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THE WORLD IS THINKING

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Good evening. I'm Peter Schwartz from the Long Now Foundation. It's my pleasure and privilege to introduce tonight's speaker Stewart Brand. I don't have to give you his resume, everybody here knows Stewart, but Stewart has been shaping the world of culture and ideas in the Bay area for 40 years. And for a lot of that time, I've had the privilege of having him as a friend and collaborator. It's all about the questions. It began with the question, why haven't we seen a picture of the whole earth yet. And in all the years we work together, what Stewart has done has always asked the hard questions. And tonight, he will be asking the hard questions that he asked so well in his brilliant new book, "Whole Earth Discipline" and he'll be asking the hard questions tonight that made him to rethink green and may lead you to rethink green. Stewart Brand.

This talk is going to be little like firing a bullet through my book. It will touch on a few things, miss most and not take very long. And the book title I know it sounds like its whole earth catalog revisited, some of it is but mostly it is not because this time the title is used literally instead of decoratively. It means the planets whole climate and its whole population. The world population is about 6.8 billion now and of that the developed countries are 1.1 billion, the developing countries 5.7 billion. That means 5 out of 6 of us live in the developing world. That's the crucial fact. In the developing world, our lives are changing drastically mostly for the better as we move into town, create jobs and educate our kids. Our countries in the developing world are building infrastructure and we're still learning about the critical value of natural infrastructure: forests, aquifers, biodiversity and a predictable climate.

In the developing world, we control most of the planets land surface in Africa or in Asia or in Latin America and we're on the move toward opportunity whatever it may be. Most of that opportunity is in the cities that's why we're going there, it's the dominant demographic event of this century, is the screamingly rapid urbanization. By mid century, the whole world will be about 80% urban, the way the developed world is now and that's the sequence. The developed world passed the 50% urban point back in 1950. The developing world is going to get there very shortly and a balance of power will shift. Nearly all the action in the developing world in the global south and when you compare it to what happened in Europe and North America, the developing world is urbanizing 3 times faster and 9 times bigger. Now supposedly the world's largest cities are always the drivers of history, as we see from looking at history, we now have a distribution of urban power similar to 1,000 years ago. In another words, the rise of the west was great but its over. The aggregate numbers are overwhelming, every week 1.3 million new people in town. Some of them are born there, most are moving there. The question is what's the attraction? This is Kibera bustling squatter city outside Nairobi, everybody is busy getting the hell out of poverty as fast as possible squatters are grassroots entrepreneurs, if you can't find a job, create a job. Same thing with your

town. There is an equally busy lane in Delhi slum. Another busy lane in one of Mumbai's many slums. And a busy market in Rocinha one of Rio's countless favelas. This is urban life at its densest and social capital at its richest.
Everybody in the slum neighborhood knows each other well whether they want to or not. Because what's going on is this intense mystery called the informal economy, which specializes in being visible to itself and invisible to authorities. It's huge. Economists have not yet figured out how it works or taken much account of how it feeds the formal economy of nations and feeds the world. So for example in Mumbai, the economists are still catching on the slums do not undermine posterity, they help create it. Mumbai is said to be half slums, which is also one-sixth of the gross domestic product of all of India. Informal economy, steals electricity from the formal economy. This is homemade infrastructure. Here is a dramatic slum interface in Sao Paulo. If you take a close look at that edge, you see something interesting. Cities specialized in jamming ways of life together and thereby creating value, you put supply right next to demand. Here the cooks and the maids and the gardeners and the guards in the lively part of town in the left walk to work in the boring rich neighborhood on the right. Proximity is amazing. Its like a coral reef of humanity. Proximity empowers, urban intensity is at its most resourceful in in the working slum. A far reaching train and the near reaching market can brush together in a strangely intimate dance. Good luck thinking about that one city planners. The Darvi slum performs no end of services for itself and for the city at large. Among other things it has 4,000 recycling units and 30,000 rag pickers sorting 6,000 tons of rubbish everyday, now that's recycling.
Basically, the greenest of all humans are slum dwellers in the developing world. They use minimal energy, material and food and they recycle everything. Here is one. But they are that green because they are so poor and they do not choose to remain poor. Nor should anyone in the developed world require them to stay poor in order to stay green. They will climb the food ladder toward more protein and they will climb the energy ladder towards more electricity. This is in the Darvi, a gentleman named Lakshman says for toilet purposes we have to go outside and that's a problem. We have to go on the road. The electricity is on for two days then off for two days, then not on at all. We don't have much space for the children to play in. They use the road to play and accidents take place again and again. I've not studied at all and I'm illiterate.
For work, I stitch government jeans and pants. ThatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s fine but the workday ends late. I want to educate my kids until the day I die I'll educate them. As long as I'm around, that's guaranteed. I don't want to be in the way of this gentleman. He will make these things happen. Parents in the slums pool in money and hire teachers often their neighbors to do private tiny unofficial schools and education going on in those places changes the world they are often pretty good schools sometimes better than the official ones. So the big event in the world is that for the next 30 years, you can have a world full of young people in new cities in the global south and the rest of us in old cities being old people in the global north. Now, where do you think the action is going to be?
Now, if you want to save a village, here is what it takes, bear the city in mind, you want a good road to town, you want a good cell phone connection. This of course is one of Jan ChipchaseÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s slides from Nokia. It is no accident that the developing world now dominates cell phone innovation. They did that with $10 cell phones. Imagine what they

are going to do with $20 Smart phones. And right now they are charging those cell phone batteries with diesel fuel hauled in by truck but if they can get electricity, good electricity then the village comes back to life and its no longer a dark trap. Because villages emptying out is the main thing is making cities green in the developing world. The people leave the poverty trap and ecological disaster of subsistence farming behind. When they are gone, the natural environment recovers and those who remain in the village develop cash crops and better land for the new customers in town. In the developed world where our cities are green because the city dwellers use less energy and materials than people in the suburbs or countryside.

So, coming to my book and one of its points is that cities are green. Both in the developed world and the developing world, as soon as people move into town, they immediately start having fewer children. In the developed world, it's way below actually the replacement birth rate of 2.1 and its rapidly getting there in the developing world.

There are four major news items in my book, I think people will keep asking about these are the man bite dog story. Nuclear power is green, genetic engineering is green and geo engineering may well be necessary because thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s the other main whole earth event thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s going on besides this huge move to towns. This is wealth finally coming to the developing world and thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s climate change.

I'm not going to do much on that you've all seen J curves and what not but here is a little sample of how gnarly it gets. This is a quick look why the climate news is going to keep being worse than we expect sooner than we expect. Climate is profoundly complex not only our system full of run away positive feedback hidden thresholds and irrevocable tipping points. These are some of the ones that we know about. Now, one that's interesting positive feedback is this one. The Arctic ice melted 40 years ahead of the schedule because of a positive feedback situation. Bright ice like this reflect sunlight. But dark water doesn't as can you give me some dark water, there is the dark water, yeah I see and the room lit up and then went dark. Bright ice reflect sunlight, dark water absorbs it, warm water makes less ice, which then makes more water which make less ice and that's positive feedback and it keeps going until there is no ice left..

Similar dynamics are going on with tundra and methane with the rainforest drying out and going away and taking the rain, the clouds and the million species with it. Its something I constantly want to do is, is look at the next interesting thing going on and the next interesting thing to me is its relatively easy to detect positive feedbacks with just things taking off. Negative feedbacks can be mysterious. Here is one and there is the good news. So there is this unidentified sink of carbon which is quite large and they can see how big it is but they don't know where its going. These decades a lot of carbon is disappearing from here, we don't know where its going and that's the good news is its happening and the bad news is we don't know what's happening or why its happening so we don't know how to help it or at least stop hindering that.

Another such story is the peculiarities of this wonderful algal coccolith form. It forms huge blooms that are visible from space. It brightens the earth's albedo and it does that, draws down vast quantities of carbon into its hard shell and then politely sinks to the bottom of the ocean. In the process it emits dimethyl solidified particles that become the nuclei for water droplets thereby creating reflective clouds. And it prospers even when

the sea becomes acidic, which is what's happening these days. Now few weeks ago I spoke to the state department and one slide its unreadable but it gives you a sense of where the climate refugees are expected as the problems to climate continue to multiply over the next years and decades.
Climate events are expected to lead not only the massive motions movements of refugees what you get with that is resource wars, chaos wars and potentially a massive die back if climate keeps being going catastrophic. Jim Lovelock's version of this is that if we go to the warmer world of 5 degree celsius warmer that he thinks we're now on progress toward the carrying capacity of maybe a billion and half humans. We're already seeing bits bits and pieces of this. Darfur is a classic case. Basically drought is the great civilization killer, it is the great carrying capacity reducer and it leads to people fighting over the diminished resources left. We're also seeing not only fire but fire squared as they say in Australia and the American west and lots of other places. So trees dry out they burn more easily another positive feedback there they are putting a lot of carbon into the air when they burn.
One of the direst potential places is the Himalayan plateau because global warming is melting those glaciers such as these in Bhutan and those glaciers feed gives water which is 40% of humanity. Look at the major rivers there, the Indus, these are major rivers, the Ganges, Brahmaputra, Mekong, Ayeyarwady, Yangtze and the Yellow river. Talk about the developing world that's where everybody lives. So greenhouse gases, how do we reduce greenhouse gases, get down the water takes to make base level electricity, lot of them are in the developed world, a lot coming in the developing world, I was just with Peter Schwartz and friends in Cambodia, Singapore and Vietnam a couple of weeks ago. And as soon as those people get any money at all they are getting air conditioner, its going to be Miami globally thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s a lot of energy.
So the real fact is our climate problems are caused mainly by coal, which is the cheapest source of energy. Everyone would keep burning it until governments make it expensive. Cities require base load power, electricity available all the time wind and solar so far can't provide it. The only carbon free substitutes for coal nuclear and hydro and hydro most of the world has already maxed out. Now, I thought we might have solar beamed down from space and then I got beaten up by Elon Musk who knows a lot about space and a lot about solar and said, no fucking way. Even if we could get the equipment to orbit for free beaming it down direct channels underground and the rest of it is just too expensive and impossible, so forget it.
So sorry about space solar which would have been nice, itÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s be on 24/7 but we're back to hydro and nuclear. Bear in mind that the folks in the developing world want that electricity they will either at present get it from coal or from nuclear. And while we are at it in the developed world likes to leave the lights on at night, that's what we do, that's how we refer to cities, bright lights. So coal and nuclear, this the main green argument that I see from nuclear compare what happens to the waste products from nuclear versus coal. And bear in the mind the differences in pure scale here. If all the electricity are used in your lifetime came from nuclear the waste would just fill a coke can whereas a normal one gigawatt coke plant burns 80 real cars of coal a day. Each car holding 100,000 tons of coal and that turns into 19,000 tons of carbondioxide plus no end of slurry fly ash atmospheric mercury and the rest. Where does that carbondioxide go, now

the nuclear waste is small and contained to cast a year for a gigawatt plant whereas the coal 8 million tons of carbondioxide go into the atmosphere where we can't do much about it. We don't even know what the hell is doing there, its truer its hard to get it back. And when you compare the lifetime emissions for kilowatt-hours from the various energy sources, nuclear and you added all up compares to hydro and wind and it's ahead of solar so far. Now if you don't think that coal and nuclear are competitive just ask the miners in Australia who mine for coal, they don't want nuclear.

Okay, wind and solar. I remember the whole earth catalog was when wind was something put on your roof. Wind now is huge infrastructure that's great but that's where the efficiency is, is at very high altitude, high as you can get and with this bigger diameter blades you can getting out of over 300 some going up to 500 feet and by the way the wind in people are usually in different places who have very long power lines where they are usually expensive loss of efficiency moving the electricity you get from wind into town. And in fact there are all supplemented with gas fired plants because of the wind not always blowing problem. The solar issue is one not only the solar isn't a massive supplier of energy yet in fact they say there is 10 gigawatts of solar capacity in the world all since that's 14% efficient in terms of that is not efficient but in terms of I mean when the sun is on and everything is working. That means you get one at present in the world you get 1.4 gigawatts of electricity from solar which is less than 1 large nuclear plant.

And the footprint issue, go to a pretty place in the desert and think about what it will look like when you drop the solar panels for these large solar farms on them. It is basically a bulldozing process and you might think this is particularly a nice part of the Southern California desert but as you can see from the goggle location in the photograph in the middle of nowhere and is exactly the kind of place that will be bulldozed for these things. Saul Griffith is in the audience. You will recognize part of what I'm doing we just talked a few weeks back. Civilization currently uses about 16 terrawatts of power most of it from combustion, getting it to level off, getting our climate to level off by getting the parts per million of carbondioxide down to 450 over the next 25 years. It requires replacing 13 terawatts with new clean energy. He says you can do it with 30,000 square miles of solar panels, 15,000 square miles of mirrors this was in 25 years. 2.6 million turbines, which take about 100,000 square miles give or take in good locations. 1.5 million square miles of engineered algae for the biofuels, If you got geothermal finally going it takes over 27,000 steam turbines and this is you can keep those footprints down to that point by saying and lets get the 3 gigawatts from nuclear and there will be only 3900, 1 gigawatt reactors.

That's mitigation that's what it takes. Added all up and its an area about the size of North America thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s what Saul refers to as Renewistan. So talk about the sacrificial this is a world sacrifice area all of North America is going to give up with sunlight and landscape everything else everybody will have solar and wind energy, not going to happen. Something it didn't make it into the book. There is lot of stuff in the book about how radiation is not as worrisome as we imagined and its one of the reasons that Jim Lovelock is so comfortable with nuclear because he used to be as professional originally was in medicine and he worked with isotopes and he is completely familiar with how relatively manageable and undangerous radiation is after all we use in the hospital all the

time. But then there is this thing called radiation hormesis and here is a little story in case of the radioactive Taiwan apartment houses.
So there was this contaminated recycled steel, it had a whole bunch of radioactive cobalt 60 went into 180 buildings in Taiwan, 10,000 people and they were exposed to an average of 1300 millirem a year for 20 years in succession. So their accumulative dose per person range from 40,000 to 600,000 all around bear in mind that people at Chernobyl died when they are exposed to 400,000 millirem in an acute situation. This is chronic versus acute. They did the studies in Taiwan, what's the normal cancer rate there among the similar population, 10000 people and normally would be out of 10,000 people in that 20 years 232 would die of cancer. That's the general population. Now for the 10,000 that were exposed all this radiation the big question is how many of them died of cancer in that 20 years time and I welcome guesses twice as many 600 3 times many 400, half, 150, 235, 110, 0 that would be a miracle. Actually that one is the closest.
Seven of those people died from cancer in that 20-year period of time. In other words they had 3% of the normal cancer rate. Thanks to being exposed to all that damn radiation. Here is the chart from the paper and the paper, which is titled, is chronic radiation an effective prophylactic against cancer. Its published in 2004 in the American journal of Surgeons and whatever it is, too fine print to read. Something weird is going on with radiation and studies are finally now going forward you see is radiation good for you, you immediately start thinking, gosh maybe this could take care of our spent fuel problem instead of burying it in the ground we'll carve it up in portable hunks and sell it to people to put under the bed, so they won't get cancer. The hell it is they actually work. We should have some in the lobby.
Okay, the big bug bear Chernobyl. What was it? 46 workers died and 9 children from thyroid cancers that was mainly that happened because the government didn't get, its very easily treated in children and everybody except those 9 that got the thyroid cancer are now cured, the 9 they didn't treat fast enough did die. You got to Chernobyl now, lots of people do and take a very dour expression to take these really scary photographs of how weird and awful it is there and the reason they can do that this is back to background of radiation. So like any other part of Ukraine or here for that matter. A few hotspots, one of the great things about radiation is really easy to pick up whether dosemeter or Geiger counter whatever it is, there it is put a flag around and it and then it fades quickly, that's really what radioactivity does.
So what we've now got in the Chernobyl area is and this is a great quote from one of the biologists who studied the area for 15 years that the animals came back because people stopped doing the things which is hardest on animals which is farm and log and living places. As soon as we move out this is a whole chapter I think in the world without us. The animals came back that's a wolf, and we have wolves generally in that part of the world they've reintroduced some of the European bison and so on and Prypiat meanwhile 50,000 people moved out and it is now reforced it and looks quite beautiful. So the best thing and this is something the United Nations recommended after visiting there is that the area its main problem now is not radiation is very economically depressed and the best thing they could have is tourists. So the Chernobyl National Park would be I think an amazing thing to have and once they get the big sarcophagus over the exploded plant it will probably last as long as Stonehenge be even more interesting to think about.

I'm going to brush by the whole question of proliferation. Its well to remember that nuclear energy has dismantled more nuclear weapons than any other activity, This is for some reason quiet program that buys warheads from Russians and turns them into nuclear power, And in fact seeing the number of warheads that has been converted as of June. 20% of nuclear power in the US comes from 20% of our electricity comes from nuclear. Half of that is coming from the Russian warheads, thank you. And when we're finished with theirs, we're going to start using ours. There is no other weapons system that has as much civilian value in it when you decommission it. All right, how about spent fuel, the standard thing you hear is the spent fuel such a difficult problem and there is no place in the world where we can put spent fuel. Well, we were going to put it in Yucca Mountain but that's out and hence budgeted a month ago.

So where it is it is where has been for quite a while now, dry cash storage and the various reactor sites around the US and around the world. You can go there and be photographed standing next to the thing, no bad thing will happen. And that's a perfectly decent interim solution while we figure out whether we want to recycle the stuff or burn it in integral fast reactors or stick it the way the hell down in the ground. If you want to stick it way the hell down on the ground, we've already got a site that works very well for us, which is the WIPP. The waste isolation something plan, pilot plan, thank you. And it's a pretty good deal, they go down half a mile and do the salt formation and that's pretty interesting down there. This is what it looks like, its really easy to mine and that salt gradually heals itself. So whatever you put in there heals in around it. And here is a slide from Jim Conca who runs the environmental oversight for the WIPP. And basically he says that this is how it works. That salt formation, the Salado formation, they are now estimating that if humanity used nothing but nuclear power and did a once through with its fuel into waste, probably by then we'll be using some thorium, and stuck it in the ground.

Civilization you could do that for 10,000 years and there would still be room down there in the Salado formation to stick it in the ground and stop worrying about it. The Salado formation has been there for 250 million years, its not going anywhere, salt doesn't get into it, doesn't get out of it. Its really a good place to park the stuff. Some of you may have seen Rip Anderson was here talking about that he was the science officer at Sandia that made that go forward. Another thing that people worry about is oh! Gosh what about moving the stuff around. Its so dangerous, itÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s the guys at Sandia had some fun looking Shipping containers have been loaded on the truck that was crashed first at 60 miles per at how dangerous. They can keep it for being --.

hour and then at 80 miles per hour into a 700 ton concrete wall. They have been broad sided by 120 ton locomotive traveling at 80 miles per hour. Another physical test involve dropping containers in a 30 foot free fall on to steel reinforced concrete. Comparable to hitting the concrete slab head on at 120 miles an hour. They've been dropped on to a six-inch diameter spike and the containers have been burned in a pool of aviation fuel for 90 minutes at temperatures of more than 2,000 degrees Fahrenheit, The result in each case. There were no ruptures or significant damage to the used fuel containers themselves although dented and charred. The containers remain totally intact to protect the used fuel they would carry.

You think you love her tone of voice. So these things have been traveling around from

10s to 1000s miles on US highways and there have been no accidents because this is part of why. These reasons and others are why a good many of my fellow environmentalists already noisily or quietly support nuclear power. James Lovelock you've heard from, John Holdren is now Obama's Science Advisor he has said many positive things about nuclear. He is the reason that Jared Diamond when he was on the stage said that he was in favor of nuclear power. Tim Flannery, the biologist in Australia is supporting it. Paul Hawkins says he was converted by my book from being anti to pro, so want to think about why you want to read the book now. Jesse Ausubel at Rockefeller University has come out with a very good article basically looking at footprint analysis and saying nuclear is green and renewables are not green.

Patrick Moore was one of the foot cofounders of Greenpeace. He left their board, he was their only scientist in the senior leadership and he left when he thought the organization trend the anti science, he is now spokesman for the nuclear industry. And he was PhD in ecology and he still pushes forestation, and geothermal among other things. Al Gore says very, very quietly, well I'm not opposed to nuclear. I want to expect to see some modest increases in the use of nuclear reactors. I doubt that they will play a significant role in most countries. HeÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s mainly concerned about proliferation and Bill McKibben is really quiet but he says he expects the nuclear will increase pretty much in line with what the IPCC is suggesting. And there is a generation shift that's happened over a lot of younger environmentalists are finding themselves comfortable with nuclear because the cold war doesn't dominate the world, the climate change dominates the world. And nuclear goes from being a problem to a solution with that switch.

Just to draw a couple of interesting examples. One was Hugh Montefiore who is on the board of Friends of the Earth in Britain. Some years ago he said climate change is too important, he was coming out for nuclear power and he was thrown off the board somewhat noisily. Another interesting one is Stephen Tisdale who from and I think 2001 to 2007 or so was head of Friends of the Earth, UK. He said my change of mind wasn't sudden but gradual over the past 4 years and he finishes up it was kind of like a religious conversion. Being anti nuclear was essential part of being an environmentalist for a long time but now that I'm talking to a number of environmentalists about this, its actually quite wide spread, this view that nuclear power is not ideal but its better than climate change.

Then we come to James Hansen. When he said a while back we've got to get from 387 parts per million of carbondioxide down to 350, that became a rally in for a huge movement. And indeed there is a large 350 event happening on the October 24 was participating in that but also January of this year James Hansen wrote an open letter to Barack Obama saying coal plants are factories of death. The danger is further down the letter that the minority of vehement anti nuclear environmentalists could cause evolving the advance safe nuclear power to be slowed such the utilities are forced to continue coal burning in order to keep the lights on that is a prescription for disaster. 350 doesn't quote that very much.

So what's going to need to happen coal has to be made expensive, climate has to be taken as an issue by the throat. Four major governmental areas European Union, United States, Canada, China and India. If those four all act we might come out okay. If they don't or only some do we are in a world of trouble because the climate change gets to the point

disrupting economic resource for conditions that governments could flip and to total self preservation against the other states and then you get the downward spiral of wars driving worsening climate, driving more desperate wars that's a positive feedback you really, really don't want. Nukes are actually pretty familiar, I grew up in Rockford, Illinois this is just down the highway a little ways, its one of the reasons that Barack Obama who was a Senator from Illinois is rather comfortable with nuclear because he had a lot to do with those things.

In the developing world, that's now actually the cutting edge of a lot of new construction going on and we can rejoice that so many countries are building nuclear energy plants and we're doing what we can to help them. And I think of particular interest to these customers and maybe to us is a new nuclear technology and most people haven't heard about. Now this builds on the environmentalist idea of distributed micro power. That's the way we would reduced losses from long power lines building resilience and adaptivity. And usually environmentalist mean solar and wind and cogeneration, but the new micro reactors might work even better. The first one off the line is Russians were building these small floating reactors on barges 35 megawatts that they are going to use along remember the melting ice shipping is now going to commence along the complete shortcut north of all of Europe and Asia along the northern sea route as well as the northwest passage.

So they are building these and they are pouring concretes for the ports along that route and this will be the energy source. They are also selling them, we'll sell them to coastal developing countries that would like put 35 or 70 megawatts to power their coastal town. Scale is pretty interesting, the large reactor these days is 1.6 billion watts and 25 million watt reactors, 25 megawatt. This is 64th of that size, its not one reactor, one small town. Most of these micro reactors are meant to be buried and relatively left alone. You don't need a lot of guarding of it and this is a design from Toshiba. Here is one that they designed across the way at Lawrence Livermore lab and here is one that claims its going commercial right away based in the Mexico the design from Los Alamos uranium hydride technology. The thing on these micro reactors is they are relatively cheap, they are quick to build and the designs evolve rapidly. All of them are meltdown proof and proliferation proof and various forms of idiot proof. There is another company in Oregon called New Scale and its designing a light water reactor meant to be built in modular form you put in one of these and when you like it or you grow your town or whatever and you add some more. An old player in the game, Babcock & Wilcox, they've been building navy reactors for 50 years. They are now getting into this and they have 125 megawatt modular reactor coming out with this. The weirdest one probably is say that thorium reactor that designed by Lowell Wood. Freeman Dyson loves it, its been developed by Nathan Myhrvold in Terra Power they are based in Washington. This thing you stick in the ground, it has all the fuel it needs for the lifetime, which might be 60 years and you just leave it there. And its thorium so it doesn't have a lot of the problems that we associate with Uranium. Okay that's enough on nukes. Well this is kind of nukey. Food apocalypse this is romantic environmentalist, at its worst. So this will fuel what you've seen as unnatural basically vampires. It's only unnatural if you don't know the biology. All microbes swab genes promiscuously all the time the selection pressure on problematic genes in the wild is fierce. Genetic engineering really reduces the huge

impact of agriculture unnatural systems and you'll notice that are renowned biodiversity biologists like Peter Raven and Ed Wilson take no part in the campaigns against the genetic and engineered food crops. So then you ask, well, who likes them? Well, the Amish for one like them. In the world they are extremely popular and Africa especially wants people catch on. So in South Africa, we don't eat genetically engineered sweet corn in this country. We just eat feed corn which becomes corn meal and tortillas and buns and muffins and things like that. But in South Africa one of the most popular of all foods there is white maize, it is genetically engineered and they love it because it works so well for the farmers heading off both pest and weeds remember about 40% of the worlds crops mostly in the developing world is lost every year to weeds and to pests. So for that reason that because they work so well against those, this is most rapidly successful agricultural innovation in the history, good for the environment because another thing is they enable no-till farming and that protects the soil it reduced pesticide use especially in things like BT cotton and the increased yield and that frees up rural land to remain wild. Now this map from 2006 is out of date because it shows no African countries doing stuff that's because the European environmentalist with Friends of the Earth International and Greenpeace International went to enormous lengths to terrify the leadership of the African nations that this was poison. People starved as a result of that directly and great harm was done. But now the agriculture the African nations are finally getting up to speed and after a decade of delay may be two decades of delay caused by greens in Europe.

There is no good reason for genetically engineered food crops be controversial. I think my fellow environmentalists have been irrational in this subject and really have done harm. Now, if you got a question about that ask the Nuffield council on bioethics who took serious detailed exhaustive study of the issue genetically modified engineered food crops especially in regard to the developing world and basically said it is a moral imperative to make GM food crops readily and commercially available to people in developing countries who want them. Bear in mind, besides the obvious matters the food supply and enhanced attrition, these GE crops are can be made drought tolerant, salt tolerant and flood tolerant as Pamela Ronald over here has done with rice and they are going to be crucial for adapting the climate change in the developing world and that's just the beginning. Genetic engineering is sort of the sleepy backwater biotech these days as we saw when Andy came here and spoke.

Synthetic biology is taking off this steep angle. Children are having their minds focused on the opportunities of screwing around with genes and the question that I've been asking for the last few years where are the green biotech hackers has been answered by the jamboree IGEM international genetically engineered machine. Jamboree they hold in Cambridge every year they are up to 21 countries 1,200 participants, 84 teams and its growing like burning man and it doubles every year.

I wonder if there is an overlap. One of the things that I as a preservationist restoration want to see dealt with is that I think that genetically engineered bio controls could help a lot with these invasive species. So youÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢ve got your Guam brown snake you got your kudzu, your French broom, red imported fire ant, zebra mussels, northern snake head the cane toad that is poisoning Australia and most graphic of all the lamprey eel. And the huge question is how do you fight back once you have an infestation. Well, the thing

we've learned in bio controls is the smaller the organism that you point at trying to control and invasive the better you can target it exactly and it doesn't do the wrong thing. And that you can its already happening a lot of these and in fact the cane toad they are developing a lot of viral engineered virus that may well head off the cane toad problem. There is organisms we like earthworm. The term for what they're doing now is called ecosystem engineering or a niche construction. And what the earthworm does is it takes a crappy from its standpoint areas soil and basically improves it for itself but it happens to be improved for resilient other organisms at the same time including us. So we like to have earthworms in the soil because the garden grows better and the rest of it. Another ecosystem engineer is the beaver. One of the reasons the Yellow Stone Park went to hell is because when they got rid of the wolves the elk increased enormously got lazy started eating up all of the trees down on the rivers, riverine, foliage, and trees went away. There is nothing for the beavers to cut down and make dams out of so the beavers went away then they brought the wolves back, the elk got scared, ran for their lives where they are supposed to do for now. And then the trees grew up, the beavers came back to cut down the trees and make dams and this huge enrichment that goes on with beaver ponds is back in the Yellow Stone Park, thanks to the wolves. There is another famous ecosystem engineer Aldo Leopold. He inspired a lot of us in part by doing kind of wild and crazy restoration in the 150 acres in Wisconsin, brought the trees back, actually brought too many back they had to cut a lot of them down.. He undid serious damages are really frapped out farm that he took over got it retrieved brought it back made a wonderful as a whole Aldo Leopold museum and study center they are now. He was undoing the damage for 150 acres. We have damage done due to larger area maybe the whole planet. And that's going to get here. So here is part of life. Geo engineering is you can already see it being taken seriously sooner than expected its because we're starting to face these harsh realizations. Geo engineering is direct intervention on climate mechanisms severely non-linear mysterious system that I spoke off, that's what makes it hairy that's just beginning of the hairiness is then you get to fine who is going to control it, how do the international agreements work. It is so cheap to do some of those things, you can change the climate for everybody if you were a very rich person or a country like say in China was just we are tired of having western China go dry on us. We're going to put a bunch of something in the atmosphere little dim the sunlight a bit and sorry about you guys downwind but that's what weÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢re doing. Well you know we do here or downwind to them we see their coal now as red sunsets we would say that's an act of war.

We don't have governance forms that can deal the geo engineering yet and they need to start emerging. Now in case you want your things well this stuff can possibly work. This is one of these most popular climatologist because they know it works. The Mount Pinatubo volcano exploded in 1991 sent 20 million tons of sulfur dioxide, 20 miles up into the stratosphere. That then cooled down the planet by 0.5 a degree celsius. The ice came back in the Arctic. The polar bears came back and the polar bears of the years '92 and '93 are known as the pinatubo cubs.

We now realize that it is technically possible for humanist to do the same thing year after year as Mount Pinatubo at a cost of maybe 30 billion a year, not that much. And if not Pinatubo had kept doing its thing year after year, it would have taken the global temperature down not 0.5 degree celsius but 3 degree celsius and guys were really

dubious about all the stuff worked into it and the modeling makes it look pretty good. So that's the one that probably going to be experimented with most first that really green one is the one that John Latham and the engineer Stephen Solver came up with to atomize sea water so that the salt water and tiny particles goes up dries immediately you get a little grain of salt that becomes nuclei for cloud particles you can brighten the clouds a lot with the ocean, brighten all over the earth sounds great.
And this is it desperately cool sailboat. Salter design with this flattener sails. And another one Jim Lovelock and Chris Rapley from the science museum in London came up with this the idea of having 400 foot pipes that can reduce the thermocline problem and the stratification of ocean when it gets too warm and it dies. Its also way to cool water on coral reefs or to prevent hurricanes from coming through it. Another idea is artificial trees Klaus Lackner came up with the idea of doing air capture of carbondioxide and the idea would be to put these things where you can sell the CO2 in the industrial chemicals for greenhouses, food process and dry ice water treatment from the application side. Another idea that everybody likes because the Indians came up with first is what they call terra preta or biochar which is basically paralyzed smoldered plant waste, agricultural waste and log in waste and just what to go into the ground that turns bad soil into good soil stays down there for 4000 years and it can be done in many scale, the big question is whether you can actually scale up. Scale is part of what's going on. WeÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢re already dealing at scale and noble prize winning climatologic Paul Crutzen calls our era our geological era the anthropocine the human dominated era.
We're stuck with its obligation is the whole earth catalog first words were we're as gods might as well get good at it those were innocent times. First words of the new book are we are as gods and we have to get good at it. The looming catastrophe of climate change is forcing the change and environmental thinking. The reality of the developing world where most people live is forcing the change the environmental thinking. The shift is from the ideology to pragmatism from romantic identification with nature the scientific examination of nature thrown at us unlike anything we've seen before we have to understand. Ecology is not yet a predictive science it needs to be one. Climatology is not yet a predictive science and it needs to be one. We're required by circumstances to be ecosystem engineers at planet scale. We need to figure out how to do it with this light touch as possible and as much intervention is necessary.
Ecological balance is too important for sentiment and it requires science. The health of natural infrastructure is too compromised for passivity that requires engineering. What we call natural and what we call human are inseparable. We live one life. Thank you.