Panel Discussion

SUNAMI: I am Sunami, professor at the National Graduate Institute for Policy Studies. The mandate to bring together in one direction this gathering of minds from different fields all over the world is an absolutely impossible task. Today, we've been listening to lectures on a vision of the future based on various cutting-edge research, and one conclusion that can be made is that perhaps, from hereon, development will no longer be linear as heretofore, but will change somewhere into a non-linear, dynamic type of development.

In this sense, since minds representing diverse fields are gathered here, I look forward to a dynamic panel in which discussions are, in a sense, non-linear and any idea can just pop out.

Since our time is limited, allow me first to deliver to you the message that has arrived from Dr. Haken who was supposed to attend this symposium. I will read this message which is in English, and request the interpreter to do it in Japanese.

Dr. Hermann Haken

Born in Germany in 1927. The 13th Honda Prize laureate in 1992.
Professor emeritus at the University of Stuttgart. Former Consultant to the German Sciences Foundation

On the occasion of the 35th HONDA PRIZE Commemorative Symposium I am sending all of you my very best greetings.

I had planned with great enthusiasm to participate at your important event, but sudden illness prevents me from coming. Nevertheless, I wish to quote main conclusion of my intended talk on "Sustainability and Synergetics":

"The formation of public opinion as governor of politics is essential.
We know from many examples of Synergetic Systems:
The effort of small but active groups as initiators of new developments can be decisive and can lead to the cooperation of all nations (big and small) in politics aiming at sustainability of life on earth. This underlines the importance of the activities of the Honda Foundation."

I wish your Foundation further great success.

Hermann Haken

SUNAMI: Let us now move on to the discussion. Later on, I would also like to raise Dr. Haken's message in the discussion, but let me first explain how we will proceed. Based on the presentations that the respective participants have listened to, the message, and the various thoughts that have come up which we shall introduce one by one, we shall subsequently proceed towards a discussion.

The latter half shall be a Q & A from everyone, in which we shall take questions as we proceed with the discussion. I would appreciate it if you could prepare your questions or comments now.

SUNAMI: Okay, so we will start our discussion. Why don't we ask you first, Dr. Clemens, to initiate the initial reactions?

CLEMENS: Thank you for staying here after the lectures. My comment is about this program and the message of the president. Exploring sustainability is the direction scientists or engineers should go to face global environmental issues. I think that is an important point.

You don't know me that well because I have given no lecture, but I have developed a material that is being used in a new type of aircraft engine, which can reduce emissions of CO_2 and NO_x and also reduce fuel consumption.

I think this is something that is really sustainable because the problem in our world is we use too many of our resources and also we endanger our resources by producing emissions like CO_2.

I took some notes during the presentations and all of them were very good, very to the point. So maybe if I'm allowed to start something I will make some comments.

Mr. Reddy, in his presentation, spoke about freedom from slavery, freedom of religion, and also freedom from discrimination. These are points that were formulated a long, long time ago; however, if you really see how the world works it's a big difference.

I was surprised when you mentioned freedom from slavery and you gave a comment about how it is in India these days with so many people in danger of doing slavery work. Then there is freedom of religion, and in my opinion, because if you look at

what's going on in the Near East now with this Islamic war and so on, I think in Europe, especially, we have had really a good time since we had this so-called Age of Enlightenment when we separated politics from religion.

I think this was very important for the progress of Europe because we had a lot of the wars in Europe concerning religion, but this was key so in the last 200 years we've had no wars on religion. Maybe in Ireland, where they have problems; however, separation is good when you separate politics from religion.

Freedom from discrimination is also an important point. We spoke about women, the role of women in our society, and the fact that women have not reached a point in their recognition in our society. Women still earn less money doing the same work, do not have the same chances to have as good an education that men have, and so on.

Maybe one point on your presentation with CO_2 and water, I think CO_2 and water they are really related, and this comes back to my research because if you have too much CO_2 in the environment, you have a change of the climate, and this is what you see everywhere now, especially now in Europe.

In the last 10 years, we have had a lot of change in the climate so we have lost a lot of money by damage. Things that never happened

before have occurred in Europe, like heavy rains, flooding, and so on.

These are related to the increase of CO_2 and this is where my invention comes in, or where I have helped a little bit. People know that more than 3.5% of the change of climate is related to air traffic, more or less. Just to give you a number, more than 600,000,000 tons of CO_2 is released into the environment per year. One ordinary car runs at four tons per year, but when you multiply that by the number of cars, you get enormously high numbers of CO_2 emissions.

Maybe one point from my side because you told us that this diffusion of water molecules is very important for the human body. In my case, because I'm a materials scientist, I do not like diffusion at all because diffusion at high temperatures leads to very serious problems with materials. Very simply said, if you have a rotor blade and it's rotating, you have a force on it, and during high temperatures, with the help of diffusion of the elements, the blades become longer. This is something that is not allowed.

So, this is my statement, maybe, for the first round.

SUNAMI: Okay, thank you. Now I would like to invite Dr. Le Bihan. You're welcome to use Japanese if you want to.

LE BIHAN: So, if we have to talk about sustainability, I would like to talk about sustainability of the mind. I think what makes humankind a little bit special compared to the other animals on earth is that we have developed a writing system.

It started in the caves long ago and the first humans, as we know, started to use drawings to communicate and to transmit information from generation to generation. Then the real writing system came, and then we had books, and books were a tremendous invention to transmit knowledge over generations.

Nowadays, we have IT. We have Facebook, Google, Microsoft, and we have clouds, so we can store a lot of information. But my point is that we can only transmit what we are aware of. We can transmit only what we are conscious of. There are many things that we use to communicate that we don't know how to translate.

For example, when we exchange email over the Internet, it's very easy but you don't know exactly how people will react to what you write. I think all of us probably have some experience of emails that we really regretted sending, for instance, and that's easy to explain.

How people communicate is mainly outside of language. We use, for instance, facial expressions, and there is eye contact, which is very important because we know that autistic people, for instance, are not able to get eye contact, and so this kind of transmission of knowledge has to be preserved.

We should not forget that if we increase the number of robots, for instance, that we should be able to program something that is closer to how the human mind works.

I've seen experiments done at MIT, I think, where they had robots imitating human behavior. For instance, if you look happy, the robot will be kind to you, but if you speak with nasty words, the robot will react in a nasty way. And it was very funny to see that the robots have no emotion but because of this kind of behavior the people were responding as if they were talking to real human beings.

So we have to be extremely careful that we should preserve our way of communicating until at least we have understood very well how the mind works, which is not for tomorrow.

SUNAMI: Thank you. Okay, so Dr. Reddy.

REDDY: This is a very interesting topic. I have so many different random ideas that I would like to share with you, but let me just stick to two. They are not related to each other.

The first one is I was asking what makes us not so humane? Why is society not humane today? I believe that's maybe not a fair question because I think we are a lot more humane today than we were 500 years ago, 1,000 years ago, except we don't know all the things that they did at that time.

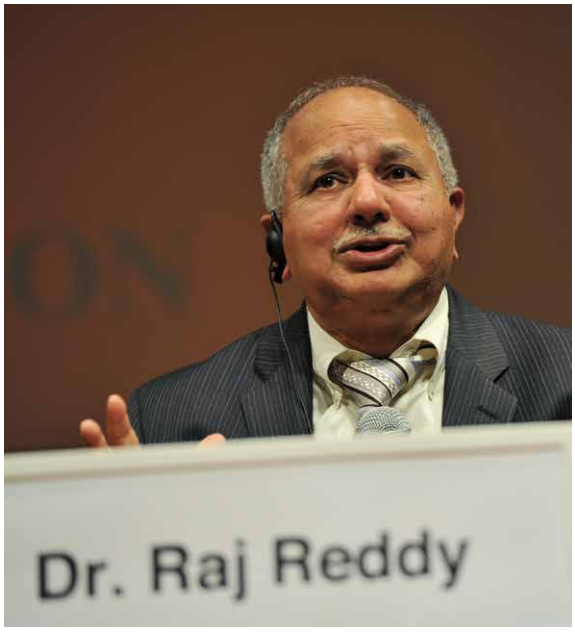
Looking at the specifics, for example, we now have terrorism and people are going around killing others. I thought maybe it's just a religious thing, even among the Muslims, the Shiites and Sunnis are blowing up each other, and the same thing happened at 9/11, and the same thing is happening with ISIS and ISIL. I don't agree that Europe in the last 10 or 20 years has been free of wars and things like that.

Take Bosnia-Herzegovina, for example. It's kind of a complete disaster. I could not believe a civilized society would behave like that in this day and age. It's part of Europe, right? We can go back to the Holocaust and even the First World War and the use of chemical weapons, and people seem to behave in ways that a thinking reasonable person would not behave, right?

But this seems to be something about the way our brain is built, and that's why I want to go back to Dr. Le Bihan. We are aggressive human beings. There seems to be some aggression in all of us and under certain appropriate conditions we forget everything else we have learned and we become aggressive.

The question is is there some way we can zap those water molecules to get rid of the aggression? That's one kind of thought.

The other one is more positive and uplifting. It turns out, if you look back at what happened 500 years ago, 1,000 years ago, 2,000 years ago, in Japan, not much existed. It is very difficult to find anything even 100 years ago because people have not been keeping most of it and whatever is there is in archives so most of us cannot have access to. Some documents are there and ultimately they



will stay in those basements and they will ultimately rot in a few hundred years more and they will be lost.

Finally, we have the technology, we have the opportunity to capture our culture, our heritage, our knowledge, and everything we do everyday. That is, in the old days people used to think of books and music and movies as different media and different things. Not anymore, they are all bits and we can capture them and store them forever.

And not only the famous musicians, not only the famous movies, I can make a movie and store it on YouTube and it will be there, I'm hoping, for 1,000 years. So if you take a newspaper, a newspaper after it's published, two days afterwards, it's worthless and no one keeps it. But they are all born digital so they can be captured and stored forever.

One of the great things about information storage technology is I paid 2 million dollars in 1972 to buy 40 MB of memory. Today, I can buy 4 TB of memory, which is 1 million times more, for 100 dollars, so memory costs are becoming cheaper. To give you a number to remember, it's doubling every year, which means in 10 years you get a thousand-fold improvement in magnetic storage. In 20 years, you get a million times improvement, and that's going to continue for at least 10 more years or 20 more years.

The cost of memory is getting cheaper, so now you can afford to store everything, and we should be doing that. That is, we should be capturing all the books and all the music and all the newspapers and all the movies and make them available free for the whole society forever.

It doesn't have to be free today. Caruso's songs I should be able to listen to for free today, but if it's making money, let them keep it as copyright. But if it's not making money they should let it become public domain.

There are ways in which we can do this, and I don't want to take up much more time, but the important thing is there are so many things that we can do to make society more humane and we should do those.

SUNAMI: Thank you. Now, I would like to ask Dr. Andersson.

ANDERSSON: Okay, I will tag onto one of the points made by Prof. Le Bihan on communication and the complicated nature of communication.

There is somehow a rather common confusion of information and knowledge in the discussion about communication. We are all teachers and we know that you cannot assume that if you have given absolutely correct information over an email to a number of students that it will actually be transmitted in the true sense.

Teaching and learning is a very complicated process and one has to be skillful as a communicator in much more sophisticated ways than any information technology has mastered. Teaching and learning is kind of a transformation of information into knowledge, and knowledge to me is models and theories and sometimes even superstitions, but basically its models and theories that are the soul of teaching and learning.

Therefore, I don't have such a great trust in the information revolution or in the communication revolution. It contains aspects like persuasion. You have to persuade, and John Maynard Keynes actually wrote a number of essays on persuasion where he showed that the trick in getting people to understand his theory had nothing to do with printing the books in very abstract ways.

He said that you have to persuade, you have to convince people that they must give up their old ideas and they must learn these new theories, these new models, and that's very time-consuming and hard work, and it depends on very intensive personal communication where movements of hands, contact with the eyes, iterating the same information over and over again, and getting people to be friendly with what you are saying are kind of tricks of the trade.

So beware of seeing the information and communication revolution as the solution to the problem of getting learning as a basic aspect of our future. And even more, creativity and innovation are important aspects of development.

SUNAMI: Thank you. Dr. Reddy, are you ready to say something?

REDDY: It's a short comment. Dr. Andersson, I agree with what he has just said, except that I don't want to read into his comment that you should not be reading books or attending classes because your teacher will communicate.

Whether we like it or not, the information transfer process is imprecise and there are experiments that were done where somebody said something, it was copied many times, and then

ultimately it's called hearsay in legal terms. Hearsay is not admitted because when something is transliterated by many people it's not the same thing anymore. Therefore, we have this problem.

But nevertheless we educate people in society, we communicate, somehow the imperfect knowledge is communicated, sometimes maybe some innovation happens or maybe other things happen, but we have to be aware of the problem that is impreciseness of communication. That doesn't mean we shouldn't write books.

ANDERSSON: I'm a great friend of books, but my feeling is that it's only after teaching verbally and tutoring that I have managed to get the students to actually read the bloody books that they should've read at the start. It's an interaction between reading, tutoring, having lectures and seminars, and so on, and there is no substitute in the form of looking at a screen and becoming skillful.

Especially if you take a field like music, there has not been any successful first-rate musician who hasn't had intensive tutoring as part of going from information to knowledge and from knowledge to skills. The same is true of the lab physicist or the lab-oriented chemist or the doctor in a hospital. They have to be in this very important process where information from books and from screens and so on are a very small part of the total learning experience. That's what I would like to say.

SUNAMI: It's very nice to hear from an economist nowadays about the importance of reading books rather than modeling.

Dr. Le Bihan?

LE BIHAN: I agree with what you said and I would even go further away, that now you have so much information available that the brain cannot handle it. You have to model it, so we take only what we want. The problem is that, for instance, I have seen that the brain needs to have many inputs to keep memories and to understand.

In the good old times, as we say, teachers were using the blackboard, they would write things, equations and things, they would talk, and students had to write quickly because it would disappear. This was a way to get imprints in their own brain.

Today, you have a PDF and this is awful because you feel that you can see many things, maybe to prepare for an exam it's enough, I'm not sure, but just a few months or years later what will you keep? Nothing.

I think the problem with information technology is that we are invaded by so much information that we really don't know anything. For instance, let me give you an example. I'm sure some of you live in a house, and you have a set of stairs in your house. If I ask you, for instance, to imagine the stairs, you can see the stairs very well because you see them every day. But if I ask you how many steps

you have in your stairs, usually you cannot respond, even if you have used the stairs for 20 years. The brain has recorded some information that is useful, but the number of steps is not so important information.

We are filtering information so even if we have hundreds, thousands, millions of books, we will retain only what we want and this is why we need to have people communicating so we can share common knowledge and we have to be very careful about that.

SUNAMI: Let me explore that a little bit more. Last week I was in Scotland and on the way back from Scotland I was on the airplane watching movies as I usually do on a long flight and there was a movie called Transcendence. It's a Hollywood movie talking about the singularity problem in 2045, and you see the huge expansion of big data that transforms the world and everything that we know.

And there are big discussions in Europe, for instance, about how big data changes the way we produce new ideas and new knowledge, science 2.0, right? Because we do networking and you're communicating. How, in your field, do you view the impact of big data? Will it change or transform your field? What is your vision or what do you think the influence will be?

LE BIHAN: I have positive and not so positive views about it. Big data, especially to understand the brain, is crucial, and maybe you know, in Europe now they have what is called the Human Brain Project. It's a very, very rich program and the idea is to get as much information as possible from many, many brains to understand the brain. So it's great and we have to do it because the only way for us to understand is to have a lot of information.

But what I usually say to my colleagues is that the information will not create the model. We have very smart computers with many, many data, but you need to have a program corresponding to your model. If there is information that is not modeled, you will not see it. It is like dark matter, if you like: we don't see it and we don't feel it, so we don't know it is there, but in fact it is a lot of the energy

we have in the universe.

So I think it's the same. The problem with big data is that we promise to retrieve the information but we need models. Unfortunately, so far, computers, to my knowledge at least, cannot really do that. Of course, you can use some learning processes, algorithms, that are able to see some information and classify information like vector machines and so on, but it's not the same as creating a model like we have in physics, for instance, that comes out of the human brain. We are not ready for that.

SUNAMI: Dr. Andersson.

ANDERSSON: Well, there have been some tries at using neural network theory to, so to say, have an endogenous production of a theory or a model. Unfortunately, when you look into these, it turns out that they are critically dependent upon certain assumptions at the bottom. There must be some triggering mechanisms that somebody has come up with in order to get it going. The model is there, although it looks very implicit. So that's one part of it.

However, we have a school in financial economics that claims that we have already the consequences of enormous information flows in the stock market. The stock market is said to be a "super brain" because it aggregates all the wishes, demands, projections, and so on of all the investors into a price.

Unfortunately, it's not very stable so even if it works we have the stability problem.

My problem with these mass data, for instance, the mass data in the transit traffic system, is that if it's transmitted to people who are very reactive on each other and on this dataflow, they can actually generate catastrophes because they might be moving in massive conformity just to cause the problems that this massive set of data was assumed to solve.

If we were completely independent of each other and not interdependent individuals in a social system, then it might work, but we are, fortunately or unfortunately, social creatures who imitate and react on each other, and that can very often cause very severe instabilities in a rapid process.

SUNAMI: Dr. Clemens.

CLEMENS: I'd like to step back to memory because I like your statement in your presentation that we should take care especially of old people because there is a lot of information stored. I've also problems with my father-in-law. He's now 79, and he has started to lose his memory. It's some type of Alzheimer's disease.

Because there's a lot of memories stored in his brain, I think they are still there, do you think in maybe 10 to 15 years it will be possible to read out such information from a brain?

LE BIHAN: That's a tough question. I think it might be possible to retrieve some information in some time, but 10 to 20 years I think is too short. We are not ready to do that. The problem is that it's like when you have recorded information on a tape, for instance. You need a device to read the tape. If you've lost the device or if you have no device what do you do?

So today, in the brain, the only way we know to retrieve information is to talk, right? We don't have anything to pick up the information. We don't even know what memory is exactly about.

If you want to retrieve information, we have to communicate, so you have to regenerate something, but as I said, for instance, look at your stairs in your house. You think you have a memory of your stairs but if you are asked a question about them you cannot respond, so that means that you didn't memorize the stairs properly.

I think that we have to be very careful about what we call memories. If there is an accident and you have 10 people next to the scene of the accident and you ask them what they have seen, usually you have 10 different versions, right? If everybody had in their brain a camera, well, only one person would be enough, right? But we have to average out 10 different responses to get a clear response.

So I think that what memory is exactly is not so clear. It has been proven now that some of what we call memories are in fact reconstructions. Very often, children claim they remember something they did when they were 3, 4, or 5 years of age, but we know that memory is not very clear at that time. Actually, they heard their parents telling them what they did at that age. At some point this became "I remember what I did" when in fact, no, this was told to them.

So I think we have to first understand really how memory works and what it is before we can retrieve it artificially.

SUNAMI: As you know, there is a worldwide effort now on the problem of dementia and I think the Europeans and the US and Japan are collaborating to find the answer. There's so much economic loss and social problems associated with this, right?

LE BIHAN: Yes, but I think so far the idea is that if you lose your memory you cannot live in everyday life. If you forget, for instance, how to drive a car or where you are then you cannot live. So I think the urgent question is to have those people not lose their memory. It's not to extract information stored in the brain to transmit to other people.

This is your question, and I'm sure at some point we will be able to do that, to suck up the information and transmit it, but we don't know the rules, we don't know how it works.

But dementia is a very important problem, especially in Japan because you are lucky to have long lives. And it is the same in France, people have long lives, and in many advanced countries now, but if you have a long life and you cannot profit from it because you have lost memory or you have strong cognitive impairment what is the point to have a long life?

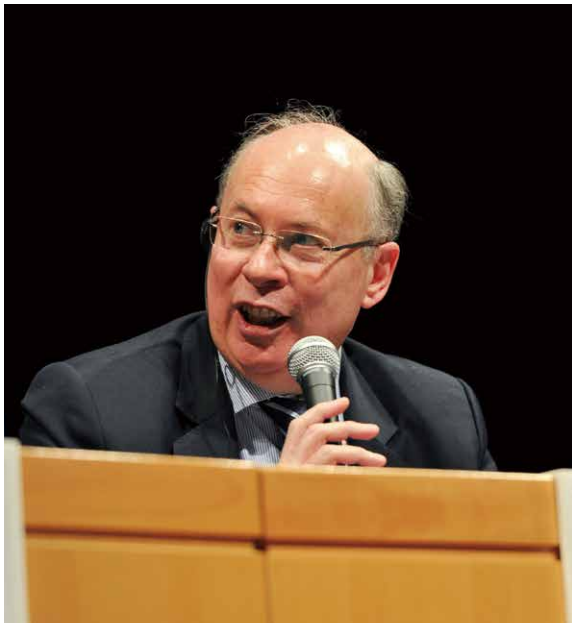
We should really focus on trying to maintain the brain level. The brain will decline with age, but that's okay as long as we can think properly.

SUNAMI: So, Dr. Reddy, what's your reaction to the world with big data? I mean you are working on a lot of cultural heritage or diversity problems, but they really come from this idea that we have controlled this big data and can manage it, right?

REDDY: Basically, I agree with many of the comments but with a complementary, additional thing. It turns out there is no question we have a data glut problem. Because of that, you know, we are not even able to process all the stuff that we are supposed to and a lot of things just stay there.

That problem has always been there, it's just that we were not even exposed to it before because all those books were in the library and we never got to read them. Now, they are all in a PDF and I have them on my Kindle, but they still can't be read.

Having said that, I want to caution you not to throw the baby away with the bathwater, as they say. It turns out there are a lot of things we used to have to remember, the skills that Dr. Andersson talked about, where we go from information to knowledge to routine skill, but that is no longer necessary.



You don't have to remember your multiplication tables. You don't have to remember your phone numbers; they are already on your contact list. You don't have to remember a lot of things you used to have to remember.

More importantly there are a lot of things that you might know but you forget, and sometimes you may not even know but you want to find out. All it takes is a Google search. There is not a day goes by where I don't search for some piece of information I used to know and I know I ought to know.

Ten times a day I find something that I should remember. I don't try to remember anymore, you know, I'm not trying to, and that's okay. You don't have to remember multiplication tables anymore. You don't have to remember phone numbers anymore because they're there.

So in that sense, we need to kind of compliment the fact that we have this big data and somebody else can search and give you some potential uses of information, which is very important.

For example, yesterday I was coming here on flight Japan Airlines 9. In the past, for any amount of money I couldn't find out, but now all I have to do is type "JL 9" into the search box and it tells me exactly where the plane is, when it's going to land, all of the information.

It comes out of a data glut. Every plane, all the

information is there. I don't need to know it, but nevertheless if there is a tool I have and I can use it effectively then big data is good. There's a data glut, but I don't have to deal with it. Somebody else is dealing with it.

SUNAMI: Okay. Yes, Dr. Andersson.

ANDERSSON: I think at this point we agree that it's good to have a toolbox, and if that toolbox is very easily accessible and I see the information systems as parts of a toolbox then it works much, much better now than it did long ago.

I would like to return to the issue that was mentioned on the growth of people who are annoyed at development, who might like to fight in Iraq or Syria or who might join an extremist movement in France or in Sweden or in Norway or in Denmark or in any other democratically, very well-functioning context.

We've done some studies of this and it turns out that the growth of extreme-right movements in these countries is driven primarily by the loss of traditional jobs and the impossibility for those who lost them to find an employer who would like to hire them to do the new jobs.

With the transformation of the economies in Europe, we are bound to have this kind of growth of extremist movements, and some of them are actually then immigrants who have come from Syria and Egypt and Iraq and so on and they are doubly confused about the future, so they might even accept a job with ISIS as a very attractive, although extremist, alternative to being unemployed.

I think one of the sustainability problems in this change process is to have the machinery and institutions that will generate new jobs for the people who are losing them when the old activities are abandoned in society.

SUNAMI: That's a very important point. My professor, actually, when I was doing my PhD at Columbia, did a study on innovation across the different sectors and which sector is more innovative than the other sectors. As it turned out, education is a sector that is less innovative. We haven't changed the way we teach people for years. We are very much in that sort of a rare realm where education becomes very important to make this kind of transition to be more sustainable.

So would you care to comment on education because tomorrow the Honda Foundation will be hosting the Young Engineer and Scientists getting together for the next-generation engineers and scientists?

Yes, Dr. Reddy.

REDDY: This is a very important question. Basically, if you think of education in the last century, basically, what the teachers used to do is teach us all the things that are known, known facts. These days all those facts are already available on the web. The question now is what is the role of education?

I'll give you a simple example going back to Dr. Le Bihan. There is all this data and all the other things. If I did not know that I could find some information, I would never know it. So it is not the case that I don't have to know the calculus, I just need to know the basic principles of calculus so that I can apply more advanced ones when I need to do it by just-in-time learning.

The issue is how to restructure education so that you no longer have to simply give facts that are already available. What you need to do is give them the reasoning abilities to do problem solving and apply knowledge to solve the problems you have.

The question is how do you do that?

I was giving the example of flight information. I have a problem, I need to know what's going to happen. I knew that I could type it and get the information and that is the problem-solving process. So we need to begin to give every child, every person, a series of skillsets to survive in the 21st century. That is not learning all the facts because the facts are there.

LE BIHAN: If I may say something. We have two things to learn. We have to learn how to learn, so the processes, but we have also to learn how to memorize. So, at least in France, when I was a student, a child, there was some conflict about people who are good at math. For instance, with mathematics you learn how to think, except calculation, and you don't have things that you learn just by heart. You have to think to make some new ideas arrive. While if you go to people who specialize in history or geography, they have to learn by heart many, many things.

But we need both; we need to memorize. I've been studying a little bit of Japanese and for kanji, for instance, to write kanji is very important to memorize. If you just look at kanji on a computer you will never memorize them and you will never learn what they mean. I admit it is my problem.

I think we need everything. This is how the brain works. As I said, many inputs, and we need to consolidate our memories. So even learning by heart things that you can retrieve with Google doesn't hurt because it is training your memory. And you know for people who get Alzheimer's disease, for instance, we try to maintain their memory even by learning mundane things, it's good enough.

So I think we have to balance how to learn things that you can find and things that you can't find, but today if you lose your smartphone and if you have put all of your phone numbers there, you will have nothing and you are dead.

REDDY: I want to reinforce what Dr. Le Bihan said. There are three phrases used: "learning to learn," "learning to think, reason, and solve problems," and the third one is "memorization is equivalent to," what Dr. Andersson called "skills."

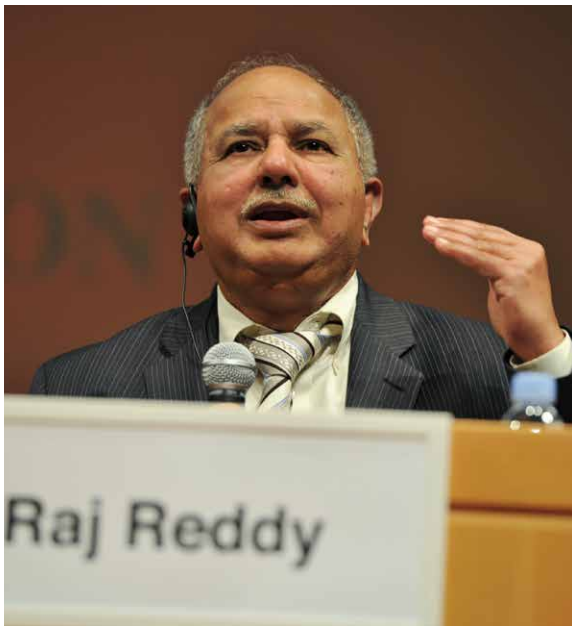
Supposing you needed to do something and there is no substitute for learning kanji unless you practice them so all the three skills are needed. Except now what used to be thought of needed skills in the 20th century are no longer the skills you need in the 21st century.

For example, I come from India where the sounds are the same but the letters are different. In 20 different languages there are 20 different scripts. Europe is safe that way because they only use one script. The problem is I don't want to learn all 20 scripts, and so what I do is I have the same letters transliterated into my language. I know how to speak with intonation, everything, so when I see it in my language I can figure out what to say.

So it turns out, depending on the technology, depending on where you are in time, we need to be able to say what should you memorize and what should you not have to memorize.

For example, this kanji character-learning thing may go away in the following sense. All I need is a smartphone and I take an image of it, it reads it, and tells me what it is. Then I don't have to actually learn the letters. And it can be done today.

The same is true with respect to translation. I'm in a meeting in another country. I don't know how to speak. All I need is my smartphone to transmit it, translate it, and then play it back to me. This technology was demonstrated in the last 3 or



4 years. We can do speech-to-speech translation now, and that doesn't mean we don't need regular translators, but there will come a point in time where no matter what language you grew up with, you don't have to learn all the other languages because you can listen.

SUNAMI: Okay, Dr. Andersson.

ANDERSSON: I once studied a famous mathematician Polya, who was from Stanford, and he kind of summarized his learning as a teacher. He wrote a book called *How to Solve It* and what he claimed I found very useful as a complement to what you said.

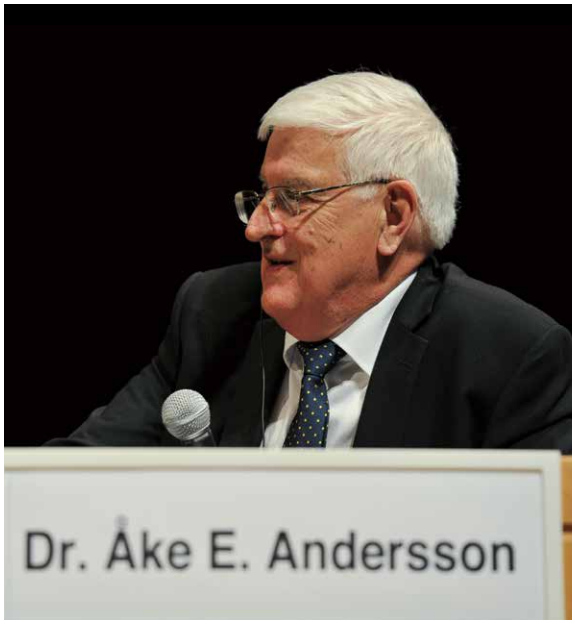
He said that, first, the trickiest thing to get people to understand is how to not only elegantly but also productively generate problems. Formulate problems. How can you formulate a problem that nobody has formulated before in a way that it is amenable to analysis?

Once you've done that, and if you are a student you have learned to see this as the basic part of creativity, then you come to the question, how can you solve it? How can you solve this formerly unknown problem because there is obviously nothing in the toolbox to be used directly?

So he said you can use analogies. There are analogies maybe from very strange parts of the knowledge field. You might be a physicist who wants to do something that no physicist has done, so maybe you should go into the deep cellars of mathematics or chemistry to dig up something that seems to be similar and sufficiently similar.

And I found this is a very nice way of opening up some students' eyes. They come and ask what they should write their dissertation on, and they want me to formulate the problem, and I tell them the only important thing is that they do something completely different from what I've been doing and then they look very confused.

But some of them come back after a couple of months and have actually by themselves formulated a new problem, and then we can start discussing what analog structures are available to solve this problem.



LE BIHAN: In fact, we know today that the brain works a lot by analogy. What learning is, basically, is having an experience about what should be done and what should not be done. If I say for instance "cat," you can think about a cat because you have seen one. Otherwise, there's no way, right?

Children, especially, when they learn, they learn by analogy so they try to compare different situations and try to mimic. Sometimes it is not appropriate and they make a mistake, so they learn not to do it again. And it goes very well.

For instance, some people have shown also that the way Einstein's vision came was just by analogy. If you look at the two articles he wrote about relativity, in the one in 1905, it's not $E = mc^2$, it's E/c^2, where E is some kind of mass. Even Einstein himself didn't catch what he found. And in his paper on the general theory two years later, then he revised the equation to $E = mc^2$ and said that this mass must be the mass.

So, I can see what he was thinking, from what I could read now, just by comparing different fields or different ideas and trying to propagate knowledge from one area or one field to another one, and I think that is really how the human brain works. So we don't have a digital brain; we have an analog brain.

SUNAMI: Okay, now I would like to invite questions from the floor.

FUKUNAGA: I am Fukunaga of the Abduction Research Group, and I'm making a presentation at the Cognitive Science Society. I once heard about the following discussion. This has something to do with Dr. Andersson who, it seems, earlier made the important remark that a complex system is the shortest algorithm.

This is something I heard from a chaos researcher, that in one's brain one can knead a pie, in Mathematics the so-called baker's transformation, a transformation activity in which chaos comes out. A complex system comes out. One kneads a pie by stretching it far or near. This so-called baker's transformation is a process that occurs in one's brain. There exists this kind of complex system through which the brain scans broader knowledge. I heard from this researcher that the brain, making the most of this chaos, might be scanning broader knowledge.

I think it fits splendidly with what Dr. Andersson earlier said that the complex system is the shortest algorithm. Is the professor's view compatible with my present example? Do you think it is a comparable example?

SUNAMI: Dr. Andersson.

ANDERSSON: There is one problem for me in answering this question, and that's I know too little about the brain, so I think that part Dr. Le Bihan will have to deal with.

The basic idea or the basic relation between complexity and chaos is a very sophisticated discussion that's now going on among mathematicians because it turns out that complex systems are at the heart of Godel's theorem. This means that there are certain problems where you cannot actually prove that a statement is correct, but you can know intuitively that it is correct somehow.

And that's especially in situations where, let's say, a number series is so complex that it can only be described as chaotic, and yet you can somehow grasp, or the brain can grasp, that there is some structure to it even if you can't get a computer, for instance, to solve the problem or even if there is a well-behaved algorithm around.

Already Turing struggled with this problem and made a version of Godel's impossibility theorems adapted to general computing. So this is a very, very complicated issue as far as I'm concerned...

LE BIHAN: May I just complete your response with the brain side?

Well, it is obvious that the brain is complex, but we should take the words or the definition. We know today that complexity is really how the brain works. In fact, in a sense, if you go to the bottom, to the molecular level, if you sum up all the molecules, you cannot create the level which is above the molecular level, so there is some synergy, something new that is coming out of each element at the molecular level.

Then when you go to the cellular level, again, if you put all the neurons together and everything, that's not enough, something else is coming, synergy is coming out of the collections of the neurons. Then you have regions and again and again, so each level is not the sum of the elements at the level below. This is complexity.

Also we know that the brain doesn't work linearly. It's highly nonlinear. Some people even think that it's similar to quantum mechanics, if you like. When I talk, for instance, about the fluctuation in the brain, this is what we see now. There are fluctuations and the system is somewhat chaotic. There are some fractals that have been used, for instance, to describe the electric waves produced by the brain.

But we are not aware because what we feel in a conscious state is only a very small part of all the machinery that is permanently occurring in our brain. And as you know very well, when we're completely asleep and we start to dream, the fourth level of sleep, we are totally unconscious. We are dreaming, but then this is the time the brain is the most active. A lot of information is processed at this time and this information processing shapes the brain. This is how we make our memories and this is how we learn, so the brain is really a model of complexity in a real sense.

SUNAMI: Okay, let me call Prof. Suzuki.

SUZUKI: I am Masuo Suzuki, a councilor of the Honda Foundation. I study Theoretical Physics and so I have a lot of comments regarding the earlier discussion. But I will not touch on those to save time and ask instead a general question.

On today's theme of Creating a Truly Humane Civilization, discussing the future based only on the present state of affairs gives us quite a narrow perspective. Learning from history—and there's a saying that history repeats itself—in thinking about a future sustainable civilization, and citing Japan's culture as an example, we can point to such stable cultures, in the spirit of "mottai nai" or not allowing anything to go to waste, although the aristocratic culture of Heian period, and the very plebian culture, such as kabuki and painting, of the Edo period flourished.

From the perspective of discussing the future based on what we learn from history, are there precedents in Europe that can serve as our reference when we think of a future sustainable society? I would like to address this question to wise panelists from Europe and India.

SUNAMI: Who wants to go first?

LE BIHAN: This is a very interesting question, but I think it's not specific to Japan. There are periods where things are stable, like if we take the Middle Ages period, for instance. In Japan and in France it was completely different, but it was somewhat stable. You had the organization with the shogun and everything, but at some point some chaos started and this is how you change from one system to another one, from the Middle Ages to the modern time.

In France, it was exactly the same. In the Middle Ages the system was very, very stable with the king and the people and everybody had his own territory and that was very stable. At some point, for some reason, people started to think differently and the system had to change.

I'm not sure history is repeating itself, it's just that for some time we had something stable as a society and then we switched to another system. This has happened in Asia, in Europe, of course the United States has a much more recent history, but I think it's not reproducing the same. It's evolution, but you have steps where everything looks stable. That's what I feel.

SUNAMI: Okay. Anybody? Yes, Dr. Andersson.

ANDERSSON: Well, I think that there are certain things to be learned from history and that's especially true for the countries who have not yet become industrial societies. We know that Japan got a remarkable rate of growth because they were, like Sweden, latecomers into industrialization, so we could benefit from all the errors and mistakes that had been done or experienced in Britain.

It was very common in Sweden, and Japan, to

make trips among innovators to Britain, or a little later to Germany, to see how they have organized production or how they have been working.

And today it's even more useful to look at the history of the countries that have had a very rapid expansion like we had earlier. Now we are a slow grower, but earlier we were very fast growers because we were imitators and learners.

Today, in Africa for instance, some of the countries who have started their industrialization process benefit from benchmarking and going to and seeing what other people have done before them, and using the useful organizational principles and the useful technologies and so on, and thus they grow much faster than we could do.

China is a good example of very systematic learning from history, but one shouldn't go too far back to learn. I don't think it's meaningful to go back to the Medieval times, for instance, in Europe and try to learn anything except negative things.

You can see how it works when power is monopolized by small groups and hierarchies become too stable and not inclusive and so on. Otherwise there is not much to be learned by going very far back. But going, let's say, 100 years back can be a very useful type of historical study for developing countries.

SUNAMI: Thank you. Any other comments?

Questioner A: Thank you. I have also watched the movie "Transcendence" and got to thinking about singularity these last 3 to 4 months. In chess, between Kasparov and Deep Blue, Deep Blue won in 1996 and 1997, and presently, in the battle between chess and man, teams are formed and those teams fight against one another. In Japan, last year and this year, five professional shogi players played against five software programs, and won only once in each year if my memory is correct. The humans did poorly in that competition.

The difference between chess and shogi is that there are more pieces in shogi, and since you can reuse a piece taken any number of times it's complicated, but it is said that even in the world of shogi, the computer has also caught up. Interestingly, the shogi player who lost to the

computer last year, was in a slump when he studied using that computer software and played with it, but this year, his performance has improved remarkably. This year, that computer software was lent to shogi players and the one who studied it thoroughly and polished his strategy won.

As I thought subsequently about the relationship between man and computer, in the end, even a professional shogi player learns unexpected moves from the computer software. One can learn from the computer by way of gaining new ideas that are different from what one has studied so far. Earlier there was talk about big data, with big data, the world that is invisible to man expands rapidly in such a way that a medical doctor, for instance, makes a diagnosis from computer results that he/she does not fully understand.

In this way, I would imagine the relationship between man and computer changing dramatically. May I hear somebody's opinion on this?

SUNAMI: Okay, so I will ask Dr. Reddy.

REDDY: What you say is very true. It turns out there was a phrase coined by J. C. R. Licklider in 1962. He is the grandfather of the Internet. He is the one that actually started the work, started the research in that area, and he also coined the term "intergalactic

computer network" or something like that.

One of the other phrases he coined was the phrase "man-computer symbiosis," so essentially any time you can have a human being and a machine who have worked with each other, understand who is good at what, they will always win over a computer or a person because they bring to bear the best of both worlds in some sense.

In particular, for most of the games of the kind that you're talking about, chess, Go, and so on, it is now possible, given the terabytes or petabytes of data available, to put inside every chess game that has ever been played and every move for every condition. That's not the same as all possible moves, which is more than the number of atoms in the universe, but every game that's ever been played can be put.

If you have that, then all that you have to do is do a table lookup or a search, in the Google search sense, to just look at that particular move and say does it lead to a win or not and then do it.

If you come up with a new position that nobody has ever seen before, what you do? That point is where the computer's power comes in. It can actually explore millions of possible moves and find out what is the best solution. Once it finds the best solution it becomes part of the folklore and every chess player will learn that particular thing saying, "If I know this, I can make this move."

And as we know, Grandmaster chess players know 50,000 different patterns, whereas most of the rest of us maybe know 1,000 patterns, and that's the difference. They have so much more knowledge and when they find a new position, a new winning strategy, it becomes their winning thing.

So basically coming back to the discussion on cognitive science and cognitive memory, the evidence now is, if you look at what happened with Kasparov and Deep Blue, the evidence is that it won mostly by brute force. A little bit of knowledge and a lot of brute force search.

The evidence now, at least looking at the brain research, is that a lot of the stuff in the brain is brute force, namely it can recognize there are different parts of the brain, 10,000 faces, each one has a separate computer that detects your mother and father and your brother and everybody, it's completely differently localized.

At the same time that doesn't mean there shouldn't be a complexity model that tells us this concept is understandable, it's simple in this context. That's where mathematics comes in. It doesn't mean the brain uses that particular structure, but it's better to understand it.

Similarly, for example, not everything can be formed into a mathematical principle that Dr. Le Bihan was talking about. A lot of the things that we know currently are all completely statistical models. It is not precisely formulatable as a model. I think you mentioned quantum mechanics. Quantum mechanics is mainly probabilistic mechanics and so the issue here is that the brain may be operating on a quantum mechanical basis and that may be an interesting possibility.

LE BIHAN: When I was a student learning IT at the end of the 70s, I remember very well my teacher gave us a definition of a computer: "It's something stupid with a very, very good memory." And in fact I think for our brain it's exactly the opposite. We don't have such a strong memory but we can think.

The advantage of the brain is that it is highly parallel. We have millions and millions of cells that can do processing in parallel, and so far, even with the best computers we have we are very far from that.

Now there is evidence also that the brain is using the Bayesian theory so waiting for different outcomes and comparing with what has been learned in a completely non-conscious way to decide what is the best behavior.

In fact, the brain we should consider is a machine to protect ourselves, to avoid dying, and so it's a learning machine. It is always learning. Even for old people, we are always learning and we are trying to decide what the best is for us. Sometimes we make mistakes, of course, but our brain is here to protect us, to preserve our life.

SUNAMI: Can I just invite one more question because we are running out of time and then we will go back to Dr. Andersson.

SUNAMI: The lady over there, you raised your hand earlier. Do you have any question?

Questioner B: I am presently raising a child. Since birth, this child has been surrounded by IT and PCs, which, with all due respect, if I may guess their ages, was a very unlikely environment for the professors here. I would be very glad if you tell me, for instance, that contact with nature is very important as an experience in early childhood, but in your opinion, at what age should a child start to have contact with a computer?

SUNAMI: Dr. Reddy.

REDDY: Always, but that doesn't mean that they shouldn't go out into nature. As Dr. Andersson was saying, you spend only 7% of your life, maybe 10%, working, so 10% of the time let them work with IT, 90% you do whatever else you want to do.

LE BIHAN: Yeah, I think we have to be careful to teach our children that life is not all in computers. There is real life and more than what we call social networks like Facebook. I hate this word because there is nothing social about them. We have to be extremely careful.

On the other hand, I talked about genes and the brain. If you give to a child a smartphone, in a few minutes he or she knows how to operate it although he or she cannot even read the manual. So genes are not responsible for us to use our smartphones.

So I think that if such devices are used in a good way, it can benefit the development of our children. For them, we have to realize that it will be like a pencil is for us today. One thousand years ago this would be a very strange instrument, right?

So we shouldn't make a mystery about such devices and we should make them just part of daily life. As you say, there is nature and communication, and these should not be forgotten. Unfortunately, there are teenagers playing games, for instance, on the Internet and for them this is society. That's very dangerous, of course, so we have to be careful.

SUNAMI: Dr. Andersson.

ANDERSSON: I would just like to ask a question to the brain specialist. I have been wondering if

Haken's idea of fast and slow processors might not be useful in understanding the workings of the brain because if you have a nonlinear system like the brain is, it would be chaotic most of the time. And we know that we are not chaotic most of the time. It happens now and then but on the whole people are quite predictable.

I discussed this once with a famous differential equations guy who wanted to model the brain, and he actually said that in order to model the brain with his mathematical tools he had to separate it into two parts: one that was slow and one that was fast. I wonder if this is the case that the brain is actually subdividable into two interactive processors, where one is kind of stabilizing the other part?

LE BIHAN: Well, it's not completely that way. There are different scales, as I said before, different scales in space, so from molecules to cells to network, and it's the same with time.

There are different timescales at the molecular level, at the cellular level, so, yes, we can see that, for instance, in the electric waves produced by the brain. There are different frequencies. But it's not only two. Some processes are slow, some are fast but they are interacting all the time, and even if chaos is present it doesn't mean that the brain is globally chaotic.

It's like the weather. We know that there is a lot of nonlinearity in the weather but we can predict it somewhat, and so it depends on the timescale you are talking about.

SUNAMI: Okay, Dr. Reddy.

REDDY: So there is a Nobel Prize that was won by Kahneman on slow thinking and fast thinking and it is another way of talking about cognitive science.

What we know is there are things you memorize and if you memorize them you immediately recognize them; therefore, they become fast thinking. Things that you don't know, that you have to reason about, that's kind of slow thinking. There's nothing magical about them. It's all been known in psychology and cognitive psychology for many years.

SUNAMI: Thank you. I think we are almost running out of time, so I think we should close now, but before we go there is one sort of important question that you raised, and I have some questions that I have been collecting.

How do you make us more humane, in a way? Is the innovation of eco-technology a solution? You know, you talked about the separation of state and religion, or state and faith, and that's sort of the beginning of the rise of modern science, yet now we are facing so many complex problems including religion and other sorts of things. Would anyone like to comment on this? Let's take turns to make a short, brief statement. Dr. Reddy.

REDDY: The only solution I know is education

about ethics, and Dr. Andersson mentioned that so maybe he should talk more about it, but mainly until we train the next generation about what is right and what is wrong, and put them in the shoes of the people that are being tortured and build up their empathy, we are not going to have a humane society because most people have not been taught. They think they can do anything and get away with it.

LE BIHAN: I think maybe I will respond with a question. If we say "more humane," what is "humane," first? I think it is a big question. Researchers now, some of my colleagues, are trying to understand what makes us different from animals, for instance. Is there a difference or is it just continuity?

I know especially for the brain, people are focusing now on if there is a way to understand what makes humans different from nonhumans, and that I think is an important question because if you want to be more humane we should understand first what humans are. And that's not so easy. In fact, that's a very difficult question.

CLEMENS: I think maybe it's quite simple, the answer to getting a truly humane society. I think if you give everybody a chance for the future that will solve all the problems. I think the problem is that you have areas in the world where people have no future, especially young people.

I agree fully with you that what we really need is a full education, a good education, for young people. And then we also need a transfer of money because in Europe, or here in Japan, everybody's living at a high standard. If you give the others a little bit of our high standard, I think we can solve a lot of problems.

ANDERSSON: I think that the keyword is "tolerance" because you know the old saying in France about brotherhood, I think that's a devastating idea because brotherhood means you care for your brothers and you don't care for the ones who are not your brothers or sisters. Tolerance means that you can accept anyone and you will look upon anyone as a human being and accept the deviations. I think that's the first thing.

The other thing is, as you said, to provide a place in society for everyone. Everyone should be needed somehow. You can be needed by being employed or you can be needed in some other way, but everyone should have a feeling that he is needed. Otherwise, he will migrate to any society, criminal or whatever, where he will be needed.

The third thing is something I don't know, but I heard a lecture on. That was a lecture by a biologist, I think he was a zoologist, who said that what makes humans unique compared to the other primates is that this is the only part of the primate system that has an inbred capacity to educate, that each of us, starting already with our babies, starts educating our babies and goes on teaching them how to solve simple problems all the time by imitation and so on.

So tolerance, a place in society, and proper use of our inbred capacity to educate each other, especially the younger generations, I think these are three parts of a humane society.

SUNAMI: Thank you very much.

SUNAMI: Since time is up, let's conclude the panel discussion here. Let us give the panelists a big hand.

SUNAMI: Thank you very much.