TRANSCRIPT OF REMARKS BY
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I want to share with you some very important convictions about the status of undergraduate science, math, and engineering education, again restate and impart the situation as we face it now, but then quickly try to get a discussion about what can be done.

Before I do that I want to acknowledge, with deep gratitude, what Anna Harrison has done to influence my professional life. I became active in the Division of Chemical Education many years ago when she was the Chair of the Division of Chemical Education and, of course, she became the president of the ACS and the president of the AAAS, member of the National Science Board, and so on. The list goes on and on. In everything that she did she was very determined to see to it that quality of science education at all levels, especially for the nonmajors, received proper attention from those of us who had majored in science. And so, Anna, I want to acknowledge your influence on me. I want to present this small token of appreciation. This is a (laughter)....

I also want to say how happy I am that Sigma Xi is taking an interest in the topic of education. Sigma Xi, of course, is a research organization. At least, it's an organization that has researchers. I became an associate member then a full member. I'm sorry to say I'm inactive right now; that means I'm paying my dues is what that means. In that sense I'm inactive, in every other sense I'm very active in support of research, in support of education. I really am pleased that Tom Malone and others came to see me several times and talked about the kinds of ~~things~~ initiatives that Sigma Xi ~~can~~ might undertake in science education. There's a whole slew of things that Sigma Xi can do and very frankly must do because there's a great deal at stake in terms of what faces us as a nation, what our society has to deal with, and what we must deal with very quickly.

I also want you to know that I am aware of another activity that Sigma Xi has undertaken. Just last week I had a visit with Louise Canfield at the University of Arizona who is helping organize activities for the various chapters of Sigma Xi in conjunction with National Science and Technology Week, and having National Research Day, and so on. I think all of these are important activities and I want to be very supportive and very encouraging of the continuation of this involvement. I want to make one observation though about that so that you would begin very quickly to understand the perspective that I have in terms of what I am about to say.

I'm not interested in a single pulse ~~of~~ followed by rapid decay _______ after it occurs. We're interested in sustained activities, in meaningful activities, and it takes a lot of intellectual power and dedication to see to it that we have a process rather than a single event that can take place. And so that's what I want to try to talk about in the next few minutes and then I will talk about national ~~leads~~ needs, and I will try to deal with those issues;

Alice: retrieve [illegible]

can't deal with all of them just want to quickly survey what some of them are. I want you to keep those words you see on this screen in mind ~~though~~ as we go along. I will not mention them as frequently as I would like to because of the time element.

I would also like you to keep the word "attitude" in mind. That is, the attitude of the practicing scientist, the attitude of the society that the practicing scientist is in, the attitude of the society that the practicing scientist usually does not deal with for whatever reasons. So attitude's an important word for me.

I'll talk about value systems-our own individual value system, our institutional value systems, our societal value systems. And so when I say to you there's a great deal at stake here, I really mean it and I want you to be convinced that I mean it because I think the solutions to those issues depend on two things at least--individual initiative and institutional initiatives. Both have got to be there and there's a lot of interaction between them. So value system is an important set of words.

And then "expectations," our own self-expectations and expectations of our institutions, that is institutions of higher education, societal institutions. So those are the words that I would like you to keep in mind as we move on and discuss what faces this country and what can be done about it.

I want to try to have us focus on the "what" part more so than on the "how" part. I want to ignore the how part. I want to make sure, if you'll pardon my analogy, that whatever it is that we are dealing with is "thermodynamically" feasible. And then we'll worry about the next part.

~~Now~~ In my judgment the situation that we face now, as a nation, is by far more critical and more consequential than what we faced in the immediate post-Sputnik era. That is so for a lot of reasons. Let me quickly mention three of those reasons.

First, the population of the United States in the past ~~50~~ 30 years or so has increased by about 50 million people. Now to put that number in perspective, that happens to be the approximate population of all of Great Britain. So that the buildup of the population is 50 million people. So what does that mean? That means that we have more students to teach and we need more qualified teachers at all levels--precollege, undergraduate, graduate--more qualified teachers to teach them. And our institutions of higher education, indeed society at large, continue to be sluggish in responding to this change. This is a change of scale basically. And this is what I would like you to remember as the first point as to why the situation now is more critical and more consequential. The fact there has been a tremendous change in scale and the fact that we as a society continue to be sluggish in responding, in dealing with that.

The second reason as to why the situation is more critical, more consequential, now than before is that for our country to retain its international pre-eminence in science, in technology, in the local economy, in the arts, in the humanities, we must have a good supply of scientists and engineers coming through the education systems. And as you know, that's what NSF set out to do in the immediate post-Sputnik era. All teacher institute activities, all the curriculum development activities, and everything else that NSF did in the education arena was aimed at seeing to it that there would be good flow of talent into science, mathematics and engineering careers. What I'm saying now is that we have to maintain that. Of course the_____ data we looked at last night and that some of you heard about this morning, and which I will show you again shortly, will cause us to be alarmed. That's the second reason.

The third reason as to why the situation now is more critical and more consequential from back from the late 50's early 60's is that we now live in a much more advanced scientific and technological society than we did back then. And it's the education in science and in technology of the nonspecialist that we have to pay attention to. Scientists do a good job of communicating with one another. They do a good job and their vernacular allows the job of communicating science to nonscientists. And that's what we need to work on. We need an educated citizenry who can distinguish between astronomy and astrology. We need an educated citizenry that can understand the complex issues of animal rights. We need an educated citizenry who can successfully deal with pollution control problems, because as I said before, it's the quality of life that is at stake not only in Racine, Wisconsin, or Washington, D.C., or

Pasadena, California, or in this country, but it's the quality of life on the planet that is at stake. So we have both a national responsibility as well as a global responsibility as enlightened people to deal with these issues successfully.

Let me try to summarize what I have just said. The mission of the National Science Foundation now is a dual mission. One has to do with the flow of talent into the so called pipeline, the research-education pipeline, but the second mission is to educate the public, the rest of us, in science and technology. In this connection, let me give an analogy, analogies sometimes get a bit confusing and remember from my teaching days at Madison when the students remember the analogy but don't remember what it ... Just like they remember the author of________, but they don't know what to do with it. Anyway, the analogy comes from sports. Just as we have professional football players, basketball players, hockey players, baseball players, etc., we also have sports fans. And you know, without those sports fans the entire professional sports enterprise would be nothing. And you also know that's not an exaggeration. That's what we need; we need scientists and we need science fans. We need to see to it that these science fans are physically fit, not just sitting in the stands watching. We don't want them to be professional scientists you understand. We want them to appreciate and understand what the process is, to look forward to events, to learn from these events. We want activities at the minor league level too. At all levels, that's what we need. Now, if you don't like that analogy, and some people don't because they don't relate to sports all that much, at least some of the people that are in our circle, let me offer another one. You need good orchestra players and we need audiences to appreciate what the performers are doing. That's the dual mission of NSF now. It's different than it was 30 years ago. Thirty years ago it was to produce people like ourselves. That still remains our mission, but not the only one that we have in life.

Now, I want to quickly go through some of the demographic data, again to help us focus, as _______ has done at the start, last night and right to this morning. Before I do that I want to say something about this gathering.

NSF made a small investment to see to it that Sigma Xi, in collaboration with other organizations, such as the Johnson Foundation, gets a good group of people together and we are happy to have made that investment. The results are necessarily disproportionate in terms of the amount of that investment. Most of you don't know what the level of--size of--grant ~~load~~ is; doesn't matter--it's ~~too~~ small. But the outcome will have a tremendous impact. And so I want you to know something. I want something in return for that investment. I want a report that has very pointed recommendations to NSF, to the scientific community at large. I want specificity. I don't want us to remember three years from now that we came to Wingspread near the end of January and the weather was some good luck, it happened to be not snowing and not icy, and that was it. I'm not interested in single events, as I said before. I want something--I want a process, I'm interested in initiation. I'm interested in catalyses, that's want I want. And my remarks not only will allude to that, but in the end I hope in the discussion you can try to pin me down to say to you some of the specific things that you can do. You have to understand my position in Washington in an Administration that truly believes that education is the responsibility of the states and localities, I live a very difficult life because I mostly believe that education is also a federal responsibility. We can't get into that, but you need to have to try to get me to say some of these things that I may not be accustomed to saying because I watch carefully what I say in Washington and it has paid off, as I will show you. It has paid off to help not only you, but to help the country.

Now, let's just take a quick look at the number of 22-year olds in this country. These are data that you've seen before, I want to go through them very quickly. The number of 22-year olds in this country will continue to decline through the year 2000. And there isn't anything that anybody can do about this to change it. This is a fact. Unlike the other data I'm going to show you, which are projections, this is a fact that nobody can change even if you all got busy tonight. It'll take 22 years to change it. So you want to remember that the number of 22-year olds, the traditional age at which people get B.S. degrees, has declined. That's one thing I want you to remember.

The second thing I want to show you is the production rates in the natural sciences and engineering, B.S. production rates, and I would like you to remember that this number is approximately 4 per cent of the number of 22-year olds. So 4 per cent of 22-year olds despite fluctuations due to computer science and so on. Does that graph look familiar from what you saw last night. That should give you some confidence that people on the East Coast, people on the West Coast, use the same data. Or at least they agree on it.

Excluding computer sciences big surge, followed the same decline, is about 4 percent. You see, once again, the shape of this curve reminds me as to why I am not interested in single levels, because it is apparent afterwards. I'm interested in sustained levels of effort.

There are engineers in the group here, ____ Fred, Karl Willenbrock ~~Lowenbrough~~, and some of the others, so I thought I'd show you the data and sort out engineering out of this.

Engineering is typically under 2 per cent of the population of 22-year olds. So that the population of 22-year olds is going down, 4 per cent roughly of that population get a B.S. degree in mathematics, science and engineering. Let's look at the same kinds of things that Weems said yesterday. Looking at expected freshman intentions. Now, he had more elaborate detail. I just want to show you this one just to have you see that in the late '80's there's a decline. Again, remember the general states of these curves is what counts. And by the way, I promise Ann I will make copies of my remarks and copies of these transparencies available very quickly to you. So the point is there's a decline in expected freshman intentions. And as we saw last night, a person declares an intention to be a major in a science, ends up going to something else, not the other way around. I give you a private analogy here. Going from business to science is a forbidden transition; not the other way around. So we need to be aware of these trends, and that's my purpose in going through them quickly.

Here is the picture for Ph.D. degrees, as we have it, and you might keep in mind all along that in our society there are great forces that influence education, just as education influences the rest of society. And you might want to think about the reasons for this rise in the Ph.D. degree production and why it peaked when it peaked and why it started going down, and why it's kind of pitching up now. The point that I'm trying to ask you to think about here is what happened in our society in the late 60's, the draft, the Vietnam War, and so on. National Defense Education Act, fellowships, NSF fellowships, all kinds of things that the country did to get people to go on and get a Ph.D. degree in science and in engineering.

Here's a piece of information that would be of interest to you, because not only Fred mentioned the retirements in the next 12 - 15 years being in the 40 - 50 per cent range, but this is a projection as to what the country will need in the year 2004. The academic entry is quite clear, business and industry is clear, other refers to people like myself and Bob Watson at the

National Science Foundation, who work for the government, people who work in national labs, and so on. Even if these projections are off by 50 per cent, that's still a big situation that we must deal with. In fact, it's so big that the projected shortfall in B.S. degree holders is about 430,000 by the year 2000. Does it really matter whether it's 430,000 or 450,000, or 350,000? What matters is that it's a large number, that's what matters. And that's what I'm trying to share with you once again, to help motivate all of us to act in some concerted fashion to address these difficult issues that we face as a country.

The shortfall at the Ph.D. degree level takes into account foreign students who come to this country and sometimes stay, as I did when I came from my native Lebanon in 1957. I've enjoyed the wonderful hospitality and the great opportunities in this country, and I've stayed. But other people from the developing countries are being lured back, for the developing countries need scientists and technologists. So that takes into account foreign students and the shortfall is of the order of about 8,000 Ph.D. degree holders in the year 2004. That's what this turns out to be if you haven't looked at the scale very carefully.

You know, it's the greatest tribute to our institutions of higher education that people flock from all over the world to our shores to study science and engineering. It's the greatest tribute.

Can we get our native-born students to pay the same kind of tribute? Can we? My answer is yes. We will get to the "how" part later. Remember, it's the "what" first and then we get to the "how" part.

I thought I'd flash quickly some of the same kinds of data that Greene showed you yesterday. Look at B.S. degree production for mathematics because that was a dramatic drop that we saw last night. I want to call your attention to these little small studs down here, they represent minorities, and keep them in mind because I'm going to come back to that. The B.S. degree level is rapidly, very rapidly, declining. It's moving up again, which is good. That's at the B.S. degree level.

At the M.S. degree level that's what the picture looks like. Again, remember the general shapes of these curves is what we want to keep in mind.

At the Ph.D. degree level that's what the situation looks like. Now this is the same kind of picture in other areas, in physics, in chemistry, and so on. These are the general shapes that are involved. This is a time when the country is about to mount very big ticket items, whether it's the space station, or the mapping of the human geonal, or dealing with AIDS, or superconducting super colliders, or SDI. That's why we need more people in science and in mathematics, and in engineering. We also need that supporting environment that these people must work in. Are we going to rely on foreign mathematicians to do the necessary work for SDI? I don't care whether you are for SDI or not for SDI, and I'm not revealing what my own personal opinion is, but what I'm telling you is that we, as a nation, are undertaking, or contemplating undertaking, these big ticket items and we had better know what we are getting ourselves into. We better have the right infrastructure in place to deal with those issues.

Since Fred is a chemical engineer I thought I would show the data for bachelors degrees in chemical engineering. There's a big oscillation that he knows about. That's at the B.S. degree level. That's at the masters degree level. And that's what it is at the Ph.D. degree level. Again, there are still some studs down there, I just you to remember how small those numbers are. And Fred gave you some exact numbers last week, can count only on two hands how many Ph.D. recipients were minorities _____________ in the 1987-1986.

Let me show you a very important piece of information that, again, Fred alluded to. I want us to look at this very carefully. This is the persistence of natural science and engineering interests from high school to the Ph.D. degree level. The population in 1977 of high school sophomores was more than 4 million ___ people. It doesn't take a mathematically literate person to understand that a small change in this slope, it's a very small change, will result in a very big change down here. Maybe it does take a mathematically literate person to do this. Our newspapers are full of graphs all the time. How many people understand how to interpret those graphs. Of course, that's not our problem, that's the problem of the economists who put those graphs in the newspapers, or that's the problem of the journalists who put those things there in the first place. Right Sharon. That's not the problem of the scientific community. Can I take my tongue out of my cheek now? Be sure you understand what I'm talking about.

Look, tremendous leakage from this pipeline, tremendous leakage. It's not even a leak, it's a hemorrhage. Great talent is being lost as we saw last night. I want you to focus on the undergraduate years because that's the focus of this activity. I want to put that in the context of everything else. I don't want you in this report to go into the ocean, ________________________________ to do, I want to focus on the undergraduate years and what can be done at the undergraduate years. How can small variations on this graph affect the flow of talent in the science and engineering careers. As you view that I don't want you to think only about the blue part of this curve, I want you to think about the rest of the population that's flowing down here. Remember the dual mission that we have. Not only the 10,000 people who are going to get a Ph.D. degree in the natural sciences and engineering, but the people who are going to support them as they pursue research, as they pursue their professional interests.

Forty per cent of undergraduates are lost. Forty percent of those who express an interest in science and engineering are lost. That's staggering. Not 4 per cent, 40 per cent! Can our institutions of higher education do something about that? Can my own home institution, can my own department where Tom Record and I are colleagues, start producing more chemistry majors than is being produced now? Of course, we are a research department at Madison, but we have a responsibility to the pool of talent. We also have a tremendous responsibility to these lawyers and business people who happen by some fluke, accident, to enroll at Madison, or Berkeley, or what have you, or Tennessee. We have a responsibility to see to it that their education in science and in technology is a good one. Please remember this, this is a very important piece of information.

Now, with a different audience I would go on from here and say that the real battle is not in the sophomore year in high school, the real battle is before that. It's very well understood and even agreed to that there is where the battle is lost or won. But that's not the domain of this group, I want you to focus at the undergraduate part and see what you can do to help NSF, to help other agencies, to help the country deal with this kind of issue.

I want to show you a couple of other cuts of this. Looking at the same population by gender. You see, again, we have to be somewhat mathematically literate to understand that the slopes are different and that a small change at the top will result in a big change, a significant change, at the bottom. It's a shame that great talent is lost. It's a shame.

The picture for underrepresented minorities is about the same. That's, again, a big change because of the loss of talent we have to the scientific and engineering ____. This is looking at it by the ethnic groups. And Fred mentioned some of the data, and they are fairly well documented.

Well, let me shift gears here and talk a little bit, having spent some time talking about quantitative issues, I'm going to talk about qualitative issues. Quality is what I'm going to talk about because I've already asked you to focus at the undergraduate years. I also want us all to be aware of the flow into the undergraduate years. All of us feel a heckuva lot more comfortable with the flow out of the undergraduate years to the graduate level. But I want us to take a look at the talent that we have in this country.

Very quickly I want to tell you about some information I'm sure you've seen. This is a comparison of student achievement in about a dozen countries that participated in an international survey that dealt with science at the fifth grade level. That's where U.S. students rank. In this very quick survey I'm going to through here, take a look at the position of the United States, also the range of scores, because both turn out to be important. Those are the students who are going to be enrolling in your institutions not too far down the line. You can do the arithmetic and figure out when they will show up as freshmen. That's where the U.S. ranked in the fifth grade level.

At the ninth grade level, that's where the U.S. ranked. As I like to say on such occasions, you and I would like the situation to be like this. You know what, we can make it that way. That's what we're talking about. Because the teachers of these people are undergraduate students at your institutions. That's what the picture looks like at the ninth grade level. For people who are interested in undergraduate research, and I know you are, I mentioned the early youth programs in research expands for undergraduates.

For people interested in Ph.D. students, I want to tell you something about the talent that's coming down the line. In this study where comparisons made for students taking the second year of science, in the jargon of this study the so-called specialists, this is where physics specialists ranked. These are people most likely to be taking advanced placement physics so when they show up at Madison, Tom, they have a 3 or a 5 on the AP test, they're exempted from taking freshmen physics. We're not talking about your average run-of-the mill student here, we're talking about our good student. Bill, I'm sorry to show you that this is the picture for chemistry. Again, advanced placement students. And I'm very sad to show you the picture in biology. You know that more people in this country take high school biology than any other science.

Now, these data tell us that there's something in our society, something in our educational system, that we have to be paying very special attention to. We, the scientific establishment, the education establishment, otherwise, we will be doomed to become a second rate power, a second rate nation very quickly.

The data in mathematics is very similar and I'm going to skip those because I want to get to a couple other things, especially a discussion of___________ as to what can be done.

I want to say a little bit about NSF, because you may remember I asked you to think of national needs, attitudes, value system, expectations. I show you the picture for NSF funding since day 1. The green line is the program NSF budget in current year dollars, the blue line is the support for research, and that red line that is very close to the axis is the support for science and engineering education.

NSF mirrors what goes on in the field. I want to come back to that because it has to do with expectations. Not only mine, but other expectations.

So, the support for science and engineering education is the way to perceive it. Showing it slightly differently, looking at the form of a pie chart and chunks of years, you see that there has been a change in what NSF has been doing in science and engineering education. I showed this to a colleague of ours who happens to be an Adele Weiss winner in chemistry, and he said he's heard of the land of the rising sun, but this reminds him of the land of the sinking darkness. Note that research and education ought to be pitted against each other. It's a very important point that I want to talk about.

Looking at the same kind of data by the way, and some of you may recall seeing this in Science magazine, but looking at it in constant 1988 dollars, you know that the NSF budget is in 3-

year line items, the support for research and related activities, the support for the U.S. Antarctic program, and the support for science and engineering education. It's from about the mid-60's to the last part of this decade that you see the NSF total effort is about the same, although the distribution within is different. Again, I want you to think about the value systems, I want you to think about expectations.

Now looking at science and engineering education by itself, that's the part of NSF that I deal with, this is in current year dollars through 1989. We were shut down early in this decade and you see we made a remarkable recovery since then. So that part I was alluding to before about what I say and where I say it, well it made a remarkable recovery. We're at the highest level ever in terms of support in current year dollars. Distribution of effort is different; it doesn't have to stay this way. But I also want you to look at the same data in a different form than constant year dollars. Again, think about value systems, expectations, purchase power. We are less than one-third of the effort that we had in the mid-60's. Yet the population has changed by about 50 million people. The needs have changed. This is something for you to contemplate and to think about as we deal with these difficult situations.

Now I'm often asked the question "Why does the National Science Foundation provide support for education?" Why? I say that's the same reason as to why NSF provides support for research. A lot of people nod their heads and say yeah, that sounds good, but a few people say what is that reason. Why does NSF provide, why don't the Feds provide support for research and for education in science, mathematics, and engineering? Let me share with you what these reasons are.

The first reason, and we can dwell on any of these and discuss them as you see fit, the first reason is that we provide support because it's good for our national security. Whether you like it or not, the vast majority of scientists and engineers who work for industry and so on work on contracts for the government. As I say, we can debate whether that's good or bad, but it's a different discussion. I'm just giving you the facts as I know them.

The second reason that support is provided is because it's good for our economic security--manufacturing jobs, other kinds of jobs, affecting the economy quite straightforward.

The third reason is that we believe in living in an effective democracy.

So those are the three traditional reasons for which the Federal government provides support for research and education activities in science, math, and engineering.

Now what I'd like to do is ask each one of you a very personal question. Ann, I want to ask you that question; Bill I want to ask you that question. Mark, I want to ask you that question. Fred, everyone of you. Did you go into science because it is good for our national security or because it was good for the economy, or because you wanted to be part of an effective democracy? Did you? You went into science for a whole slew of reasons, mostly, personal reasons, not the least of which was, and continues to be, personal enlightenment. You are curious about the world that we live in. A list of what constitutes curiosity is endless, and I'm not going to go into it right now. But personal enlightenment is a major driving force that you went through, and still go through. That's why you stay in science. There are other people who feel the same way about it, and we went into science and math and engineering because we wanted to enjoy learning. The fun part. Doing science is fun in the best sense of the word. Someone once went into science, math, and engineering because they wanted to get a job for a whole bunch of other reasons.

Now, let me tell you what the problem is. I and my colleagues at NSF face it every day. We go up to Capitol Hill to talk to our elected representatives who govern, the government of this country, we talk to the Executive Branch, and we discuss funding for NSF for research and for education. If I were to tell him that support should be given for these reasons they would do what you are struggling with now, the whole_______ would laugh. If I told them that this is why we need support right away. See what the problem is that we in the scientific community have to deal with. We need this environment that is supportive of us, especially when we do science, math, and engineering for all of these reasons.

I wanted to say just a couple of more things about this situation because you know that the NSF budget is about $2 billion; you may not know that 50 per cent of the NSF budget goes to about 20 institutions. And those 20 institutions, as well as the other institutions, owe something back.

In our society we have a science-rich sector and we have a science-poor sector. The science-rich sector owes something back to the rest of society. Let me put it differently. The gap between the specialists in science and the population at large is widening at a very alarming rate. A very dangerous rate. It's not a gap between the specialists and the rest of the population, it's a gap between the subspecialists and the rest of the population. So we have to do something about that. We need to provide, and this is one important item that should be in your report, we need an intellectual base for the kinds of activities that must be undertaken as we pursue the following straightforward and oversimplified concerns. I'm just going to put them in one full swoop--concerns about students, the undergraduate level, concerns about faculty, concerns about the curriculum, concerns about the laboratory. In my opinion, it is criminal to offer a course in science without a lab component. I know we do it for a lot o economic reasons, we don't have enough TA's, the TA's that we have don't speak the language properly, and so on, the labs are not safe, you can come up with all kinds of rationalizations. We have to have courses in science, not courses about science, not only for the science major but for other students as well. So providing an intellectual base that deals with the kinds of offerings in the curriculum areas is a very important concern to us at NSF. It's not just the curriculum for the five people who are going to become chemistry majors, though those are very important and very precious. But the concerns for the 95 other students who are not going to become scientists. What kinds of offerings should be made to them. Who is going to devise these offerings. I believe very firmly that the creative talent that we have in our institutions of higher education that really excels in research should be tapped to deal with those important issues, and I would like to see that in the report--explicitly! to be directed to the NSF, to be directed to everybody. I'd like to see an explicit statement in the report addressing curricular offerings not only for majors, but for nonmajors in the sciences, in engineering, and in mathematics. And how we deal with that we'll get to that. Hold it against me that I'm focussing on the what part now, it's OK. We'll find mechanisms. After all, we're so creative in dealing with so many other complex issues in research, can't we expect a part of that creativity to be tapped to deal with these different kinds of problems. They are different, I acknowledge they are different.

I want to emphasize in this connection the importance of something called partnerships. Partnerships of all kinds, but specifically we have two kinds: partnerships among institutions of higher education, the private sector, and K-12 public education. This kind of partnership has to be of two varieties:

intellectual partnership as well as cost-sharing partnerships. And by the way, the K-12 people have a heckuva lot more money than we in higher education have. Of the $300 billion that is spent every year on education, $200 billion of it is K-12.

Now we like to talk about leverage. Let's get in there and provide some intellectual base for the kinds of things that should be taking place at the K-12. So partnership is one point that I want to emphasize.

I want to come back to something I said before. This requires individual commitment as well as institutional commitment. We can't have one without the other, it's got to ___________ taking place. I want to show you a very brief clip of the program of a television piece that dealt with interviewing college graduates. Some of you have seen this before. But I think it helps make the point about the quality of science, math, and engineering education that we have in our country. And this is from a institution that I think everybody has heard about, or can relate to in your own institution. This is from October 8, 1987, when this tape was made.

(play tape)

Now I'd like just to close my remarks by, again, trying to help you focus and give us as a target what the NSF is trying to do in science and engineering education, especially at the undergraduate level. To do that I want to tell you that NSF, for a whole variety of reasons, is organized into things called directorates. That's the organizational structure, each of the directorates is headed by an assistant director. We have one directorate where science and engineering education is, and this directorate is the one that Bob Watson and I belong to. Here is a listing of all the directorates, it doesn't really matter. Our directorate, and our assistant director (that's me), just like all the other assistant directors, expect we're not like the other directorates. I'm not like all the other assistant directors, for a very simple reason. I have a separate appropriation line in the budget. And I want you to remember that as you talk to people who influence what happens to NSF. We are the education arm of the Foundation, the rest of the Foundation deals with research activities.

Any way, our goals are summarized, there are only four goals, very simple goals, with our directorate. One deals with providing high-quality precollege education in science; the second one is to provide the best possible professional education in science, professional education; and the third one is science for nonspecialists at the college level. That third goal is the reason I'm showing this because I want you to pay attention to it; and the fourth one is informal science education, the education that takes place in nonclassroom settings, the museums, the botanical gardens, zoos, and so on.

Now let me very quickly skip the precollege goals for now and talk about the dual mission of NSF. The second goal is to help ensure that those who select scientific and technical careers have available the best possible professional education in their discipline. So we're disciplinary, there's no question about it. We want cross-disciplinary and interdisciplinary as well as multi-disciplinary approaches. So you know our job at NSF is a very simple job. All we have to do, two things, we call attention to problems that need to be dealt with and then we provide a dollar or two to help solve some of these problems. So the solution has to come from the field. And your role is to help to find approaches to those solutions. That's what I want to try to emphasize here.

So these are loaded words. The best possible professional education. What do you want the next set of biotechnologists to look like, what kind of curriculum development do you want them to have, what kind of research experiences do you want them to have as undergraduates, what kind of retooling or re-examination of the faculty do you want to have over the next 10 - 15 years? That's the second goal. There are a whole bunch of different objectives that come under that, and I'll skip them because I want to get to the third goal.

I would like to treat those as twin missions. The pipeline people and the nonpipeline people. And, of course, we have to treat them differently. If we could tag them in advance and know which ones were going to be which, life might be somewhat easier, especially when they are taking freshmen chemistry, or freshman physics, or calculus, or something. If we could tag them and make that tag stick, but we can't. So we have to think about our first year offerings, which is another issue I would you to address explicitly. The first year experience in science, mathematics, and engineering for all students, not only for the ones who are hyped up and ready to go into science. I want you to think about that.

And the fourth goal is the informal science education programs. Now these reflect, in a sense, our organizational structure, but I don't want you to be bound by our organizational structure. That's the how to part. I want to think about the what part.

And across all this we need to address the tremendous leakage of talent among women and minorities who are not in this pipeline. Now I realize that that is a social issue, a societal issue; it is not an issue that we deal with the same way we deal with synthetic organic chemistry or laser chemistry or what have you. It is not, I realize that. But we should devote some of our intellectual talent to address it.

Now, when I first came to Washington in June of 1984 I was asked by a variety of people what is the problem, Bassam, that you are trying to fix. A very, very telling word, fix. As if it can be fixed once and for all. As if we are talking about a glitch that we fix and we let it go for 10 - 15 years, we look at it every now and then, we're not dealing with those kinds of issues. We are dealing with a continuing responsibility that we have to address.

And what we're trying to deal with, coming back to value systems that I mentioned, is what we refer to (and you've heard this expression before), we talk about research opportunities and teaching loads. Very telling statement. Research opportunities and teaching loads.

We want to have a cultural change and I know that doesn't happen overnight. I would like your group to address that because I firmly believe that we as a country have the capacity to deal with these issues. I have a question or two as to whether or not we have the will to deal with those situations. And I would like Sigma Xi's effort to be part of developing that national will to enhance the quality of science and science education in America. And I know I don't want much. (laughter) But if this group, and what it represents, does not give it not only one good shot, but several good shots, we truly are doomed to fail and this would be a tremendous failure of human_______.

Thanks very much.