Good morning. For two or three of you out there who don't know me, I'm Bill Hecht class of '61. And I'm your senior employee as head of the Alumni Association.

[APPLAUSE]

You might wonder how a guy from the class of '61 got a red coat. A number of years ago the class of '24, which is celebrating its 70th this year, had some issues that needed settling. And somehow or other I was able to settle them for that class. And as a great privilege and tribute they made me an honorary member of that class, insisting that I always wear a freshman tie.

So I now have my own two connections, a six and a one. My graduate degree was in '76 and my undergraduate in '61. And '24 which I'm just as proud of. And I'm busting my buttons to say that in '95 my daughter will get a master's from this place, so I'll have another MIT connection.

I wonder if you all know that last night's pops was not only a very special night for us, but it was actually a test for the potential new conductor of the pops.

[LAUGHTER]

[APPLAUSE]

It is said that he practiced Arthur Fiedler's hand motions studiously before the mirror. And I think that I'm going to take on the job of being his agent and represent him, because I think we can get a hell of a good contract.

Finally, it's my great pleasure in addition to welcoming you all here today to introduce Chuck Vest. Chuck is president of MIT as you know. He came to us about four years ago. And he may be a little wistful today.

As you know, many people who come in the fall of four years ago graduated about a week ago. His class, the class of '94 did leave. Chuck, I guess fortunately for us, but perhaps not so fortunately for him, still remains with us. So let me introduce Chuck Vest, president of MIT.

[APPLAUSE]

Thank you very much, Bill. I'm just signed up for the new five-year master of engineering program. That's all. I've been for years wanting to get up the nerve to ask Bill exactly what this great favor he did for that class is. But because I'm not sure of its legality I've been afraid to ask.

[LAUGHTER]

On a more serious note, and a very happy one, I understand that we have a record number of alums and families here for reunions on Technology Day. You are over 3,000 strong. My congratulations. And we all have an exciting day ahead of us.

[APPLAUSE]

The speakers for today's program are truly a stellar group of men and women, who will talk about art and culture in the Academy, and specifically at MIT. Here at MIT, where the arts have evolved over a hundred years from a single extracurricular activity in 1884, the MIT Banjo Club, to a panoply of artistic and cultural endeavors that you're going to have a chance to sample here today in 1994.

Special thanks go to Jorge Rodriguez, chairman of the Technology Day Committee. And to all the members of the Technology Day Committee, the Council for the Arts, for putting together such an astounding and exciting program. I might add that the watercolors reproduced in the Technology Day poster was painted by one of our graduate students in the School of Architecture and Planning, Lian Quan Zhen, and that there are other examples of his work on display today in the lobby.

Now to some it might seem odd that in this bastion of science and engineering we bring together our alumni and alumni to celebrate the arts. But most of you probably had at least a brush with the arts at MIT, and many of you I'm sure became more deeply involved in our music and theater arts programs.

And now more than ever, our students and our faculty are engaged in a wide range of artistic and cultural pursuits. In the visual arts, and architecture, music, theater, creative writing and photography. As well as in the emerging media of interactive video, holography, and hyperinstruments. Still, some of you might ask why.

While it is true that MIT is best known throughout the world for the caliber of the engineers and scientists we send out from this place, the Institute has in fact produced a steady flow of artists, architects, musicians, dancers, actors, and others who are best known for their artistic endeavors. We have string players and wind players, composers and conductors in orchestras around the country. We have actors on Broadway and in Hollywood. And we have MIT graduates on the faculties of music schools and many other universities.

Of course, most MIT students continue to pursue traditional careers in engineering and science. But we are no less serious about teaching music, theater, and the arts to these students. The arts, when taught seriously and deeply, offer our students opportunities to expand their imagination, broaden their perspective, and imagine ever-widening new possibilities.

This is true for all of us. When we develop our ability to think creatively, we were able to find new solutions to the problems on which we are working, both in our laboratories and in other aspects of our lives. Take for example the fields of engineering, and particularly engineering education. We are moving very dramatically toward a more integrative style of education, with increased emphasis on design and synthesis, and a little bit less emphasis on analysis and reduction in science.

I think that art, and an appreciation for the aesthetic components of all that people do is very helpful in this regard. As we work to improve the quality of designs and products, it's going to be increasingly important for engineers to co-operate with artists to tackle the visual, tactile, and aesthetic qualities of their work.

But quite aside from their role in scientific and engineering endeavors, the arts should of course still be an important part of our lives and of our education. Why? Because they are part of our humanity. They reflect our human experience.

The arts give us a different kind of connection with the world, and they can help us to understand the many cultures that make up our community and our world. The arts allow people from very different perspectives and backgrounds to communicate, and to interact with an almost build-in degree of mutual respect. This is important for our graduates as they take their skills into an increasingly interdependent, global, and multicultural world.

And this is very important for MIT. The more innovative we are in celebrating and encouraging the richness and diversity of our community, the better off all of us will be. In some, the arts at MIT are essential elements of our education and of our community life. Not only are they healthy here, they are thriving.

This is great testimony to the talent, the dedication, and the enthusiasm of a great many faculty and students. And it is particular testimony to one person who has done an extraordinary job in stimulating and supporting the arts since she arrived here at MIT in 1989. I refer, of course, to my colleague Professor Ellen Harris, associate provost for the arts at MIT.

Ellen is a distinguished scholar of music, who is also known widely as a soprano soloist. She came to us from the University of Chicago, where she was a professor of music and head of the Department of Music. As a scholar, she has been recognized for her work on the music of Handel. As a singer, she is best known for her dramatic stage performances.

Those of you who were here for commencement last week and heard her sing the national anthem know precisely what I mean. Ellen's arrival on campus was the final fulfillment of a set of recommendations made in 1987 by an arts review committee, which recommended the appointment of a senior officer who would also be a faculty member in either the performing or visual arts. Someone to take broad responsibility as an advocate leader and coordinator for the creative arts program here at MIT.

Believe me. Ellen Harris serves superbly in that role. Ladies and gentlemen, professor Ellen Harris.

[APPLAUSE]

Thank you, Chuck. Good morning.

Good morning.

Oh, good. It's often been said that at MIT one's education is like taking a drink from a firehose. What I have noticed is that so is Tech Day. We have you here before 9:00 in the morning after having you out very late last night, and I appreciate seeing you all here so bright and raring to go.

I'm proud and privileged to welcome you to The Wonder of It All, the Arts at MIT Technology Day 1994. And I want to add my thanks to Jorge Rodriguez, the chair of the alumni Tech Day committee. And also to Eliza Dame, who does so much, more than I can possibly say, to make Tech Day work year after year.

Many people like to talk about the arts at MIT as if it's an anomaly, as if it's a surprise, or as if it's something new. But of course you know better than anyone else that that is not the case. The arts have been a part of MIT since its founding. MIT was the first school to establish a school of architecture in 1868. It actually began offering courses in architecture in its first year, 1865.

In that same year we were offering courses in photography and in drawing. In 1884 we not only established the Banjo Club, but we established the Glee Club. In 1928 we established Drama Shop, the forerunner of our theater curriculum today. And in 1948 John Corley came to MIT to establish the MIT band, an organization that he continues to conduct today.

[APPLAUSE]

In 1950 the Hayden Gallery opened, which was the forerunner of our now internationally renowned List Visual Arts Center. But perhaps most importantly, in 1944-- 50 years ago today-- MIT first established its eight-semester sequence in humanities.

Those of you who have been at the Institute since 1944 will remember your eight courses in the humanities. They used to be different than they are today. But in 1944 they included I think a first-year course in writing and English literature, second-year course in history, third-year course where you could choose from a number of subjects, including economics. And in the fourth year a wider selection of courses, including a yearlong course in music.

Because of this eight-semester sequence of courses, which parallels the eight-semester courses in science, MIT has had for many years a program in education which has been referred to here as dual literacy. MIT students have been asked to be literate not only in science, but in humanities and in the arts. In fact, MIT may be one of the few educational institutions in the country that asks this of its students. It is very, very easy at many liberal arts institutions to avoid the sciences. Not so easy at MIT to avoid the humanities.

In fact, this dual literacy has meant that we have within our students and alums many people who have gone on to careers in the arts. In fact, in the class of 1994, I can think of four cases immediately. Two young men who have double majored in mathematics and music, both of whom are going on right now to graduate school. One to the University of Chicago, and one to Duke in music composition.

We have another student who majored in civil engineering who has received a full scholarship to pursue writing at Boston University. And we have another student who majored in theater at MIT, who is going on to pursue his work in theater, who hopes to establish his own theater company in the countryside of Mexico. I sometimes think we must graduate the most scientifically literate artists in the world.

But this is not something that was just true of the class of 1994, and I was looking at the reunion classes for some other examples. And obviously, we have a lot of people today here from the class of 1944. Right?

[APPLAUSE]

Well, one of your members, John Bavicchi, who graduated with a major in management, has gone on to be a very well-known composer and conductor, who has been for many years on the faculty of the Berklee School of Music. From the class of '64-- '64? Do I hear the class of '64?-- we have John Miller who double majored in humanities and engineering, who has made his career as principal bassoonist with the Minnesota Orchestra. Class of '69.

[APPLAUSE]

You had with you for some time James Woods, who was majoring in political science before he went on to become a very well-known actor. In '79--

[SCATTERED APPLAUSE]

I think we need more energy folks. Liz Maruska, who went on to become a practicing artist on the West Coast, who paints beautiful canvases in watercolor and gouache expressing time and space. And finally, class of '89, five years.

[APPLAUSE]

Ken Goodson, who majored in both mechanical engineering and music, received his master of science in '91 in mechanical engineering, his PhD in '93, is now studying and performing as a baritone soloist in Germany. I love, about Ken, that when he performed at Tanglewood as an MIT grad, it is only appropriate that when singing in Stravinsky's work, "The Flood," Ken Goodson play the role of God.

[LAUGHTER]

But obviously MIT does not graduate all of its students to go on in the arts. You don't need to be an arts professional to benefit from the arts. And whether you worked in Doc Edgerton's strobe photography lab, or perhaps became interested in physics through Bernice Abbott's extraordinary photographs of physical phenomena that were published in many high school textbooks and that were taking at MIT, or whether you played in the symphony, or sang in the Glee Club, or acted in a theatrical production, I am sure that at some point art touched your life at MIT, and has continued to touch your life thereafter.

Arts offer us discipline. Anyone who has practiced the piano knows that. Arts offer us imagination. They offer us the flexibility of a pursuit where there is not one right answer. But they also offer us new ways of organization-- of organization of sound, and space, and time.

The arts offer us a doorway into cultures other than our own, that enables us not only to tolerate but respect difference. The arts challenge us, surprise us. Sometimes they anger us. But the arts also bring us wonder and joy. And today we hope to explore, through our presentations, the wonder and joy of the arts today at MIT.

This of course, leads me directly to our first speaker, Philip Morrison, Institute Professor emeritus at MIT. You are probably familiar with his work in astrophysics and cosmology. Maybe less familiar with his work as a filmmaker. I first came to know Philip through a copy of a keynote address that he gave in 1986 for the 15th anniversary of the Council for the Arts at MIT, an organization founded in 1971 to advise and support MIT in the expansion of its arts programs.

At that time he said, and I quote, "It's clear that if an institution like this one which deals with the material world did not have the side of art, it would be a self-defeating proposition which in the end would be all genetic seed and no fruit to the apple. And an apple is not made that way." I think that I can do no better in introducing Professor Morrison than to quote his colleague Victor Weisskopf who said of him, "Scientific knowledge and understanding is not a purely cerebral affair. It is soaked with emotion, excitement, and nervous tension, as everybody knows who has ever heard Professor Morrison speak." Ladies and gentlemen, please help me to welcome Professor Morrison.

[APPLAUSE]

Thank you very much. Much equipment here. All of it seems to work. I'm especially impressed by the video projection system.

The Wonder of it All at MIT: The Arts at MIT is a very nice title. Doesn't say much. Commits very few speakers. I would certainly like to affix firmly onto the word "wonder," because clearly that's the kind of motive which lies behind nearly all the things that go on at MIT, translated as eventually they are into the hard tasks of earning a living and making this world work.

The old classical Chinese scholars always like to pretend that the ideas they had were very old. So they found some mysterious figure of the past who nobody knew much about, typically the Yellow Emperor. And they said, well, the Yellow Emperor first said, and then they made up their own books.

[LAUGHTER]

We don't do that now. We have a much more forward-looking-- we don't look back in general. It's always new. That's the same error in reverse. People have this tendency for bipolar positioning, bipolar stability of large axis. Because everything is both-- has something old, has something new, or it's not being pursued very far. That's the typical lesson. Ask a historian, he'll take it back for you. Ask a projector of the future, he'll push it forward. Both things lie in time.

I wondered however, and I didn't always know this, and I became more and more convinced of it in the past recent times, few years maybe, the proposition that this issue that we now debate is extraordinarily old. I could invoke no newer phrase for it than this Latin tag of the Institute, mens et manus, mind and hand, to talk about it. Because of course, that is the exquisite pleasure of the MIT ambience-- that minds and hands are equally well-occupied.

That means to say that a lot of mechanical things are done-- a lot of things in the material world, or with the refractory symbols of the world, they're hammered away at, whether it be metal, or melodies, or whatever it is. But it's not done by and large by rote. Obviously some rote goes into all operations. Experts become routinized. But thought is at the basis.

And it turns out that that unity, which is a profound unity between art and the triune quality of modifying and knowing the world physically, craft, engineering, and science in their relationships goes back a very long time. And I brought along a few slides to justify that and to get us well started. So it's not a new task that we're looking into.

This wonderful picture in the center, collection of rocks, deserves some close attention. Those rocks are not natural rocks. The fact that they are quite similar I think is pretty evident. It's also quite evident-- if you look more closely, not easy to see perhaps, it's better to handle them. We can't do that, but I think it's enough to suggest it in a context like this.

You can see the three edges here, the double ones there. Every one has faceted edges. This one has in fact a slight double, a kind of blade-like edge and so on. This is a pile of rocks-- a section, a collection-- made by the excavators in Olduvai Gorge in the rift of East Africa.

These were not found that way. They were found stratum after stratum, carefully located, carefully arranged in position so they could be dated. But the photographer simply gathered a lot of them to give us an impression of how many hundreds, indeed many thousands, of these stone tools are found.

Now, the remarkable part about them-- this of course is mens et manus. Mens is pretty thin still. These are not even our own species. These are our distant forebears. They were poor. They first walked the earth fearful of the beasts. Pretty soon that stopped, and the beasts tended to avoid them.

Before that perhaps even they scavenged on the kill of the lion. But sooner or later, this kind of operation symbolized here-- mind and hand-- began to change where they were. And they did marvelous things on a very slow time scale.

The pieces represented in this collection, just that arbitrary piece of a large collection, are measured not by centuries, but by thousands of centuries. Yes. By hundreds of thousands of years. A few 100,000 years corresponds to a typical collection at Olduvai, which might extend to a million years or more. But to be generous we'll say a few thousand centuries.

Now the striking part of this is that these tools, without very much change, are found over a very large part of the world as the next slide will show. There it is. Here are famous sites. Anyone who has read anything about early archeology will recognize these kinds of locations.

From Britain up here, into Europe, France, at the Pyrenees. Especially very important in there. All across Africa, East Africa. Here we have Olduvai itself and down to Cape Town. So from Britain to Cape Town, and from Cape Town across Asia, Central Asia, India, North China, Peking, further north still and into Java.

All these-- the major sites. Each site feathers out into many, many little excavations. And from all of these places about the same kind of tools are collected. Yes, the experts argue a bit, and they can somewhat classify them. But it's really quite hard to date them except by the attendant pieces of mineral which can enable you to date them by radioactive means.

But you'll notice that not one site is found in these islands or Australia. And I've left out the Americas. No use to put it on the map. Because not one site of this kind has ever surely been found in America.

No. Australia, the great islands near Australia, and the two Americas do not belong to these people, who I don't wish to say are-- they are our ancestors. Cannot speak ill of them. They were in fact the Prometheans. Because somewhere in the middle of their span Homo erectus figured out how to make and control fire. And the hammer at MIT is entirely secondary to the fire, and all that goes with that symbolically.

So I don't show you those sites, though of course there are very many sites in America. But none of them show the bones or the tools of these ancient folk. We truly, like the Australians-- the Australian Aboriginals, the Native Americans-- are the modern humans, like all the rest of this place has also been filled in by modern humans. I don't mean to say we're-- of course we're not. Most modern humans live in this part of the world.

But the same species occupies this whole region. And only after a long time, after thousands of centuries, it managed, they managed, in the course of some internal change, which is what we would call a change in species to Homo sapiens, they managed-- by means that can be well debated and interesting to study-- they managed to be able to cross the then much shallower coastal seas, and finally the great Gulf of the Timor Trench.

And come somehow by canoe or raft to Australia, and in the same way go across the relenting Arctic where the glaciers were melting, and follow the coast line of America. And go down the full length of both continents rather quickly, and that completed the occupation of the world by modern humans.

So we are the new world. Not because of Columbus or any feature of historical importance. Those are small matters. The real thing was we we were new, because the new people who filled up the old lands very well had a way also to get to new lands never before occupied. So our histories go back only a few hundred centuries, not a few thousand centuries.

There's an order of magnitude difference between the kind of thing you saw in the Olduvai rocks-- bifaces, choppers, hand axes they're called, and the kind of thing that came when a new set of persons of whom we are all descended, we can prove by the deepest of biological means how united the whole world is in our single species, with subspecies as we well know.

And the next slide will show what you find in these new sites. Now please compare these, which are nice American pieces. They were made about 12,000 or 14,000 years ago. These are found in a region in Montana. And of course they're specialized for killing big game.

And if you'd like to know what the big game was-- probably you do know-- it was elephants. Pieces quite like this, spear points like this, have been found in contact with the bones of bison and mammoth. And of course, where the other rocks had 10 or 20 rather cunning blows struck which you and I could not do, which people can train themselves to do today, these have many hundreds of knowing strokes to chip the blade just correctly. And even along the edge you can see to sharpen it with a wonderful thing, very detailed marks up there, all of which are significant in producing a handy and useful blade.

So I have no doubt to say this is craftsmanship, possibly even engineering. At least its high-quality craftsmanship, because we know now that many of these blades have to be heat treated in order to allow the chert and the flint to respond to the chipping.

But now I'd like to go a little farther and show what they did. And it happens that the preservations I have now are again the same new people, our people, but now coming from France and not from Montana, the following. A bone object used for working sinew and straightening arrow shafts. You can see the hole there.

But it wasn't enough to make it utilitarian. It has this marvelous leaping horse worked into the same material. And this was about 200 or 250 centuries old from Bruniquel, a cave in France. We have art so much from France and Spain because the caverns are so well-protected there. They guarded the art behind stalactites for many thousands of years.

And the next slide, perhaps even more striking, an image itself, an elk of the period. The biologist will find fossils that fit it quite well. Beautifully drawn in charcoal and ocher on the wall of the French cave. This was the famous cave of Lascaux.

So I rest the case that the relationship that changed, that came to human beings, we don't exactly know what it is. Most likely it was the acquisition of a powerful language, which enabled them to work cooperatively and to model the future, gave rise to the craft and the art, which you unmistakably see here, which goes back not merely thousands of years, but tens of thousands of years. This particular piece is dated about 15,000 or 18,000 years ago, the previous one about 20,000 years ago.

And all from that same flood of persons who occupy the world, maybe in all not more than half a million of them by the time the Americas were settled. And we've grown them from that half million to half trillion, a very large number of powers of 10 in population. Thank you.

Now the linkage between the craft-- engineering, science, art-- between hand and mind expressed in this way, I maintain this is demonstrably old. Indeed, we can see it even in the beginnings of science, the time of the Enlightenment of the late Renaissance, you couldn't buy a microscope that wasn't worked up and chased and engraved to bear some art.

Partly that was style. I'm not denying it. Partly that was royal patronage. I'm not denying that either. Nevertheless, the work of the hand was to be admired. And it was rare to have such skilled craftsmanship in these new materials with a new purpose.

And to some extent, we've lost that feeling because of a utilitarian quality, and the already great expense of making the complex instruments which now replace the sledgehammer of the MIT seal. Or augment the sledgehammer. I don't want to run down the sledgehammer. Still a very indispensable instrument.

What I would like to emphasize, though, is that this connection is a profound connection. And I'd like to describe a little bit why I think it's so, and why it parts the hand-mind relationship from a more symbolic one, which is not absent from either. Any of you who have tried to learn a craft, or a skill, or above all an art, knows how very close the reaction of the hand and the mind must be to make anything work the way you choose. And if you don't do that, another draft has to be made.

Now of course those who deal in symbols alone have some of the same quality, but the hand is much less present. The symbols are, by nature, more conventional. What is characteristic of art and science engineering together is they represent-- almost always they're presented to us, and they need to be presented to us in concrete form. In single concrete examples. Perhaps something more than the poet Blake called "minute particulars," which he felt all art and science were compacted.

But certainly not generalities. Generalities edged towards philosophical description. True, there's a big domain in-between. There are theorems and propositions that are indispensable, that come out of thought, and which govern many of the things we do. But I think it's fair to say that works of art, and the data of science, and works of the engineer, are all concrete examples.

And if you don't have those, you have a very dry subject indeed, that consists of nothing of theorems, about mechanics without notions, or diagrams, or examples, or particulars, which I suffered through as a graduate student once long ago at another university when I was studying mechanics. We couldn't ask questions, and we also couldn't understand the propositions. We sure could learn the words quite well.

Now there are differences, of course. I think that the principal characteristic of art, which I admit it is somewhat rapidly losing, but hasn't lost yet-- it can be seen in almost all parts of it-- its products, its particulars, are perceptual to the human being. It's very hard to imagine art translated through-- it's not impossible, we see it today-- translated through some intermediate device, which turns it into printouts and numbers.

Then you have to regraph it. This is hardly art. The immediacy is gone. Though of course, a great deal of the world of science, great deal of the data of science, go beyond human perception, involve intermediation by instrumentation of complicated kinds. And auxiliary calculations to bring together the reading of the instruments or program inside the computer, which is doing the same thing. And by and large, that's the biggest distinction I can see on the side of how the work is done.

It is also true that they are united in this. Niels Bohr defined science not only as effort to order the world, which surely it is, but there it does not deal-- it does not differ from philosophy, or for that matter from poetry. But it seeks to bring a new experience, which again is close to art, though perhaps rather different from the philosopher's work.

And if we talk about engineering, I think we have to say to bring new means for the game you've experienced this, too, is necessary. But all of this definitional style would very much connect these two or three-- it's hard for me to think of them as three, but certainly a multiple view of these matters.

I'd like to go still further and talk about their internal-- the way it appears to practitioners of it. All of you as students were practitioners. All of you now are practitioners in some direction or another. And I think you will recognize, feel sympathy with what I say, when I say that there are a couple of apparently polar divisions, contradictions opposites, which have to be united in each of these things. A curious but quite realistic account of what people do.

For example, the passive absorption of information to learn a language, to learn mathematical formulation, to learn the use of a pen or a brush, to learn the language of the stage, whatever it might be-- to learn the notes of the scale and the keys. All of those things can be done as a passive game where someone feeds the information-- a book, a program, a person-- and you gain it.

But of the other side, activity is indispensable, especially if to learn those things with that beautiful word, "productivity." So it can again recombine them for yourselves. We know that the people who teach physics at MIT and everywhere else, that the solving of problems-- onerous as it may be-- is a way to secure the active knowledge of the things passively observed, underlined in yellow marker, the big propositions in the textbook.

You've got to put them together. You've got to make them work for you. You have to feel somewhat what we say at home with them. Until that's happened, no genuine understanding will come in. The answering of multiple-choice tests in familiar language, choosing the right one of six, is not a very powerful test for science, for engineering, or for art.

It may be good enough for learning certain received bodies of truth-- fine. I'm not against it entirely. But it is clearly-- in our day it's a basis of controversy, and surely overused. So we have to combine the passive and the active, and activity is the sine qua non of the hand and the mind.

The same similar dichotomy goes between the analytic and the synthetic. It was said in popular psychology only a few years ago-- it was quite popular in the magazines-- there were halves of the brain, the left and the right. And one attended to the holistic things, the organization, the concepts. And one attended to the details, the rigorous logical thinking. One was suitable for children, one for grown-ups, and that was the general idea.

People who said that, of course, were mostly writers, because they understood writing very well. They knew how hard it was to formulate good sentences and paragraphs. And they said, well, in the kindergarten they can draw quite well and make images, and that's enough for that.

Of course, this is a caricature. It's a very bad proposition. Analytic and synthetic again are together. The analyst indeed may take things apart. But the tools he uses were themselves synthesized by earlier designers who synthesized the scalpel, or the method of least squares, whatever it might be, by putting together something new that had not existed before.

So I reject that as a harsh division of the world and say, no. Both halves of the mind are necessary. All parts of the mind, like both hands. And the unitarity of this is visible, and visible in the sense that we all know that for every geometrical statement in Euclid, an algebraic equivalent can be formed. And vice versa.

The symbols of language the symbols of x and y and plus, are no more foreign than the lines and the angles. They're just different ways of presentation, and they have a one for one correspondence. Of course, the symbolism of our world is so powerful now it extends. It goes beyond what we can easily draw. You can do any dimensionality. I accept that and use it daily. But this is the issue.

Now there is a feeling that there's a difference in tone, and there is some difference. The scientists and engineers seem serious. They're concerned with matters of prosperity and penury. Or sometimes life and death. Or sometimes peace and war. And this seems more serious, perhaps, than the more playful activity of the artist.

But I recommend you, thinking through our language, the word "play" has wide connotations. The player may play Medea, or Hamlet. Hardly a lighthearted affair. Something plumbing the depths of human behavior.

Lightness of heart is not the whole story. The primary colors, and the cube, the sphere, are fine things for the elementary school, indispensable for the small child. But they are not the whole story of play. Play, which is unique in the vertebrates, and best developed in those closest to us is profound.

I worked a lot with Charles Ames, who said that one of the most serious activities in life was play, and he demonstrated it every day by what he did. Play is a means of-- clearly what the word implies-- model making of the future. What would it be to do like that, not to carry it out, not to make that full investment? But to acquire the mastery in a more benign, a more acceptable, a more easily entered environment. And that is what play is.

And since you cannot master the world in a stroke, play is an indispensable feature of human behavior. From word play of the infant and the mother in the home, to the most profound thought of an Einstein or a composer of great value, Bach in the course of his work, as any exposure to art demonstrates that these things have. And the scientists, too, must have it.

I'd like to say a word for playful engineering, which I think is an important issue of our time that we have not yet fully engaged. It's not new. There always has been such a thing, but I'd like to show an example of it in a slide.

I hope you can recognize this slide. It's a very unusual slide. It was made in 1936. It shows one of the greatest works of playful engineering, the Eiffel Tower. You can perhaps recognize the Avenue Chaillot down here, and the arches of the Eiffel Tower there, all heavily illuminated in this time exposure from 1936, where of course, what you see is a pyrotechnic display, fireworks, off all parts of the Eiffel Tower.

But of course, the Eiffel Tower was built strictly as a playful operation, a decoration for Paris from the 1889 World's Fair there by a great structural engineer. It worked 10,000 tons of wrought iron, not of steel, of wrought iron and rivets. And made playfully.

Of course, managing to extract a fee from the people who come so it can keep going, keep itself painted. And indeed, pay the shareholders quite a considerable income, I understand, over the years. But nevertheless, that's its foundation. It doesn't do anything but stand there magnificently.

At first, of course, attacked by half the artists and writers in Paris. And now inseparable from the nature of the city. And I'm sure that you could not possibly tear it down without a major revolution swirling about the base of the tower.

Now playful engineering is not enough practiced in our time. It is practiced some. We all know about it. We know about it in sports where it's become a specialty, and almost lost its playful call because of its heavy rewards.

And at MIT, from the impromptu and very light-hearted hack, of which I need not give you any examples, through the pedal-driven aircraft of great renown, to the wonderful stroboscopic work of Papa Flash, the late Doc Edgerton. To the sophisticated work, whose 25th anniversary is being celebrated tomorrow at the of Center of Advanced Visual Studies, which I remember for sort of three or four works of grand works. Not single works, but whole campaigns of playful engineering. Mechanisms of extraordinary wit and pleasure.

The use of aerial photography as an art form, not as a geodetic study or a way of measuring crops. And sky art, lasers and balloons on grand scale just beginning in this world in the last few years.

And I am quite sure also that the Palais du Louvre has been recently subjected to something which is architecture and playful in its qualities, and at the same time profoundly purposeful. And I'm sure that IM Pei and Dean Mitchell will describe something about that in their talk of recent work just to come.

Now I'm going to close. And I want to close with a somewhat novel end, which I had not really planned, but it was forced out of me as I went through these thoughts in the last few weeks. I see one danger.

The danger is an extraordinarily clear one, and I think we have found the best way to avoid it. I'll tell you what that is and see if you agree with me. Please think about it. It's something novel. It's something of great importance to all of us. And it needs widespread attention.

And that is it's clear that nowadays art produces its own truths. The artwork is not judged by its comparison with another canon necessarily. Yes, it might be of the School of Beaux-Arts. It might not.

The schools are various. The techniques are innumerable. The subject matter, the minute particulars are as wide as can be. And I think we should accept that as the freedom that the artist has.

Of course, he may follow a strict form. He may wish to do that. Or he may break loose into something quite new. But in any case, there's no other criterion, no external one. The scientists must-- the input is what counts. The data must be reliably presented. The engineer, the object must work for the purpose of which it was intended or some purpose close to that.

But the artist, it is the output that counts. Does it work for the purpose he intended it-- to amuse, to entertain, to teach, whatever it might be? It doesn't matter how he got there. He isn't responsible to show you the data on which he worked.

And on the other hand, this leads to a great danger, of which a very tiny example my wife, Phyllis Morrison, helped me produce for the next last slide. Well. It's the Eiffel Tower again, right? In fact, it's the same-- you'll see it's the same pyrotechnic picture.

But spontaneously, with the matter of a few seconds, Phyllis has managed to give a kind of impression that there is a colorful pyrotechnic display coming from the great tower. And of course, you are all well sophisticated enough with images, and with now markers, to recognize that of course it has nothing to the Eiffel Tower at all. What does it have to do with? It has to do with a 35-millimeter slide that represented the Eiffel Tower in 1936, which she has then modified with just a very small spontaneous artistic work to make the point here.

But the image, however, is itself, it is there. And it means something. It's actually quite striking. And now the trouble is we make images so well today, we make so many, we can make them so seamlessly. We can change their appearance in every way.

Not only visual images, but even speaking more metaphorically, auditory and the rest. That there is a cut-off between the world represented-- may not be represented. But even those things when they are represented, well represented the image are no longer good maps of each other. The artist's intervention is so powerful that he has ended that.

Now that is not new to us. We all experience it internally, and it is probably indispensable to the human mind in the way we have evolved. It is what we call the world of dream.

In dream, visual images are produced which have maybe some semblance of your experience. Sometimes not, perhaps. But when they have semblance, we know very well that those dreams are not the relatively close approximations to what is going on. That the eyes which are always limited, and the video screen which is equally and similarly limited, bring to you approximations of the real world.

Now what I am trying to say is a danger that if we have, as we do have, the greatest 20th century arts, the one that attracts most people, and I think has gradually, gradually increased its salience is the cinema. And I strongly suspect the 21st century will make the video equivalent of cinema with its music, with its changes, which is probable 3D nature. And its motions and change will probably transcend all previous visual experiences, will make an enormous push upon the world.

Whereas the capital of this world is only going to double or triple and plateau out. There isn't room for more. There's not room in the atmospheric balance and the heat sources for more. These sources of information and image are enormous, and they will continue.

And the real question is that we not be swamped in a dream world, where we no longer pay attention to what the representation was of, but only the nature of the presentation itself. That is, after all, the artist's task. And I cannot think of a better way of understanding that problem of conquering it than by having people who know both sides of the operation, who have studied the arts to see how much you can do to make entertaining and wonderful things that didn't exist, but also how much you can do to represent scrupulously and meticulously the data of the real world, the actual performance of engineering without hyperbole and public relations and the rest.

To take only one side or stay away from the other, that will not work, because people are too clever and they'll transcend it. What is the best is to expose them both. Come right up front and say, yes, this can be done, the artist has one direction, the engineer scientist has another.

Both recognize their enormous similarity, but by their mutual understanding we can have a world which both contains dreams, but is not solely based on it. And I think that's the only kind of a world which is safe for us to try to carry on the legacy of the canyon at Olduvai. Thank you.

[APPLAUSE]