

THE TRILATERAL COMMISSION
2006 NORTH AMERICAN REGIONAL MEETING
CAMBRIDGE, OCTOBER 20-22, 2006

FUTURE TECHNOLOGICAL DEVELOPMENT
AND NORTH AMERICAN CULTURES

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I want you to imagine, for a second, what would happen if you picked up a newspaper from the Renaissance? So just imagine that you had the *Renaissance Times*. What do you suppose would have been the headlines in the *Renaissance Times* 500 years ago?

Well, one might have read: “Islamic Terrorists Attack Yet Again.” “Deadly Plague Headed Our Way.” “Oil Traders Accused of Hoarding and Corruption.” “Violence and Insecurity in the Streets.” “War Worries.” And perhaps, because it is an Italian paper, one might have even seen a headline or two that read “French Treachery?”

The interesting thing is you pick up *USA Today* and it's the same headlines. But the world changed a tiny bit, and even though the political debate is the same as it was 500 years ago, and even though not all of us can name the lead peace negotiator in the Balkans in 1700, in 1800, and 1902, there are some things that truly matter. The things that truly matter aren't just politics and it's not just what *The Economist* was projecting. The things that truly mattered are the things that weren't the headlines.

As Eric Lander said, the difference between a man and a mouse is about 5 percent of the genes. Lay the genes of a human being next to the genes of a mouse, and the man and the mouse differ by 5 percent. But the thing that animals don't do is they don't transmit data across time. There is no animal on this planet that is able to teach its kids in writing this is what we learned 10 days ago, 10 years ago, a 100 years ago, or a 1000 years ago. The thing that humans do that animals don't do is they write on cave walls, they transmit, they code, and the history of wealth is a history of technology and code. This long wall painting tells people, this is how you have a baby, this is how you do fire, this is how you do music, this is how we dress, and you're able to tell what people did a couple thousand years ago.

As that gets standardized, the difference between a tribe and an empire is the code has become standard and portable. Because you've standardized this code in Egyptian hieroglyphics, one can read “Juan Enriquez” on this slide. You can write any of your names in Egyptian hieroglyphs. Because you can write your name in Egyptian hieroglyphs, you can have a civil service, you can have laws, you can print books, and you can teach people in Upper Egypt and Lower Egypt how to organize a trade system.

Changes in code really matter. Think of A, B, C's: 26 letters in English and 29 letters in Spanish. In the measure that you can code in 26 letters, it's a lot easier to print a book, transmit data, and teach people stuff. We have gotten very efficient at teaching our kids a lot of data.

What happened over the last 30 years is we changed code yet again. We collapsed this code into two digits: 1's and 0's. Every word written and spoken in English or French or Spanish can now be coded in two digits. If I'm in a good mood in the morning, I'll send you the first line of code **01101100011011110111011001100101** and it says I love you. If I'm in a bad mood in the morning, then

I'll switch to **01101000011000010111010001100101** and it says I hate you. Digital code has not only collapsed every alphabet, every written word on the planet in English, Spanish, French, Armenian, Egyptian, whatever you want, it's also collapsed every bit of music and every moving image.

And, by the way, that had a slight impact on the global economy, because the global economy in 1960 was one-third manufacturing, one-third agriculture, one-third services. Today agriculture's 4 percent, and knowledge is about two-thirds of the global economy. And, by the way, it has an impact on who's rich and who's poor, because if you made it into the Fortune 500 in 1935, you could expect to be there for about 94 years, but if you make it into the Fortune 500 today, you can expect to be there for about 14 years. This is why the average tenure of a CEO is three to five years. Waves of technology really do change stuff. They really do come at countries and overwhelm some. They really do come at civilizations, and they change the rules of the game. As the rules of the game changed, Latin America didn't go digital. Because Latin America didn't go digital, Argentina, which was one of the richest countries in the world in 1930 and was producing a lot of Nobel Prize winners, all of a sudden became irrelevant to the global economy. The reason we're not discussing Latin America here is because, one, they're not creating a huge mess in terms of politics and, two, they're not terribly relevant in terms of wealth creation, technology, patents, and the future.

We can actually put numbers on that. It takes about 3000 Americans to generate one patent, 4000 Japanese, 6000 Koreans, 800,000 Argentines, a million Brazilians, a million Mexicans. That's a 200 to one differential in terms of productivity and knowledge. I don't care what the inflation rate is, without knowledge there aren't going to be a lot of new jobs. In fact, you're going to have the same number of companies on the Brazilian, Argentine, or Mexican stock exchange as you had in 1985.

Now the map and source code has changed yet again. This is the map of the new language: that of life. This is Rosalind Franklin, 1952, and it's a map of what life looks like. Watson and Crick looked at this and argued that all life on this planet is coded in a double helix, AT/CG. All plants, all viruses, all cows, all sheep, all humans, and all politicians are coded in the same letters. As Eric showed you, those are really boring books, but what those really boring books do is they make this orange the new coding system. This orange is a computer, except it doesn't execute digital code. It executes life code.

The way this orange works is you don't plug it in, you simply drop it, and the first line of code says ATA, CGG, make a root. TCAG, stem. GCAA, make a flower that's white, that blooms in the spring, and smells like this. And, by the way, if you take a series of 1's and 0's and change them, it goes from "I love you" to "I hate you." If you change a couple of lines of life code, this thing, an orange, becomes a lemon, or a tangerine, or a grapefruit. Very small changes in gene code can alter the function of this life form.

As you go forward in this, what it means is that you can define life as imperfectly transmitted code. This is the new coding system driving change in the global economy. This is becoming the dominant language. What happened over the last 30 years is you went from nobody speaking digits, outside of a couple of labs, to 94 percent of the data on the planet being transmitted in digital code. If you don't speak digital code, you're functionally illiterate in the language that drives the global economy. The same thing is beginning to happen with life code. This stuff is driving mergers of academic divisions. All of a sudden you get the cardiovascular and the biology and the molecular biology and the imaging coming together. Now the same trend is occurring in large companies.

In 2001, with the human genome, you had a whole source code. So you had start-ups, you had about 239 companies, right around Eric's labs at MIT. There were all these nifty little interesting companies. Some of them went bust in 2000. It was amusing but not game changing. Today it's very different, because we tend to overestimate the impact of this in the short term and underestimate it long term.

What does that mean? Well, for example, Degussa, a large European chemical company, is now being driven by life sciences. DuPont is now making most of its new materials, most of its new stuff, not out of polyester, not out of nylon, but out of biomaterials grown in bacteria. BASF is doing the same thing. Energy is also working—some of the ethanol plants are getting very large. And there is a lot of bioenergy investment. You look at a company like DSM, and you see this evolution from coal to fertilizers to petrochemicals to materials to life science and biologics. Economies that don't evolve in that way, schools that don't evolve in that way, and CEOs that don't evolve in that way risk becoming rapidly irrelevant. Life science is spreading far and wide.

Basic production is changing. This particular animal comes out of a Cambridge company. They took some cells out of an adult animal's mouth, they stuck that gene code into a cell, inserted that into a fertilized cow's egg. One species gave birth to another different species. That's already happened.

This stuff is not just happening in the People's Republic of Cambridge. This is spreading very quickly. This photo was taken in a gene-cloning lab in Argentina. You walk out, you find a very friendly cow that thinks it's a Labrador retriever. You pet the cow, while you're petting the cow, these two other cows show up, and you say to yourself, those look a lot alike. Yes, they do, and, in fact, they look a lot like the first cow. They look a lot like that cow because of the way these animals were made. They took some cells from this part of the ear, they inserted those cells, gene code, into a fertilized cow's egg and gave birth to two clones – adult cows.

This is a more interesting animal. This cow was born a few months ago. They modified this clone in such a way that this animal would produce a medicine called EPO in its milk, so this is a clone that produces a cancer cure in its milk. Twenty of these animals substitute for this pharmaceutical building that you've got right next door here.

As you think about how you're going to make biomaterials, as you think of how you're going to make medicines, as you think of what's going to drive the global economy: for the last 30 years it has been digits. The next years, as Eric said, it's the convergence of digits and the biological revolution. That's why countries rise and fall. That's why the productivity of countries increases and decreases, and as you think about countries, one of the really interesting things is how short a time they last.

From 1950 to 2000, we've been increasing the number of flags, borders, and anthems on the planet very rapidly. Here's what Europe looks like 50 year ago, a 100 years ago. Here's what it looks like today: triple the number of flags, borders, and anthems. And, by the way, that's still happening in Spain and Italy and Austria and Netherlands and England and in northern Italy. Same is true of Asia and Africa.

But there's an exception to this. While we tripled the number of flags, borders, and anthems on the planet in Africa, Asia and Europe in 50 years, we have not done so in the Americas. The last truly new border in the American continent was Panama in 1903. That is really strange. Any time you see an outlier that is that big in a system, you better study it. There is of course, one obvious conclusion: It'll happen to everybody else but never here. Except that flags and anthems turn out to be myths. As soon as your kids don't believe in the same symbols, then these symbols end up in archeology museums. That happens very often, because there are no natural borders. Borders are human creations and they only last as long as you and your kids and your grandkids believe in the same thing.

It's surprising how you can take old politically charged phrases and find a lot of people who agree with this in the world. For example, “Long live the red, white, and blue.” In fact, the Russians agree, and so do the citizens of Luxembourg, even the French or the Dutch. Their flags, after all, meet this standard. If what you really mean is “Stars and stripes forever,” then surprisingly, the Cubans agree, the Danes agree, as do the North Koreans.

So here's a question for everybody: How many stars will be in the U.S. flag in 50 years? Why would anybody ever ask such a stupid question? There's no historical evidence for any change, is there? Except if you look at trend lines, you see constant change. The U.S. is one of the very few countries along with Brazil, that's consistently gotten bigger since independence. There's a little dip here with the Civil War. Never mind. This picture of Eisenhower with a new flag in 1959 means there has never been a president of this country buried under the same flag he was born under. Ever. We assume continuity where there is none. As you think about this stuff, and as you try and answer that question about the U.S. flag, try a thought experiment. Say it is 1902 and your name is Robert Cecil, Marquis of Salisbury, Prime Minister of Great Britain. The map on your wall looked like this. The entire world was a highway to get to your empire, and you were just trying to figure out how to manage your 11 million square miles. If you took an inventory in the British Cabinet room, you had the strongest universities, the best manufacturing, your Navy could sail anywhere, and you were the dominant reserve currency. It was not obvious what would happen to this country 50 years later. Had you asked the question, your answer probably wouldn't have been something that looks like this: 11 million square miles turning into 89,000 square miles.

Maybe the U.S. follows historic trends and gets bigger. Maybe you get 60 stars in the flag. That's easy to see. Bring in maybe a part of northern Mexico, a part of Canada, Puerto Rico, the Virgin Islands, maybe Guam. If that sounds totally far-fetched to you, you have to remember that in 1949 Newfoundland left Britain to become a part of Canada. But there was a debate, and a big brouhaha as to whether Newfoundland was going to be independent, whether it was going to be a part of Britain, whether it was going to join the U.S., or whether it was going to be a part of Canada. By the way, Ronald Reagan tried to swap Baja for the Mexican foreign debt not that long ago.

The maple leaf flag that we all take for granted and is a wonderful, beautiful flag is from 1967, and Canadians today pledge allegiance not to the country of Canada but to Queen Elizabeth.

If you look at European trends, it is conceivable that countries can and do split. If it can happen to Britain and France and the Roman Empire, and The Netherlands and Belgium, the rest of these countries, dare we even ask the question, would it ever be conceivable for even the U.S. to get smaller?

Well, it already has. There is a reason these flags (Panama, the Phillipines, Liberia, Cuba) all have stars and stripes in them and are red, white and blue—they could have been U.S. states. There could have already been 55 or 60 stars in the U.S. flag. The real danger to this country doesn't come from Iraq, doesn't come from Iran, doesn't come from outside. It comes from inside. Do we have any evidence that we might be squandering resources?

Here's a trend line on debt. Here's what the fiscally conservative and responsible governments have done, and here's what the numbers look like, to the point where, just as happened in Britain in the early 1900s, the world's reserve currency belongs to a debtor nation.

As you go forward in these trends, this is a very spiky world, it isn't a flat world. Richard Florida, I think, is more accurate than Tom Friedman. You're getting regions that get it, with life science clusters, nanoclusters, and photonics clusters in a very few places. You're getting real political and wealth divisions. You're getting a debate that is based on dividing people, not bringing them together, and you put that together with a bad education system, and you find rapidly growing disparities and disagreements.

We are going to double the amount of data generated by humans—in the next five years. You take all the data generated by human beings, across time, across history—we're going to double that in five years. You've got people who are absolutely driving this thing forward and doing what Latin America doesn't

do. Eric Lander and his lab have probably generated more new companies than Mexico has in the past six years, never mind new patents.

If you want a long-term takeaway from this talk, it is that this science stuff—changing maps, changing code—really matters. This education stuff really matters. Not assuming that your flag has always been and will always be there really matters. The divisions that could take a country down are internal, they're not external. If I had a bit of advice, it would be: Do not take your country for granted. Countries are fragile things.

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