can better realize that Dr. Rechnitzer has been, and is, in the forefront of his field. He was also recipient of Special Commendation from the Commanding Officer and Director of the U.S. Navy Electronics Laboratory, and received a special commendation from the Guam Legislature. He was selected twice as the outstanding young man of the year by the San Diego Junior Chamber of Commerce.

Prior to coming to NAA he was Deep Submergence Program Coordinator and Physical Oceanographer at the U.S. Navy Electronics Laboratory, San Diego. Before that, he was a Research Staff Member, University of California, Scripps Institution of Oceanography, La Jolla, California. He is also Scientific Advisor, Science Advisory Committee at the California State College, Fullerton.

He is a Commander in the USNR. He was Chairman of Cub Scout Pack 108 in Fullerton! His list of publications would take too long to read. He is one of the men in our nation who is at the cutting edge of bringing into being a NATIONAL program of Ocean Exploration...if I may editorialize...he may some day be known as the "Von Braun of the Oceans".

He, too, accepted this speaking engagement with interest and enthusiasm. He will talk on "New Discoveries in Oceanology"..... Dr. Rechnitizer.....

NEW DISCOVERIES IN OCEANOLOGY

by

Dr. Andreas B. Rechnitzer

I'm sure glad Ed didn't introduce me as one who has sunk to lower levels than anyone else in this room! I did go down to 19,000 feet in the ocean and some might feel that perhaps I've been closer to the devil than anyone else. But actually it is scientific fact that my colleagues from the Navy Electronics Laboratory were twice as close to the center of the earth as they were riding in the warmth and comfort of a submarine beneath the North Pole. In fact it wasn't too well known a few years ago that our earth is not a perfect sphere but an oblique spheroid. Another way of saying it is that it's squat, and consequently at the North Pole the diameter of the earth is about 28 miles less.

John Moore mentioned this morning that there is a need for a generalist. I think I probably fit into this category. After working at North American for three years with engineers, worrying about new vehicles which we call systems, my boss called me in, (being a fellow Scandinavian we were on pretty good terms) and he said "Say Andy, what did you get your degree in, Physics, Math, or Engineering?" And I sat back a little chagrined and was silent for a moment and said, "No sir, I have three degrees and they are all in Zoology!" To be more specific, I am an ichthyologist, sometimes known as an ichthyologian. It's awfully tempting to get off on to the subject of ichthyology because this represents one of the most fascinating groups of animals in the world. It actually led me into deep submergence and participating in the deep dives of the bathyscaphe. If it hadn't been ichthyology and the desire to get out of Michigan and back to California, I probably would have been working on insects. We may take great pride in the fact that there are many of us and we are all different, but I'll have you know that there is nearly a half million different species of insects. These organisms are so varied and so strange that it's well that some people pay heed to them and not just to the flies and mosquitoes. In another area I trained as a zoologist. I worked in physical oceanography. Now I am in the field of engineering. After working all those years and spending twelve years in college to get a PHD in ichthyology and zoology, I haven't practiced in the field.

Having a broad exposure to a lot of the sciences is mandatory for an oceanographer because oceanography can be defined as a field activity and not a science. It is the campus and the arena where people trained in physics, biology, chemistry, geology, and combinations of these geochemistry, biogeochemistry and so forth: this is the place where they go to work to apply the techniques that they have learned. They work in an environment which has many intriguing things to offer in the way of new discoveries. It is somewhat ironic that we have to wait this far in man's history to really begin to know and understand the ocean.

So like all scientists and friends of scientists we must feel awe struck at the breathless pace of scientific discovery of truth. What is scientific truth? A man would be rash indeed to accept current scientific ideas as immutable truths. And I think perhaps that is one of the problems that we as laymen have with the church in communicating, in sematics, in interpretation, is to understand the truths you people are trying to relay to us, those of us who are specializing in other areas.

Our generation has seen the conservation of matter dissolve into a generalized conservation of energy. Whereas lengths of a thousand atomic diameters are at the limit of visibility with the best light microscopes, the electron microscope has pushed back this limit to ten atomic diameters. With the electron emission microscope we go still further and see the individual atom inside a molecule. Of course, X ray and electron defraction techniques sometime ago enabled us to deduce the structure from the measured distances between atoms, but man has not pushed far beyond this frontier toward the infinitely small. The nucleus with a diameter of one 100,000 of that of the atom is open to exploration. Scattering experiments and radioactive decay are revealing the structure of the nucleus itself and there is no apparent end to this exploration in the direction of the infinitely small. In the direction of the infinitely large, telescopes reveal bodies which lie two billion light years away, and there is no reason to support that there are obstacles to seeing further, other than those due to the quality of our telescopes. The red shift, a term that I am sure I won't take time to define, indicates that the universe is continuing to expand. If the galaxies originated in a compressed state and have since expanded, our universe must be billions of years old.

The geological record we find on earth, and the complex evidence from radioactive decay, suggest around five billion years as the age of our solar system. That's a long, long time. How do we know this? We find that everywhere we turn

we are confronted by clocks and thermometers screaming with times and temperatures of past and passing events. A case in point, using radioactive carbon and normal carbon, we have been looking into Indian villages along the coast and in these villages are old refuse heaps in which we find sea shells. Sea shells of organisms that no longer live along the coast adjacent to these refuse sites, but live more to the north of Point Conception and these are found in Baja California. Going in we can find that the Indians were here as long as 21,000 years ago, right on the Scripps campus and other places along the coast. In addition, from another combination, or ratio, we find the temperature of the ocean at the time these sea shells were laid down by comparing the oxygen 16 oxygen 18 ratio. So not only do we get the age but we get the temperature, the mean temperature, of the ocean back in prehistoric times. The only real problem here is to read these ratios correctly. Radioactive decay, such as the change of uranium into lead, proceeds independently of the low temperatures here on earth so that from certain ratios the geologist can construct a geological time scale that goes back $4\frac{1}{2}$ billion years. This time scale is something the educated man must consider in fitting himself into the scheme of things. In Africa we found that man was here in the vicinity of 175,000 years ago.

With the launching of satellites, man has begun the conquest of space. But actually Sir Isaac Newton using his own mechanics and gravitational theory could have told us all about the orbital behavior of satellites 300 years ago. Now we have mechanized to realize the truths he discovered. Space travel is here and man has at least in a small way taken the beginning step in the discovery of a new world.

To the religiously inclined, like myself, this is just one more step in an eternal progression. But I have to relay to you at this point a remark made to me by one of my fellow colleagues that ' how can you be a scientist and have religion ?' The question could be turned around and say, 'how can you not have religion and be a scientist'. It comes back to a communication problem. I don't think there is a naturalist alive that doesn't fully appreciate, probably more than anyone else, the wonders of nature and wonder of life in all its variations, complexities.

It has been stated that perhaps the coming decade will be a decade for biology. Most of the other sciences have had their heyday, particularly chemistry and physics. Maybe the next 10 or 20 years will be like the heyday for biology. Many of

these fields are being discussed in various press media today in magazines, journals, newspapers. In genetics there have been great advances and discoveries DNA and RNA. Here again is the intermingling of the biochemist, the life chemist and the tools of mathematics and computers that help with these studies.

The day of the individual who can come up with, and be a creative individual and bring something startling to the world, seems to be receding. It takes more of a group effort and more a melting of man's talents to achieve great things. In the area of oceanography this is not still the case because it was Professor Piccard who opened outer space and the singular man also opened up inner space.

But where is science taking us? Many people are more than a little dismayed at the scientific gene that has escaped into the world, possessing unbridled power for both good and evil. Where will all these discoveries take us? Most of us applaud the freedom from want and the leisure that science and technology bring to us today. But along with these benefits come the spectre of nuclear, chemical and biological warfare which could bring an end to civilization.

Science is like a rollercoaster which frightens and fascinates those who ride it. If all goes well, it gives its devotees a thrill and an exhilarating ride. If things go wrong, those who ride it as well as those who are just standing by may pay the supreme penalty. The natural impulse is to just try to bring such a powerful force under control or to abolish it. Unfortunately, it is impossible to completely separate the benefits of science from the risks. Since we are unwilling to forego the benefits, we are saddled with the risks. Nobody can predict with certainty whether or not we will continue to move from one scientific success to another in a never unending triumph, or whether civilization will come to an untimely end in a series of firey atomic explosions.

The risks we face are unnerving but since there is no longer any place to hide we are necessarily all in this adventure together. The only thing to do is to work for a happy ending. So endth the evening's sermon!

Note: Following these remarks, Dr. Rechnitzer spoke for an hour using many colored slides and film. Since pictures are necessary to properly illustrate the material, the text will not be included here. The lecture covered oceanography.

P A N E L

NEW DISCOVERIES IN OCEANOLOGY

by

Dr. Andreas B. Rechnitzer

Question: Can you define two things for me that I didn't understand? You talked about "convection cells" in the center of the earth and you used the word"krill", what do they mean?

Dr. Rechnitzer: (Sometimes I feel just as baffled in church). These convection cells that I referred to might be witnessed, I suppose, on your kitchen stove when water begins to come to a boil. You see the cells of water beginning to move up from the driving force of heat from below. We do believe that the core of the earth is a molten mass and that we do have comparable motion. It's very slow and very sluggish, but it is taking place. Those of you who have mixed a can of aluminum paint might have seen the same thing. You see the particles drifting around and we have no set pattern. It's like smoke boiling up into the sky.

There are many organisms in the sea, which, regardless of their size, are the mercy of the current. They can include large objects, such as the large jellyfishes, or the very tiny plants and animals. The single cell ones live in the ocean and cannot swim strongly enough to move upstream. Krill refers to a group of shrimp-like creatures that live in the ocean. They are small shrimp about an inch long that actually exist in huge clouds in the ocean, grouping together, and the whales come through and scoop these up. They take a mouthful and squirt the water out and hold on to the shrimp.

Question: I was interested in your comment, Dr. Rechnitzer, with regard to some of the international legal problems that may be involved in oceanology. You indicated that exploration of the bottom of the ocean on continental shelves adjacent to land masses is given to the continent to which they are adjacent, while the water above are open waters beyond three miles out. I suppose that may create some real problems of conflict between nations.

Without governmental funding, which is obviously now primarily for the purposes of national defense, what are the chances of private industry for peaceful purposes really moving into the field and developing? You mentioned some companies that were already showing some interest. Is this really a possibility?

Dr. Rechnitzer: Exploitation of any resource is dependant on the supply and demand formula. If someone is willing to pay for it you will go ahead and extract that resource for profit. For example,

we've stop mining gold for the most part, unless it is a very rich lode, because it is just not economically feasible to do so. The carrot has been dangled in front of the commercial community in the form of manganese and phosphorite, and there will be attempts to develop the technology to economically extract these from the ocean. In the case of diamonds in the Delta areas in Africa, it is economically feasible to do so. Although they are getting some 60,000 to 100,000 dollars worth of diamonds a month, sea operations are expensive, and I don't know that they are clearing a great amount of money.

The problem in the North Sea became very acute about a year ago when they began drilling for oil and hitting a few gas pockets. There was a hint that there may be a resource of oil there, so they had to settle on the question very quickly as to who owns what. The lines are a little peculiarly drawn out there, but for the most part they are extension of the natural border of the country. In the case of England, it's an island, and she doesn't have any straight lines running in any direction for her sovereignty or extending her sovereignty out into the ocean. In our case, like between Mexico and Baja California, we draw a straight line out. Even locally, we get into problem areas in that the state of California is hasseling with the federal government as to who owns the waters and the reserves between San Pedro and Catalina. The State of California wanted to draw a three miles limit from points out three miles beyond the channel islands, and then get to a point down off the international border. That took in a lot of off shore property. The federal government didn't see it that way and so we lost it. This is a perennial problem and we all see the same situation with the shrimping industry. Where do these lines rest? The other problem comes in if you really want to maintain sovereignty on every piece of property you better be ready to protect it, and as far as the deep sea is concerned, no one is really in that position yet.

Question: My question has to do with the sea as a potential for food?

Dr. Rechnitzer: Who is the expert? I stated a little earlier that the oceans are not a particularly good producer. There are resources out there, however, that have not been tapped in the most effective manner.

I would point out that to work any piece of capital, or land, you do it in this manner. For your investment you expect a reasonable capital gain each year. That's what you take home and spend. When we go after a natural resource we should do exactly the same thing. We have to leave enough root stock there to perpetuate that resource and only take the capital gain. Now, can you define the capital? This is very difficult because we do not really know the extent of these resources. What kind of population of sardines, anchovies, tuna, halibut, do we have out there? Then to compound the problem we have to look at what mother nature might do about our taking some of that root stock away periodically. As you know, there are natural catastrophies where temperature might change radically, or some food resource might go down for them, so that they'll die off naturally. Well, we don't want to lose that proteim, we want to

harvest it. So the conservationists, the bureaus of commercial fisheries, sport fisheries, department of fish and game, these people, are constantly working on this problem and trying to maintain a satisfactory balance. If we over fish a given resource, such as we did the sardine, there is a good chance that we may eliminate it completely, or drive it to a point where the "creditors" will come in and eliminate it.

We don't always know what the minimum number or minimum population for any species might be. I can illustrate this with a little Bobwhite in the east coast (which we studied when I was in Michigan). They have a procedure in the wintertime to keep warm. A covey will get together and all stand in a circle with their tails out. The ones that are cold move to the inside and pretty soon they get warm all over; then those with cold rumps move into the middle and they get warmed. But, when you get down to a population of three, that's the end of them!

Question: Would you shed some light on possible physiological changes in man, even as there have been some physiological changes in the astronauts as they circle the earth in a weightless condition.

Dr. Rechnitzer: Well, I can speak as an expert on that one, because two of the aquanauts visited my office last week, and it turns out that there are some very interesting changes that occur in these individuals. Number one, the metabolic rate apparently went up about 20 per cent. Their heart beat went up from 72 to about 90. The food consumption went up. Every time they went by the refrigerator the door was pulled open and they went in for food. Despite this abnormal amount of food consumption, however, their weight went down. Their oxygen consumption went up from about 260 liter per day to about 300. All this was not due so much to pressure, but they were having to live in a helium, oxygen, nitrogen atmosphere instead of air. Well, helium draws off heat from the body about six times faster than air. So all the time that they were in the hut despite the 83 degree temperature and 75 humidity, they were constantly radiating heat away from their body. They also had trouble sleeping. They worked eighteen hours a day, but were unable to complete all the chores that had been assigned to them. Despite this rigorous schedule, they found it difficult to sleep. They would wake up at night in a cold sweat in spite of the fact the temperature was up. Earlier experiments also showed that their red blood cell count went down. When a man moves to high altitudes, within about four days the blood cell count goes up to accommodate for the reduced amount of oxygen that is present at high altitudes. In this case, it goes in the other direction because there is usually more oxygen present in this environment. They performed very well and as far as their work effectiveness was concerned, their mental capabilities were excellent; they were very sharp; they were able to carry out psychological tests rapidly and their vision was even (they felt) somewhat improved.

There was a psychological impact on these fellows. They were all seasoned divers, but when they left Sea Lab and went out for a little sortie,

they carried along a line like Tom Sawyer in the cave, so when they decided to turn around and go back they could follow the string. But as they went along and could no longer see Sea Lab (this meant they had to be away a few hundred feet), they would think, "where is Sea Lab, where is Sea Lab"? They fully realized that they could not go to the surface and their only retreat was to go back to Sea Lab. The gas supply on their back was their only livelihood until they could get back to Sea Lab. They apparently enjoyed their stay, but there were certain implications here that suggest that they were worried, and rightly so.

Now, as far as human occupation for extended periods, this will be done initially for commercial purposes. There is great advantage in staying down at that depth and not going through this long, tedious decompression cycle of some six hours, because once you go down, you can stay there, (we now know) for at least a month. Scott Carpenter stayed for a month and one of the other navy personnel stayed for a full month at 205 feet. All the other aquanauts were only there for two weeks. We figure they can stay there that long and work extensive periods, and then they only have to go through one decompression period. Heretofore, they would go down and work fifteen minutes and then take eight to twelve hours to decompress, so that the amount of effective work done was very short,. As far as making a livelihood and staying down there, it is going to be quite a problem. Actually, the boys complained that they spent 90% of their time just taking care of the logistics chores. You know, they had a porpoise down there awhile delivering mail. The boys didn't think much of that experiment though, they thought it was an awful waste of time, but they got a lot of publicity for the program.

Question: You were not under pressure in the Trieste?

Dr. Rechnitzer: No, we were in the same pressure that you enjoy in this room. Because of the terrific pressures that are involved, and the fact that man cannot withstand significant pressures, there was no point in making any change. We talk about this in "atmospheres", which in here is 14.7 pounds at sea level. At the bottom of the Marianna straits, it is an even one thousand, so we are only good for a few atmospheres and then we get into trouble with air, and we have to go to the helium mixes, consequently the structure had to be made strong enough to withstand it.

Let me tell you a little story. When we made the first 18,000 foot dive, it went off without a hitch except that we got very cold. We were sopping wet at the surface and this was because it was nice and warm up there, the water was 85, the air was 85, but when we got down to the bottom, it was 37½ degrees. I felt like I had been walking around in a snow bank it got so cold inside. But we came back to the surface and were quite elated that we had again seen daylight. At that moment there were two loud explosions; or at least I thought they were explosions, and my eyes shifted immediately to the depth gauge, because I thought we were going to make another record dive back to the bottom! But we stayed afloat. Fifteen minutes later we had the ante-chamber open and Picard

went up on deck to look around, but saw nothing wrong. He said, 'Looks fine up here, close the door and come on out!" I came out gladly. Well, we towed the craft back into the harbor and the next morning, we opened up the sphere and found several gallons of water inside. This sphere had been made in Germany and had been bonded together with epoxy resis. This is this new super glue. It had parted company with itself and the only thing that kept that sphere from opening up like a walnut shell were the steel bands that held it to the float! We didn't tell anyone back home what had happened and we made repairs. After that we made fifteen more dives with the craft.

Question: What is the energy potential of sub mantle heat?

Dr. Rechnitzer: Well, I guess the answer is how far down do you want to go for this heat? Actually we have little reason to go after this source of energy because a lot of it comes right up to us anyway. Around a crater in Hawaii they use this steam to heat the hotel. I have forgotten exactly what the temperature rise is per foot, as you go down into the depths, but I think that to spend millions on a little heat that we can easily get out here in the desert is hardly worthwhile.

Question: Could you comment on some of the materials that are under investigation for submersibles?

Dr. Rechnitzer: Material for pressure hulls to protect human beings is, of course, the old standby steel. We then move into thick aluminum, then titanium and beryllium, which has one bad feature, it's quite poisonous when it's being machined. Then we go to a filament wound reinforced plastic, which is nothing more than taking the old knitting technique, and wrapping up glass fibres and impregnating them with resin, epoxy and then finally to glass itself. The latter are good candidates, except that as far as I am concerned I don't want to ride around in a glass sphere. I am kind of afraid of that material, but there is extensive research going on to determine whether or not it will be possible to produce a working pressure sphere made of glass.

You might have noticed that in the motion picture, we had quite a few shots of the sea floor. These were taken through a plexiglass window. We use plexiglass rather than glass, or pyrex, or sapphire. The vitrous materials become very brittle under high pressure and if there is any grain of sand, or a point where there is a stress concentration these will get up to a point where they will shatter, and that is the end of it. However, plastics tend to relieve their stresses, so plexiglass, despite its softness and weak mechanical strength, makes a very fine window. It also has the same refractive index as water, so as you look through a 7 inch thick piece, you're really not conscious of it being there. Some of the photographs you saw were taken through that window. I made the comment at Punahou High School on my way back from Guam, that the windows were actually stronger than the sphere itself. In the question period some youngster said, "Well, why didn't you build it all out of windows?"

Question: Well, why didn't you?

Dr. Rechnitzer: This is being attempted. At the Pacific Missile Range there is a group of freelance thinkers building an all plexiglass sphere. They will have segments of plexiglass glued together, and if the pressure is applied proportionately it will tend to hold these together.

Question: There is a question here, sir, that seems to say there may be some rather serious moral implications in our space exploration, our medical exploration, and science exploration, that the church must grapple with. This gentleman is saying that he doesn't feel there may be as much of a moral problem with the inner-space exploration. Would you comment?

Dr. Rechnitzer: I don't think that I am going to evoke the 5th Amendment. I may miss the point here, but I will attempt to answer the question. The moral problems, or the man against man problems, man understanding man, is going to be compounded in inner space to an extent. (I don't think we will have to worry about outer space, except to be nice to those people if they ever come down). With the population explosion there is going to be a greater return to the sea for its resources. As an avenue of communications, it will provide some real problems in communicating across, from nation to nation, that will really be magnified. The community (when we say it in a different way, the world is getting smaller and smaller. Cross fertilization, communications between countries is becoming more frequent and much easier.

We go back to the old adage the British had, that he who controls the seas, controls the world. I'll draw to your attention, the Russians are pressing us for being number one in our small field of oceanography. They are moving rapidly ahead to be number one in fishery. They are virtually number one in the maritime. They are working very hard with their satellite countries to provide themselves with a major maritime fleet while ours is going right down the drain. They are, of course, very strong in submarines. Their activities in the ocean....they are everywhere and there must be a reason for it. Of course, they have one good reason in that their productivity at home has not come up to par. This we have read time and time again. Their wheat harvest has been down. They have a large need for a good source of protein and they will take it from the sea. We are not faced with this as we have lots of beef steak to eat, and lots of protein, but as you look at the protein problem around the world, the other countries are not as well off. There are problems in India. They do not like to eat sea food. They will eat food from fresh water, but not things that come from the sea. This is part of their religion. The ironic thing in our country is this: when we go to the market you pay 60,70 cents a pound for fish when, you can produce a high quality protein flour from anchovies that could feed everyone in this room for two cents a day! Fishmeal, which has been reduced to flour, can be incorporated into any of our bakery products, but we can't sell it in this country because it is a <u>whole</u> fish that has been ground up and chemically reduced to this protein concentrate. In other places in the world that would not be a problem.

Question: On this matter of Russia's being in the oceanography game too, is there any possibility of pooling cooperation for the sake of pure truth and the like?

Dr. Rechnitzer: Here is where the oceanographers shine over all the politicians in this country. We have, without a doubt, established excellent rapport with the Russian oceanographers, and this cooperative exchange of information has been going on smoothly without a hitch. They have had their problems in getting information out. For us to send scientific paper in, is never a problem, but we usually have to wait for them to come out from behind the iron curtain, to some international meeting, then they pass information on. It is even getting easier now. We have a National Oceanographic Data Center established in Washington, and also an International Oceanographic Data Center, where the information is pooled from cooperating countries around the world, and that includes Russia.

Question: Would you comment on the oceanographist, if that's the word, as a vocation for the future. Whether it is a possibility? What sort of training is required? How long and where? (This is a pastor who wants to become an oceanographer).

Dr. Rechnitzer: Well, the future appears to be fairly bright. I can't help but be optimistic about it. On the other hand, I wouldn't want to pass on the impression that it is something that is here today, that there are endless opportunities and things are getting better. Now as far as training is concerned, this is a very simple formula. A basic background in any of the sciences at a liberal arts college puts you in a good position to move on into graduate training. There is no point in going into oceanography unless you will go for an advance degree and preferable the Ph.D. There are plenty of people who can take over the technician's job, but there are too few at the top. At the present time the population of oceanographers in the United States is about 500. The annual input of new Ph.D.'s is about ten. Most of these, ironically, have come (in the last few years) from Texas A.& M.

Where? Well, again it goes back to the fact that almost any good college can put you in a good position to go into oceanography. As you heard earlier, it involves all the disciplines. If you have a whim for physics, fine, or for engineering, mathematics or biology. Most of the oceanographers are biologists and an individual will have to bridge all of these disciplines, though, when he winds up in graduate training. For instance, at Scripps, the four basic courses you have to take are geology, chemistry, biology and physical oceanography. So the "generalist" approach comes out very strongly in this area of oceanography. As far as where is concerned: the University of Washington, the Scripps Institution, Texas A.&M., the University of Miami or the University of Rhode Island. Many of the old institutions on the east coast have the capability of turning out a Ph. D. in oceanography. When I took my

degree, if you couldn't cut it in zoology, you took oceanography. Now it is much more popular to be an oceanographer and the zoologist is pushed off to the side. I can't belabor that point, but I personally feel very strongly about this education for young oceanographers and also for advanced education. There is simply no substitute for getting lots of it behind you.

I N T R O D U C T I O N

for

Dr. Thomas B. Weber

Dr. Weber received his B.S. in Chemistry from Oklahoma State University, His M.S. in Biochemistry and his Ph.D. in Biochemistry from Louisiana State University.

He is a member of: American Association for the Advancement of Science
American Association of Clinical Chemists
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He is the Manager of Advanced Technology Operations, Beckman Instruments, Fullerton. Beckman is known throughout the world for their work in bio-instrumentation.

He has authored over 50 publications. In his assignment at Beckman, he is out on the leading edge of a thrust into the future of medical instrumentation. He spent several weeks this summer at the International Conference on Bio Medical Electronic Instrumentation where he evaluated recent advances in this field.

Prior to Beckman, he was at the USAF Aerospace Medical Center, Brooks Air Force Base. Research here included instrumentation for biomedical investigations: such as, cryogenic collecting systems, gas analyzers for atmospheric respiratory studies and mechanisms for isolating body fluids.

He has also served as head of the Biochemistry Department of the Naval Dental Research Facility, concerned, among other things, with the isolation and identification of trace constituents in body secretions.

For his Doctorate he was an AEC fellow and studied the effects of radio-isotopes on biological systems.

He has served as consultant to universities and industries in the United States and around the world. Like many other speakers, Dr. Weber accepted this speaking assignment with great enthusiasm and interest. He has a genuine spirit of adventure!

He will speak to us on "How Man Measures Man"...Dr. Thomas Weber....

HOW MAN MEASURES MAN

by

Dr. Thomas B. Weber

Measurement is the basis of all knowledge according to Lord Kelvin. For many years man has monitored and accurately measured many elements in his surroundings. More recently he has decided that it is time to measure man. What was considered only a novelty for use under adverse conditions only a few years ago, today is becoming a routine mamouth task. Instrumentation requirements in order to measure all aspects of man is on the order of one billion dollars a year. The statement that 90% of all scientists are alive and practicing today is well established; however, the fantastic growth rate in the biomedical areas is only now become apparent. Presently there are over 7,000 journals devoted strictly to the biomedical sciences. Much of this deals specifically with the equipment necessary to accurately evaluate and measure the changes induced in man.

This morning I would like to discuss with you the latest innovations in this measurement. These innovations are essentially that which has taken place within the last ten years, and, in some instances, the last ten months or ten weeks. The era of measurement of man is basically of this decade; the sounding 60's. Equipment and means used for this problem as late as the 40's or 50's is essentially a museum piece today. Measurement of man only 20 years ago was a crude and primitive procedure. Basically this included instrumentation that was cumbersome, difficult to regulate and even more difficult to interpret.

The Cell

The very basis of man, that of the living cell, as many of you may recall, only 20 years ago was described, and quite accurately so for the time, as an inner and outer part. The inner part was called the nucleus and the outer part the cytoplasm. There were also numerous inclusions within the cell and names were assigned to them, but no function had been relegated to them. Today in any modern biomedical or biological textbook the cell has come to life. The particles have been named and vividly described and functions have been assigned to them. This is the result of man monitoring man. In all of the popular journals today the terms RNA and DNA, ribonucleic acid and desoxribonucleic acid are common terms used to indicate the transmitters of inheritance and the tying in with genetics and propogation of life. These are depicted now within specific parts of the cell. Areas where high energy is made available is now known and definite assignments have been given to the mitochrondrial structures.

A whole new field has been envisioned and developed strictly on the cell. It has now become a powerful diagnostic tool. The pathologists uses

exfoliative cytology as a means for the early diagnosis of many diseases. The Papanicolaou smear, for example, is an early and accurate indication of cancer of the cervix. Cytochemical studies have arisen where it is now possible by diverse chromatogenic methods to specifically assay many of the numerous enzymes and enzyme systems of the cell. This is truly an accomplishment. An enzyme is a relatively large molecule which is sent to accelerate or catalyze specific chemical transformation. We commonly think of them as aid in the digestion of foods and the breakdown in complex substances for digestive and/or metabolic processes. Many of these enzymes have a molecular weight of literally millions. These enzymes generally exist as enzyme systems, that is, a series of large molecules which react in microseconds or a millionith of a second and carry out metabolic transformations. Where do all these metabolic changes take place? Naturally, with the cell. The human body is composed of billions of such cells. Each cell in itself contains enzyme systems. If man tried to duplicate an enzyme system, that is, set up a factory, it would probably be built on an area of one square mile, would entail innumberable amounts and kinds of equipment and would require hundreds of people to operate. Its efficiency would only be a fraction that of what takes place within a single cell. The single cell is truly a remarkable achievement. This is the building block and it is this entity, a special created entity, on which the basis of man monitoring is based.

Predictive Medicine

Measurement is the basis of all knowlege. We have built and worked on this premise for many years. Only recently, however, has the equipment and the knowledge and desire been made available to check specific physiological and biochemical changes in health and disease. While we have spent considerable time looking at the stars, looking at the ocean, looking at rocks, we have now come forward with the simple statement that it is time to critically and scientifically look at man. A new and important science, which is only now emerging and which will become increasingly commonplace, is that of predictive medicine. Predictive medicine is predicated on the basis of establishing normal values within man, then carefully assaying slight changes of certain components and physical characteristics and then saying that man is ill. With the (1) increased present-day requirements of our health programs, with the (2) increased age of individuals within the country, the (3) increasing demand placed on the technical people in the biomedical area and (4) with medicare and related programs, it becomes imperative to establish the parameters on which to handle the vast health requirements. Predictive medicine appears to be a possible solution. This bioscience consists of establishing baselines months or years before the healthy individual becomes a patient. The components in the blood of certain physiological measurements can be established. They can be documented and compared at intervals of once or twice a year. When a variation is ultimately noted, then that serves as an immediate warning sign. The diagnostician would counsel the individual "Certain fatty acids or triglycerides in your blood have increased, the shape of the S wave on the electrocardiogram has changed and, as such, that an indication that an impeding cardiovascular disease will befall you if changes are not made."

Fortunately, there are remedial methods to follow. You may change your diet, you may initiate an exercise program, or otherwise alter your present processes. By this alteration you will avoid this impending cardiac malady. Hence, by predictive medicine we are able to establish deterioration, maladaptation or malignancy within the individual before the advent of clinical manifestations.

Predictive medicine is a possibility today, and not yesterday, because of three major advances. The first of these is new instrumentation, new bioanalytical methods which are available to monitor man and to monitor body fluid and biopotentials from man. These instruments, such as gas chromatographs, electrophoresis and ultracentrifugates, make it possible to monitor materials on the levels of one part in a billion or one part in a trillion or even greater. In fact, in the last two years it has been necessary to coin new terms to meet these minute levels. For example, one formerly talked of grams and milligrams and then the time came when we spoke of micrograms, a.e., a millionth of a gram. Now we are talking about a millionth-millionth of a gram and we use such words, and they are becoming commonplace in the literature, such as nanograms and picograms. Through bioanalytical instrumentation it has become possible to accurately monitor extremely minute changes in the components within man. The ever so slight changes are extremely important to man's health.

A second major innovation we are finding is that there are meaningful body materials other than the conventional blood and urine which gives us new, diagnostic insight. We briefly mentioned that most information that is available in singie cells, such as cytochemistry and exfoliative cytology. Additionally, there are other body fluids that are now being routinely used as powerful diagnostic tools. These include, for example, the saliva of man and its components, perspiration and even expired air. The values of these for diagnosis is that they are continuously emitted and, as such, can be continously measured. Secondly, it is possible to affix sensors to measure the breath, the saliva or the effluents from the body surface. These are non-stressful and can remain affixed indefinately and the stressful situation of blood-letting with a hypodermic needle or confining the patient to a small area is negated.

The third big advent that has made this new and facinating field of predictive medicine a reality is the ability to handle large volumes of data. We are all acutely aware of the computer operations of data handling and retrieval. This is obviously necessary since ennumerable samples are being collected and rapid readout must be achieved. We now have data handling systems that can utilize a half-million bits of information per second.

Predictive medicine is now a reality: we have the sensitive tools, we can take these sensitive tools and monitor continuous effluents of man under nonstressful conditions, this mass of data can be rapidly fed to large data handling systems and the final analysis is a series of meaningful indicators on the status of health of a specific individual.

New Instrumentation

A brief discussion on some of the more pertinent new instrumentation that has become available can be made. That is, instrumentation that was new to us less than ten years ago and is obviously still in its infancy but it has already proved by innumerable applications its reliability, its sensitivity, and hence its value as a mean of measuring man.

Gas Chromatography and Electrodes

I mentioned earlier, these two modern innovations which are essentially so-called little magic black boxes. It is possible to put in a sample of material and through various physical and chemical procedures separate the material into separate and distinct components. With gas chromatography there is what is known as a packed column. This column has different retention times for select components and they are eluted from this column at different times and passed over a sensor. Such things as hormones and steroids and many other biologicals in the body are separated in this manner. Electrophoresis applies the same principle. A small sample of a body fluid is placed on a select medium, with a buffered solution, a charge applied to it and the conglomerate separates out into discreet entities. This is used routinely for blood analysis and is diagnostic for diseases within the blood. It rapidly tells of the various albumin and globulin fractious.

Thermography

A new and facinating field is that of thermography. This is also known as differential thermal analysis and microcalorimetry and entails the measurement of extremely slight changes in temperature. The field of cryogenics, the antithesis of this, is well established here and is now being used for hypothermia studies as the temperature is depressed to the extreme cold to the region slightly above absolute zero molecular and subatomic particle studies are conducted. Thermography in the measurement of man is finding widespread uses. The diagnosis of tumors or malignancies is routinely responsing since health tissue is easily measured.

Abnormal growths within the body consist of aberrent cells and tissues and they generally have a slightly higher temperature, maybe only a thousandth of a degree, but with a sensitive thermopile we can now see this difference and immediately read a signal in all areas of the body. A newer concept is that there are even slight temperature changes between benign and malignant tumors. So here it may be possible to diagnose the type tumor even before the surgeon gets a chance to see and examine it searchingly.

Another important area of thermography is that of fertilization. We talk about, and are acutely aware of probably the greatest problem facing civilization today. The exploding population problem has been with us for

many years. It was discussed hundreds of years ago, but it was less than 70 years ago that we actually became aware of conception. This was the first time that the union of the sperm and the ovum had ever been explained. It is now possible by slight temperature changes to observe the time of ovulation and also the time of actual penetration of the sperm into the ovum. This can be carefully programmed and made meaningful. Extremely effective contraceptive drugs that have been developed which have been shown to be effective and non toxic only within the last 3 or 4 years. We observe conception and know how to eliminate it. Here is obviously an area where theology and science must get together and define what parameters will be established.

Ultrasonics, something like a sonar principle, is another new and meaningful tool for the measuring of man. For example, with ultrasonic instrumentation it is possible to locate all types of abnormal growths and foreign bodies within the body and normal as well. For example, with an ultrasonic system it is possible to get a complete outline of the heart working outside the body. All the wave undulations and configurations of the brain are shown and anatomical shapes as well as various lesions or abnormal growths are indicated by this method. It is also possible to locate such things as bullets that have become lodged in the body and other foreign objects.

Trace Contaminants

With our great sensitivities in measurements we have opened this new and meaningful field of trace detection of metabolites of minor elements and gases that profoundly affect the body. For example, we have compiled over 400 materials that are known to be given off by man in variable amounts. We have located with our advanced bioanalytical instrumentation extremely small amounts of metals, like cobalt, magnesium, and zinc that profoundly affect the normal operation of man. As a result of this advanced assay we can determine how much man should have to keep him in a normal metabolic manner and detect any nutritional or degenerative diseased state.

Predicitive Dentristry

As a result of the same advances for predictive medicine, we are now opening up the vast and meaningful field of predictive dentistry. Certain determinations have shown that it is now possible to predict such things as periodontitis and gingivitis, that is, the diseases of the hard and soft structures of the mouth, based on incipient chemical changes that are diagnosed in the fluids or tissues within the mouth, or even the expired air. Here is a very meaningful field for all of us who have had toothaches or have had periodontal involvement. It is one where we have one hundred thousand professional people using tools that have not materially changed for 100 years. If you don't think they are primitive, take a look at their chisels and drills. All of this is being changed as the result of tools soon to be made available for this profession.

Aerospace

The big trend to aerospace had obviously had profound influence on sophisticated, new and novel ways of measuring man. Dr. Hoover will describe that more fully. As a result of all these space applications, so-called spin-offs have resulted in numerable tools that can be used in more mundane surroundings.

Another area which was developed as a result of thermonuclear war was that of radiation medicine, specifically, radioisotopes. Radioisotopes have found thousands of uses in their ability to monitor man. Man can drink these isotopes, they can be injected into man, they can be inhaled, or can enter the body by almost any route. Within the body they can be continually measured, or the rate which they are excreted from the body is measurable. As such, it is possible to quanititively look at the metabolic processes and say, yes, this is normal, or this is abnormal, or this organ or system is not operating within a physiological range. This has been made possible by the recent development in counter attached to sensors which can be placed at any site on the body and easily monitor any type of radiation whether it is alpha, beta, or gamma rays or a combination thereof. Again this tool was made available 20 years ago but only within the past 3, 4 or 5 years has critical assay at very low levels, whereby dangerous levels are negated, been made available for the function tests or tests which are used to accurately portray the performance of man by monitoring his activity and monitoring changes in critical systems and monitoring performance decrement as well. Conventionally we have placed man on a supine, basal and sedentary condition and measured certain body processes. Today we find that these are largely of limited value and to accurately determine what man is doing, observe him in his normally active state. That is, put him on a treadmill walking,running or doing step tests, or put him on a centrifuge, or tilt table. Activate the subject and get the cariovascular system performing biodynamics. Then take these various measurements and observe pronounced changes between the normal and the pathological cases. Today this is possible as a result of two advances. One is the monitoring under the non-stressful conditions the various body fluids and body components which were mentioned earlier. A second is the ability to monitor many of the physiological functions, that is, heart rate, brain waves, respiration, etc., with unattached sensors or with sensors that read out by telemetry so that man is unencumbered. Now it is possible to get accurate readings of these, whereas 20 years ago we couldn't make the readings at all. Now they are made under typical environmental conditions.

Ultracentrifugation

Many years ago components were separated by twirling a container at the end of a string. That was probably the first introduction to centrifugation. Then it became possible to turn a hand crank and revolve these things into the substances, at probably 100 revolutions a minute. With electrical power a few thousand revolutions per minute were obtained. Now we have ultra-centrifugation, on the order of hundreds of thousands of revolutions per minute under a variety of conditions of controlled temperature and

pressure. By this method it is now possible to take body tissue fluids and cellular components and separate them into discreet layers and differentiate components that go into the making up of chromosomes and other minute particles. Here is another powerful analytical tool for biochemical and genetic studies and even more important the study of the life processes. Such materials as viruses are separated in this manner where there is acutally nothing more than the separation into discreet layers of genetic transfer of material. Here we are gaining insight into man. We are measuring at a critical level and it is here where the basic life processes themselves are being studied. Here is where the spiritual and the secular probably will meet on a common ground, a ground based on thorough knowledge and academic backgrounds, where there is a meaningful place to start and enter a rational disciplinary approach.

Artificial organs are another key area that will assist not only the maintenance of man but his propogation. As a result of our critical and continuous monitoring we can build biological analogs. These analogs not only monitor, control and regulate areas of man, but even more importantly they serve in lieu of the original organ which had to be excised for a variety of reasons. To date it has been possible to build artificial kidneys. There is an intensive study now in building an artificial heart. Ultimately it would be possible to build a simulated organ for almost any part of the body. The key to this is an accurate quantitative measurement of the functions and production of this organ. So now we are talking about not only measuring man but putting prosthetic devices throughout the body and accurately measuring these artificial devices.

Educational Aspects

An all important aspect of man measuring man, and one which has an analogy with theology, is the education for the operation of instrumentation to monitor man. It is not only necessary to have sophisticated and advanced technological tools but also capable people to operate and interpret these devices. One of the areas in which universities have pioneered in the last 5 years is that of special courses in instrumentation methods or in instrumental methodology. Students at both the graduate and undergraduate level take courses learning how to not only operate these tools which is a minor part of the problem, but also to interpret and to prescribe the theory of operations of these tools. People must be taught to appreciate and learn the limits of instrumentation. The value of measuring man is limited by the persons doing the interpretation and the meaningfulness of interpretation. It is utterly fruitless to try to monitor and interpret esoteric and exotic data when the sensitivity of the instrument or the reliability of parameters are severely limited.

Another area in instrumentation of education is the actual design and construction of instruments for specific educational uses. A research or scientific tool is expensive and must be restricted to those doing advanced work in the field. An economic instrument or its components

which would accomplish essentially the same thing could be offered to the student in the university with the understanding that, here is your tool, learn it and make it meaningful to you.

A recent advance for rapid and semi-quantitative measurement in a normal and diseased state has been the introduction of diagnostic sticks, tabs and kits. These are pre-mixed, pre-imbedded, or previously prepared papers or mixtures which allow a rapid analysis of man for a specific substance. They are often employed for diagnosis of such things as uremia, diabetes, and a host of other diseases. These are packaged in a small compartment, opened and immersed in a body fluid sample. An immediate color reaction is elicited which can be compared to a standard and in a matter of seconds it is possible to note changes from the normal range. This will find and is finding now, widespread application in the home as a do-it-yourself packet. In the future much of the diagnosis and measurement of man will be made by man on himself in his home at his leisure. It will be possible to critically check on a variety of disease conditions. For example, one of the main killers today of both adults and children is diabetes where it is necessary to know at all times the sugar level in the body. It has become commonplace now to take a body sample, the body fluid may be saliva, urine, perspiration or blood and apply it to a sensor or diagnostic kit and immediately get an accurate reading on the current level. If an aberrant value is observed then immediately the patient is sent to the hospital. It is probable in the near future that this can be done for most of the common diseases and for many of the infectious and degenerative diseases so that it will be a simple matter for a subject who has a diathesis towards a disease to critically monitor himself as a routine with his morning hygienic ritual. This diagnosis will probably be more accurate than could have been made by the best team of physicians 10 years ago.

Data Handling

Ultimately for man as a result of advancements directed toward his measurements is a small card probably to be carried in his possession at all times which will give a complete picture of him and all of his critical values. An individual would visit a predictive medicine center, for example, for a group of routine tests to establish his specific biochemical signature. These values would be determined by automated bio-analytical equipment and the data would be handled by computers. With this information a diagnostician would evaluate the data and advise the subject of any potential condition which might threaten his health. The subject would then be directed to change a basic pattern or habits, is warrented.

This biochemical signature would be coded on an identification card and would stay with the individual at all times. It would be up-dated periodically for the continued prognosis and diagnosis and for the determination of his body or chemical profile.

Micro Sampling and Measuring

A significant facet of man measuring man is the recent tendency toward microanalytical procedures that have developed for the analysis of body fluids and tissues. Formerly we talked in terms of getting several ounces of blood to do determinations. With a single drop of blood or other body fluid 15 or 20 determinations can be made. This microanalytical procedure has obviously several advantages including that of not debilitating man in the collection. It is ultimately useful with,for example, very sick individuals and in children, where limited amounts are available. By the same token, earlier workers used ponderous, encumbering equipment to measure the heart, respiration or brain waves. Now we do all of these measurements with a simple bit of equipment including the electronics, the sensor, and even the readout will weigh only 2 or 3 pounds and can be worn routinely on the body.

What has instrumentation to do with the pastor and the church laymen. (1) He must learn the fundamentals of this fruitful area. He must update his thinking to go in accord with current knowledge and retain the attention of those working in this area as well as those outside this area. Illuminate those not knowledgeable on this remarkable and mushrooming concept, and more importantly, inter-relate it to other dogma. (2) It is now time to initiate an interdisciplinarian approach. The social scientist, the theologian, must work and live with the physical scientist, the instrumentation engineer and reach accord with them. This is possible only by the mutual interest, respect and exchange of ideas to convey and establish common grounds of semantics. It is necessary to understand at least in part the fundamentals of the basic working tools of your counterpart. (3) The theologian can make direct usage of instrumentation and it will materially assist him as it has done in the medical world, the dental world, the scientific world, in his day-to-day operations. For example, if the theologian would run and interpret the brain waves of members of his congregation and make this meaningful by computerized data, he would be able to see while in church that (a) the subject is alert and if so is his arousal a result of the sermon or the message that is being conveyed, or is he distracted or asleep. This would show up on the brain wave. Additionally (b) how is he responding emotionally to a key point, that is, not only is he awake, alert, and listening, but is this being meaningful and affecting him. It should be possible to show that this along with other characteristics is arousing a response and that the minister is doing his job of conveying the message to the subject. (4) It is possible to conceive that this instrumentation will ultimately be routine and will be accompanied by the individual in his everyday life. Those afflicted with debilitating conditions will be forced to have portable instrumentation. It is critical to the biomedical types as well as to the minister and others engaged in religion to know and recognize this and to define and in case of emergency be able to assist this individual in the operation and the proper performance of this valuable equipment.

In summary, an inter-disciplinarian approach is necessary for the scientist and the theologian. Through this mutual understanding and cooperation in the ability to monitor man, it will be possible to open up a complete new facet in our everyday lives.

P A N E L

HOW MAN MEASURES MAN

by

Dr. Thomas B. Weber

Question: Do you see the use of physiology profiles as a de-personalizing factor or an increase in the awareness of individuality?

Dr. Weber: The physiological and biochemical profile are in themselves separate and distinct entities. From these we should be able to tell a diversity of things about man. Obviously we are not taking away any of man's liberties when we do physical studies on him. I didn't cover an area that is tremendously important, that of the psychiatric aspects. We feel it is possible to diagnose many of the mental diseases today by biochemical changes. This is actively being pursued at places like John Hopkins and Spring Green Hospital in Maryland. Perhaps some of man's individualities and his rights may be taken away if you characterize him but you are in no way making him an automaton. It would be foolish if he doesn't participate.

Question: One of the areas of concern in the dialogue between science and religion had to do with the problems of the epistemology and also with problems of ethics. It was suggested out here a moment ago that what our speaker said could well lead to some changes in our translation of the Scriptures such as "Let not your plastic hearts be troubled." "You believe in science believe also in me".

I am wondering now in terms of the inter-disciplinary suggestion that you made whether or not you feel that it is possible for the clergy to be enough educated in all of these things to be helpful to their parishioners? Secondly, can the scientists and the clergy find the time together to be helpful in recognizing this kind of thing?

Dr. Weber: The adage is that if you want something to get done give it to a man that is extremely busy and he'll find time to do it. Yes, I think this interdisciplinary approach is feasible. I feel we can find time and I believe there is a commonality of meeting ground. For example, at the Physiological Congress meeting I attended there were seven Nobel laureates there. I had an opportunity to talk with five of them. Obviously these people are brilliant. That was the first observation. Number two, they were all bio-politicians so they could communicate at every level. Now what I am proposing is not for the clergy to forsake the ministry and get a Ph.D or an M.D. and five years of residency! What I am saying is that by spending time with scientific groups in mutual exchange it will be possible for the minister to gain new insights and new knowledge. We're not all that far apart on what the needs are. The layman could obviously participate too. Many of the church laymen are themselves scientists and it might be feasible for

for them to instruct the non-scientist within the group. Since this is such a tremendous problem and there is such a tremendous impact I think that this interdisciplinary approach is absolutely essential. If nothing more comes out of my lecture than just this, I will be satisfied. I think if it can be initiated, if a germ, or an embryo, can be set along these lines it will have been well worthwhile.

Question: Well, Dr. Weber, communication is, of course, always a tremendously interesting concern not only for the minister but for everyone else. These interdisciplinary discussions have already been carried on, as I am sure you are well aware, among psychologists and psychiatrists. We have to communicate with one another, but we also have to communicate with the physical fields with which you are dealing. One of the things that we are primarily concerned with is what do we do with this information? You are concerned with research. You develop deep areas of knowledge that we haven't gone into before. Now, what do we do with this? Of course, you communicate it to those who are going to be able to make some use of it.

Let me be specific. Have these things that you have been doing had much to do with getting an understanding of, for example, the causes of aging in the human body? Are we beginning to understand what happens when the human body ages? What are the implications of this for the future?

Dr. Weber: It was probably about five years ago that I first heard the term geriatrics. It may be older but not much. This problem of aging has come upon us rather rapidly. A prime motivator in this area is the National Institute of Health. There have been a few basic reasearch grants along these lines but this enigma of aging is truly a most perplexing one. It won't be solved easily and one of the reasons that it may not be solved easily is because we don't have good instrumentation for measuring aging. When is a man old? I work with individuals that are 70 years old that think as I do. They are as spry as I am. I work with people that are 30 years old that are stagnant. They want to go home and watch the idiot box. Their contributions are nil. Of all the things you could have picked, aging is the worst. Within the next five years we will get a much closer insight into aging. Through such areas as predictive medicine we are going to establish the physical scientific background for this. We know, or suspect, certain chemicals that cause aging, certain chemicals that bring about loss of vitality of the cardio-vascular system, where we get degenerative nerve cells and so forth. Probably that will turn out to be a chemical reaction. Whether it can be made irreversible is another point.

Question: Being mindful of the "punch and push" approach, finding out what's wrong with you on the inside, and also realizing the need for expediency in finding out what is wrong in some cases, I was quite interested realizing that we've come a long way in diagnosis from such things as the thermometer. How long does it

take to analyze samples in this new approach?

Dr. Weber: The broad spectrum of predictive medicine is predicated on the idea that with the advent of our new capabilities, of our new technology, it should be possible to take samples and do them under dynamic test conditions. Possibly under other conditions and end up with as many as two or three hundred different things to be measured. Most of these will be measured by automated bio-chemical and physiological systems. Over in Sweden, one of the major hospitals has developed a piece of equipment that will monitor 20 substances simultaneously and will do 4,000 an hour. That's just an initial start, and when we say 20 substances these can be a wide gamut of materials. As we improve and increase our technology speed results. For example, here in Long Beach they would initiate a predictive medicine center which would run possible a thousand people a day. The manpower required would be considerable initially but with our automated systems and our ability to handle large volumes of data it's conceivable that a person who would come at eight in the morning would be issued his new chemical profile by ten or eleven o'clock. He would go to a certain place and pick up his new card, which would be something like a draft card. (I'm sure you wouldn't burn this one. Your life may depend on it).

So at the present time we are automating systems. There are systems in use that are automated and we are talking about multiple battery testing in terms of hours and, of course, when you tie it in with a computer, the computer will give you your answers in a matter of a few minutes. So it's a complex of things and ultimately they are going to be inter-related. There are going to be key communications and predictive medicine stations throughout the United States. There will be no other way to handle this and initially it's going to be extremely costly.

Question: Do you feel that in terms of bio-chemistry we will have the ability to predict when a man may die, for example? Supposing a doctor knows, with all these studies, in a few years that this particular individual (assuming everything remains fairly constant in his life) will die in such a such a time. We begin to understand that all these kinds of things are possible for us in terms of the mechanical aspects of dealing with our physical body. What implication does this give that they can literally depend more and more upon the material and so called scientific aspects for their salvation? Will this put a heavier burden upon the church or otherwise?

Dr. Weber: There will be a heavier burden on the church. I feel that scientists are overworked right now. Obviously this is not the final answer and the panacea when we talk about our predictive medicine stations. I think this is probably one of the

most important things for mankind in this country today. There are very few of us around who are not immensely interested in our health.

Here is the point, the place, where we might affect this inter-disciplinary approach. There would certainly be more expected of the clergy because the clergy can fill a vital role here. By the same token the scientist would be more willing to work with the clergy. Just as many of the people in the audience do not understand the scientist, I don't understand the clergy very well either!

Question: One of the questions that has come up in relation to a comment made, Dr. Weber, in the context of your own address concerning some of the possible toxic affects of contraceptive chemicals. We are all concerned with population explosion and what our role is in this both from the moral standpoint and from the standpoint of helping members of congregations understand their role in the emerging society. What are some of the purely medical problems involved in the development of these contraceptive chemicals?

Dr. Weber: The food and drug laws now are extremely stringent for a pharmaceutical house to get a new product on the market. It generally requires many months or even years now. The main problem seems to be that any breakthrough in chemicals that we might have, whether they are vitamins, tranquilizers, or antibiotics, all exert a side affect on the individual. We are very familiar with such things as penicillin rash. Obviously its therapeutic affect justifies a bit of skin allergy, or something such as that. Many of the early contraceptive drugs were found to have quite an adverse affect on the woman and they were pulled from the market.

I may be over cautious, but I am extremely skeptical of any of the new therapeutic remedies that we have because they may be cumulative in nature. They may not even know it for five years. For limiting this population explosion, here again is a very emotional thing. Probably contraceptive drugs can do it, but many of the women with whom I have talked developed a guilt complex and a variety of other things. I would hope that the theologian would have something to offer here. If we don't stem this population explosion there's not going to be any world, possible even within our lifetime. The scientist can offer suggestions, all of which go unheeded and ultimately end up in quarrels and emotional turmoil. I think we must again go back to this inter-disciplinary approach, and say how can we be rational in this limitation. These toxic affects are extremely difficult to detect and they may not show up for twenty years. Fortunately we have a very good watch dog in the Food and Drug Adminstration for all these various pills.

I don't feel that this is the answer to the explosion population and

and one of the questions that I would like to ask this panel -- what is the answer to this? You people should be giving considerable time and effort to this. I am sure you have had panel discussions on it, but we are not making much progress that I can ascertain.

Panel Chairman: Within the last two months I sat down with two people from the Probation Department of the county of Orange and they wanted to discuss with me the possibilities of getting more community support for a birth control clinic approach in our country. I think responsible leadership can be given here by the church. Orange County for the first time has a planned parenthood group and this has happened only within the last year. It has to have church and religious support. I know that in some countries it has been very late coming. Maybe there are other places that don't have a planned parenthood supported activity now, and I think that the church, at least in some areas, has been very helpful. We can go a great deal further in terms of working with other clergy groups, who are perhaps not as well informed yet, or interested. Getting them together to influence the county and the people who are still negative. This is essential and we ought to get behind it. The key point was, what are we doing right now? We're still forming all these committees. This is budgeted. This has dollars and cents in it. The question came up as to whether or not county money should be put into offering prophylactics. To make these available at county expense. This is being done now in the county of Orange.

Question: I was interested in this fact of communication, particularly logistics. There is such a tremendous amount of data being complied. How in the world is this going to be passed on to future generations so that we can build for the future on what we are learning now? Is there a mothod for doing this?

Dr. Weber: There are very good methods. Basically it can all be boiled down into data reduction. We again can thank our computer friends. They can, in essence, take a large body of material and translate it and reduce it. They can even take it in a foreign language. For example, in our country we have today a computer translator. If I want a paper in Russian and want to know the content of it, a computer can translate it for me. It can also be reduced.

For example, you might give a sermon of one hour and a computer would take your complete sermon and reduce it down into thirty seconds!

Question: We need a new doctrine of creation to really appreciate the close ties between God working in this world and what you fellows are doing. I am for a symposium which tells us how to communicate in such a way as to break down the obvious

defense and the old thinking that is somehow jamming up this whole thing. We're all for this improvement, but I realize that the wonderful things that you are telling us stop as we face another man head on. As to whether he is willing, at that point to even hear, is another question.

Dr. Weber: I think you got to the central problem. Not only the problem between the scientist and theologian, but the central problem of all mankind today. Communication. We are basically unable to communicate with each other, even though we may be in extremely related areas. Even though we are doing exactly the same work, and speak a common language. Our semantics are such that things go askew and we become hostile over something where hostility is not indicated, and we condescend when in actuality the fact shows we should violently disagree. Again, there have been many committees set up on this communication bit. I spend three fourths of my time as a scientist writing reports and editing what other people have written. It would be extremely valuable if I could get rid of this burden, but there are truly so few who can communicate. A gifted writer is an extremely valuable asset. I don't consider myself one. I consider myself adequate and most of the people that work for me I consider inadequate. Unfortunately it's my fault. I hired them because they are good scientists and engineers. It's just that they can't write. Solution to this proglem will have to go back to the first grade. We should start there teaching children how to communicate, which we don't. An ideal place might be in the Sunday school.

I N T R O D U C T I O N

for

Dr. George N. Hoover

Dr. Hoover received his Ph.D from the University of California in 1959, with graduate studies on the Davis and Berkeley Campuses. He has authored more than a dozen scientific papers and co-authored a textbook on the physiology of exercise.

He is a member of the American Physiological Society, the American Institute of Aeronautics and Astronautics, and the Aerospace Medical Association.

He is Manager of Systems Support in the Life Sciences Department of the Space and Information System Division of North American Aviation. Prior to this assignment he supervised the Physiology Group, and later was Chief of Biological Research.

Before joining NAA in 1962, he was Assistant Professor of Preventive Medicine at the Ohio State University. While there he held research appointments in the Research Foundation and the Engineering Experiment Station, as well as part time lecturer in the Department of Physiology. Research activities were directed toward the problems of human responses to mechanical vibration, altitude, rapid decompression and exercise.

Teaching responsibilites included environmental physiology for physicians enrolled in the Aviation Medicine Residency Program.

Dr. Hoover has conducted many experiments--- many upon himself. He will speak to us concerning one of the most interesting and far reaching disciplines just now coming into its own---the field of Life Sciences.

His subject....."Life Sciences and the Future of Man", Dr. George Hoover.

LIFE SCIENCES AND MAN'S FUTURE

by

Dr. George Hoover

It has only been in recent years that the civil service commission recognized the biologist as scientist. When the raises were passed around for scientists and engineers, the biologist always seemed to be left out, much to their dismay. But about five years ago, we finally gained formal recognition. To put the material I would like to give you in proper context, I would like to briefly trace the history of a life scientist and its relationship to industry, particularly to our aerospace industry.

In the beginning a biologist was merely an "observationalist". He saw the plants and animals around him and tried to classify them into various kinds. This goes back to some of the quotations in the Bible. As he became more and more sophisticated about his classification, he found that to separate two species, one from the other, he had to get a little more knowledge regarding the functions of the animals, and he began to delve into some of their behavioral aspects, the anatomical aspects and some of their functional aspects.

In this country in the early 1800's and more heavily 1880's, after the land grant college system was established, a full-fledged applied life science began with the marriage of agriculture and biology. It is here we find the most significant advances, in the applied biological sense, in the last 100 years. Another applied biological science was medicine, and as recently as 100 years ago, medicine became an experimental science. Even today as the title and the phrasiology suggests, one practices medicine. It is largely an art instead of a science.

Now in the aerospace industry a unique requirement has come about over the years. Within the development of aircraft, especially in the early 40's and early 50's, it became pretty obvious to the pilots, and to the people who were designing the aircraft, that they needed to know more about how man performed. Even such simple things as how far he could reach, how much work he could do in a given period of time, and so forth. I am thinking of a group of specialists called human factors engineers. Some of these were trained in psychology but by and large most of them were engineers with some piloting experience, who more or less said "I handle it because I can sit down and figure it out." Eventually it became

a more specialized and intensive scientific discipline, to the point where today most of these people are trained engineering psychologists with extensive backgrounds in these particular areas. In the 50's, when the high performance aircraft began going much higher and at higher speeds, the implications of what the environments around these people would do, became more and more apparent and we find the physiologist and biologists coming into the act with a lot of experimentation, particularly in high altitudes. They became concerned with the affect of the "g" forces and the affect of vibration on the ability to perform given tasks. As the pressurized aircraft became a realized goal the affects of decompression, should cabin pressure be lost, and so forth, were added to the inventory of the scientific data being applied to aircraft. This work was readily available and carried through to the development of the jet transports which we use today. We are now looking at the supersonic transports, spacecraft, and a lot of other unique applications of this information. Whether the supersonic transport is the method of transportation or whether the exploration of space is going to continue, doesn't really make too much difference, because for some time we have known that an equivalent altitude of 63,000 feet, man was essentially in space anyway. So anytime we send a man over 63,000 feet we really had him in space insofar as the life scientist is concerned. These mechanisms to protect him are well known and well understood. Most of the effort we are now going through in aerospace research and development is the long term space exploration missions and the unique requirements centered around them.

We find that we have a large group of individuals who, through the process of experience and education and a lot of hard knocks, have fallen into a systems oriented group with a lot of specialized knowledge. The question is what do we do with these people? Do we say to them,"Your jobs are no longer required and you can return to society; a society which has no other particular requirement for your talents in terms of existing jobs." Or, should they be sent to quietly look at the problems existing in the world where their talents might be applied. This latter case has been our philosophy. This is greatly aided, I might add, by the impetus of the great society and has given probably a much more degree of urgency in our thinking and planning than would have occurred on a normal evolutionary basis.

I am sure you have all read in the newspapers and magazines, and a lot of other periodicals, about the term "space fall out". We are very eager and interested in applying new techniques, technologies, new scientific facts learned within the space program, to civilian requirements. The government has a special office for this. Their prime goal is to dig out these technological advancements. To me one of the greatest fallout items that we have is the thing we call "system engineering", the "systems" concept. Now what is a system? System really is made up of two or more things which interact and influence each other. Now under that definition, two of you sitting at a table discussing an emotional fact become a system. You are in fact influencing one another. You may not want to realize it at the time, but as your arguments continue you will find

yourself repeating what your adversary was mentioning earlier. A government is a system, with people interacting. A spacecraft is a system with many, many sub-systems that interact one with the other. Using the engineer to analyze these systems and developing techniques has been a very important factor in establishing some of the space craft requirements. You don't always know when you set down a requirement to the engineer, for example, that instead of a pure oxygen environment we want at least half nitrogen and half oxygen. You may say that this is ideal for our situation, looking at it from a man's point of view, yet the engineer will turn around and say you are out of your mind. This means I have to add 10,000 pounds of nitrogen storage and gas valving. I have to add an equivalent amount of propellent. We can't make it. We then argue for another ten days about how we should compromise. There are methods for this, largely analytical. Fortunately with the use of computers this is a fairly simple technique of identifying each of the components in the major system and assigning values as to how they interact and how they relate one to the other. If one is changed we can calculate the impact all the way down the line. I think those of you who followed the Gemni V Mission recall the impact of the 89¢ heater going out.

So here is the systems concept which gives us the ability not only to look at a second problem and see a solution to that problem directly, but to look at that problem in the context of all that it touches and how a given solution to that problem might interact with some of more peripheral and less thought of things. I have a classic example here. In Australia, I think about 1850, someone decided that he was missing his rabbit hunting very badly from England, so he imported a couple of rabbits. The biggest problem Australia has today is the rabbits eating the grasslands. There was a photograph, I believe it was in Scientific American, of a fence running down across a grange land. It was a rabbit protective fence with lush green grass on one side and a barren desert on the other. The desert side obviously was the rabbit side. Now here is a simple little thing, two rabbits. To compound this situation, some of the far thinking scientists at the time said there is a disease called rabbit fever that we can introduce to the rabbit population. It doesn't affect the sheep and we can let the rabbits communicate the disease and transmit it around the colony and we will wipe out the rabbits. There was a large campaign to introduce the disease to the rabbit population. Someone miscalculated. The sheep did contract it and although it wasn't fatal, it reduced the sheep population and the edibility of the sheep considerably.

It is not always the most direct and the most simple solution, that is the best solution to the problem. We should use another term when we speak of systems and solution to systems problems. It is not the best solution, but the optimum solution. That which is really best with all factors considered.

Now in terms of some of the problems where the life scientist can

use the systems concept are some of the major worldwide problems that we face, not only here but throughout most of the underdeveloped countries as well. Some of the information falls directly from the early programs we had relative to the space programs, but now it has broadened into thinking in terms of large scale solutions. Here is quick indication of the amount of emphasis now being placed in the life sciences within North American. Our Life Science Department at the Space and Information Systems Division is by far the largest and we are running about 325 people.

Now the first step in a systems analysis is to identify the components. Some years ago we were faced with identifying the components in an overall closed ecological system, for long term mission. Perhaps the most significant thing about man, is providing a solution to his waste problems. He generates as much waste as he takes in. Once the food and oxygen is provided, the carbon dioxide and other gases removed, we are still left with a large amount of liquid and solid waste that can either be stored or reclaimed. What we are talking about, if you look carefully, is the food cycle and the waste cycle of the world. Food must be provided, water must be provided, oxygen or atmosphere are quite necessary, the carbon dioxide (that we exhale in every breath) must be in some way eliminated. The waste must be handled and I think if you drive around the country long enough and look at the wastes in the sky; look at the waste piling up along side the roads; look at the amount of land devoted to cut and fill garbage disposal; the amount of facilities devoted to waste disposal and waste treatment, you can see there is a major and significant problem. But even more significantly is the fact that the amount of water available is not endless. I think those of us here in Southern California feel this more acutely than in any other part of the country. In areas of the world where the water supply has not been developed, even though the water available may be more than adequate on a total basis, it is the development of the water supply that counts. There are still a great number of areas with highly significant water problems. In the mid-west and east where the polution of the water is a problem, you find that the available amount of pure water is rapidly decreasing in the United States. More important, food cannot be grown without water. Approximately 90% of the water used in irrigation is lost in the air. The natural process of evaporation, rain run off and so forth is not enough to supply the population as fast as it is growing. It has been estimated that by 1970 there will be a major famine in China, India, and Pakistan. In 1980 a major famine in Africa and South America, unless major steps are taken to avoid it. 1980 is just a little over 15 years from now.

One approach to the problem begins with the use of the simple group of animals known as algae and bacteria. Some of the algae that was tested in the past had very unique characteristics in that they always tasted like fish. Several years ago when I was at the University of California at Davis, I was invited to a reception at the Japanese Council in San Francisco and we were fed an entire tea, including ice cream and cookies, all made from algae. It tasted like fish.

If the esthetic value can be overcome it is a good food source. However, unless the culture permits, as it does in Japan, it is not going to be a major source of food in the United States for some time to come. It is an excellent animal food and one of the major shortages of food in the world is protein. However, animals compete with man for grain foods and for leafy foods. Everytime a step in the food chain is added, such as a step from the plant to an animal to man, a great deal of energy and efficiency is lost in the transfer. It has been estimated that 14% of the available energy that entered the plant from sunlight, is transmitted into the actual production of the cow. This has been somewhat increased, for example, in poultry which is a 50% situation. But there is always a tremendous loss of available energy that comes to the earth from the sun. In such things as corn, you can estimate about 2,000 pounds per acre per year of dry protein. In algae on a per acre basis, the equivalent is about 52,000 pounds per year. As an animal food, algae is highly successful.

Two years ago, we came up with the system of taking domestic waste and culturing it with a large spectrum of algae and bacteria, which will degrade the waste materials, separating it from the water and essentially reclaiming the water. This water is then available for recreation, irrigation and industry, with the biomass (referring to the whole glob of green junk that comes out) as animal feed. The process in itself is not economically feasible if it is only used for animal feed or the reclamation of water. But <u>together</u>, it brings it down to a cost range that is quite acceptable and as we continue to study this, it looks much more acceptable as we go along.

A pilot plant was built adjacent to the Los Angeles County Sanitary District Settling Ponds at Lancaster. Recently we had a feeding trial with chickens, through the cooperation of a friendly chicken farmer whose feed prices got too high. We successfully raised seven batches of 1,000 fryers each. We fed them on a very high algae level. The chickens were fed to a group of individuals, (fortunately I had to be out of town that week), but the results were such that it indicated this would be a very acceptable technique in the feeding of chickens. They fried and boiled them, but there was no evidence of the flavor of the algae coming through. (Now several years ago, I know at the University of California at Davis they used some algae from the Richmond processing plant in feeding their chickens and there was definitely a fishy flavor to the meat in these.) This program has been going on now for two years and we are really just getting up full steam. We have already been approached by several agencies representing Latin American countries and European countries on the application of this process to large scale municipal problems. We can eventually develop and can conceive large scale systems which would adequately handle the food, water and power supply for a fairly good sized town. This is one area of thinking and one direction we are taking with some of the things we have learned. It looks very fruitful and the further we get into it the results become more encouraging.

Another area that we have been thinking of is medical systems. Those of you who have had occasion to be in contact with patients in the hospital recently have heard the woes and the crying, justifiably so, at the cost of hospitalization. You realize that the cost is going up at a fantastic rate. The cost is really not in the techniques and clinical treatment, or in the hardware, beds, and facilities, but in the labor and the number of people required to maintain a hospital. A hospital is a system, as well, and can be completely conceived of as one, and a thorough analysis made in order to cut many corners in terms of labor savings and cost to the patient. Obviously, predictive medicine is a part of this. A good example occurred while I was at Ohio State. An instructor I know, who was an industrial engineer, went in for a gall bladder operation. As he was lying in the hospital watching all the gyrations of the nurses and orderlies and janitors, he began analyzing what they were actually doing. In his own mind he laid out a thinking process. It went something like this: with the myriad of motions they make back and forth through the halls everyday, the locations of various supply depots within these wards, the central supplies, warehousing, etc., there must be a fantastic amount of money tied up in equipment sitting on supply shelves. After he was dismissed from the hospital, he talked to the hospital administration and was told there was about five million dollars in internal inventory. To maintain the hospital there had to be an adequate supply of whatever item was necessary to meet an emergency. Several graduate students thoroughly analyzed the patient load record of the hospital for a two year period. They analyzed their stock records, their warehousing techniques, then went to the computer, programmed it, set up a few pertinent questions and came back with some very significant results. They were able to reduce the inventory on hand (and be able to meet any emergency) with a $500,000 stock inventory. A factor of 10 reduction in the amount of money tied up sitting on the shelves, plus the fact that some of the materials, particularly drugs, had a very short shelf life and had to be replaced frequently.

The army has long since realized that this is a very significant factor and has embarked on a program to develop system oriented hospitals.. We are working on a contract for a mobile field medical laboratory. The concept here is to design a highly mobile laboratory for modern army operations with a maximum laboratory capability, particularly with regards to the number of places in the world we might send troops. This ranges from the Artic to the Tropical areas and you find there are specific diseases in each of these specific locales. This is driving some of our analytical people mad right now. The capabilities, the flexibilities, the mobilities, the rapid set-up, and the adaptability for use in various conditions is a system design problem. Systematically, then, this represents the "mission" (hospital) being loaded on aircraft, flown to a situation, trucked to the laboratory site, unloaded manually and set up rapidly.

Breaking each of the functions down to sub-funtions, sub-systems, the modular concept develops where everything has its place, and

always goes in that particular place. There are replacements on the flexible items that are specialized for different parts of the world. And even within the over all large module we break it down to smaller ones to the point where each specific item of instrumentation is identified, stored, and set up in such a manner that it is there when it is needed and able to do the job. If we extend this kind of thinking to the field hospital, we find that we must also think of the logistic support, the ability to move these things, the ability to bring in replacements for the expendable replacements on the breakage rate, and replacements in terms of expected work loads. In addition to this there are the personnel logistics, which get into such simple things as how much soap is going to be needed for the daily cleansing of the laboratory personnel, how many paper towel will be needed, or is there some other technique which is even better, such as little pre-packed wash and dry units. What are all of the problems and how can we set this up in the most efficient manner? Now the concept thinking in terms of the over all hospital is really in an embryonic stage. It is not simply a concept of "here is the patient", "here is the hospital". We always have to consider that the most influencing factor in clinical treatment is the doctor-patient relationship. You have to provide him with adequate laboratory information regarding his patient's condition; you have to give him adequate room to move around in; adequate support in terms of handling the patient and maintaining cleanliness and maintaining all the aspects of the hospital. Hopefully in a couple of years, if it takes that long, a lot of these things will be identified, but it is taking a great deal of study and a great deal of working around in various hospitals, getting the comments of the people that are actually working in them and looking at their mistakes and trying to do better. It is unfortunate that one of the large organizations in the United States who have been building several hospitals have not hired the same firm of architects twice. Consequently the mistakes in building each hospital have been made over and over again. Once, however, the total concept is developed, we can improve the ability of our hospitals to render personalmedical care at hopefully a more reasonable price.

Earlier Dr. Weber touched briefly on the artificial heart and artificial kidney. Last Saturday night we attended the Southern California Artificial Kidney Foundation benefit at the Ambassador Hotel, and prior to that we had been their guests at a meeting at Veterans Hospital concerning the use and distribution of artificial kidneys in the United States. There are approximately 12 (I believe) in Los Angeles county, and there are about 1,000 in the United States. In severe kidney failure, these are capable of saving a man's life. In milder forms of kidney failure, periodic attachment to the device and more or less cleansing his blood will tend to maintain his livelihood for a good period of time, and maintain him at a level of productivity for society. There is always a severe moral, ethical and legal issue involved in selecting a patient for use in one of these devices. There was a series of articles in the paper not too long ago regarding some of the problems here. The individual charged with making these choices (as one of them said

to me), is literally playing God, because he is making a life or death decision. He is not always certain it is the right one because he cannot be certain the device is going to completely cure the individual he has selected.

Recently the National Institute of Health, particularly the National Heart Institute, established a task force to study artificial hearts. They have gone to industry for a more thorough analysis on a systems basis. What can be done, even to the point of, "is the artificial heart totally feasible"? What kind of an artificial heart can be implanted within a man and have him walking around, free and productive? There have been successful demonstrations of cardiac assist devices, and some mild forms of assiting the heart, in some hospitals around the United States. Perhaps most of you have seen some of this material in the Times. One of the nations foremost surgeons in cardiac surgery in the United States was chairman of the President's committee on heart, stroke and cancer diseases. Again we are going to face, not only the systems analysis, and the development of these particular kinds of hardware, (I believe it can be done in time) but then that tosses the ball back into the moral, ethical and legal aspects of the artificial organs in general.

Some article, not too long ago, discussed the legal aspect of whether to remove one'$ heart and replace it with a mechanical device was not legally murder, since in most states the definition of death is on the beating of the heart. Wrap that one around your brain a few times! Then the question comes up about whether or not we will be able to produce <u>enough</u> artificial hearts so that they can become available to selectively give one to everyone who has recently had a heart attack. When these become available, and I am thinking in terms of other artificial organs as well, the moral issues are going to change a lot of thinking. It is going to change a lot of our thinking and a lot of our education and a lot of our personal beliefs. But, it's not going to be half as drastic as realizing that some day the water that we now flush down the toilet (and runs out through the Hyperion Outfall, which incidently is as pure as the water coming out of the taps in your homes), will some day be fed back in our reservoirs and reused as drinking water. This has actually happened already. This is not esthetically very nice, but at least it is practical, and it raises no real moral issues. It raises some legal issues, yes, but morally, in terms of the artificial organs, there is a lot to be done and gentlemen this is the challenge I leave with you!

P A N E L

THE LIFE SCIENCES AND MAN'S FUTURE

by

Dr. George Hoover

Question: It seemed, as I heard you speaking and talking about systems, that you were talking about efficiency, yet I noticed there was a certain exclusion in all of this regarding probably one of the most inefficient parts, the human being himself. I was wondering, if, within your work, there are certain areas that you do not probe because of the defenses or the moral issues of such?

Dr. Hoover: Possibly we always feel that there is nothing inviolate from the eyes of the scientist. However, there are a lot of things that get in our way that keep our eyes cloudy at times, emotion being one of them. In general, in speaking of the efficiency of man (and this is when you have a man and a system) you must realize his importance to the system. You are right, he is a very inefficient part of the system, and a lot of our effort over the last couple of years has been directed toward defining the performance efficiency of man. Now this is his ability to do a job, not his ability to think, or his ability to react as a responsible citizen. There is a lot of thinking going on now, as a matter of fact I spent yesterday morning with a member of the welfare planning council from Los Angeles, in terms of looking at the population dynamics. Now turning away from the individual for a moment, and looking at group behavior in terms of motivations, in terms of self conscious attitudes, in terms of the general end result, he was pointing out some interesting facts. They have set up two mental health clinics. One was in a Negro area and one was in a Mexican-American area. Neither of these were utilized. But for two totally different reasons. The family unit and the religious staunchness in the areas that they have selected was quite different in both cases. In the Mexican-American group it was much stronger and they felt they didn't need this. They were getting it all either from the church or within their own family. However, in the other area, it was almost nonexistent and they didn't realize they even needed this kind assistance. So here is a group dynamics which gets back to the motivations, the attitudes and to a large extent the total sum of their experiences and their environments. Now this is as far as I can counter because I am really not trained in this area, I am merely repeating what I have heard, so if I am sounding like a parrot,I am. But this is definitely, I think a part of the future responsibility of a life scientist.

Question: I want to read a statement and then get your reaction to it in connection with what you have already said:

"Has science any contribution to make to the solution of the problem of the nature of man? Any such claim must be extremely modest, for the social-psychological sciences are must younger than physics and physiology. Nevertheless, science can do two things which, though modest, can be important. It can challenge the emotional reactions, which political leaders take for granted, by saying that these emotional reactions are appropriate subjects of scientific study and may therefore be capable of modification. Secondly, as scientists international, it can bring together scientists of many nations who are prepared not to take for granted the emotional attitudes of their own society, but to look beyond them in search of the common interest of all nations."

I would like you to comment on both of these two suggestions of ways by which your discipline can make a contribution. I am thinking particularly about the second one of what science learned in Germany under the reign of Hitler where they permitted these scientists to do the kind of things they did. What have we learned, for example, in our discipline comparable to this that can be put to good use?

Dr. Hoover: Let me comment on the first point, before I get into the second. In general, I believe that the entire reason for a scientist to exist is to understand himself and the world around him. Now these are not aways amiable investigations and indeed as we probe deeper into scientific fact for every question that we answer, we ask 10 new questions. Whether we can really make significant contributions in understanding man is not a matter of wide conjecture. I personally feel it can be, otherwise I wouldn't be here. I do feel we have made great strides in the last ten years, partially because there are more people engaged in the activity, partially because the level of sophistication of our investigation has gotten better. At the same time what the systems people call a noise level, (that's a lot of useless information floating around) has increased as well, and this is in large due to the emotional reactions. Other individuals, scientists, clergymen and anyone else, as human beings, are all prone to be emotional animals. Maybe this is what sets us apart from the lower animals. It is the "emotionalities".

The second part is a much more difficult one to understand. In meeting with scientists from other countries they are always eager to understand, always eager to cooperate within the limits of the political restrictions placed on them. It is always possible to sit down and have a good thorough scientific discussion with them without becoming too terribly emotional. Of course, the secret of this is never to attack the individuals own personal work. He is always in love with his own ideas. I think the greatest difficulty we have now is with the language barrier for one. Secondly, there is a lack of funds by which to carry on more of the international meetings and getting people closer together.

And finally to the last question, as to the work that was done in the Nazi regime', I highly recommend for reading, if you haven't already read it, Doctors of Infamy which is essentially a transcript of some of the Nuremburg trials in terms of the human experimentation that was done. Believe me, anyone of us today who touches a human being in an experimental situation is treading on the same thin ice. There is an international code known as the Nuremburg code relative to human experimentation, which was designed to eliminate attrocities that were committed. Many of these were done in the name of science at the time. As far as I am concerned from reading thoroughly the transcripts and the data that was presented, I don't trust the data because the experimental conditions were so poor that usefulness of it is completely questionable.

Panel Chairman: It might be good to add another book to your bibliography if you are interested in this area. A new book called Science and Religion by Shillings. It does a pretty thorough analysis of some of these science and religious questions. It raises some of these moral questions and then discusses them.

Question: We have heard Dr. Hoover talk a little bit about some of the moral implications of the use of artificial organs. I wonder if we could explore this just a little bit further. What are some of the moral implications involved in the use of artificial organs?

Dr. Hoover: I think the first moral question that comes to my mind, (I am speaking strictly as a layman), is "What are we doing by extending a man beyond what would have been a natural death point? What are we really doing?" If he is an Albert Schweitzer or an Einstein who is potentially worth the productivity of a thousand others for the next hundred years, this might have some justification. But there are a whole series of problems that then are generated around extending the useful life of man. I can step back further than that and get into some arguments that go back to the discovery of insulin. You might not think now that the use of insulin is a moral problem, yet it really is to my way of thinking. When insulin was first discovered and began to be used as a therapeutic drug for diabetes, approximately 2% of the population were diabetics. Today, 24% of the population (approximately) in the younger age groups where the insulin type of diabetic shows up most frequently, are potential diabetics, and 12% are actual diabetics. What has happened? This may raise a moral issue. By the people being extended beyond their natural death point, they became part of the population and allowed to retain the genetic characteristic causing this disease in the population as a whole, and it is being transmitted along with all the other genetic characteristics such as hair color, etc. To me this is a moral issue. Is it right or wrong? I am not going to try to answer that one. But it is the same kind of problem.

Suppose an individual at 55 has a very serious heart attack or heart condition which would normally allow him to die predictably in a year or two. You make the decision that he will have an artificial heart, and assuming that these things are going to be reliable, maintainable, and so forth, it could go on beating forever. Assume at the same time that some of the chemical background regarding tissue aging is also known so we don't have the secondary complication, hardening of the arteries, deteriation of tissues. We now have a man who maybe has, by today's society, a few productive years left until he is 65. Biologically at this point in time he has reached a fairly senior position within his company, or within his organization, or whatever he does for a livelihood. Sooner or later they are going to say, ' well it was nice having you around old man, why don't you go out to pasture! Unless he is a real dynamic sort of individual and tries to find a new career after his first retirement, he becomes a nonproductive member of society. Now we have to look at it from the standpoint of society as a whole as well as his own individual desires and his own individual responsibilities. He no longer has a major source of income, his livelihood has essentially stopped, he becomes a ward of the state and the question then is where the systems implications come in. Is the state prepared for the extra ten years that he can produce beyond the point of what would have been a normal life point? Can he produce now to justify carrying him on? Now this is a very hard and cold impersonal evaluation. Yet these are the kinds of things that I think enter into the moral picture aswell as in the purely theological implications of carrying a man beyond his natural death point by interfering with what would normally have occurred.

Question: May I ask you a specific question about food production? Do you anticipate the day will shortly come when food pooduction will be a governmental matter entirely, that is to say that it will be out of the hands of free enterprise and will have to be under social control?

Dr. Hoover: The trend, at least in today's farm industry, as I understand it from the reports that I have been hearing, is toward the large corporation farm, away from the small individual family farm. The corporations are moving in taking over. They can, through their vast holdings and their capital backing, buy large equipment and set up large simple processing facilities, etc. I think as long as this trend is prevalent and the efficiency of food production increases, at least the costs are maintained at a low level (although I don't see that happening too frequently), that the agricultural production will stay out of government control, at least within the United States.

The most difficult problem in food production, is not what we can do in the United States. Actually if you are aware of the situation we are storing enough food every day to feed over half the world's

population. The problem now is one of distribution more than anything else. It is a very simple thing to hand a chocolate bar to a child in Korea, but this is not food distribution because there is no political implications, there are no sales or international relations involved. For example in the paper this morning it announced that there was 400,000 tons of wheat sold to Red China by Canada. Now here is a very hot political football, selling wheat to Red China. Yet here is a country which as I indicated earlier, by 1970 according to the best predictions, will have a major famine.

Question: What possibility is there for applying the systems approach to cope with these predicted famines? Is there any government supported or private company working on this? If not, what can be done to get it underway?

Dr. Hoover: There is none that I know of. There is no effort at all in this direction. Other than the organizations who are working through the United Nations directly within these countries themselves. One of the major problems I think you have all read in the last couple of years in Russia, for example, one of the major problems they are having, is in obtaining nitrogen fertilizer to grow crops with. In certain other areas, it's a matter of water distribution, or lack of proper tilling of the soil. Every area has a lot of specific problems and one of them is just low production yield per acre by people who really don't understand the latest techniques. Through the Peace Corps, and through some of the United Nations Organizations, a lot of these methods and techniques are being transmitted, but whether they will be effective or not, I don't know. To my limited knowledge there is no major organized effort going forth to attempt to forestall any of the major famines that have been predicted.

Question: A surgeon recently indicated that it is quite feasible to cause changes in the function of the human brain chemically. This raises concerns in the area of education and also in the area of throught control. Is this true, and how difficult is this problem for science?

Dr. Hoover: I may have to make up an answer. I am assuming that the chemical you are referring to is some of the studies done with DNA & RNA acids that Dr. Weber mentioned earlier. It's been shown in some of the lower animals that memory can be transmitted from one animal to another by use of these chemicals, by physically extracting it from one animal and placing it in another. There has always been some effect on the brain by any drug we take. For example, simple everyday drug aspirin has a very profound affect on the brain. In terms of thought control processes I really don't know of

and studies that have been done along these lines that can directly affect the human being. The only drug that I know of that really controls, and really affects thought control processes, is our old friend alcohol, and that really affects it. But there are people thinking along these lines believe me. There are people that are trying to alter behavior with chemicals just as in the past they have for surgical techniques.

Question: Has any work been done on data retrieval out of our brains?

Dr. Hoover: The problem of how the brain functions is a real 'lulu'. We understand what it looks like physically. We can show many, many excellent electron microscope slides of what has been discovered anatomically of the brain, but we have no idea yet how this marvelous organ functions. It's a very complex thing and I would estimate from my own experience that it will be probably fifty years before we even begin to understand the total fundamental mechanism of the brain. Until we know that, we have no chance of cracking information retrieval.

Question: I have a practical turn of mind, Dr. Hoover, and maybe if I can get a practical question out here I can get more understanding of how we're going to proceed with the future of this world's problem of the need for water, the need for nutrients, and the need for waste disposal. The American economy has been traditionally that of the rugged individualist. At least man farms his own acre, or ten acres, or 120 acres, and if he had to build a barn, he got his neighbors in and they had a barn raising (which maybe was the beginning of socialism, I don't know). But when we face the problem of salt water conversion, for example, my neighbor and I (in fact all the members on my block) couldn't possibly get together and find enough money to finance a scientist to tell us how to build a water conversion plant. How are these things being accomplished financially now? What is the political-economic implications of the fact that we need to do things on such a broad basis that my neighbor and I can't handle it?

Dr. Hoover: Well, fundamentally corporations are in the business to make money, obviously. Stockholders get very unhappy if we don't pay them. The work we have done to date on the waste management problem has largely been funded by the company. We have had excellent cooperation from the County Health Department and the U.S. Public Health Department with regard to the work we have been doing, particularly in allowing us to use some of their land and some of their people from time to time. We're speculating on this from within the company. We think it is an area which is going to be required, and it is going to be required in large enough numbers so that we can

eventually install these units at a price which is acceptable to you and your neighbors. We hope also to install them in many areas around the world and eventually we will make a few dollars. Really this is the approach here. In certain other areas there is always money available through government agency and government sponsorship of course, and through the proper approach to these people you can have partial support of the work you are going to do. The advantage here is that this then allows the information to become part of the general public knowledge. It allows the information to be a part of public domain, and the government can license anyone whom they feel is the best producer, to build the system. Again you have the situation here of a government-industry relationship which is going to have to be broadened in our thinking if we are going to be able to accomplish some of these other tasks, for the costs are inordinately high. We are considering some work right now which would cost in the order of five million dollars. Approaching our research directors and our people who make such decisions, they don't feel the risk, at this point, is worth it. So now we are faced with the alternative of going directly to the government and showing them our ideas on the basis that we think they will work. The company cannot finance us. (Can you?) They may or may not say yes. But then all the work that we do will go into the government and will not be something that we could use to provide a general marketing base, if you will, for our own particular products.

Question: How can this systems concept and systems analysis, which is now used for hospital design, be used in the design of the Sunday church school? I see this as a rather serious question. What is the magnitude of the cost involved in using a computer program and how can the church be strengthened in its program by the use of these technical facilities?

Dr. Hoover: Computer time is as high as $1500 an hour. Now this sounds like a lot of money, but it isn't because a small program may take only four or five seconds. The larger costs involved are in actually getting a program established around the functional area that is being studied. A lot of times when you begin an analysis of your problems you already find that you know the answers and don't need to run a computer program. The first step, to the author of this question, is to sit down and in your own mind pick out all the elements involved in your operation. Write them down on a piece of paper and then try to establish a flow chart showing how each relates to the other by directional arrows. In many cases this is enough to show you exactly where your problems lie. Beyond that point it usually involves a long term study where you actually test the relationship between two items to get the dynamics and quantity in some manner so that you have a fixed relationship in numbers. You then go on and test the next two relationships until you have all of them interacting among themselves. Then you put these inter-relationships into the computer.

Question: How do you operate in the area of social taboos? For instance thinking back to the time a physician could not look at a cadiver because of the social taboos. I am wondering how there might be a cross disciplinary conversation between, say the clergy and the scientist, to explore the areas of taboos. For instance, in the area of life itself. Can the scientist produce life? What would this bring into focus?

Dr. Hoover: You are bringing up good questions. I think what has transpired in the last fifty years in the general realm of what we might call taboos in science has not had the implications, both legally and morally, that it had before 1900, in terms of a given taboo. For example, the studies I am sure that were conducted on some of the fertility drugs and antifertility drugs could not have been done fifty years ago where now they can be. I think when a group of people who call themselves professionals have a problem to discuss, they must sit down together and discuss it openly, intelligently and trustfully. We'll always have a very deep and significant communications problem unless this is done. This may be the basis for some of the communications problems because there is a lack of trust. However, there are so few areas that I run into in our area that I find are restricted, either from a moral or a legal implication, that I don't think it really creates a problem. I think, first of all, particularly with work on human beings as reasearch subjects, that your own personal moral code is going to have a lot to do with how you approach it. As Ed mentioned in his introduction, I have done a lot of research on myself because I always feel I have to be there first. If I design the experiment, I want to do it on myself first before I hurt someone else. I'm crazy enough to do it and if I'm crazy enough to come through, then it should be safe for someone else. But this is a moral imposition one has to put on himself, and obviously there was a time when there were a lot of scientists that didn't feel this way. Back to the matter of your own personal moral code, and your own personal ethics, I believe that what we consider as taboos in terms of research activities really aren't a major problem as yet.

Question: Dr. Hoover, in my family there were ten children and all of us were born at home. There was a system developed in the community in those days that took care of that. Has life become so complicated that it is beyond the realm of possibility that we don't need more and more expensive hospitals to which we go for every ailment and every minor problem? Isn't there a possibility that science would now provide for us the kinds of information that could be available to more people who have more leisure and discretionary time to do at home all of these kind of things? Isn't there a way that the new systems program can help us to do for ourselves what now we are expecting somebody else to do?

Dr. Hoover: This is an excellent and beautifully present point. As some of you may know a lot of people are put in the hospitals for things that they shouldn't be. I think childbirth is probably the best example. There are in the state of California right

right now three registered midwives. This is a legal profession in the state of California, and a very fine one I might add. There is an effort to push for training of more midwives and to return childbirth to the home. Now this is meeting with a lot of opposition, particularly from the AMA. I think in looking at it from what has transpired over the recent months in terms of the Medicare bills the AMA is trying zealously to hold within their confines those things which they feel are inviolate. Now if there can be some agreement reached as to the degree of competency, in not only midwives, but in some nurses. Some nurses are quite competent in dealing with minor routine kinds of illnesses. I think this is one of the areas that we really ought to take a careful look at in terms of what can a nurse be allowed to do with relationship to the patient, as opposed to what she cannot do by law. I think the first place to start is in this particular area with childbirth and the midwife approach. It's been working in England beautifully for years.

Question: Now that we are in the area of personal responsibility for health, we have a question. Please explain the executive exercise program. What is your own exercise routine?

Dr. Hoover: Someone said I worry a lot, and that's part of it. The program that was in the Los Angeles Times yesterday morning was set up by our medical department head, Dr. Morrison. I spend many hours with him. He is using a straight forward weight lifting program. In addition, he is throwing in some running exercises. I have been trying to convince him in a few areas to broaden them somewhat. In general, if one speaks of physical fitness, he has to speak first to himself and say what do; I want to be physically fit for. I think it is becoming more and more obvious to us that it is a fundamental part of feeling up to par to do your job. We know from a lot of experimental data that it is helpful in prolonging life, if not making it a happier life.

There are three aspects of physical fitness to my way of thinking. One is the aspect of strength. The other is the aspect of endurance, and the other is the aspect of flexibility or specific mode of skills. Now if you are training an athlete to play 60 minutes of football, particularly if you're training a quarterback or a halfback, you want to spend a lot of time in developing his speed and particularly the moves and the specific skills he has with that particular sport. However, for an individual who is in, shall we say, an executive class for a lack of a better word, really what he wants to do is extend all of these as far as possible and practical, within his own personal time available. Now if any of you are considering going out on your own to do this sort of thing, let me first recommend that you see your physician and get a good physical checkup. Secondly, if you haven't exercised in a good period of time I could recommend several programs. I think the easiest to follow, and the simplest in terms of time, is

the RCAF exercise programs, which are available in paperback. Running is probably the best exercise in the world for all of us, also swimming. My personal program consists of running and swimming, and I don't have any particular fixed rate. I have a dog that loves to run on the beach and we go down as frequently as we can and run for a couple of miles a day or maybe sometimes running a couple of miles a week. Walking, running and swimming are for the average individual the very best there is. I strongly suggest if you have elevators in your church you take them out.

Question: Dr. Hoover, I would like to get back to a very fundamental and I suppose simple question. You said that biology began first as primarily observation and cataloguing and only later became a science. My question is what is science? What is a scientist if he isn't and observer and a cataloguer? Where does he cease being just an observer and become a scientist? Can you define that any better?

Dr. Hoover: It's almost as bad as defining what is a system. In current thinking, in terms of the philosophy of science, I'm sure a lot of good scientists are observationalists. But one must present himself to whatever problem he has. After that there is a given question. Now, it can be a very complex sort of question such as why am I here, or, it can be a very simple question, such as what is this microphone cord made up of? The second thing one has to do is ask, how can I approach this experimentally? What measurement must I make to evaluate the question I have asked? If you start with the first question, why am I here, then you begin to get confused, because what are the obvious measurements? There are many of them, yet there are not. We come down to the very simple one (the cord) and we say, "I want to do a chemical analysis and find out what its basic constituents are". I have to weigh it, and I have to make a selection of a piece of it and boil it down (or whatever is necessary to analyse it) and measure the chemical components of that particular cord. You have to do this in such a way that you're certain that you are not getting false results. You have to be certain that the answers you're getting are true and you don't often know this until sometime later. Everything depends upon the approach to answering the question experimentally, I think. This is where I would draw the line. It is between real observation and real scientific research.

Question: A comment was made earlier this morning that measurement is the basis of all knowledge. I am not quite sure what one would do in measuring a wife's love or loyalty. If I understand systems at all it seems to me that it implies that you have to bring together a number of disciplines in order to understand anything. I am wondering whether in terms of the aerospace approach there is much attention or consideration given to the weighing of, or the observation of, an individual's values or beliefs? Does it make any difference what a man believes if he is going into the space program?

Dr. Hoover: Wow! In terms of direct conscious application I have to answer no. In terms of the inter-relationships I think you have many in your congregation involved in these applications. You must realize that a large part of the effort depends on the interaction between people and reliability, or the trustworthiness, of the individual. This is ture, particularly in the pure sciences. If we do measure it, we measure it in this way. If I cannot trust a man, if I cannot believe that he is telling me the truth at all times, and qualifying it with his opinions where they are in fact opinions, we cannot afford to have him around. We cannot deal with nonfactual material. We have to have trustworthy people. I think this goes back to what is their fundamental moral code and where did they get it.

Panel Chairman: There is an interesting comment in Einstein's last book which he wrote just before he died. He makes this same point, that science is only possible where you have men of integrity. But integrity gets into the realm of value judgment which is outside the realm of science per se. So then he led into this thing that has been quoted many times, that science describes 'what is', religion tells 'what ought to be', and in the realm of values there is much room yet for exploration. Science without religion is lame, just as religion without science is blind.

Question: We've come full circle now and have one final question concerning the closed ecological system on the Apollo spacecraft. Is it possible to describe this in lay terms just briefly?

Dr. Hoover: Unfortunately time does not permit me to describe it adequately. The Apollo spacecraft has what is now known as the simplest closed ecological system. The true closed ecological system, the only one in existence, is the one on earth. It starts with the only outside source of energy coming from the sun, the plants then taking this energy and converting it into food which goes through animal bodies. The waste goes back into the soil to be used again to grow new plants with all the energy being added from the outside, There have been several attempts to design small mechanical systems which would do this, none of them to date have been terribly successful.

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