GUTTAG: We've gone out of our way to find some provocative post-lunch speakers to avoid the postprandial nap syndrome. So I'm sure you will be more than kept awake by the group. Our first speaker this afternoon is Nicholas Negroponte. Currently, I guess, he's founder and chair of One Laptop per Child. But I think around MIT he will always be thought of as the founder of the Media Lab. Nicholas.

[APPLAUSE]

NEGROPONTE: Thank you very much. And I'm delighted to have been asked to present. And I will do roughly sort of one third on the Media Lab, and one third on One Laptop per Child, both of which fit squarely in this topic. And I'll tell you a few stories, actually that have never been told, partly because I never had an audience to tell them. But-- an audience that would appreciate some of the MIT aspects of it.

But I came to MIT in 1961, which feels unbelievable, and went through the school of architecture-- actually twice. I did two degrees. Because at the time we had an undergraduate and a Master's. And as I went through that, I realized that my interest was computers and graphics. And later became, more generally, the human-computer interface. But when I started as a young faculty in 1968, I started something called the architecture machine. And by the year 1977, it had become really very generalized. And I will show you some slides that go back to it.

But this was a room we built in Building 9 across the street. And Building 9 is quite important. And this was, how do you immerse somebody in this computer environment with a big display, quadraphonic sound, a lot of interactivity, and so on. And we built this room that gave you displays to your right to left, and through the chair you could navigate, and we did a little thing that was data land. This display had little calculators and maps on it. In fact, at PARC, they were still doing much more stylized things and you could navigate it.

What was important about this project was that it was on the same floor and 300 feet away from Jerry Wiesner's office. And Jerry Wiesner was President at the time. He was the last President, few people know this, who had a chauffeur. And what Jerry would do at lunchtime is take his guests out to lunch walking through our laboratory to show them these things, because they were pretty-- you could sit down in the chair. And you could fly around this case, Aspen, so-called movie map. And you could navigate and then sort of get up and go off and have lunch.

So after a few years we became quite close friends. And he confided in me that Howard Johnson, who was then the chairman of MIT and younger than Jerry, was doing such a good job that when he, Jerry, was going to retire as president, which he had been announced yet, but he didn't want to go on to be Chairman. He wanted to come back and do research at MIT. He said, but there's no lab for me to go to. And I said, I have an idea. We'll build one. And he liked the idea. And we discussed. And we had a few faculty meetings, or meetings with faculty on the subject.

And the one thing, even though he was President, he was told, and I was told as a consequence, it's fine, there's just two words you cannot use in your name. And one of them is computers, and the other is communications. Otherwise, you can call it whatever you want. And we said, well what about media? And people literally went, yuck. You mean things like journalism and stuff? I said, Yeah. And so we got it. It was frictionless.

And then the second little secret, dirty secret about-- there are three dirty secrets about the Media Lab that don't interest most people except MIT-- and the second one is that when we started, we got permission to be both an academic department and a lab. We could admit students, hire faculty, award degrees, and so on. This normally doesn't happen. And the argument at the time was that we wanted to admit people who wouldn't normally even apply to MIT, let alone get in. And that was quite important because we wanted to bring people from RISD. We wanted to be-- people, journalists, people who had, if you will, the creative content to work in a place where the new media would be invented.

And then the third little-- it's not really so much a dirty secret, it's a fact, and that is that MIT did not have a film school. It didn't have an art school. It didn't have a journalism school. It didn't have an Ed school. It didn't have the constituent parts. So when I went around to the then provost or various deans and says, I would like so-and-so to come and join us. In the case of Seymour Papert, who was reporting directly to the Provost at the time, the Provost said, you want to take him? Bless your heart.

So a lot of the people who joined the Media Lab in the beginning were very much [FRENCH], people who were not particularly welcome. And so we felt like a band of people who would go out and prove that there was something, god knows what we were proving, but the result was the Media Lab. And then by 1979, which was sort of when the idea was still Jerry, we still hadn't built the building, some of the things-- and it was very early work to start taking voice and gesture and combining them, and I won't go through the specific project.

So this what interests me because it's actually little earlier than 1979. It was the first display that looks like and feels like an interactive book. And there was a bicycle repair manual. And a project that never survived-- also the same period-- was a pressure sensitive display. It took advantage of the fact that friction between your finger and the glass was such that when you touched it, you not only could touch, but you could introduce forces in the plane of the screen. So the length of that arrow is how hard he's pushing in that direction. There were some wonderful applications.

And this actually has the date on it, a little bit later, '81, you'll even see hyperlinks. Tim, with the cup-- the little things you could touch and get the next story, and up would come videos. And people would get gasp. And it was sort of still considered-- well, was it computer science, was it not? It didn't matter.

So I did that for the next 20-25 years, depending on how you count. And after doing-- oh sorry, there was one more piece in that era, and that's where Seymour Papert and I were starting a project in Senegal Pakistan in Columbia, at the time hosted by the French government. And this really is a photograph from the era where we were taking his works, completely his body of ideas and theories, and we were implementing it in the developing world. And while the project didn't continue with traction in any way, this child outside of Dakar played that Apple 2 like a piano. Didn't speak English, didn't speak French, but was just-- there was no noticeable difference between her and the kids here in Lexington and Concord.

Flash forward almost 20 years. During that period I'm running the Media Lab, and what happened in 2001 was that my son was living in Italy. He was having girlfriend problems. He had started a company that didn't quite work. And I said to him, I said, Dimitri, if you can suffer the indignity of working for your father, why don't you go to Cambodia where I've built a school and-- I just did it out of philanthropy, long story-- and why don't you connect it to the Internet. And I'll buy some laptops on eBay and send them to you.

So he goes to Cambodia. He sets it up. These kids get their laptops. The village has an average income of $42 a year, $42 a year, no electricity, no telephone. And when they took those laptops at home-- to home at night, it was the brightest light source in the house. And I said to myself, this is the tooth fairy, in this case me, going to a village. But is it scalable? And in 2001, when I looked at literally that picture, I said, what in that picture will not happen through normal market forces? Because when I wake up in the morning it's the only question I ask myself. Will normal market forces do what I'm doing? If yes, stop.

And when I looked at the picture I could tell, what didn't take clairvoyance, that the telecommunications piece, the satellite in the background, was part of an entire agenda that over the next 10 years would get cheaper, and more widespread, and better performance, and more bandwidth, and lower et cetera, et cetera. Why you can't see the power, the town had no power, but I could also predict that power would inside-- whether was locally made power, green power, grid, whatever it was, was probably going to happen. But the laptop bothered me. The laptop bothered me because I saw no force in the market that would stop this escalation of sort of adding features, and faster processor, and more Microsoft uses it, and so on so that everybody's laptop was basically an SUV. Where you're using more fuel to move the car than the passenger.

And we said, if every child is going to have a laptop, can we break that spell? And that's the reason we started One Laptop per Child. And I also figured I'd been at the Media Lab for so long, that it was kind of my turn. I didn't have projects at the Media Lab. I just ran it, and raise money for it, and went out, and just very rarely on campus. In fact Chuck Vest used to send me emails saying, there a sighting today. And I was very rarely on campus, maybe one day every two weeks and the rest of the time I was sort of-- it was little bit like sort of going off and sending remittances home. And that's sort of what I did for 20 years. And the remittances were pretty good. And the place was running with a lot of funds. So I decided now it's my turn.

So I started One Laptop per Child. And now after it's been going on for five years, it's had an extraordinary impact. And it gets a lot of negative press, interestingly enough. I thought that I would have a Mother Theresa shield around me. I don't draw a salary. It's a nonprofit organization. I just thought, all we're interested in is children as a mission, not as a market. But it's getting a lot of grief. But there's still 3 million of them out there in 40 countries, 25 languages. And one country has done every child, Uruguay, I'll talk about it again in a moment. And the impact is extraordinary. Those two children are going to grow up very differently than they would have otherwise.

Here they are in a [? village. ?] This happens to be Nepal. They're connected. And this child is in Peru, a remote part of Peru, is teaching his grandparents how to read and write. Now the self-esteem of that child is extraordinary. It's taking all the things that Seymour taught us about the self-esteem, and teaching children thinking, which was his first lecture in 19-- at least public lecture in 1970, April. Here the child takes it home, becomes a totally different member of his family and his community in this case.

This girl I just-- this picture was sent to me the other day. And I said, I don't know exactly what's going on, but the intensity that that girl had-- don't know exactly what she's doing. Look carefully, you'll see her little brother behind her in a pink hat also. This child-- again this is Uruguay. These are images of the children alone. Nigeria. We spent so much time designing the handle of that laptop, I can't tell you.

This is Peru, which is again now a different kind of view of it, where children work together. If you know of Sugata Mitra's project, Hole in the Wall, you get nine, eight, nine children and they can do anything. Because each one of them can do something, and collectively, they do very, very well.

And this is perhaps, to me, the most heartwarming picture. Because this teacher taught class perfectly aligned. The kids sat in rows and so on. Didn't want to twitch because if they were asked a question and got it wrong, they were probably hit with a cane. Corporal punishment was part of the curriculum. This is how he teaches today, hasn't stopped teaching for the past three years. This is what class looks like. The kids run to school. They take their laptops with them. They go home. The parents are hanging through the windows. It's just a whole different-- that's the result that I like the most.

Now by being a nonprofit, we had partners. We launched it with the UN. This was what we launched in Tunis with Kofi Annan in November of 2005. Sort of silly in retrospect, but it got a lot of publicity. And the publicity that everybody remembers, still to this day, people say to me, where's the crank? Because we took the crank off the machine because it's really stupid to put the crank on the machine. You've got to shut it, and crank, and so on. We still have cranks instead of AC adapters. And most of our machines are used where there's no electricity and cranking is an option.

But in Tunis, when we showed this, these were engineering models quote unquote. And the room about the size of this, but just cameras all over the place recording for various TV stations, and some still photographers, and somebody yells from the back of the room, Kofi Annan and Negroponte, crank your computers! So we close them, and Kofi Annan puts his on the table, starts cranking, and the handle falls off in his hand.

He is such a cool cucumber. He did not look down. He did not blink. He continued in exactly the motion that the handle would have been in. There was this vertical yellow piece sticking up. And his hand was going around in the right arc until the cameras finished. And I don't believe to this day anybody knows that the handle fell off. That's the status. I'm not sure that makes any difference.

And for those of you who don't know it, I'll just step through it. This is the so-called $100 laptop. It never got to $100. It got down to about $140. But then the dollar kept going down. And every time we got 20% out of this thing, the dollar went down. So we chased the dollar. And one of the important things is it transforms into an electronic book and a games machine.

And the book part of it, surprisingly-- I wouldn't have predicted this when we started, we ship 100 books in each laptop. So now if you're sending 100 laptops into a village in Africa, what people don't think about is that each of those 100 laptops have 100 different books. So that's 10,000 books in that village. You and I didn't have 10,000 books when we went to primary school, at least I didn't.

Then the little ears, there's a mesh network. It worked reason-- it worked very well for sharing books. There's some intrinsic things that are problems with mesh networks. But it was fine. I'm very glad we did it. And I will close it up and just make some closing remarks about the various countries. Because it's interesting to me to see the countries where it's been a success and the countries where it's been less so.

When I started, I went to selected countries, for whatever reason. They were sort of geopolitically scattered. There were six of them, Brazil, Argentina, Nigeria, Thailand, and Pakistan, and one more. And in the last one, the Head of State gave me these long lectures about democracy, and direct democracy in particular, and how referendums should be run. I spent a lot of time listening, he had written a book on it. It was Gaddafi.

And Libya was one of the countries that was going to do One Laptop per Child and never did. But that was the six distributed around-- I thought that was pretty good to get started. But about three years ago, it was obvious to me that those big guys, big in terms of money in the case of Gaddafi, or big in size in the case of most of the others, or geographically distributed. Nigeria was very interesting to us because one out of four Africans is Nigerian. So that was a good place to start.

But it didn't seem that they were going to really do it. There was a lot of agreement, sort of Lula hugging me, or campaigning with the fist sign with the laptop and his fist. Kirkner-- this would amuse you-- Kirchner, who was then the President of-- Mr. Kirchner was then the President of Argentina when-- since we run Linux at the time, when you opened it up, Linux would boot. And you have to be Argentinian to know this, his nickname is the Penguin. So when it booted, he thought we had made a special version for him.

[LAUGHTER]

So we didn't-- it wasn't going to happen. So it's a little bit like dating. And when the beautiful girl or a handsome boy, you know it doesn't work out, then you look at who's smiling, and who wants to talk to you. And in this case, it was Uruguay, Peru, and Rwanda. In the case of Uruguay, and this picture is Uruguay-- the President of Uruguay decided it would be his legacy. He said, I will do One Laptop per Child before my term ends, which was 18 months. And he told publicly to everybody in the country that this would be his legacy.

And this particular school, the reason I show the slide, is the teacher had been teaching for 30 years. And when she heard the laptops were coming to the school, she decided she would ask for early retirement, which she went and did. And they told her at the Social Security Office, come back in six weeks. She went back. And during the intervening period, they arrived in her classroom. And it only took her two or three days to see what it did to the classroom, the energy, the enthusiasm, and so on. And she went back and asked for late retirement.

In her class, after asking for late retirement, she'd given a homework assignment to do a project on cows. Now Uruguay's a little bit special because each child has an internet connection at school, most of them at home, email address as well, all of them do. And so they were doing their project and one girl went home a little bit disappointed and said to her father, I'm kind of stuck. I don't know what to do for my project. And the father said, you know, you're very lucky. Because our cow is having a baby tonight. There's a camera on the laptop.

And so she stayed up and she photographed the birth of this cow and brought it in as her project. And the next day, everybody in class was so taken by this particular project, they figured out as a group how to upload to YouTube. And it got 100,006 hits. The teacher said, I never thought got my homework assignment would get 100,000 hits. If you look up vaca and Uruguay and you'll get this kid's cow YouTube. It completely, again, just changed the esteem the child had, the sort of hold-- and Uruguay put us on a postage stamp. I kind of-- it's-- never thought I'd aspire to a postage stamp. Mongolia.

I think I want to end by simply saying go back to the very, very-- well this is the tablet we're building. Actually, I thought I would mention it. We are building a tablet. But this time, we may actually only have to threaten to build it. And so we have engineering models coming out. They have of all sorts of properties, price points, not breakable plastic, all of these things. But if we can just get them out fast enough for people to copy, then that's the approach that will happen this time. And that's what's going on.

I believe the last slide we'll show will show the regional school. If not, it's just our website. Yeah, it's just the web-- I guess it's not the original school. So that's what I've been doing. And I think in keeping with the name of the session, even though I would have hoped by now that it would be a number more like 50 million, not five or four million, but that's where it stands. And thank you very much. And there might be two minutes for questions. Thank you.

[APPLAUSE]

GUTTAG: There is, in fact, two and a half minutes for questions. And I'm sure Nicholas would particularly appreciate an annoying question or a provocative question.

NEGROPONTE: I said that. It's not-- this isn't-- Yes.

AUDIENCE: [INAUDIBLE].

NEGROPONTE: $75. It's an interesting thing about what the-- because once you go below $75, people don't really care anymore. In other words, especially if you amortize it over five years, which is typical. And once you're down to $75 amortized over five years, it's not clear you need to go further.

AUDIENCE: [INAUDIBLE].

NEGROPONTE: The question is how important is multitasking to the tablet? And I think multitasking is extremely important because it's kids, and they have this every hour of the day. And what you want them to do is everything. You want to do their music. You want them to play their games. You want them to do their email. You want to emphasize the integrative nature of life and learning.

And so the tablet has to, itself, integrate those and be really many, many things. You should be able to hold it up and it's a camera. You should lay it down and it's a chessboard. You should be at-- it really has to be more multipurpose than the stuff we have today. I love the iPad. But it's a media consumption device. It's not a constructionist device. So this has to be a constructionist device that is all to extraordinarily multipurpose.

AUDIENCE: You have an enormous amount of amazing experience. I wonder if there are things you can encapsulate as lessons learned, or things you know now that you wish you'd known at the beginning, things you would have done differently, are there reflections on this amazing body of experience that we could profit from?

NEGROPONTE: I might not have pissed on Intel and Microsoft so hard.

[LAUGHTER]

I used to think it was a badge of honor to have big enemies. But I think I would have-- if you put me back five years, I would have done it more gracefully than I did.

AUDIENCE: You said you wanted an annoying question.

NEGROPONTE: Yes.

AUDIENCE: And I wanted to ask about your role in digital television. There's a scene in Joel Brinkley's book, *Defining Vision*, that portrays you and your role in digital television. And you're showing surprise, but it doesn't portray you favorably.

NEGROPONTE: I haven't seen it, so I can't be annoyed.

AUDIENCE: But I was wondering if you could tell, from your perspective, sort of the transition in the '90s of going from analog to digital television, and now we have YouTube, and it sort of changed everything. How did you see that?

NEGREPONTE: Well, I'm very proud of my activities into digital television because in the early days, most people don't remember this, the United States in 1985 advocated high definition analog TV. It was our foreign and industrial policy. And we even had a faculty member here who kind of advocated that. And I said, no, no, it's not, that's not the future. The future is digital. And then people said, but no, one thing we know is it's 16 by 9 aspect ratio. I said, give me a break, it's not 16 by 9. And it's 100 Hertz. No it's not. It's any of those things.

It can be as many hertz as you want. It can be whatever aspect ratio you want. Some might be 3D. It might be 2d. But the one thing I can promise you it will be is digital. And people didn't think that was a property. And so the fact that it has become that, there is YouTube, there are all these things, I don't know how it was portrayed in this thing, but I sort of look back fondly because I think being digital, if I can quote the title of my own book, was really very important. And in retrospect, that was the key.

GUTTAG: We're out of time. So you don't get your annoying question.

[APPLAUSE]

GUTTAG: Nicholas will be around after the session. And you can annoy the hell out of him then, if you want. Our next speaker is Tim Berners-Lee, Professor of Electrical Engineering Computer Science, member of CSAIL, and often thought of as the father of the worldwide web, though he looks too young for that role.

[APPLAUSE]

BERNERS-LEE: Hey, I'm old enough to be a dad, maybe not the grandfather of it, but. Say, hey, it's an honor to be selected to be on the stage among this, and following some amazing people that-- or actually, it's really pretty much an honor to be at MIT at all. I was growing up in London playing with transistors. I know I probably wouldn't have imagined that would have happened. So I could spend-- we've done out a little bit of looking back, I suppose, and a little bit of looking forward seems to be the norm of these sorts of things.

Looking back, to put things in perspective, so this is the 150th anniversary. MIT then, 150 years ago, when they were writing the charter, apparently, the first transatlantic cable had been put in. It had been tested. A famous first message had been sent. And then it kind of broke pretty soon. And the investment was sort of a bit lax. And so you think, oh that's a shame. They couldn't use cable, they must have had to use wireless. No, actually, no that was before radio was invented.

So in fact-- so you can imagine, how did it work when you're buying and selling, exchanging currency of pounds and dollars in New York, and you're doing it in London. And you couldn't know what, immediately, instantly, what the price was at the other end. You had to wait for the ship not only to go to one side, but to actually do a round trip. And to ask a question and get an answer, you had to wait for the ship to come back again. Whoa, difficult to imagine. But there were people, meanwhile there were people like Pierre Teilhard de Chardin, the French priest philosopher who was a-- who picked up this idea, previous idea, of the noosphere, which is this sphere he imagined around the world of human thought as being all connected. How were you connected? He didn't, I guess, worry about the hardware too much.

And so there were people like the famous MIT's Vannevar Bush, who wrote this amazing article in 1945 where he imagined a hypertext machine. He imagined this thing called the memex, the memory extension, where all of the record, all of mankind's knowledge would be brought, and microfilmed, and put in one box so that the scientists could have access to it. He designed this wonderful photoelectric mechanical thing-- device which would allow him to actually pick up a row from when he was reading one paper, and you would pick up a reference from the bottom of one paper using photoelectric systems, to index, to get from that reference to the actual paper that was referenced by that-- referenced at the bottom of one paper. So he had a hypertext system. And amazingly, he designed it without even using communications to put some of them, and information somewhere else, and without using computers, even though people were starting to develop the idea of computers at that point.

And then later on in the '60s, Ted Nelson's famous for coining the word, "hypertext" and "hypermedia" and for posing a wonderful system called Xanadu. And in fact there was a whole hypermedia group of people who were not considered computer science because when they started a news group in-- for those of you who remember, they used news groups.

When they proposed something like computer systems dot hypertext that didn't get enough votes to count, and they had to do it in the alternative tree of newsgroups where you didn't have to get any votes at all. So it was alt dot hypertext was the place where hypertext people hang out.

But all this anyway I was blissfully unaware because I personally grew up-- I did a few years of physics at Oxford. That's not really enough to call yourself a physicist nowadays. But then I got involved in microprocessors and I was a software engineer. I'm fairly happily doing all kinds of fun things in England.

I was just too the wrong age to actually get to Woodstock or the Isle of Wight Festival. I didn't know what Mets were anyway. The moon landing was impressive but in 1969-- so I was unaware the first message across the ARPANET in 1969. But in 1989 I got to the point where I was working at CERN which is a wonderful place, and where I met lots of people who were totally frustrated the fact that there wasn't a web, and was basically allowed to build it because by that time the internet had got as far as being available just about in Europe. It became politically reasonable to use it.

And a wonderful guy I was working for, Mike Sendall, my mentor and advocate there-- he didn't find an excuse to let me do it, except for the fact that the next machine had come out and he let me do it as a play project. So I developed the web. I wrote the web browser, web server, designed HTML and HTTP and defined URIs or URLs, you might think of them, these things to start HTTP colon as a way of identifying any piece of information and put it out there on the net.

So I actually wrote the first memo about proposing the web in 1989. I wrote the code in 1980. Wrote a paper for the hypertext conference in 1981 and it was rejected. But we got to give a poster and go demonstrate it. We were the only person with an internet connection at the hypertext conference. And that's sort of how far apart the hypertext world and the internet world were at that time.

And then, from then on-- I've never really pushed what Bob said, but I can imagine that it has a property that it seems that when you watch it on TV that you push it like crazy for a bit and then after a while it picks up and you really have to jump in. If you don't jump in at t point you don't get don't get the chance to steer.

So it was to a certain extent the same with the web. After a year or two people were starting to ask how they could get involved in the evolution of the technology. And some of the people-- in fact, some people who ended up in my office at CERN said, you should start a consortium-- an industry consortium to do this so we can all join in, and you should base it at MIT.

And when I was thinking about these things, I was at a networking conference in the north of England. It was really wet and really dark. And to get to one place in the conference, to get to the dinner or something you get onto a bus and got onto to the bus and I ended up sitting next to one, David Gifford. And asked what I was up to and I was saying that I was sort of looking for what to do with this web thing. And he told me-- and I sort of marked down the back of my hand or something, MLD at LCS dot MIT edu.

And he told me, you should talk to Michael Dertouzos. Talk to him in the lab for computer science, this MIT place. So I did talk to Michael. Michael came over. In fact we met in Switzerland. And we met at LCS. And later I found out that maybe David and Michael had talked about this and maybe I was a little setup. Maybe the whole conference and the rain had all been arranged. No, maybe not. But in fact Michael turned out to be a another tremendous mentor and advocate.

Now unfortunately the first Michael, Mike Sendall, he was discovered to have a form of bone cancer just about when the web project started. He was given five years, lived for 10. So we're without him. But Michael Dertouzos really took me under his wing and I think also with tremendous support from Chuck Best at the time. I think two people among the several some of whom you've seen already on stage who looked at it and said, yeah. Yeah, that will be a good thing to do at MIT. That will a good thing to be based at MIT. Michael used to say, well, the web's home is at MIT. It wasn't that it was born there but it moved there.

So what was needed was a consortium which would be based somewhere with integrity, which would be neutral from the point of view of academics. And now it has gone from strength the strength. It's got around 400 members and it is based right down the road there. It's also got a base in Japan, a base in Europe. And one of the things that Michael really supported me was making it very international, not making it like an America thing.

And if you want to find out what's happening-- you might have had HTML5. It's not just a markup language. It's a complete computing platform. If you're tempted to make it a phone app for your phone, don't make a web app instead. You might have heard of the web of data, which is the huge. And in a way it might not be as exciting to browse through. It's a web of music and movies. But from the point of view of building applications and making industry work and making government transparent the web of data is really important.

I've been privileged to be involved in a short project in the UK putting a lot of stuff online. And overall the data, which is in what we call the linked data cloud-- there's this mass of data, which even though it's stored in lots of places is linked together. So you can follow data. When you put the information about one thing you can follow it to find information about related things, a bit like following links in the hypertext. But it's all data that you process. So the linked data cloud is growing by-- it's about doubling every 10 months, which is exciting.

Another thing, of course, is that the web is moving to lots of devices. You've seen it on a green laptop and you've seen it on a green tablet now. In fact, the number of devices out there is getting ridiculous because some people would like it on their watch, or some people will have it built into their glasses. As the cost of pixels goes down, the size of screen is only going down but it's going up. So you have to build information systems so they will cope with this tremendous change.

So if somebody happens to be one on a mobile device, booking a plane flight for example, and they arrive at home or they arrive in a friendly room, where the device can then negotiate with the wall, then obviously it'd nice for the website, where they're booking the device to immediately be able to put up a massive picture of the place that they're going and a timeline and so on, when it's got the advantage of that. But the moment they lose that, it's got to go down to a way of being very efficient way when doing it on a portable device.

So moving to different sorts of devices-- mobile devices, in fast, and smartphones are something which is exploding at the moment. The penetration of phones is much greater than the penetration of the internet. So there's a hope that the penetration of phones which get a little bit smarter and have web browsers will follow. But it's not just having a phone. It's not just having a phone with a web browser. It's having a phone and a web browser and using the web, which involves having information in your own language.

And it's not just a sponge for information. It's participating. So it's realizing that when this information, in your own language, about things that you care about, you can write them if they don't exist already. And that's one of the things we've noticed. When you see teens in Africa or at an internet center in the village, that they understand about browsing the web but they don't necessarily understand about being creative.

So anyway, go to w3.org, or when you're here, drop in on us in the fifth floor of the Stata Center and get involved in the onrush of web technology. It is very exciting.

Meanwhile, when you're doing that, you might, as some of us have recently realized that it's all very well to be involved-- like most of the people in this room are probably early adopters. You're probably people who have got six devices on which you can browse the web. But when you realize that now, in fact, 25% of the world do use the web then I'd immediately ask, what about the other 75% of the world?

We've started a worldwide web foundation, in fact-- webfoundation.org-- to look at that. And it works with the Web Consortium to address broader issues. And, in fact, because it's young, you can get involved, and also get involved in selecting which things we're going to try to push on to try to get people part of being part of the information society and all the things that that involves, like e-government and health and so on.

Nicholas decided he was going to push on [INAUDIBLE]. He looked at that picture and decided he was going to push on the laptop. You may decide you're going to want to push on other things like content and different things. You might want to push on justice in general, trying to make sure it's not just that everybody has access, but it is the web, something which is inherently just.

When you have access, does it allow you to connect to whoever you like? Or is your access being controlled by a government? Or for the price of having really cheap access, have you given away the right to communicate with whoever you like? Have you ended up using an ISP which is actually controlling where you're connecting to.

So these are issues about justice on the web starting to look about access to the web as being now a human right. Because, yes, you think well, the right to freedom is surely more fundamental. Maybe a right to water to is more fundamental because it's possible to live without the web it's not possible to live without water. But if you've got water, then the difference between somebody who's connected to the web and is part of that information society, and somebody who's not is going bigger and bigger.

And every cool thing we do online, every tool, a new e-government thing, a new commerce thing, cultural thing we do online widens that gap. And as getting [INAUDIBLE] it's so important, becomes such an important part of world culture, then we elevate it. We say, you know what, it's starting to become possible to start talking about getting everybody online. We'll give everyone the opportunity even if they don't take it. But I wouldn't want to push it, given how happy quite a lot of people seem to be without having access at all.

So the challenge before us is then-- one of the challenge is getting everybody involved. But at the same time we are rolling out new technology for the consortium. And we're not going to just do that out of a vacuum. It's really, really important as well that we don't look back at the incredible rush all things which have happened relatively fast and faster, and faster, and faster, and faster, and look back from this 150 years of MIT and say, wow, that was amazing. Now that that's all happened, I'd imagine it's not going to go on going faster and faster and faster. So it's really crazy to think that there shouldn't be lots and lots of research to understand what should be the next step.

And it's not just research about how I can make a cooler device and how I can make a cooler website. Because one thing which changed now, about the web-- now it is so ubiquitous, now it's so big-- when you look at the web out there, there are about 10 to the power of 11 web pages I'm told. And I'm also told, by other sources that there are about 10 to the power 11 neurons in your brain.

So this means that if you took all of-- imagine you that you take all of the web pages out there and bring them together. I could bring them down into a sort of brain-sized thing, that would be-- so there would be the same number of web pages as neurons. But actually, if you do that with a brain, then the brain actually falls into two halves and it's got various pieces. And we're starting to understand more and more what the various different pieces do.

If you do this for the web, it wouldn't. It's not like that. It has a very different structure. We know some things about it. It has some really, really tangly, thick pieces and some really straggly pieces. And in fact, in general, it has scale-free properties. So there are structures on every scale. It has some really interesting properties. And so we started to talk about web science because we need to study this thing. We need to study this thing because we rely on it in a different way that we rely on our individual brains.

But society operates through this web. And as society is operating through this web-- so we have, I think, just as we have an obligation to try to figure out and understand how the economic system works, we have to understand how information propagates across the web and how society works. Humanity as connected by technology, that's what the web is.

We have to look at humanity and understand how it's different and what possibilities there are out there. We have a duty, because to start with, we don't want a nasty tipping point to arrive and suddenly for the web to turn into some instrument which only spreads unfounded rumor and conspiracy theories, instead of truth.

In fact, to a certain extent, we have a duty about the web which is greater than our duty about the brain. Because the brain, we just analyze. It's a science. But the web, we actually get to engineer it. We can change it. So we have a duty not only to have fun playing with new protocols, but think about how those protocols will affect humanity connected. To do that jump from designing the microscopic-- the way two computers communicate, the way two people communicate-- the publisher and the reader or the group leader and the participant.

How two people interact by using technology? To think, how is that going to affect the world of academia? How is that going to affect the world of democracy? Will I be able to use that to make scientific review more effective? So if you're going to get involved in web science, you could be coming from one of many disciplines.

This is extremely multidisciplinary. And there are some institutes in the world that sort of get something to pull people together very much. And I think maybe it's time we started doing more on these lines at MIT. Because when you look at a link and you wonder whether-- and you look at the way links spread-- well, links are made by people and they're followed by people. And they're made by people so that other people will follow them.

So you need psychologists to understand the microscopic piece. And maybe you need all kinds of very, very strong mathematics to figure out how, when you connect those people together in a certain form of network, they will end up creating new network links. And how they will end up then creating different emerging macroscopic phenomena.

So if you need, for example, something to aim at when you're doing this web science-- when you realize that your field, whether it's economics or mathematics or biology or physics is really involved and really essential to web science, then if you want some things to aim at, here's a couple.

Just imagine that our goal for the web is that we will connect all of the scientists in the world so effectively, so they are sharing with themselves and with computers everywhere, the mass of data which we currently have about all of the life sciences. We will connect all the sciences together so that they're sharing this data very, very effectively with their co-workers, some of whom are computers and computer programs and some of whom are people.

And so that the half-formed ideas of people can be, in fact-- so that when there's a problem which is so big that no one brain has all the pieces, but when the half-formed pieces of it on in different brains, the web can act with a way of allowing those half-formed ideas to come together. We will do that in such a way that those people will collectively manage to solve the huge problems like understanding Alzheimer's, curing cancer, and understanding how AIDS works, for example. All right, there's one. Throw that out. That is the challenge-- design the web so it will work for that.

Here's another one-- when people go online into massively multiplayer games, you find that they tend to talk-- even though they can talk to anybody in the world when they go on and they start playing games with people, they end up playing games with the people next door-- people in the same culture. They don't actually bridge divides.

How can we design the web so that it tends to lead people, instead of just talking to people in their own culture, it ends up getting them involved it whatever social network it is you write, whatever it is that you program-- it tends to make them wonder about other people who have got different ideas and get them to spend more time understanding why do people have those ideas. And as a result, just incrementally changes the parameters so that we all stop fighting each other. OK. That's the second challenge. I could come up with a bunch more. But I will wait until I get responses from those two because I think those are big enough.

So there it is. That's your challenge for the web. We have to design the web so that it could be useful and it would be reliable for these really, really important challenges that we have-- that humanity has in general. Thank you.

[APPLAUSE]

GUTTAG: Once again we have a chance for about two minutes of questions. And I'd like to hold your questions to 15 seconds, and end them with a question mark.

BERNERS-LEE: 15-second question?

AUDIENCE: I'll try my best. 15 seconds is up. MIT and many people talk about machine learning. And of course the front-end of a machine learner will be a good search engine. And once again I bring up IBM Watson's Jeopardy computer as an excellent search end on the front end, because in order for the back-end to learn, it has to be able to search through the database.

Number two about Negroponte's speech about the netbooks and tablets. There are tablet copycats for $199 that are made in New York City stores and they run Android. The third very quick point-- these are questions for you to make commentaries on.

And one last point, if I may. I'm sorry. I'm trying to make for my lack of annoying questions to Professor Negroponte. The thing is that, there was an article in the *New York Times* a couple of weeks ago on the front page of Leisure section. And this had to do with why you and Negroponte were placed in the same section about internet, the worldwide web, and the consortium. And a lot of people are actually quite irritated about Google search engines finding out their past digital history. And there was this whole big thing about people wanting to erase their digital. Facebook--

GUTTAG: I'm sorry. There's are lots of people with questions. Why don't we move on to someone who's going to end something with a question.

AUDIENCE: If you have any comments on these I'd like to hear it.

BERNERS-LEE: [? We'll take ?] [? them ?] offline. Go ahead.

AUDIENCE: My quick question-- currently three different companies at least are working on new technologies to securely connect one cloud to another. This is to form a new network where each node is a cloud. Do you have any opinions on this nascent development of what people are calling the intercloud?

BERNERS-LEE: Well, I suppose I-- well, I don't know the details of that particular development. So when online storage, which people are starting to call the cloud-- one aspect of the cloud is, if you're going to have a lot of it online storage, I'm all in general all in favor of A, interoperability between different cloud providers, and B, really well developed and thought out security systems, which are also compatible.

So some of the areas which we're thinking about at W3C-- but I can't comment on that particular project because I don't know the details of it. And for those of you who are wondering about this cloud thing-- that basically anything online is now labeled a cloud. You don't have to worry about it. So it's online web storage. But you're talking about storage as a service sort of thing then. And that sounds like their important questions.

AUDIENCE: Yes, can you tell me the important questions that need to be asked and answered?

BERNERS-LEE: Well, for the first 45 minutes of my answer, I'm going to be-- the important questions that need to be asked and--

AUDIENCE: [INAUDIBLE].

BERNERS-LEE: I've actually got a massive-- I use the Semantic Web. I have got a Semantic Web graph in which I keep the important questions to be asked and answered, and all the related issues in a graph. And it's got a large number of nodes. And email me and I'll send it to you. But one that I find personally exciting for example-- there are lots. There are hundreds. One that I'm personally interested in, is if we can have all this data online, how are we going to make a really, really powerful user interface to it? But that is just the tip of the iceberg.

GUTTAG: I know there are more interesting questions but we are out of time.

[APPLAUSE]

The last speaker of this session is professor Suzanne Berger, the Raphael Dorman-Helen Starbuck professor of political science at MIT, director of MISTI. And though I think she's never officially been a member of CSAIL, she's in everything but officially a member of CSAIL. Thank you, Suzanne.

[APPLAUSE]

BERGER: Well, I'm very honored to have been invited as an old friend of the CSAIL family to participate in this celebration. And I date my membership in friends of the CSAIL family to work that I did 20 years ago with Michael Dertouzos on the Made in America project. And I guess I'm also here as the sole representative of what Michael called the humies-- the humanists at MIT. And I tend to think of myself as a humie, or at any rate, a social scientist who has tried, as Michael urged, to nurture at least a little bit of techie in my soul.

So in thinking about today's topic, computation and the transformation of practically everything, I thought I'd go back to Michael Dertouzos's work and start from what he thought computation and IT were going to change in society. Michael's basic idea was, I think, that the world was going to look more and more like an information marketplace.

And when he thought marketplace, the image that came to his mind was the Athens flea market. Now, the Athens flea market, and in fact all markets, are level playing fields where the people who come, or the players who move in and out of the market are not at all changed by the fact of interacting in the market. And I think it's on this point that Dertouzos, despite all the radical changes that he did foresee-- I think it's on this point that he did not see a future that was coming into being even as wrote.

In fact, information technology and specifically digitization and the possibilities of codifying the interfaces between functions carried out in huge vertically integrated companies-- those companies were the big players in the world at the end of the 1980s. In fact, digitization and IT was going to radically change the players.

So this was an information marketplace. Moving into the Information marketplace was not going to leave the players unchanged. In fact it was going to change them totally. And I think in that sense, Made in America, which was written at the end of the 1980s, was in a way the end of a world. It marked the high watermark and the end of the world of the huge vertically integrated companies, at least in America. And a new era was about to open with players that had been profoundly transformed.

We were moving to a world that was really going to be much more a world that look like made all over. But as we think about the world of Made in America and the pieces that we're going to change here, I think the points are that the players in the world up to 1980s were large, vertically integrated companies, operating in huge mass commodified markets, and all the functions within these companies, from detailed engineering, really from R&D through detailed engineering, through manufacturing to sales and after-sales were functions that took place within the four walls of the corporation.

And as digitization, among many other changes, took place in these companies, we were going to see a profound change within the companies themselves. In fact, we were moving to a world in which IT was going to be transforming the content of the corporation. And the corporation itself was going to be fragmenting.

Now of course there were other changes and important ones taking place in the world at the same time. The opening of China, the fall of the Iron Curtain, the rise of new markets, new competitors, huge new reservoirs of skilled workers and engineers were appearing outside the old advanced industrial countries.

But I think we have to see in these transformations that IT was a key enabler. It made it possible to take activities that once had been tightly integrated into large corporations-- it made it possible to relocate them all around the world in suppliers and contract manufacturers.

Take something like cutting a mask for chip fabrication. Still in the 1970s, the engineer who drew the circuits had to work together with the technician who cut the mask. And these two men-- and in those days they were men-- these two men had to work side by side in the same company. But once an engineer could send a complete set of digital instructions to a cutting machine located anywhere in the world, and probably located at TSMC in Taiwan, then chip design and chip fabrication no longer had to be carried out within the same integrated company.

And we saw the same shift from tightly integrated corporations into fragmented activities that took place in companies focused on their core capabilities. We see the same shift taking place across multiple sectors and in multiple companies. And this has led to the creation of profoundly different players, new products, and new components.

And these new products and components really look a lot more like LEGOs then like the old model airplanes that we were producing at the end of the 1980s. I guess as a humie, I tend to think about these images when I'm thinking about the changes from the 1980s to today. Because at the end of the 1980s, the products that we were building, in these large vertically integrated companies, were still products that fit together in unique ways.

If you've ever bought and tried to make a model airplane with a child, you know that the first major or the first major question is, when you open the box, are all the pieces of that model airplane in the box? Because if they're not, there's absolutely no hope of making that model plane. You need to have all the pieces, and all the pieces fit together in one way and only one way. And once you've made that model plane, you can't make it into a boat. No one could come and add something. It can't be made into anything else or changed ever.

Today, production is organized around products and components that are made to be fit together in, if not an infinite, at least a very varied and large set of different ways to produce novel and perhaps even unimaginable products and processes to those who first come up with the pieces.

And so what we've seen from the world of Made in America, to a world that's been transformed by IT is a world that has enabled modularity. And in this world of the last 20 years, I'd say that almost all of the great new companies in America have grown up out of a paradigm of modularity. If we look at companies like Cisco, Broadcom, Apple-- they are companies that have focused on some pieces of the functions of the old integrated corporation, but only on some. And in particular, these are companies that have handed off production and manufacturing to be carried away somewhere else in the world. So we've come to think of manufacturing as a commodity, something that can be purchased cheaply abroad.

We know that in an iPhone, for example, an iPhone that costs about $400, there's about $3 worth of assembly production that's taking place in China. And we realize that there's really little reason to be interested in locating that assembly in proximity to the R&D or locating it for any reason in the US. And I think it's because of the enormous success of the companies that have been founded over the last 20 years-- the Apples and others like it, that we've come to think that production, by which I mean manufacturing and the services linked to production, that they don't really matter. That they're cheap commodities that can take place anywhere.

But I think that we're now entering into a third and new phase in the global economy. And it's a phase that I'm calling made to innovate. And I think the reason for thinking of this change as one that's about innovation is because I think that when we consider a wave of new technologies in clean energy and meta materials, in biotech and other sectors, we're finding that in these new sectors, innovation is highly linked to production.

In the United States in general and places like MIT in particular, we see that we have tremendous strength in innovation. But if we can't master production in these new technologies, we're not going to be able to gain value for our own society. And by gaining value, I mean making new profitable companies and getting new good jobs here in the United States. I think we're beginning to see in these new industries, that they're fundamentally different challenges in scaling up from start-up then there were in the IT companies of the last 20 years.

Some of the differences are these-- first of all, there seems to be no clean hand off, no clearly modular structure that would allow us just to break off the production phases in many of these new sectors with many of these new technologies. We see that in scaling up from start-ups that the capital requirements of these new companies and these new sectors are immensely greater than they were with start-up software companies.

So there's no natural mesh between the form of capital markets that were so important to the new IT companies of the last 20 years. And there's no real natural fit between venture capital and the new company start-ups in clean energy, new materials, batteries. In fact, these industries require much larger capital investments and they have much longer time horizons than venture capital is used to working with.

I think there are all of these new challenges about trying to move from start-up to scale-up in these new sectors. And I think equally important, there are enormous opportunities to be gained here. Opportunities to be gained from mass customization, opportunities to be gained if we can reduce the cost of logistics, so the decentralized, smaller scale production units could be located closer to end users. So that we could come up with novel solutions, both to scaling up and also to scaling down, to sizing down.

And I think that to advance on any of these fronts, we're going to have to return to the problem of managing interdependencies from R&D through production to the market. I think this is a point that Michael Dertouzos understood very well.

He wrote that, "even though information technology can make it possible to support outsourcing of just about everything, it would be a disaster to organize a company in that way. To live well," he wrote, "a nation must produce well."

We can't just ship production out and hope to remain a society that can live well. And in particular, we can't be a society that focuses only on R&D, and hope that in these new technologies, and these new industries that are emerging, that we're going to be able to gain the value from our innovation that's truly possible. I think we're now at a point when producing well is a critical point between innovation and bringing products into the market. And that on this new trajectory, I know that people in CSAIL are going to be leaders on this new frontier, just as they have been over the past 20 years. Thank you.

[APPLAUSE]

GUTTAG: I hope you'll take a few questions.

BERGER: Sure.

AUDIENCE: So in some fields in the past, the similar process has been that you start with need for integration, but later on you can modularize. Do you see the same thing happening here or do you think these are qualitatively different fields?

BERGER: Well, I think that in these new fields at the moment they seem to be qualitatively different in the following ways. First of all, there's a fundamental difference about the capital requirements. And the question is, how can we even moved from start-up to scale-up unless we're able to actually devise new capital solutions for which venture capital is really not at all prepared to solve this problem.

But I think, to come to the technical issues, I think there really are ways in which these new industries represent problems and processes in which tighter integration is going to be a continuing feature in these industries, and not simply the problem of producing a prototype, and then moving from a prototype into something that looks like mass production. That the interplay, the learning in the production process will feed back into the innovation process. And so you'll want to keep the innovators and the people who are doing the scaling up close together, because they'll be enormous gains that can be made from the learning in the production process.

AUDIENCE: I'm not certain that this question will be particularly appropriate because you seem to be tending more toward integration than independence, but perhaps you'll have an interesting perspective. Do you suppose that the current market dynamics are conducive to the development of modular manufacturing means, or perhaps inherently inhibitive of such progression?

BERGER: Could you say again what you have in mind?

AUDIENCE: Do you think that's the way that the market works currently, say in an integrated fashion, is conducive or perhaps even inhibitive of the progression of modularization of means?

BERGER: OK, well I think that, in fact, we've seen that the market-- if we're talking about capital markets, capital markets have been enormously favorable for the development of modularized production. That companies were able, by shucking off their production facilities-- if a company in the United States could focus let's say on chip design, and did not have to build a $5 billion [? fab ?] to support its design functions, this was a company that could far more easily use venture capital and the capital markets that we have available in the United States to build its business.

The question is, what happens in fact when we can't separate design and production facilities? What happens if in these new industries, as I'm suggesting at least as a hypothesis, in order to really bring your design into the market, in order really to derive benefit from your design and your R&D, you're going to actually have to build that extraordinarily expensive production facility too. At that point, is the market really going to be able to work to solve the problems that we have or are we going to have to come out with some novel solutions here?

GUTTAG: Last question.

AUDIENCE: Are you suggesting that your production facilities are going to be essentially uni-taskers, essentially that will be unique in terms of what they would produce?

BERGER: I'm sorry?

AUDIENCE: I'm suggesting-- are the factories you're suggesting-- do you think they're going to be more uni-task oriented, meaning they'd only produce that product? They couldn't do anything else?

BERGER: No, I mean I think that would be-- I think that would be something like a step backward. I think what we're trying to imagine is a way of creating production capabilities that would be flexible, that could deal with a variety of things that looked like mass customization. Where production units could actually work with a diversity of end users and still be profitable. So what I think we really have to be thinking about are new manufacturing technologies. It's not a question of joining old manufacturing to a new set of industries. We really need new manufacturing.

AUDIENCE: Well that's what I'm suggesting. Is that's the problem you're facing.

BERGER: Yes.

GUTTAG: Thank you.

BERGER: Thank you.

GUTTAG: And I think we need to move on. Thank you.

[APPLAUSE]