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The BioTech Century

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Good afternoon everyone.

We are in the midst of a fundamental transformation, one of the great changes in history. We're moving out of the industrial revolution and into the "BioTech Century."

For the last 40 years, two technology revolutions have been operating essentially on parallel tracks: computers and gene splicing; the information sciences, the life sciences. In the last few years, they've begun to fuse together to create a powerful new technological and commercial revolution that's going to remake our entire civilization.

The computer is merely a prelude to the new economic era, and the new economic era is based on genetic commerce. The computer is the language, the organizing tool to decipher, download, organize and manipulate genes. And genes are the raw resource of the Biotech Century, just as metals, minerals, and fossil fuels were the raw resource of the industrial century just passing from view.

Let me try and place this tremendous change in an anthropological context. This shift in the next 50 years will be as fundamental as the shift from Medieval agriculture to the industrial way of life. It's going to force all of us to rethink the social contract.

For thousands of years we've been burning, forging, soldering, melting, and heating inert material from the earth's crust. We've been using pyro-technologies, fire-technologies and we've refashioned the earth using fire. We've created steel, glass, cinnabar, cement, synthetics and plastic. The culmination of the fire-technology era is the industrial age, the burning of fossil fuels and nuclear power.

In the 1970's two biologists did something in the world of biology that some are equating with the fire-technology revolution in its impact and import. Boyer and Combs, University of California and Stanford, they took slices of genetic material from two unrelated species and stitched them together; they recombined them, creating the first new, novel life form ever at the hands of human beings.

Now instead of burning, soldering, forging, and melting inert material, we can now stitch, edit, sequence, and recombine living material across the expanse of the biological kingdom.

I've had people say to me in the past, "Look Jeremy, isn't genetic engineering just an extension of the kind of tinkering we've been doing with nature since the dawn of the Neolithic revolution 10,000 years ago? We've been breeding and domesticating animals and plants for a long time." My answer quite simply is no. This is a qualitatively different revolution. I'm going to give you a few of experiments that could never have been done by Luther Burbank or any other classical breeder in history.

Years ago at the University of Pennsylvania, scientists took a human growth hormone gene, a human gene. They microinjected that gene into mice embryo. The mice were born with a human gene replicating in every cell of their body. The mice grew twice as fast and twice as big as any mice in history. And they passed that human growth hormone gene into every generation of their offspring. We now have mice with human genetic material in their blueprint. You cannot do that in classical breeding. We've never seen that in classical evolution.

Experiment two, a bit more whimsical. Scientists took the gene that emits light in a firefly; they microinjected the gene into tobacco plants, the genetic code. Those plants light up 24 hours a day. Don't ask me why they did that experiment.

The third experiment is a little bit more bizarre. Sheep and goats, two completely unrelated species genetically; they cannot mate. In the laboratory, scientists took the embryonic cells from each of these animals, fused them together, and gave birth to a new species on earth called a "geep," half sheep, half goat; the head of a goat, the body of a sheep; a chimera, a new composite creature.

And finally you're all familiar with Dr. Wilmut's cloned sheep. We actually missed the real story behind this. We're so interested in talking about when this will happen with humans. (And, by the way, if we haven't already done it somewhere, the cloning of a human being is likely anytime. It's no longer a theoretical issue; it's just a question of who's going to do it.) The real story behind the sheep is that Dr. Wilmut created the prototype for bioindustrial design. He's the Henry Ford of the Biotech Century. It is now possible to replicate in countless numbers exact copies of an original living creature with the same kind of quality controls and engineering standards we did using mass production and assembly line factory work with inert materials. That's what's so important about this animal. We moved from the industrial age to the bioindustrial age.

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Genetic engineering is called "genetic engineering" for an important reason. And it's that second word, "engineering," that we all need to heed. It's taking engineering principles and applying them to the genetic blueprints of life. What are engineering principles? Quality control, predictable outcomes, quantifiable standards of measurements, efficiency, and utility. Now we're talking about actually applying those engineering standards to the blueprint of life.

We're on the cusp of a technology revolution unprecedented in history. Scientists of life science companies can now become the architects of our own evolution and begin to reengineer a second genesis creating new kinds of creatures that have never existed and reformulating the genetic prints of those already here.

This is the most radical, daring experiment in our history. There are tremendous potential benefits to this revolution. We have in front of us the promised cornucopia. New foods that could feed a hungry world. New sources of energy when the oil spigot runs dry, energy from living microorganisms. We could create new fabrics and materials using genetic engineering, new pharmaceuticals. We could find new ways to eliminate the crippling diseases that have haunted our species.

But with all of these great benefits in store for us, a nagging question remains: At what cost? Will the artificial creation of cloned, chimeric, and transgenic animals mean the end of nature and the substitution of a bioindustrial world from the laboratory? Will the mass release of thousands and thousands of genetically engineered life forms into our biosphere cause genetic pollution and irreversible damage to our planet?

What are the consequences to the global economy of reducing the world's gene pool to intellectual property so that all of life is the patented invention of life science companies? What will it mean to live in a world where our children are customized at conception, engineered to our standards, and as they grow up, increasingly discriminated against based on their genetic make-up? What are the risks in attempting to create a perfect human being?

Let's take a look at some of these issues in more detail. You may be surprised to know the following: In the next seven to ten years, virtually all 100,000 or so genes that make up the blueprint for our species will be identified and targeted and isolated. And virtually every single one of those 100,000 genes that make up the human race will be claimed as the intellectual property of a life science company. They're claiming patents on thousands and thousands of human genes today.

Imagine the power here, unprecedented in commercial history. Corporations that are able to control and own the blueprints for our human race dictating the terms upon which our future evolution depends and making that arbitration in the marketplace.

Dr. Wilmut, who cloned the sheep -- his company, TTL, has submitted an application to the US Patent Office for a patent to cover, not only the process for cloning the animals, but every animal that's cloned will be considered his patented invention. And one other thing, he has included in his patent human embryos, cloned human embryos, as patented invention.

I hope you all heard this. Regardless of where you stand on right-to-life / pro-choice, imagine the profound ethical issues here and perhaps Constitutional issues when the Patent Office, and they probably will give him his patent: Will we give him a patent so that all cloned human embryos will be considered his patented product?

We thought we'd resolved this issue in 1865 when we decided with the...when we decided with the Emancipation Proclamation you cannot claim another human being as your commercial property. But now this same issue is coming in the back door in the form of patents on life.

The Patent Office says look, you cannot claim a human being as your commercial property, because the 13th Amendment to the Constitution forbids slavery, but you can patent all the individual human genes, the human chromosomes, the human cell line, the human organ, the human tissue, the human embryo and the fetus, none of those are covered by the 13th Amendment to the Constitution.

And now companies are scouting the planet in search of rare genes in microorganisms, plants, animals, and indigenous human populations, because genes are the raw resource for the next century. Whoever controls the genes, controls genetic commerce. When they locate these genes they patent them. The mergers and acquisitions and consolidations going on in the giant life science industries dwarf the mergers going on telecommunications, entertainment, and software industries. Does that surprise you?

It's just we hear very little about it and here's why. Our futurists have done us a disservice. For fifteen years our futurists have written books preparing us for the information age, so that's where we're focusing our debates. Calling the next century the information age is like calling the modern age the print press age. Neither are resources; both are forms of communication. The print press was essential as a new form of communication to organize a society based on steam power and coal. The computer is not a resource either; it's a form of communication to organize a new economy based on the raw resource of genes.

So what I'm suggesting here is that we're woefully behind, we in the public, where this whole revolution's moving. We have not been prepared by our media, by our academic institutions, and by our politicians.

Yet this technology revolution will more intimately affect our lives than any in the history of humanity. How we date, who we marry, how we have our children, the foods we eat, the kind of work we do, even our perception of life will be dramatically affected by this revolution. Let's look at a few of the issues.

You're going to hear a new term, genetic pollution. In the next twenty years, the Life Science companies are going to be introducing thousands and thousands of genetically engineered, laboratory conceived organisms into our biosphere, mass propagated over all the ecosystems in the world. We're already introducing thousands now. Microorganisms to eat up toxic wastes, new genetically engineered plants in our fields, millions of acres this year are grown with the first genetically engineered plants, all in the last year.

Now when you introduce a genetically engineered organism into the environment it's not like introducing a chemical product. These products are alive. They're more unpredictable. They reproduce. Chemical and nuclear products, for all their problems, do not reproduce. And genetically engineered organisms migrate; they proliferate. How do you recall to the laboratory a genetically engineered microorganism, bacteria, virus, or plant if it runs amuck and causes damage? How do you get it back? Imagine the scale here, thousands and thousands of introductions all over the world of genetically engineered life forms reseeding the earth with a second genesis, all in the next twenty years.

The ecologists, environmental scientists use an analogy: Introducing these new life forms is like introducing an exotic species from a native habitat to a new habitat. We've brought a lot of exotic organisms over to North America. Some have fit in and some have become pests. You're all familiar with kudzu vine, Dutch Elm Disease, Gypsy moth, Starlings, Mediterranean fruit flies. These were not native to North America. We brought them here; they ran a muck.

Every time we introduce a genetically engineered organism into the biosphere, it's tantamount to playing ecological roulette, because there's no history with this species in these environments. If just a small percentage of these introductions run amuck, the genetic pollution to the next century could rival or exceed the kind of pollution we have faced with petrochemical and nuclear products in the century just passing.

And you in the business community and taxpayers should know here, there's no insurance against liability. The insurance industry has said we won't insure any of these releases of genetic organisms into the environment against catastrophic damage, because there's no way to know what's going to happen, so we can't assign risk. There's no science to judge what's going to happen. So here's an entire new era in history, genetic commerce, coming into our society -- the flood gates opening, the biosphere being reseeded, no insurance. Who's going to be held liable when the first genetically engineered organism runs a muck? Taxpayers? Consumers? Unanswered questions. When I raise these issues, I here deafening silence from the life science industry.

Genetic pollution is just one issue. We also have to introduce the social implications. There's a word here that no one in the industry wants to talk about; it's called "eugenics." You older people here will be very familiar with this term. Eugenics is the philosophy of using genetic manipulation to improve an organism or to create a perfect species.

When we think of eugenics, we normally think of the Holocaust, Nazi Germany -- Hitler's dream to create the Aryan perfect human race. Although, as was suggested by the introduction in the quote from the 1920's, we should understand that we supported a massive eugenics movement in this country from 1900 to 1930. Two out of three colleges taught eugenics, how to create the perfect race. 70,000 Americans were sterilized by state law, because they were considered inferior biologically. And we even passed an immigration policy in the 1920's, shameful, shameful policy, in which we kept out of this country those we considered of poor genetic stock, bad blood. That immigration policy lasted for a half a century.

Eugenics is inseparable from the new genetic technology, because the whole point of genetic engineering is to improve an organism, to improve a species. Well, who decides what is a good gene and what is a bad gene?

Right now thousands of laboratories, corporate, government, academic, around the world are changing around the genetic code of life from the lowliest microorganisms to human beings. Who decides what is a good and bad gene?

How many here would entrust the federal government to decide which genes should be engineered in and out of evolution over the next biotech century? Let it be recorded for those listening in on radio: silence. How many of you would entrust the scientific community to decide what is a good and bad gene? How about the Life Science corporations? How about consumers in the marketplace?

All of us would be very distrustful of giving this ultimate power and authority over the blueprints of life to any institution. However, if I asked you another question, "How many of you would like to have the option of some of these new opportunities in the biological marketplace?" You might likely say "yes." Example, in the next seven to ten years, we will be able to identify thousands and thousands of genetic traits. You can come into a doctor's office now and be screened for hundreds of genes and genetic predispositions. But in five to ten years from now, you can go into that doctor's office and be screened with a DNA chip for thousands of genes. This is going to create a fundamental break in the parent-child bond in history.

If you're a prospective parent, if you're a teenager listening in right now and you're going to have a child five or ten years from now, you and your spouse will be able to take a DNA chip genetic screen test and know exactly what you're going to pass on to your child before conception. You will actually have a crystal ball which will allow you to look in to the genetic future of a child not yet conceived.

Well, what do you do? If you know you're going to pass on the gene for childhood leukemia, wouldn't you want to program that out of the egg and sperm before conception as a parent? What if you knew you were going to pass on cystic fibrosis? Well, where do we stop here? What if you knew you would pass on Alzheimer's at around 50? Or you were going to pass on a predisposition for manic depression, or for alcoholism. What if you were going to pass on poor vision or color blindness, or dyslexia, or the obesity gene, or short stature? What parent wouldn't want the best, healthiest child that money could afford? Do you know any parent that would say no to making these changes in the sperm and egg if it could improve the prospect of a [sic] children not yet here?

On the other hand, once we begin to program our offspring, it becomes the ultimate shopping experience. They become the architectural design that we've pre-programmed for them. And once we begin to see the sperm and the egg as riddled with errors, on the other side of that coin is some ideal norm of the perfect baby. What is that perfect baby? What should it look like? Who decides? And what if you're the beneficiary?

What if you're the child who is programmed to those genes and constrained by the genetic blueprint your parents set out for you? The intergenerational conflict may be quite interesting.

How likely will it be that we'll be tolerant of those who are not genetically engineered, who may have disabilities, who may have code defects? Are we likely to be more or less tolerant of those among us who don't conform to the engineering norms that we've set up?

So what I'm suggesting to you is that the new eugenics is not social eugenics. We don't have an evil cabal of political ideologues trying to force us into brave new worlds. The new eugenics is banal; it's market driven. It's based on consumer desires. We've met the enemy and it is us. What parent wouldn't want the best for their child?

So these are very heavy issues. In the book, the *BioTech Century*, I try and make very clear that there are tremendous benefits and tremendous perils involved in this technology revolution. I also try and make it clear, just because it can be done, doesn't necessarily mean it should be done. And one can be in favor this science, as I am, and still believe there are different ways to harness it technologically that may do less harm to future generations.

Let me deal with one more social issue, which already may have affected somebody in this room. You're going to hear another term in the next few years: "genetic discrimination." It's already here. In the *BioTech Century*, in the book, I have a survey by Harvard University. They've already seen widespread genetic discrimination by employers, insurance companies, adoption agencies, and schools. Employers screen you with blood tests for their health insurance plan. Do you know everything they're screening for? Employers may want to screen you to see if you have a genetic predisposition for cancer. They may not want to hire you; if you get cancer on their watch, it's going to be more health costs for their company. A company might want to know if you have a genetic predisposition for diabetes. They may not want to put you on the corporate fast track and spend a lot of money on you if you will be disabled and can't work to full capacity.

Well let's get this one step removed. What if you were hiring for an air traffic controller? Do you want to know if he or she has the genetic predisposition for manic depression or alcoholism?

Here's where the discrimination comes in. Even if you have these predispositions, you may not manifest the disease, and even if you manifest it, it may be controllable. And there may be others who become manic depressed, or alcoholic, or get cancer because of environmental triggers. The gene is not all powerful. The gene interacts with the environment. The predispositions can be triggered. For example, we know diseases of affluence, like cancer, heart attacks, diabetes, strokes. We all have different genetic predispositions for these diseases, but we also know that if you are a smoker, and a drinker, and if you eat a lot of fatty meat, and if you don't exercise, and if you live in pollution, it's likely you're going to come down with those diseases. So where the discrimination comes in is when institutions simply look at your genetics and say "Aha, this person's a problem."

Now I'm going to kind of step on some territory here that may be a little delicate. Let's take Attention Deficit Disorder. We have begun to genotype young people all over the country with various genetic links to mood behavior, the most interesting being Attention Deficit Disorder. We have millions of youngsters on Ritalin. Now, be clear, certain children are born with a genetic predisposition for Attention Deficit Disorder, but it is also possible that the fast-paced, nanosecond culture with all the stress and anxiety that we put them in could help trigger those genetic predispositions. But what's become fashionable now is to forget nurture and just concentrate on nature and say if that child has an attention span problem in first grade and there is a genetic predisposition, that must have been the problem. And therefore we don't have to deal with the environment or change the values of the culture, just simply give that child a drug.

You're going to see another term in the next few years: "genetic rights." Increasingly, as people become victims of genetic discrimination -- and this discrimination is going to be more virulent than racial discrimination, or religious discrimination, or even ethnic discrimination. When this becomes more apparent, people are going to demand genetic privacy. You and I are going to say, "We ought to have our genetic information, it's valuable to us, but no institution should be able to have this information without our express approval." Genetic rights, genetic rights will loom in the next century as important on the political agenda as human rights and civil rights have on the century just passing.

Finally, this new genetic science is invaluable. We're learning a lot about genes: how they function, how they turn on and off, how they express themselves, how they relate to their environment. The question is how do we apply this science in a way that creates a renaissance and not great social and ecological upheaval? We are risk-takers; we are tool-makers; we're moving ahead into this biotech century. How do we proceed? What's the rule of thumb?

The first rule of thumb in medicine is "first do no harm." When choosing among alternative technologies to use this science, always choose the alternative that's least likely to foreclose opportunities and options of those not yet here, not only our own species, but all the fellow travelers, the other creatures we coexist with and steward on this planet. So first rule of thumb, do no harm.

Second rule of thumb, when choosing different technological approaches to the new science, always pick the approach that's the least likely to do radical harm and the most conservative. Take the technology option that's the most likely to sustain rather than drain our relationship to the rest of the biosphere. Good rule of thumb.

Now, I'm going to give you examples of how this works out in practice. Genetically engineered foods. The first genetically engineered crops are being grown in the fields in the U.S. this year. Monsanto has genetically engineered soy growing over millions of acres this year. And Ciba-Giegy has genetically engineered corn. It's coming into your supermarket. Unfortunately it's not labeled, so you don't know which foods have those strange genes in them.

You see these new foods that are genetically engineered have genes in the foods that have never been eaten in the entire human race. Hamster genes may be in some of these crops. Some of them have petunia genes. Some of them have firefly genes. The Monsanto crop contains a gene called *Bacillus thuringiensis.* It's a toxin taken from a bacterium. And they use these various genes to develop plants that are pest resistant, or bio resistant, or more nutritious. Sounds good.

The problem is we don't know what'll happen to the environment when we place these plants out there and more importantly, when you eat these products containing genes from non-food sources, we don't know if you're going to have a allergenic reaction, because you've never consumed genes from a hamster or from a firefly.

Interesting enough, there's so much concern in Europe that the same food companies that are producing the foods here and not labeling them, they are beginning to label them in Europe, because the consumers said, "We want them labeled."

Now the reason I mentioned genetic food is we could use the same new genetic science, all the tremendous new information we're learning about the gene to create an alternative, soft-path agriculture, organic, sustainable, and an agriculture integrated with the ecosystems of the world.

We could learn, with the new science, the subtle relationship between genetic predispositions in existing plants and how to make them more compatible with local ecosystems. Instead of genetically engineering the plant and bypassing evolution, we work with evolution and steward the environment so that you can buy at your store organic, sustainable, fresh foods that don't do harm. Soft path.

Medicine, same situation, we could use the hard-path or soft-path approach. We could wait until you get sick and then use the new genetic engineering therapy to pump genes into your body to make you well. Or even more radical departure we could change the sperm and the egg, all the genetic instruction, and eliminate these diseases. Do you want to eliminate all these recessive traits that create disease?

We learn in biology that every species has a wide range of genetics so that they have a big enough pool to accommodate changes in environment and in evolution. If you monoculture an animal or plant so there's only one or two strains of variety, you risk great disruption. You're all familiar with the potato famine in Ireland; one strain of potato, it was not immune to a particular fungus; a lot of people starved.

Did you know that the sickle cell anemia recessive gene prevents malaria? We've just located cystic fibrosis, the recessive gene that we now believe prevents typhoid and cholera. If we begin eliminating all these genes from medical exams so that the next generation is healthier, is it possible, in the long run, we'll actually program our own extinction?

There is a soft-path approach to medicine. We could use the same genetic science and create a sophisticated, market-driven preventive health to keep people well with this science so they don't get sick. We know, for example, that seventy percent of the diseases that we're likely to get are diseases of affluence: the heart attacks, the strokes, the diabetes. We also know that if we can help ameliorate the environment, change our habits, we're less likely to get these diseases.

We're going to be able in a few years from now, when you eat a piece of food, we'll be able to actually trace how the genes turn on and off when they metabolize a piece of food. So we will actually be able to pinpoint the relationship between a gene, how they express themselves, with the food we eat. We could also be able to test ourselves against various types of exercise we use or environments we're in. This is tremendous information. So instead of a radical approach to medicine, actually beginning to redesign the blueprint of our species, we could use this science not to reengineer ourselves but to make our environment more conducive and healthier for all of us.

So I'm going to leave you with this last thought. I've had an interesting series of debates with a scientist by the name of Lee Silver at Princeton. I respect him but we disagree on so many things. He has suggested that what we may begin to see in the next century is the development of what he called the "genetocracy" in the Biotech Century. Those parents who can afford to program superior genetic traits in their children will do so. And after generation after generation, it will be these children and their heirs genetically who run society. He calls them the "gen-rich."

The others in society, the "gen-poor," they're going to have to procreate the old-fashioned way, because they won't have access to or be able to afford these new technologies. He said eventually these two groups, the gen-rich and the gen-poor, will be so different from each other genetically that they won't even be able to mate and will create two new subspecies. And the gen-rich will have as much in common with the natural human being we know today as we have with our nearest relative the chimpanzee. And, lest we take this too lightly, remember we share 99% of our genes with the chimpanzee. We only have a 1% differential that makes us a human being. So Lee Silver's vision with genetocracy is not too far down the line of possibility.

The last thought. I wrote this book, *The BioTech Century*, on the eve of this new century, because I wanted to encourage a robust debate, a great public debate. The greatest contribution of this new genetic science, it's going to force our generation and our children's generation to ask the big questions once again. What is life? What does it mean to be a human being? Is life just genetic codes and blueprints that can be patented, or does life has intrinsic value, not just utility value? What's our responsibility to future generations? What are our obligations to our fellow creatures that we coexist with? Should we play God in the laboratory, or are there other ways to use this genetic science that are more humane and civilized and create opportunities rather than foreclose options for those not yet here?

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So I am hoping the public can come up into this debate. We are very far behind. The developments going on -- I work with business leaders and CEO's all over the world, and I can tell you the developments going on in the Life Science industries are so fast; they're moving so quick; they're so far advanced from what the public understands that we have a great gap here. The public needs to be informed in discussions like the one we're having today, and then you and I need to be engaged.

We cannot leave these decisions only up to the scientists in the laboratory or the executives in the corporate board rooms of the Life Science industry, because these technologies should not just be arbitrated in the marketplace. They affect all future generations. If this isn't the technology revolution that we discussed broadly and intimately, which one will we ever? So my hope is that beginning in the next few years, we can begin to engage this great question about the future of our evolution. How do we move into this century of genetic commerce and how do we begin to engage this daunting new science in a way that'll benefit our children and create a renaissance rather than great upheaval for future generations?

Thank you.

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