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SESSION I

CHANGING THE SYSTEM

MEDICINE AND BIOLOGICAL SYSTEMS
P.M. SESSION

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BOWEN C. DEES: The final two speakers this afternoon, as you know from your programs, are Drs. Herman Schwan of the University of Pennsylvania and Dr. Leon Kaufman of the University of California and San Francisco and I now give you Dr. Schwan.

HERMAN P. SCHWAN: Mr. Chairman, ladies and gentlemen. May I have the first slide please.

The title of my lecture and four topics I want to present to you.

First, Emergence. Biomedical engineering, biophysics and medical physics emerged almost simultaneously. Early beginnings, date about 40 or 50 years back, and occurred at a variety of different places and in different countries. At the time, no real differences were apparent between the three disciplines, (inaudible), disciplines of biomedical engineering, biophysics and medical physics. And after a period of different (inaudible) and separation to follow, we witness today again much gross fertilization. No formal training was available originally and motivation to enter into this (inaudible) fields varied from case to case and frequently demanded optimism disregard to an uncertain future, uncertain recognition and little financial reward.

I myself entered this field with great skepticism. Biology appeared so extremely complex and it seemed almost hopeless to apply the scientific approach of the engineer and of the physicist to life systems.

At that time the sensational potential of x-rays to visualize an optical structure as a life body had been very established already. However, little was known about the hazards of the effects of such radiations and their continued great activity in advancing X-ray technology, diagnosis and eventually therapy. Little had been done to search for additional applications of physical forms of energy in medicine and biology and to systemmatically study the properties of life matter which governs promulgation of other modes of energy through it.

Early laboratories in this field developed in the 1920's. Total number was small and I do not know of any academic programs leading to advanced degrees. In most (inaudible)....early institutions engineers joined with physicists and medical doctors. Directed by the possibility to apply analytical power of the physicist scientist and its instrumentation to problems in biology and medicine.

Already, at that time, there was a good mixture of fundamental and applied research. The more basically orient work was in most case undertaken to eventually solve problems of a practical importance. I call it, Purpose Oriented Basic Research. And early research was concerned with the effects of (inaudible) radition, X-ray technology, eletrophysiology, studies of the electric properties of life matter and relevant applications in physical medicine.

After the Second World War, it became apparent that rapidly developing electronics should be able to offer much to medical practice and biological research. Interest began to focus on medical applications and the term "Medical Electronics" was coined. The relevance of engineering to biological research and medical applications became very obvious now and today the term "Biomedical Engineering" stands for the application of engineering concepts and analytical tools and instrumentation to problems in medicine and biology.

In this emerging climate, biomedical engineering emerged eventually very rapidly. To give some figures. In the early 1950's, the so-called (Inaudible) Conference of Engineering Medicine Biology was attended by about 100 people, listening to some 20 to 30 papers. Today, members of relevant societies number close to or in excess of 20,000, attending more than 100 meetings a year, with thousands of papers presented annually.

It was the Institute of Radio Engineers and the American Institute for Electrical Engineering which established administrative (inaudible) first, interest in fostering engineering medicine and biology. And they formed together with the Instrument Society of America, a committee to organize the annual conference for Engineering and Medicine and Biology which continued to this day to be a focal point, a focal event.

During the late 1950's, the National Institute of (inaudible) became increasingly supportive of bio-medical engineer activities and established a large program for higher education and research (inaudible). The first programs to receive federal funds for training, leading to (inaudible) the bioengineering allocated the Universities of Pennsylvania, Rochester, Johns Hopkins, a few others, and in about 1960, the first departmental (inaudible) programs were established here at the University of Pennsylvania and rapidly elsewhere.

May I have the next slide, please.

Oh, pardon me.

The Present and Near Future. First, academic industrial growth. Today, the IEEE Society for engineering and medicine biology alone has more than 5,000 members and a large fraction of our engineering schools have either departments, programs or institutes dedicated to (inaudible) fields. As a matter of fact, I believe it's almost safe to state that there is virtually no campus, no university in this country where you don't have some biomedical engineering going on, either there is a department or an institute or at least some laboratories strongly engaged in the field.

The total effort, the total academic effort studies, is measured by student enrollment and number of programs and departments may now approach a plateau. Biomedical engineering has clearly established itself as a productive and important academic discipline. However, much additional relevant work is also carried out increasingly in many other departments, medical departments, such as radiology, biophysics, medicine, physiology and many other traditional engineering departments.

Industrial activities as reflected by biomedical technology continued to increase very rapidly, likewise. In a recent survey of some 17 EE specialties which was conducted by the IEEE spectrum, the fear of biomedical engineering was judged to be the third most promising career path in 17, only surpassed by computer software and communications. Out of 17 EE specialties it was list number 3. Another recent survey concludes that health care service and equipment companies are among the fastest growing in the United States. It concludes also that out of 100 publicly owned companies judged to be pacesetters, 24 health care or medical equipment suppliers. It is the largest single category ahead of the 21 companies in the computer and related product categories.

Of course, any precised prediction of the future of this market is very difficult to state. The market, while rapidly growing, is far from settled.

. Almost continuously new potential applications of modern engineering advance to medicine biology appears on the horizon. Many of them no doubt run to difficulties. Others emerge with promise and potential impact which is often initially entirely unpredictable. There is no doubt that increasing medical demand and public interest will assure rapid continued growth of the medical technology market.

Scientific meetings, journals, specialties. Biomedical engineering and research at universities, industrial medical technology in the academic education effort at universities are reflected by the rapidly growing number of (inaudible) meetings in the field. For a number of years it has become now impossible to attend all of them in order to obtain a full concept of ongoing activities. I estimate the total number of meetings per year on the order of some hundred, representing more than 20 different interdisciplinary societies in the field, but with primary interest in the bioengineer or biophysical area or some of its sub-disciplines, with a total membership, as stated before, well ahead of 20,000. The number of journals devoted to the field and its sub-disciplines is also growing very rapidly. The rapid growth in presentations and published papers is indicative of an unusual growth rate of the field, complimenting the one in medical technology, some of which I suggested a few minutes ago.

You might see biomedical engineering activities in growth reflect its, what I call, two dimensional character. And in one I mentioned we may (inaudible) biomedical field into N subdisciplines, biomedical field into L subdisciplines and in the other we list M specialities in the engineering fields. Two dimensional array, listed in one all the specialties you can imagine in the biological and medical fields and in the other all the specialties in the engineering fields. Now almost all combinations then, in this two dimensional matrix, established potential fields of biomedical engineering activities. Initially, only a rather small fraction of this matrix was activated. The number is now much larger as reflected by the increasing specializations indicated by the growing number of societies and journals. Yet many spaces are still inactive in the matrix. In part, due to being without present promise or being clearly without sense and in part to be filled in time provided the proper stimulus becomes effective.

Will there be any (inaudible) to this process in time? I do not believe so unless there will be inter-supporting engineering and biomedical disciplines. As long as engineering continues to grow and as long as there is an interest in the improving health care and biological insight, biomedical engineering will almost by definition continue to grow and grow.

Some words about basic research and technology. To the outsider, the justification of scientific or technological activity is solely determined by its product, its salability and obvious utility. However, we are all aware of the importance of related scientific principles. Unfortunately, there is in most cases a signigicant time lag between the emergence of scientific principles and technological achievement and frequently only a fraction of robasically oriented sciences yield practically useful results. Which ones unfortunately are difficult to predict. The field of biomedical engineering is no exception. I indicated that during earlier times much more basic work was nevertheless somewhat purpose related. This is still true and maybe the reason why a good fraction of the more basic pursuits in the field have been productivie from a practical point of view. Yet there are some exceptions. For example, (inaudible) understanding about the mechanism which determines the electric properties of biological cells exists. However, no attempts have been made yet to (inaudible) with the rays of microscopic electrodes and to create electronic images thereby which reflect various cell properties depending of frequency and of pulse durations are chosen.

Another example is the electrosonic field. Much is known about the mechanism which is responsible for (inaudible) attenuation but much less about tissue (inaudible) properties or electrosonic (inaudible) properties. I submit that research dedicate to improve this insight, cannot fail but result in further improvements in medical electrosonic tissue visualization.

Another example is rapidly emerging field of NMR, Nuclear Magnetic Resilience Imaging Technology. This field has become a particular important addition to existing medical imaging technologies. But a full understanding of the nature of normal and tissue water and the signals (inaudible) emit as utilized in NMR technologies is still incomplete. In other words, a technology has been developed but the basic insight at the root of the technology is still not complete. (Inaudible), the National Institute of Health has just recently called for submission of research current applications to fill this basic gap.

Well, many more examples of this sort could be listed to illustrate the need for more purpose related basic research. Government agencies, such as NIH, frequently expect demonstration of a health related potential before providing funds for the needed basic research. I submit that this in unwise, even though understandable.

Some factors limiting are (inaudible). Another problem contributing to the gap in the scientific insight and technological achievement is well known. Universities provide but little incentive and reward for contributions to the translation process from basic principles to product. And industries, particularly the health care fields, are reluctant to contribute to this process. Federal funds to contribute to this process are virtually non-existent. I submit that a large program is called for consisting of three parts. First, a more systemmatic study of the electrical coustic and mechanical properties of all life matter. Second, a systemmatic study of the interaction of all sorts of energies, electromagnetic and mechanical, with life matter. And, third, a screening of these efforts to select those interactions which appear particularly productive for whatever diagnostic and therpeutic purpose. It is true that much has been accomplished along these lines but past efforts are entirely incomplete and at once it came frequently almost by accident while undertaking research intended for an entirely different purpose. Such an undertaking would also substantially contribute to another field which is rapidly emerging. It is interest in the interaction of whatever energies this life matter. It has created increasing concern about related potential health hazards. Not only (inaudible) radiation but also broad spectrum of electromagnetic non-(inaudible) fields are (inaudible) to many to be dangerous. For example, microwaves. You may have read about microwave ovens leaking, microwave is suppose to be dangerous. This interest has had initially little effect on technological progress but this may soon change. Already the installation of many communication facilities has either been delayed or permanently blockes and the Defense Department's attempts to install low frequency communication facilities for submarines has been successfully delayed again and again. And, last, but not least, construction of high voltage transmission lines has been impaired or blocked and I consider it entirely possible that severe restrictions may be imposed on the power emitted by radio and T.V. Stations. These are but a few examples of rapidly increasing number of limitations imposed on the growth of technology by health considerations. This calls for educated scientific insight about such biological interactions so that in order to combat public fear of the unknown and superficial speculation may be replaced by logical insight and practical (inaudible) physicians.

Let me just list now a very few examples of the field with comments. I cannot really summarize the total field so I picked up somewhat arbitrarily just four.

First, pacemaker. Perhaps the greatest technological contribution to significantly advanced life expectancy is the cardiac pacemaker. About 500,000 persons in the United States benefit from it and about the same number in other countries of the world. Originally, a rather simple device has evoled to fairly sophisticated, yet small device, which performs monitoring and diagnostic functions in addition to its primary task of stimulating cardiac tissue. It performs as demanded by the heart and appears to have become an ever more sophisticated device able to respond now in the future to varying physiological requirements. Improvements in electro design and battery life expectancy have been substantial and reduced significantly initial replacement fees.

Second, imaging technologies. The diagnostic potential of ultrasound is based on its ability to be beamed or focused and to deeply penetrate into tissues. It has been increasingly used since its early introduction during the 1950's. Echocardiography, the ultrasonic examination of heart function, came about during the 1960's, adding to the early electrocardiography a new non-invasive technique which is now universally utilized. Modern advances in X-ray diagnostics are largely due to sophisticated (inaudible) of signals leading to computerized actual topography. This great technological diagnostic achievement was appropriately recognized by awarding the Nobel Prize to its chief developers. Interestingly enough, one of the laureates choosed to speak about the great potential of emerging enomotic technology instead of computerized topography. Indeed, nuclear magnetic resident imaging techniques promised yet another perhaps even greater potential for diagnostics and I presume Dr. Kaufman will properly talk about that more.

There are several other imaging technologies which have attracted the attention, both of engineers in the medical community, including (inaudible) with (inaudible) and various other attempts to investigate the merits of other physical signals. In all these cases the task is how to extract information from the interior, about the interior, from signals which are registered at the service of the (inaudible) volume. Mathematical principles which pertain to this problem are well known and have been developed long ago. But at first is the arrival of (inaudible) computers, the ability presents itself to process the large amount of data needed in some diagnostic image technologies.

And the third example which I present to you is very simple instrument. It's a coder counter. It's based on the fact that biological cells conduct low frequency alternating currents poorly. At least as compared with the typical biological fluid. Cells conduct poorly. This principle is used to rapidly count cells and to measure the individual sizes somehow electronically. Almost every biological laboratory has one of these machines these days and it has become a very (inaudible) in cell studies. The coder counter has become somewhat more sophisticated with time but its full potential has not yet been realized. The use of many electrodes which probe a cell, network analyzer and/or time to meet (inaudible) is called for to provide rapid evaluation of cell size and shape, maintain properties and (inaudible) plasmic interior. Information of the sort indicated here can be readily extracted by miscroscopic electronic techniques from the individual cells which are past (inaudible) through the probing field. Electronic imaging techniques at the miscroscopic level appear now entirely feasible with the tools which have become recently available.

And last, but not least, I mention cellular manipulation, as I call it, by electromagnetic fields. There has been known for quite some time that electromagnetic fields impart forces on cells. Alternating fields create all sorts of forces on cells and bodies in general. These forces in the case of cells may lead to destruction, to diffusion, shape changes, rotation, psydoplasmic streaming and so on. These effects were until recently of interest only as a curiosity and little research was done to fully understand them. In more recent few years, self fusion has now become of prime importance in one of the most important fields to affect future health programs. I talk about biotechnological or gene technology as it is frequently called. This technology is concerned with the transfer of manipulation of genetic information and the electric self fusion technique, using AC fields, has developed as the most promising tool to combine cells and exchange the genetic content. Further refinements of this technique, and in general, what I call the electromagnetic manipulation of cells for all sorts of purposes, promised to result in an entirely new biotechnology.

Well, many more examples could be listed but the four examples, two chosen to illustrate therapeutic and diagnostic advances and two to illustrate biotechnologies may provide an idea of the broad spectrum of opportunity spanning across virtually all medical and biological specialities. The technologies directly related to health care, such as pacemakers, artificial organs, limbs and prosthetic devices, will be always of particular interest to the public but the contribution of electrical engineering to biology, such as originally the electric microscope, evoling self fusion techniques and application of electrical fields here (inaudible) to the understanding of cell function and electrical responses are equally important.

What price to pay. To me, the potential of biomedical engineering and medical technology is almost unlimited. The application of rapidly growing engineering abilities to biomedical problems, particularly in electrical engineering and the computer field, will no doubt result in ever more sophistication productivity. With the tools available and to become available we can address medical instrument of problems presently only to be dreamed about. It is no longer unrealistic to predict the electrical techniques to become eventually as important to health care as chemistry did a long time ago. However, increasing technical sophistications comes only at an increased price. Limitations in individual and federal resources may well place bounce on our ability to reach for the sky. Medicare and individual health expenditures have been more rapidly increasing than any other expenditures of the federal budget. This trend is likely to continue unless mechanisms become effective which limit further expensive sophistication in the interest of more simple and hence cheaper technologies. Usually competition is effective to bring about (inaudible) in most technological fields. But competition has so far not been very effective in the health care field. These effects have been very recognized. For example, two articles in the first copy of our National Academic New Journal Issues in Science and Technology highlights a situation. I quote just a few examples. The total health care cost rose from 6% of the gross national product in '65 to 10.5% in '82 and are anticipated to be 12.3% by 1990. Medicare costs increased from 9-1/2 Billion in 1973 to $57 Billion, I'll repeat, in only ten years, from '73 to '83 medicare costs increased from less than $10 Billion to almost $60 Billion. And while inflation during the past year was only 4%, health care costs still increased in the last year by 12%. Clearly, some steps have to be taken to bring this catastrophic development under control. For example, attempts have been made to formulate the new Medicare's prospective payment system. However, analysis demands that the successful policy of cost contain must address the total health care system, a task which has not been done as yet.

Past gross figures indicate that individual and federal expenditures for health may well approach or surpass those for other categories such as defense, other entitlement programs and all internal federal projects combined if no limiting factors emerge fast.

Now this raised all sorts of questions. Is it in the end not cheaper to spend money for preventive medicine, should we strive for ever more sophisticated medical technology, is the health care field not slowly becoming a mixed health technology field, and what should be the future role of the engineers in this field and health care boards and relevant federal agencies. These are the problems which are about to become rapidly more important. How they will be served will greatly influence the growth of biomedical engineering and medical technology in the future. In fact, biomedical engineering and technology should play a key role in alleviating these problems, I believe.

Most of engineering is dedicated to the task of improving our lot, to defend our country, to make our life more easier, to communicate better, to produce cheaper and more efficient energy, to provide better learning and entertainment. But equally important to us is the goal of healthy and joyful living extending to an increasing older age. I see no limitations to what biomedical engineers might accomplish to achieve these goals. If these are gross problems which are just briefly summarized can be solved as they surely will be. Thank you.

(Applause)

MR. DEES: Dr. Kaufman.

LEON KAUFMAN: Compared to the speakers that preceded me and that will be following, I feel like the Rabbi's driver. For those of you who are not familiar with the Law of the (inaudible), it was the 20th Anniversary that this driver had been driving this Rabbi from town to town and he mentioned this and said, I have learned so much from being your driver that I feel that I could answer the questions almost as well as you do. And the Rabbi said, Fine, we'll exchange coats, I'll be the driver today. After all the 20th Anniversary only happens once. And they got to their first town, and as it would be, the first question posed to the driver was so complexed that it would have taken all of the knowledge accumulated by all of the Rabbis (inaudible) to answer. And without missing a beat the driver said, Such a question, it's so simple, I'll let my driver answer it.

(Laughter)

I don't know what's going to be happening. I know that there has been a tremendous increase in the cost of medical care and that's well documented but I also know that while like today I would rather buy a new 1955 Chevy with Lap Belts and a collapsible steering while but otherwise I would rather have that than anything else produced by General Motors. I would not like to go into a medical institution that practices 1955 medicine. While not comparing the same services. So in fact, with all (inaudible) to Mr. Lucky, my telephone doesn't work as well as it used to, even before you guys had an excuse.

(Laughter)

We are not comparing the same level of service. The technology has changed. And if it's going to be brought under control, there are two ways that this is going to happen. One of them is limiting the access to medical care. And I'm all in favor of that, so far as it applies to you guys from this end of the line over there. I don't want to hear it from my family. And the

. other one, if in a country like ours, this is not going to be acceptable if we're not going to stand for a two-tier medical system or even a three-tier, what's going to have to happen is that technology will have to come in to make up the difference. It's people that cost the money, it's not the technology. To give you an example, to put a child through 48 hours of clinincal injection were the most complicated technological procedures (inaudible) but they wanted 48 hours of injection cost over $2,500 without doctors' fees. A $50,000 machine that can monitor temperature and inject penicillin where you can send the child home with that, will pay for itself in just one year and be pure gravy from that point on. So technology is the way to both avoid the two-tier medical system and to be able to afford it.

What I would like to do is show you a little bit of what's been happening with diagnosis. If we're going to make a formed decision as to what needs to be done to a person, where and when, we need to know what's going on. If the way of finding out is worse than the cure or potentially worse than the cure, we're not going to be able to do it and we're going to be working from an incomplete data base. Lopectomy, opening up somebody, is obviously the most accurate and easiest way of finding out what's going on but there may not be anything wrong and I don't want to be opened up just so somebody can satisfy their curiosity. We need ways to look into the human body and this is what diagnostic imaging has been providing. And I'd like to show you what's been happening and to a certain degree the IEEE has been the home of the people who have developed this technology before it became so popular, then the Medical Society picked it up as their own invention.

Can I have the first slide, please.

In the '60's, we saw the first truly known invasive techniques. And I don't call X-rays n on-invasive, and not because of the radiation. The problem with X-rays is that in many applications you have to inject hundreds of grams of (inaudible) materials that they're not exactly comparable with the body and its functioning. So X-ray technology tends to be very invasive. One of those was nuclear medicine and this is a late nuclear medicine scan and it doesn't take much to realize that this is a skeleton and that there is something wrong with this person. There are too many blotches and they are too isometrical to make this person normal. And what happens is that we're looking at somebody that due to (inaudible) carcenoma has had a (inaudible) to the skeleton and is basically beyond any treatment. The money should be spent in making a person like this comfortable rather than in operating or trying to go after the disease itself.

The other technology that came in in the '60's on its own was ultrasound and ultrasound is a tremendously powerful technology but today has a tremendous drawback. It takes competent people to look at the image and understand what it says. As soon as you need that Union card, you are going to both decrease the quality of the care; in other words, the techniques that required this have a blotchy, if you will, record, in some institutions it's great and in some it's not, and some parts of the country is great and some say this is not, depending where people go and it costs you more to be able to do it, because you need a competent interpreter. This, I was told, is (inaudible) and to tell you the truth, I don't know much about ultrasound but I cannot read it.

Nuclear medicine is part of the scan that you saw, suffers from the same problem. I have a one page from the doctor that gave me this scan as to what's wrong with this person and I don't fully understand it and I don't see it in the picture. As soon as you need that interpretation, as soon as you need that kind of technical know-how, the cost of implementing this technology will never go down, no matter what happens to the (inaudible) itself. It's because of that that people try to improve the way that you can look at the body, the clarity, if you will. Here's an example of state-of-the-art nuclear medicine, looking at a young woman's thyroid, there's a radioisotol (phonetic) that's been distributed, it's a little bit patchy, but she would have been sent home and told to come back a year later just to check her over again. We used the device very different, which never found commercial application because the people who made this device had a mature technology and they didn't see any sense in competing with themselves and they were all rushing over themselves to be the second company in the field to introduce this kind of device and as such it never came to pass. Now notice that the same (inaudible) shows some small nodules and indeed where she was operated she had multiple carcenomas two to three millimeters in diameter. They were eradicated soon enough that I see her still in (inaudible). It's interesting if you think of cost, we spent probably the better part of half a million dollars before we abandoned this project as having no future. This is the only person that it's ever helped, except the careers of a number of individuals....

(Laughter)

....and the question that you have to ask is was it worth it. I know that if we asked her, her children, you're going to get an answer that may be very different from the systems analyst answer that otherwise you would get. But, this ended. But there is a better way of looking but it ended in failure simply because the economics were not there, the incentives were not there. But people did try to do is use conventional instruments to get different views of the same kind of distributionship of (inaudible) and that's called tomography, doing cross sections that are easier to understand. And those instruments did not get better but we have started now to use computers to sharpen other images and believe it or not this is basically the bones in the head and the important ones have the (inaudible) bones here, seen with a clarity, that's for nuclear medicine, it's unprecedented. What we have done here is substituted with software for the imperfections of the hardware and tried to improve the outcome.

The same has happened in (inaudible) tomography which is a varient of nuclear medicine where the IEEE again has been the home for this development or at least for the presentation of this development and the people who do it. This is something that was available in the early '70's. Distributions of radioisotops and its transmission image to see where they are. Because the isotops are so specific that you don't know exactly where they are. They go to the organ you want but you don't see the anatomic landmarks. And this is in the heart. I think having proved to the point that you now have a recognizable myocardial wall and blood proved here in red, as well as the outline.

Now, the technology that came and seemed to be a God sent on a cure was X-Ray CT but if you look at CT carefully, what is it. It's another way of displaying X-ray density information. It's no different from a film except instead of giving you a projection of the body, it gives a slice. And it has the very same problem. First, CT started without contrast media, without injection of agents, but what happened is they were using things like (inaudible) of dose and that's a lot. That's getting to the point that you have to worry about. Now machines use maybe 100 to 500 (inaudible), certainly (inaudible), which is nothing to worry about, but 100's of grams of contrast media.

Here is a patient that the neurologist, who doesn't have a union card for radiology, called him normal right here. This is too low a density. Now, I would have never....working with them I would have never thought of this, but the radiologist, in place of his union card, said there is also something wrong here and everybody laughed. Look at an NMR scan, I don't think you need a union card to tell that there is something very wrong in this person's head. There's blood that's accumulated on both sides and is compressing the brain. What is happening here is that with nuclear magnetic residence we truly are getting into a situation where we can start to provide more information and more easily interpret all information. And I'd like to go now, very rapidly, to give you a visual impact, a visual feel, for what this technology does.

The use of the body are unparalleled. You can see here the gall bladder, this is concentrated bile, the patient has eaten another diluted bile on top, there is the liver, look at the kidneys, (inaudible); vessels, which previously needed something injected to be seen, (inaudible), appears simply because moving blood has material that's different from stationary material, so there comes the vessels for free, the spleen, you can see they got not very well because the imaging is relatively slow. Views of the spine with the nerves coming out, again, only seen in anatomy books previously. The base of the brain with the pituitary gland in detail, that, to a certain degree, exceeds what you see in anatomy books. And views that are not previously available, the slices not only come across but come from the front or from the side. Here's a person....it took very little time to put this technology to use once it was developed....here's a person that years ago had a myleorgram. A mylogram is when they put a needle through your spine and inject contrast media and it hurts. I have heard people who had it and they don't sound very nicely. This person laid down for 20 minutes to have a scan. You can see hear the CSF, the (inaudible) Spinal Fluid, and you can see four discs intruding into it. This is the information from pain which is the fuse to factual, four discs, if you're going to do something you have to do it in four places. It's the kind of information that's needed to take care of people and it's obtained in a comfortable, dignified, painless and safe way.

In NMR it's just as easy to hide disease by doing the wrong thing as it is to pick it up. This slice is exactly the same slice as is in the same patient, done a few minutes apart from each other, and it doesn't take much to know that there is something very wrong and whatever is wrong is very subtle here.

That's one of the problems with NMR and we're going to need computers to take care of that because we cannot count on people learning to use it and being able to have it distributed throughout the population with the same amount of competence. Here's a way of highlighting disease. Five or six different ways, same section of the patient, each one showing this infection due to toxicplastmosis, this is what you get from cats if your immune system is down, and notice how we have changed the ability to see it, brought it out and characterized it, for instance, this centering here.

And we're also learning to calculate these images. We may not have to obtain all of those images. This is a calculator and this is obtained image. This calculated image was done with one-fifth of the amount of data accumulation that took to obtain this one. So we're learning quite a bit as to minimize the front end, the expensive end of the device. Many (inaudible) utilization. The different views are allowing us to look now at the invasion of the bladder wall, for instance, by a (inaudible) carcenoma, very important in making decisions as to who to treat and when and how to treat them. And it's bringing up the possibility of screening for (inaudible) carcenoma. Now who's going to pay for this screening and who is going to have it. I know I will but the question is, we now need a policy because we can no longer say that the screening in itself carries a hazard, it's no longer cost benefit, but we're now talking as to....I'm sorry, risk benefit, we're now talking to cost benefit, which is very different. And we're learning to characterize this (inaudible) so a computer can make a map of the tissues from the original images, color code the tissues so we can tell what we're looking at.

Another example where screening can come in because it's so easy to see vessels, we can tell if there is something wrong with a vessel. This aorta is obviously changing in shape and it has some deposits in here. This person has a larger aorta with a great deal of deposits. Previously, it would have taken a catheter, it would have taken an injection of contrast media, and you would not have thought of screening for a disease like that, but now you can and the question is, how are we going to do it. I don't think we should be asking, should we.

And to interpret those, instead of looking at those individual sections and trying to pull them together, a computer can do this and you can see here an aorta with severe narrowings, this has been color coded for depth, ballooning in this section, ballooning in this section. This is sold non-invasively in 20 minutes of imaging simply by lying on a table. I'm noticing here we are seeing a front view of an aneurism or a dissection of the aorta that's coming around and going literally around this patient. We're coding it with different kinds of information. For instance, how fast is the blood flowing in different sections or how much of a channel is there open to flow. So, all of this is the information and this information allows to make a better decision as to what to do with people and hopefully to detect these things. Incidentally, the (inaudible) if you will, the problem, the deposits, are seen also in here, which you cannot see in an angiogram. In this case they are colored in orange and up here in green. So, we have a complete picture of what's going on in this vessel, where the deposits are, where the flow is and one can treat now based on this kind of information.

What is going to happen with this kind of technology is hard to tell but there is no question in my mind that technology is going to be the only way that's going to allow us to have a health care system that addresses the perceived and the real needs of people and at the same time that we're going to be able to afford it. Thank you.

(Applause)

MR. DEES: I'm sure that you will all join me in thanking not only the panelists that have just completed their presentation but all of those who have spoken this afternoon. The time of adjournment having arrived, I'm going to now say that we are through with this session and hope that we will see most of you back here in an hour. Good day.

(Applause)