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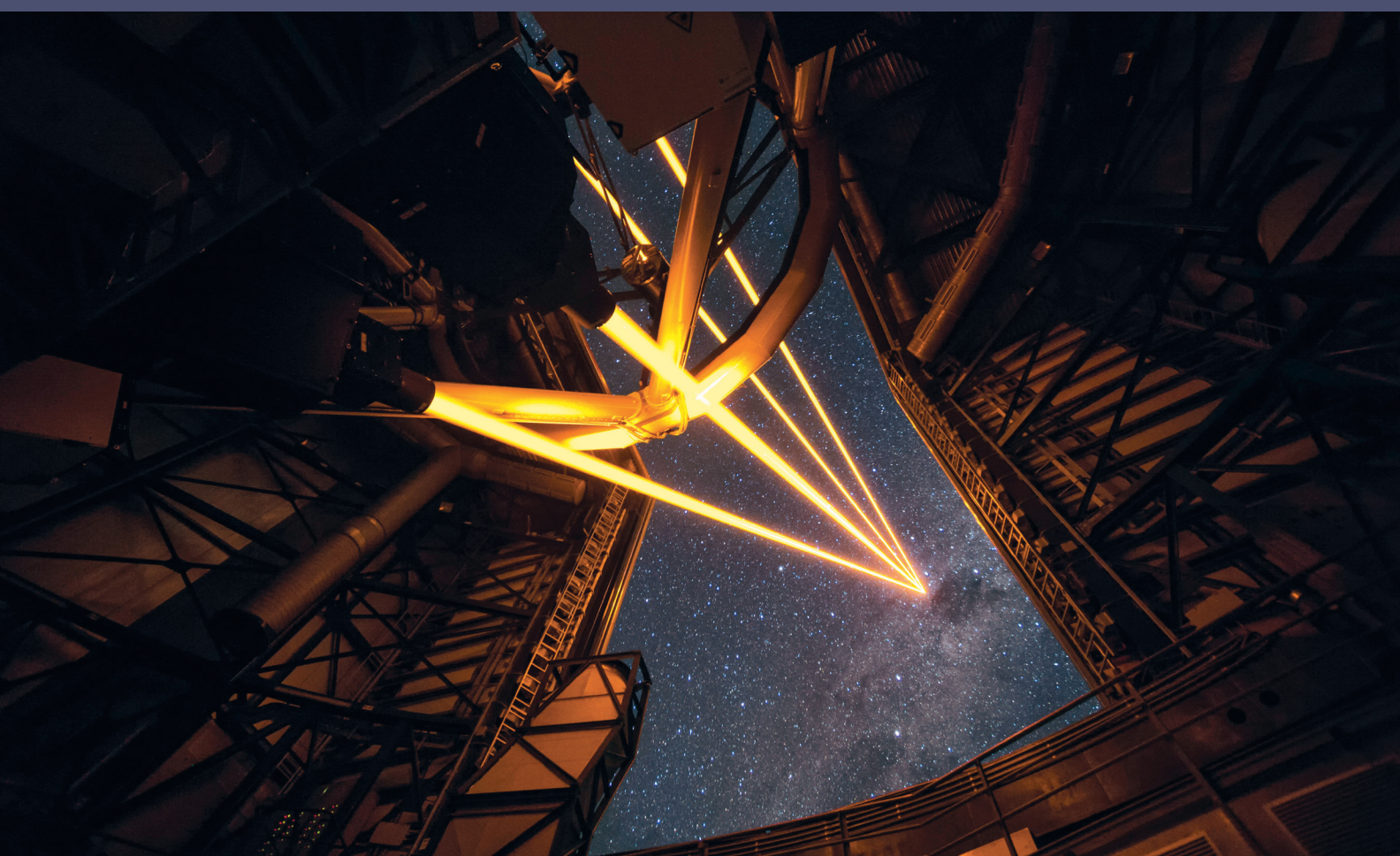
Scientific Imagination And the Future



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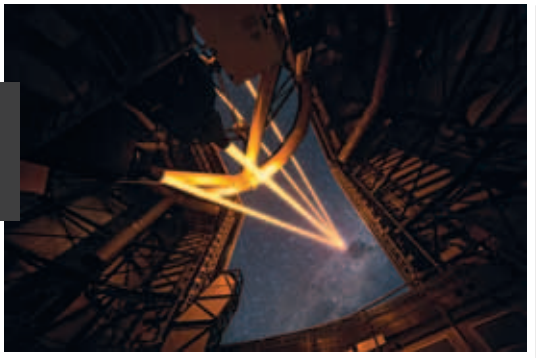
Cover This Week



European Southern Observatory

At the European Southern Observatory on Cerro Paranal in the Chilean Andes, the laser beams shown here are part of a system for achieving very high resolution images, by correcting for the distortion caused by changing atmospheric density.

SCIENTIFIC IMAGINATION AND THE FUTURE

EXTRAORDINARY SCHILLER INSTITUTE CONFERENCE

Escalation by War Party Makes Summit More Imperative Than Ever

This is the edited transcript of excerpts from the Schiller Institute's September 10, 2020 dialogue with Helga Zepp-LaRouche and Harley Schlanger. The full video of the webcast is available.

Harley Schlanger: Welcome to our weekly dialogue with Helga Zepp-LaRouche. Today is September 10, 2020. During the weekend of September 5-6, the Schiller Institute held an extraordinary conference, addressing the question of the need for a summit, for a full exposure of the coup against President Trump, and the need for a change in paradigm. Helga, give us a quick summary of your impression of the conference, its aftermath, and the reverberations from it.

Helga Zepp-LaRouche: It was quite remarkable. We were able to present, in four sessions, all the major strategic issues, and solutions. This is extraordinarily important, as there are many people discussing the problems, but we offered a genuine approach to actually solve the strategic crisis.

The first panel was devoted to the strategic situation, where several of the speakers highlighted the very clear, increasing war danger. Then, we had the remarkable speech by former Virginia State Senator, Col. Richard Black (USA ret.), who clearly spoke for a faction of U.S. military, discussing the danger of a military coup inside the United States. And I think that was a real shocker for everybody. We had two members of the VIPS, the Veteran Intelligence Professionals for Sanity, Bill Binney and Kirk Wiebe, who presented not only that there was no basis for Russiagate, but *also*—which was equally amazing—that they had the technology in the NSA that could have prevented 9/11.

So if you take this whole package, the increased danger of World War III, the danger of a military coup in the United States, and the clear effort to establish a global surveillance with that technology that these whistleblowers are clearly fighting against, I think the first panel is a must-see for anybody who wants to have a real understanding of what are the crucial issues for our time. The high rank of the speakers also underlines the importance that is given to the Schiller Institute as a forum for such a dialogue: We had the director of the Russian International Affairs Council, Andrey Kortunov; we had several very important American speakers, Dr. Edward Lozansky, Martin Sieff, Jim Jatras—these are all people known to be experts in U.S.-Russian relations. I could only urge you to watch this.

We had a beautiful science panel, where we again had extremely high-ranking and exciting scientists: Dr. Bernard Bigot, who is the director of ITER, which is the largest fusion energy infrastructure project in the world, involving 35 cooperating nations. This is a model for how international cooperation could actually function. We had very, very good presentations from South Africa, from Russia, so this was really a delight. These scientists


Schiller Institute


Miller Center


USAF/Brigitte N. Brantley

Col. Richard H. Black (USA ret.), left, spoke of the danger of a military coup in the U.S., coming from figures favoring perpetual war, including Gen. James Mattis (USM ret.), right, and Lt. Col. John Nagl (USA ret.).

ITER

Dr. Bernard Bigot, Director-General, International Thermonuclear Experimental Reactor: "First fusion plasma by 2025."

had total fun in having this kind of international dialogue.

Then we had a really impressive economic panel on the World Land-Bridge, which had the director of the CPEC, the China-Pakistan Economic Corridor, and many speakers discussing our program for the World Land-Bridge in many aspects. We had a very important sub-section pertaining to the need to build a world health system, by training young people in the United States and Europe and developing countries, to learn how to fight not only this pandemic but also future ones.

There was also a big section on the farm crisis, relating to world hunger. Then we had a very beautiful concluding panel on classical culture, "Building Trust in International Relations: The Role of Classical Culture and Combating World Famine." Jacques Cheminade, a former presidential candidate of France, gave the keynote. We had a very good speech on Beethoven by Fred Haight; and then it concluded with an archived concert from 2018, with the Schiller Institute NYC Chorus's performance of Beethoven's *Mass in C*. It provided a very elevating example of why we put so much emphasis on classical art.

Russia and China Are Now Being Blamed for Everything

I'm quite satisfied with the conference. I think we have received a lot of very important responses to it internationally. The whole aim of this conference was to get the P5 summit, and this looks very, very difficult, because what you see right now includes the blatant anti-China campaign, where China is being blamed for everything from the pandemic to the economic difficulties, and the Navalny affair that is being blamed on Putin. All of these things, apart from their own immediate intention, also has the purpose to poison the atmosphere so that such a summit cannot take place. Or that if it were to take place, it would only be a continuation of the blame-game, where the Chinese are being blamed, the Russians are being blamed, and so the atmosphere is being poisoned in this way.

Nevertheless, I still insist that a summit of the most important countries is still the only way to escape the immediate dangers that are escalating by the day. So I would urge you all to watch this conference. There is also a 30-minute, short version of the first panel on the Schiller Institute website. Please look at that.

There will also be shorter videos of the other panels. Pursue in depth what may arouse your interest, because this is really important ammunition to intervene in the present strategic situation.

Schlanger: Helga, when you talk about the ongoing anti-Russia and anti-China campaign, this is not just "talking points," this has consequences. I understand that it was decided that President Putin will not even be coming to New York, when it had been thought that he would come to New York and have a summit with Mr. Trump. What's the latest on that?

Zepp-LaRouche: From everything I know, that was the intention of Putin, to use the UN General Assembly setting to have the summit. But as I said, if you accuse China of being responsible for the pandemic, for the economic hardships following it, for everything under the Sun—if you have that in the air—the likelihood that it is then possible to have a summit is approaching zero. The same thing goes if you blame Putin, which some people do, including Pompeo, of having been behind the attempt to murder Navalny. You know, these are campaigns that were designed to ruin the summit: I think that is very clear.

The Potential for a Military Coup in the U.S.

Schlanger: There has been a coup underway from even before the time of Trump's election. What Colonel Black went through is the role that the military, the ex-military people, are now playing as part of an escalation, of the next phase of this—people like Jim Mattis, Colin Powell. What's the ultimate importance of bringing the military into this coup operation?

Zepp-LaRouche: I think it is exactly to end the Trump presidency, one way or another. The speech by Colonel Black clearly reflects discussion in the U.S. military among people who are upset with this. Then you have the opposite view that was expressed by these other two Colonels [John Nagl and Paul Yingling] in an article in *Defense One* only a few weeks ago on August 11, calling on the military leadership to get Trump out of the White

House if he refuses to leave after he loses the election.

This was rejected by the Pentagon, but it is still being discussed. And the last time it came up was yesterday: Bob Woodward's book *Rage* has a lot of similar material.

It's a book that came out in time for the election campaign, for the sole purpose of fueling the smear campaigns against Trump. And there is one snippet in there, where James Mattis is being quoted,—who, as people may remember, was the Secretary of Defense who left in 2018 because he opposed Trump's idea to pull U.S. troops out of Syria. He is one of those people who are for the endless wars and the interventionist wars. So he is quoted in this book, where he supposedly said, "There may come a time when we have to take collective action against Trump." It's somewhat ominous what that would mean, but in the context of the present discussion, it is clearly moving in this direction.

This is quite serious. Look at all the discussion around the U.S. election and the violence in the streets, which is continuing. Hillary Clinton keeps saying that Biden should under no circumstances concede the election. There is the mess with the ballots, with possible vote fraud. Some weeks ago, a hundred so-called experts ran a war game of different scenarios of what could happen in the U.S. election. The only scenario that would not end in a complete catastrophe and turmoil and civil war, would be a landslide for Biden.

Obviously, the game plan is to create conditions where you have a constitutional crisis, a possible military coup, and that is why we have been emphasizing so much, that you need to change the dynamic *before:* because once you get into this election being contested,—even the unbelievable possibility of the military playing a role—I think that that is an incredible point of danger. So I'm really calling on everybody to help to change the agenda ahead of time. We have to address this geopolitical confrontation before; it must be stopped before, because otherwise, out of such a situation you could have even a war developing. This is a very dangerous situation.

Schlanger: It's clear now that the lines are being drawn between what Trump is saying that the American people want, which is an end to these wars, and certain people in the military who are willing to carry out a coup to keep these wars going. I think that's really the issue that would be addressed at a summit or could be resolved at a summit.

Zepp-LaRouche: For all the people who are so upset about Trump, you know,—do you want to have war, or do you want to have peace? What Trump said in this Labor Day speech—he attacked the military-industrial complex. He said, I'm not talking about the soldiers, I'm talking about the Pentagon and those people who like to throw bombs and build planes and basically make a lot of money in continuously doing so. This has caused a huge freak out. Trump re-tweeted several times afterwards the famous remarks by President Eisenhower, which he made at the end of his term, where he warned of the "military-industry complex," and saying that this is something that had to be extremely closely watched. Today, with the technological developments, the cyber capabilities and all of this, the military-industrial complex has quite evolved since the time of Eisenhower.

People should rethink this question. Trump is probably the only chance to keep world peace! If you look at the kinds of people who are now speaking in support of the Biden campaign, they want to go right back to where we were with Bush and Obama, global dominance of the United States, interventionist wars. This is really what is at stake. So it's really a question of war and peace, and people should rethink their prejudices.

The Conference Presented Solutions

Schlanger: The Schiller Institute conference did present solutions. I think what's urgent is for people to go to the Schiller Institute website and spend the time, whatever time it takes, to watch these four panels. Some of them you'll want to watch a couple of times, but make this an organizing effort, *not* for something after the November elections, but something that you start doing right now.

Helga, is there anything you want to add?

Zepp-LaRouche: I think you should also have a daily encounter with Beethoven: It is still the Beethoven year. The power of sublime classical culture is what we need at this moment. We are in a challenging situation in which we need to keep our minds elevated. Become a member of the Schiller Institute and help us to build a classical renaissance. Ultimately that is the only way how we can prevent mankind from repeatedly being confronted with such incredibly dangerous moments. We all have to have an image of man like that of Beethoven or Schiller. Then we will have something that will allow mankind to overcome this.

Schlanger: Thanks for joining us, and Helga, we'll see you next week.

Zepp-LaRouche: Till next week.

Schiller Institute Labor Day Conference

War Drive Towards Armageddon or a New Paradigm Among Sovereign Nations United by the Common Aims of Mankind?

September 5-6, 2020

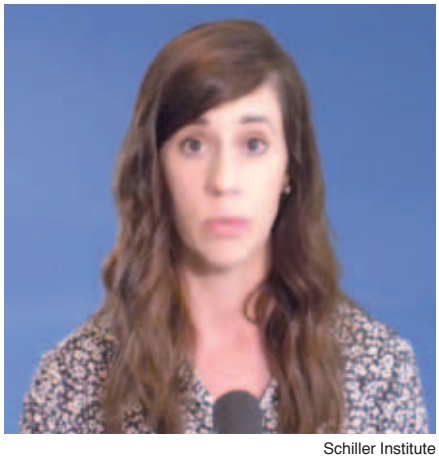
PANEL 2

The Role of Science in Creating Mankind's Future

Opening Remarks by Megan Dobrodt

This morning, we had a very sobering discussion of the dangers now threatening all nations on the planet, in the form of an increasingly unstable and confrontational world strategic picture, and the steps that must be taken to navigate our way out of those waters.

There *is* a way forward, a way toward a completely different future for civilization. But this requires that we change the basis upon which nations relate to one another, to be one of the common aims of Mankind.



Schiller Institute

Megan Dobrodt

As Helga Zepp-LaRouche put it this morning in her keynote address, "Leaders must have the courage to project an image of a new future for the human species."

In 2014, the economist and statesman Lyndon LaRouche wrote a document to that end, called "The Four New Laws to Save the U.S.A. Now!—Not an Option: An Immediate Necessity." The Fourth, and perhaps the primary of those Laws, called for an international crash science-driver program in nuclear fusion, and implicitly, its cousin, the space program.

Fusion and space are the areas of frontier scientific work which would be complete game-changers, for all people, for all nations. By their nature, these areas necessitate international cooperation for the common progress for all.

Our panel this afternoon represents top leaders and top scientists in these fields on the international stage, people who have taken it upon themselves to think about solving the big problems facing Mankind, by pushing the boundaries of our scientific and technological capabilities.

In 2016, a few days after the U.S. election, Lyndon LaRouche said the following, which, for me, sums up the purpose of what we're trying to do with our discussion this afternoon:

> You're going to develop and extend the power of Mankind, in the universe, and for the universe. The time has come to get

Note: *We present here the edited transcripts of the second of four panels of the Schiller Institute conference. Reports on the remainder of the conference will be published in future issues. The videos of the conference are available here.*

human beings to think in these terms, now. Because if you don't do that, you will fail.

So, therefore, you have to have this sense that you are a universal personality, reaching into space, reaching into areas of development of Mankind beyond what Mankind had ever done before.

What's your purpose in life? Your purpose in life, is to reach beyond what Mankind has reached before.

Jason Ross

Developing Higher Platforms of Science and Technology: Key to Human Progress

This is the edited transcription of Mr. Ross's presentation to the Schiller Institute conference on September 5. He is a co-author of the Schiller Institute's 2017 Special Report, Extending the New Silk Road to West Asia and Africa: A Vision of an Economic Renaissance. *Subheads are the author's.*

Schiller Institute

Jason Ross

Throughout his career, Lyndon LaRouche was the American political figure most well-known for his advocacy of nuclear fusion, as the absolutely essential next step in human progress.

In the mid-1970s, LaRouche founded the Fusion Energy Foundation (FEF), dedicated to making nuclear fusion a reality. The FEF published a technical journal, the *International Journal of Fusion Energy;* a magazine, *Fusion;* and a number of books. Its members were involved in the legislative process and in the discussions with President Ronald Reagan about what Reagan proposed in a nationwide TV broadcast on March 23, 1983 under the name, "Strategic Defense Initiative," a proposal to work with the Soviet Union to develop new defensive technologies, including lasers for knocking out nuclear weapons and thus make the world safe from nuclear extinction.

LaRouche believed that it was only by superseding past science and technology that poverty could be entirely eliminated, the problem of resource depletion could be overcome, and humanity would be able to perform the next generation of experiments to discover the next generation of scientific principles. This is a process of unending growth of the human species that mirrors the developments we've seen both in the biosphere—with the increasing complexity and energy intensity of life—and in the universe as a whole, with the formation of complex celestial structures whose mysteries we have only begun to explore.

In this presentation, we will take up three topics:

1. The economic value of scientific progress,
2. The infrastructural, industrial, political, and cultural platform by which scientific progress changes our lives, and
3. How great visions for scientific and technological advance bring us to an understanding of the universality of the potential immortality of the individual human mind.

The Economic Value of Scientific Progress

Human economy exists because of that which distinguishes us absolutely from the animals: the ability of the individual human mind to develop a hypothesis, an idea, that embodies something perceived not by the senses, but which acts upon the perceived world—that is, universal physical principles.

These discoveries are like tools, but they aren't physical. An ape may use a stick to extract a meal of termites out of a mound in the earth, and a sea otter may use rocks to crack shellfish to consume, but only human beings use electromagnetism, navigation, geometry, poetry, fire, mathematics, and music.

Only our beautiful species, sharing a universality of the powers of our minds, unlike any animal, has built irrigation systems to improve access to food, trans-

formed other species through the selective breeding that has given us modern grains, fruits, vegetables, and even animals, liberated the power of coal to produce motion—with the steam engine—freeing people from drudgery and making it possible to produce goods for common people, created transportation networks to bring our societies closer together, and even left this planet to set foot on the Moon, which the animals can see, but not understand or visit. (Unless we bring pets!)

Scientific hypotheses, by which we reduce the imperfection of our understanding of the world around us, are the ultimate source of economic wealth, the means by which we improve the productivity of our labor, and the springboards to developing yet better hypotheses.

How are these discoveries made? And how certain can we be in our knowledge? Consider the problem of induction. If I observe something happen without fail 100 times, am I guaranteed that it will happen again the 101st time? Imagine a turkey being fattened up for Thanksgiving. Every day it is fed well and taken care of, each day providing more evidence to Mr. Turkey that life is good ... until Thanksgiving arrives! *Repeated experience is not the basis of knowledge.*

The escape from the problem of induction is the concept of the *crucial experiment,* in which someone uses his or her hypothesized *cause,* to create something that has *never* happened before. How many times do you need to observe an electric motor working to learn that there is a connection between electricity and magnetism? You don't need 100 experiments to convince yourself of the Pythagorean theorem if you've shown geometrically why it must *always* be true. How many hydrogen bombs needed to be exploded to validate the basic understanding that gave rise to them?

As Einstein reminded the world a little over a century ago, our knowledge is never perfect, but it is *perfectible.* The universe *rewards* our knowledge—less imperfect than it used to be—with improved power to reshape the physical world, to improve our livelihoods and discover yet more. Unlike the animals, our carrying capacity is neither limited nor pre-determined. Progress brings about higher levels of population and of *potential* population density for the human species.

This brings us to the second topic.

Platforms and Productivity

How does a discovery become effective in society? How does a thought manifest itself in improved living conditions?

LaRouche discussed the relationship between discoveries, infrastructure, and production in his 2005 paper, "Science, the Power to Prosper":

> All discovered, valid notions of any universal physical principle, implicitly define a field, a *field* which is the functional notion of the extension of the efficacy of that principle throughout the universe as a whole. It is the action expressed by the impact of the potential expressed by a field upon the setting in which production occurs, which is the focus of our concern in this report as a whole.
>
> For example, the application of Dirichlet's Principle to any field of action, elevates the experimental viewpoint from a collection of calculations to a single act of conceptual thought, a conception which, like Kepler's notion of universal gravitation, efficiently subsumes, implicitly, all of the relevant, detailed calculations. It is impossible to develop any competent insight into the way a modern economy functions, physically, except by employing the way of looking at a field in the way Riemann's treatment of what he terms Dirichlet's Principle applies.
>
> The understanding of this point which I am developing here, enables us to understand *why the transfer of the production of a product, even when the same technology of design and production is employed, from a developed economy, to a less developed economy, has usually resulted, during the recent quarter century, in a net collapse of the level of the rate of generation of per-capita productivity in the world as a whole!* The transfer of production from a nation with advanced development of its infrastructure, to a nation of relatively poor people with a poor development of general infrastructure, tends to produce a collapse of the physical economy of the planet as a whole. The role of the field represented by basic economic infrastructure, has been ignored, with what tend to become ultimately fatal economic results for all concerned.
>
> By choosing a field of application which itself represents a zone of lower potential, the effective productivity of labor, per capita and per square kilometer, is relatively reduced.

Let's use the introduction of electricity into the rural

areas of the United States as a case study, to look at how an improved infrastructure platform transforms society and productivity.

The Rural Electrification Administration (REA), created by an Executive Order by Franklin Roosevelt in 1935 and funded through the Rural Electrification Act of 1936, was created at a time when electricity was becoming widespread in American cities, but still nearly 90% of American farms lacked access to electricity. The costs to string wires to those farms was considered prohibitive, in light of the small electrical use per household, as forecast by the electric companies. Using their understanding of the past, they didn't think it was worth the money to bring power to America's farms.

The REA made loans to farmer cooperatives, to build their own power lines and even to purchase appliances and equipment.

The results were stunning.

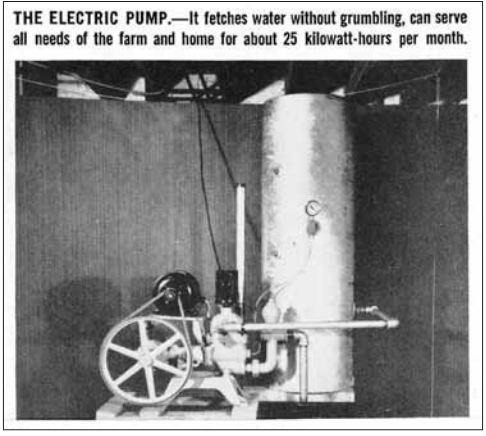
The electricity was not simply *inserted* into an otherwise unchanged geometry, used only to power the radios, washing machines, and lightbulbs of city dwellers. Rather, it had the effect of transforming the productive potential of the farms.

For example: Refrigeration reduced disease from food poisoning and ensured that more of the agricultural produce could be consumed rather than being wasted. Lighting in chicken coops increased egg production significantly, particularly in the colder, darker winter months. The chickens weren't re-engineered, but their environment—the *field* in which they lived—was changed. Electric pumping saved dozens of hours per family per year, compared to a back-breaking labor of using a hand-operated water pump.

The project was a success. By 1951, the proportion had been reversed: instead of 90% of American farms lacking electricity, now 90% were on the grid.

THE ELECTRIC MILK COOLER.—Milk keeps sweet in a modern regulated dairy cooler; 1 kilowatt-hour will cool 10 gallons of milk a day.

THE ELECTRIC BROODER.—For as little as ½ of 1 kilowatt-hour per chick, a whole brood can be raised under a modern brooder.



THE ELECTRIC PUMP.—It fetches water without grumbling, can serve all needs of the farm and home for about 25 kilowatt-hours per month.

This was an incredible shift in potential productivity, when a more advanced platform of infrastructure exists to support it, and it can be carried out again, in many ways.

Consider what nuclear fusion will mean for the world. It's not just cheaper electrical power, or doing what we already do more easily or more cheaply—think about the *new* things we can do:

• A fusion torch can vaporize and dissociate waste, separating it into its constituent atoms. That's recycling!

• Currently, essentially *all* production of new (non-recycled) metal from rocky ores requires the mining of coal, not only for its energy content, but for its chemical activity in the carbon, drawing out the oxygen. This antique method can be superseded with the energies fusion can bring.

• Space travel will no longer be limited to the energy density of chemical fuels, which are not susceptible of much improvement beyond their current levels. Rather than spending nine months going to Mars, we can go there in just a couple of weeks, by leaving the engine on as we're on our way, rather than just using it at the beginning and coasting to that destination, which is what we do now. Even with this coasting, most of the mass of a rocket going to the Moon is fuel. It's enormous. See **Figure 1**. In one sense, chemical fuel is just barely able to bring us to other celestial bodies. We need something better.

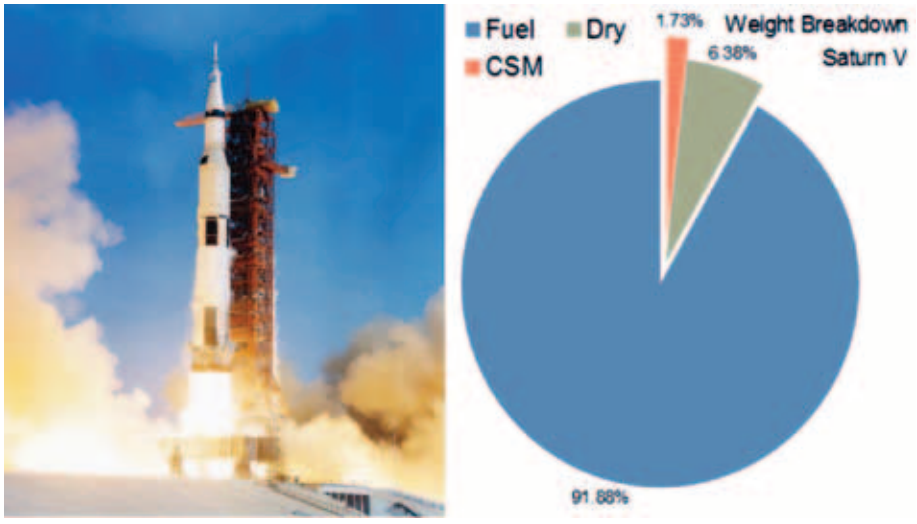
• Water shortages are becoming an increasing issue around the world, where groundwater supplies are being drawn down faster than they are replenished. But there's plenty of water in the oceans. Nuclear fusion will make it economical to desalinate ocean and other brackish water on a broad scale for agricultural use, far surpassing the small projects that exist today, primarily geared toward urban use.

• Energy-intense manufacturing processes, using large electrical currents or high-powered lasers, will usher in a new generation of production techniques.

In short, fusion power, as a platform, will enable tremendous improvements in the productive powers of labor. We should look for such progress that can create a 10-fold improvement, rather than small marginal gains.

Here is Lyndon LaRouche, writing on this topic in 2010, "What Your Accountant Never Understood: The Secret Economy":

FIGURE 1



NASA

The Saturn V rocket. (The weight of the command and service module is designated CSM.)

> We should then recognize that the development of basic economic infrastructure had always been a needed creation of what is required as a "habitable" development of a "synthetic," rather than a presumably "natural" environment for the enhancement, or even the possibility of human life and practice at some time in the existence of our human species.... Man as a creator in the likeness of the great Creator, is expressed by humanity's creation of the "artificial environments" we sometimes call "infrastructure," on which both the progress, and even the merely continued existence of civilized society depends.

In addition to the new platforms possible with fusion power, the current COVID-19 pandemic should remind us of the importance of making breakthroughs in biology.

What is the effect of living in a society committed to progress, in which every decade brings a better life than the past? Clearly, a great deal of happiness at being able to live more easily, but also a cultural connection to the beautiful potential of the human species itself, the third and final topic of this talk.

Immortality

Lyndon LaRouche wrote in 2004,

> The conspicuous shortfall of otherwise talented leaders among us, is that we have become a nation which, for all its current rant about religion, has no actual conception of a real form of immortality. In this mass-entertainment-soaked, "Where's my money" citizenry of today, there are few Jeanne d'Arcs, Abraham Lincolns, or Rev. Martin Luther Kings among us, who are prepared to put all that which is mortal in them, as a talent on the altar of service to the foreseeable good of the future of mankind....
>
> —Lyndon LaRouche, "Re-Animating the World's Economy" (2004)

A great leader, such as those mentioned in this quotation, acts in the present to change the future, of course, but also the past. The contributions of those who achieved victory in the American Revolution over the world's foremost source of evil—the British Empire—took on renewed meaning through Abraham Lincoln's success in defending the Union and in Dr. King's achievements in leading the country into greater coherence with the ideas of equality and the pursuit of happiness that motivated the nation's initial creation.

In these days, when identity politics is reaching a fever pitch, and people are drawn apart under a microscopic intersectionalism of heredity, religion, geographic background, sexual orientation, and what is called race, it is more important than ever to bring to people the challenge of acting on our *universality.*

The discoveries of a great thinker remain valid *even after they die.* Louis Pasteur is dead, but his discoveries live on, and continue to safeguard our health. Marie Curie is no more, but her breakthroughs continue to an-

imate our pursuit of the truth. Albert Einstein has passed away, but his epic reconceptualization of space, time, energy, and matter offers ever new puzzles to tease our imagination into discovering more about the universe. Dr. King was assassinated, but his devotion to his enlightened understanding of the human condition continues to inspire.

A functional immortality isn't about dying and martyrdom. Being willing to die to defend—or burn down—a dentist's office, a sandwich shop, or furniture store misses the point.

Will we wipe out poverty on this entire planet? Will we develop defenses against comets and coronaviruses? Will we create for our children and grandchildren a future in which they will have the opportunity to address their minds to new scientific inquiries and a culture that fosters that pursuit, creating a world worthy of the dignity of the human individual, here on Earth, and above it?

Or, will we shackle ourselves to centuries-old sources of power, like wind, and condemn ourselves to destitution, compared to that abundance that could be ours?

The answer lies with us.

Dr. Bernard Bigot

The ITER Project: Hydrogen Fusion for the World Energy Supply

This is the edited transcription of the prerecorded video which served as Dr. Bernard Bigot's opening presentation to the Schiller Institute's conference on September 5. Dr. Bigot is the Director-General of the International Thermonuclear Experimental Reactor (ITER). Subheads have been added.

Thank you very much for inviting me to participate in this International Schiller Institute conference. I'm very pleased to introduce you to the ITER project. Its mission is to demonstrate that hydrogen fusion could be an option for the world energy supply in the future.

The ITER site has the various buildings and equipment on their way to being erected and installed. This very large project is governed by 35 participating countries and seven primary partners.

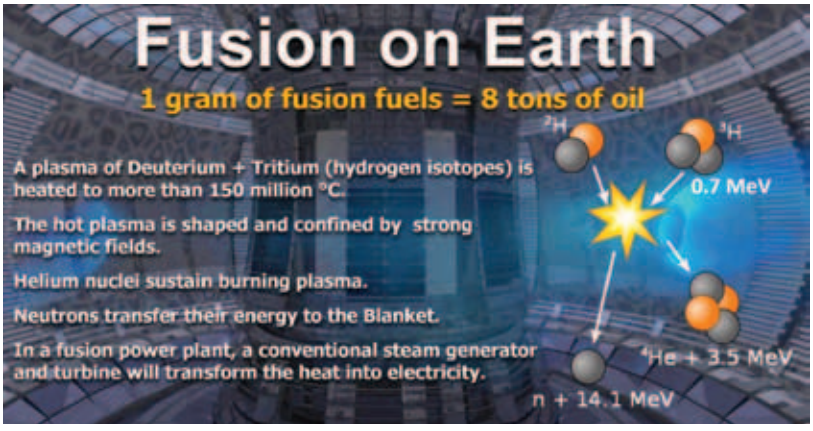
Everybody knows that we are facing a limit for the use of fossil fuels which we have been using now for over 150 years. And the alternative options are limited. We have to rely on some well-known physical phenomena.

Clearly, there are renewable energies, which are quite attractive, but from my point of view, it is a partial solution, because of low power density, coupled with intermittent availability for large population concentrations. The mega cities require massive energy production, which has to be predictable. Nuclear fission is also an option, certainly. But as you know there are drawbacks and limitations, because uranium resources are not infinite.

The Fusion Energy Option

We need to find another solution, another option. We can look at what is happening in the universe. In the universe, the most common way to produce energy is hydrogen fusion as in the Sun and in the stars. The Sun is just a big bubble of hydrogen, 300,000 times the weight of the Earth. And at the center of the Sun, there is a very hot plasma of 15 million degrees (Celsius), a high-density plasma, and the hydrogen fuses and produces energy.

How to does that happen? The compression of the hydrogen nuclei brings them closer and closer, and at a short enough distance, they fuse and produce two new particles: neutrons and helium. They move away and release a lot of energy.



On Earth, we cannot produce that energy in the same way, as you can imagine. Our physicists have been bright enough to imagine an alternative option, which is to use a very *low density plasma,* but at *higher temperature,* 150 million degrees, ten times the temperature of the core of the Sun. In that condition, we have been able to accelerate the hydrogen nuclei in such a way that they get up to a very high speed, and once they collide they fuse with high probability and in this way produce two new particles: the same helium nuclei as well as the neutrons.

The energy of the helium that you get out of this collision is an energy which is in the order of five times larger than the energy of the collision, and that of the neutrons, is 20 times. These two particles [neutrons and helium] will hit the wall and convert their kinetic energy to heat. This is the way we can produce energy with hydrogen fusion. The good point is that there is a very high density of energy in this phenomenon, since 1 gram of fusion fuel is the equivalent of 8 tons of oil.

There is a very large advantage in this technology, because:

• It can be a source of massive, predictable and potentially continuous energy, even variable in form, that complements renewable energies.

• It is safe, using only two grams of hydrogen at a given time. If any parameter deviates from the "normal" values, the reaction just stops.

• It is also environmentally responsible, because it only produces helium, which is a very inert chemical, as well as not radioactive.

• There is an almost limitless supply of fuel for hundreds of millions of years, widely distributed around the world.

• There is no impact on climate, since there is no greenhouse gas emission.

• Furthermore, fusion reactions produce no long-lasting high-activity radioactive matter, only a tiny amount coming from tritium and some activated parts of the walls of the reactor.

The ITER Mission

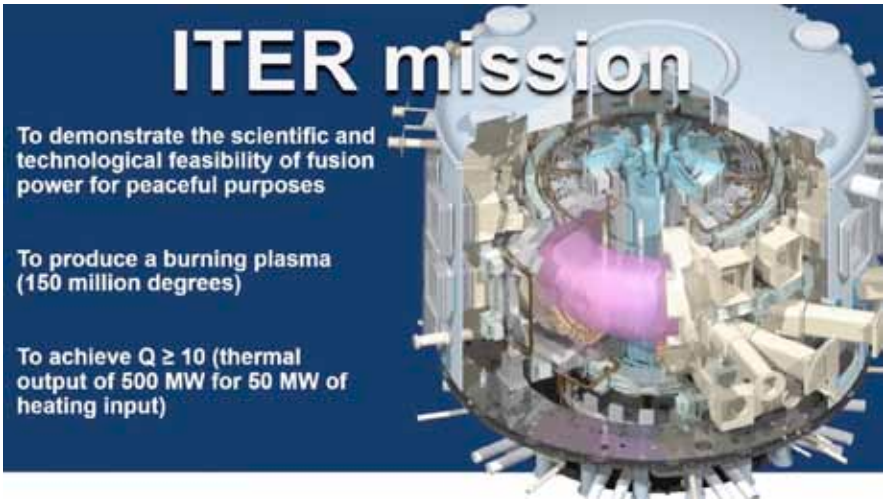
The ITER mission is quite simple:

• To demonstrate the scientific and technological feasibility of fusion power for peaceful purposes.

• To produce, for this, a burning plasma, as I mentioned, at 150 million degrees.

• To achieve a yield of over 10, when you compare the thermal output of the fusion reaction [500 MW] with the power that you have to inject into the plasma [50 MW].

Size is absolutely critical. Size matters.



The world record for hydrogen fusion is currently held by the JET [the Joint European Torus, in Culham, U.K.], with a plasma volume of 80 cubic meters. In ITER it will be ten times larger, at 830 cubic meters. The power being injected into the JET plasma, in the order of 23 MW, produces only 16 MW of fusion power, which is a net yield below 1, which is not so attractive. For ITER, the heating power is two times larger [50

MW] and indeed the fusion power generated [500 MW] is 30 times larger [than that for the JET]. So, definitely, size matters, which makes this option a little more complicated than some others.

How can we achieve this collision with 150 million degrees (Celsius) and a very high speed?

We know the way: We have to use what we call "the magnetic forces." Not the gravitational ones as in the Sun and the stars, but magnetic forces. I'm sure you remember that when you have a charged particle near a magnetic field, the particle is captured by the magnetic field and is also continuously accelerating, spinning around the magnetic field line.

So this is why we have to assemble large magnetic cages. **Figure 1** shows the size of these cages. With 18 vertical coils, 6 horizontal ones and the central solenoid, all of them nearly 20 meters wide and 20 meters high. We need a very high precision in order for the particles to circulate very efficiently on the circular magnetic field line. This is why we have to position the axis of the magnetic cages with a precision below a millimeter, compared with the axis of the vacuum vessel which we name the tokamak.

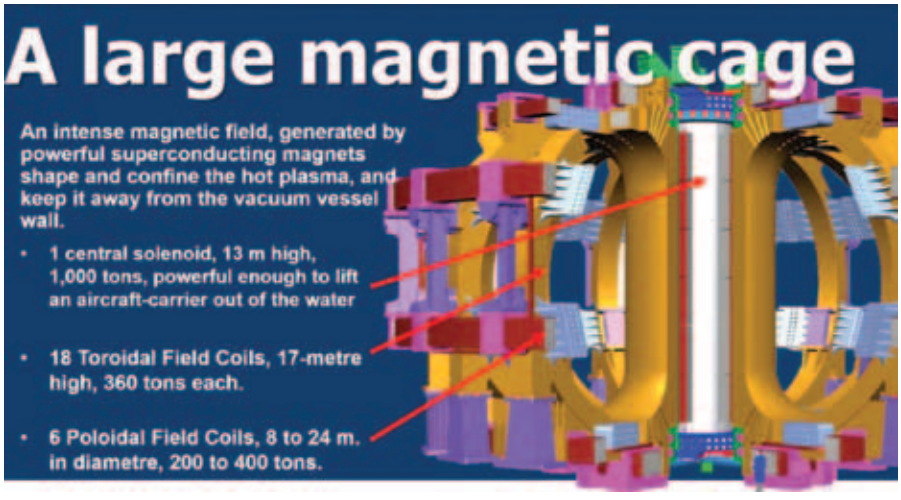
This is the reason for the size and the complexity of ITER, which has brought 35 countries to associate with seven major members. An initial agreement was reached on June 20, 2005 among the seven members to build ITER on the site proposed by Europe and the final ITER Agreement was signed in November 2006 in Paris. The seven major ITER members altogether, represent more than 50% of the world population and about 85% of global GDP.

Because all the members are really convinced that hydrogen fusion could be a breakthrough in the future for world energy supply, they have decided to produce "in kind," the various components of the equipment. They are training the best of their industry to demonstrate the feasibility and capacity of the manufacturing of the large components such as the magnetic coils, the vacuum vessel and all the other equipment.

It is quite challenging to achieve the required qualities. That is why we needed long-term planning. In 2015, after a thorough review of the project, we decided to go on and create a schedule which should let us have the first plasma in 2025, after we receive in these precise years—2020, 2021, and 2022—all of the last components and have them assembled before the end of 2024. After that, after commissioning the equipment, we will produce our first plasma in 2025.

After that, we will have what we call a "staged approach" to full fusion power with our special brand of fuel, deuterium-tritium. We have planned a sequence for installing some complementary equipment to collect the energy; to heat the plasma more efficiently by adjusting the magnetic field; and to recycle the fuel that has been fusing in the tokamak.

FIGURE 1

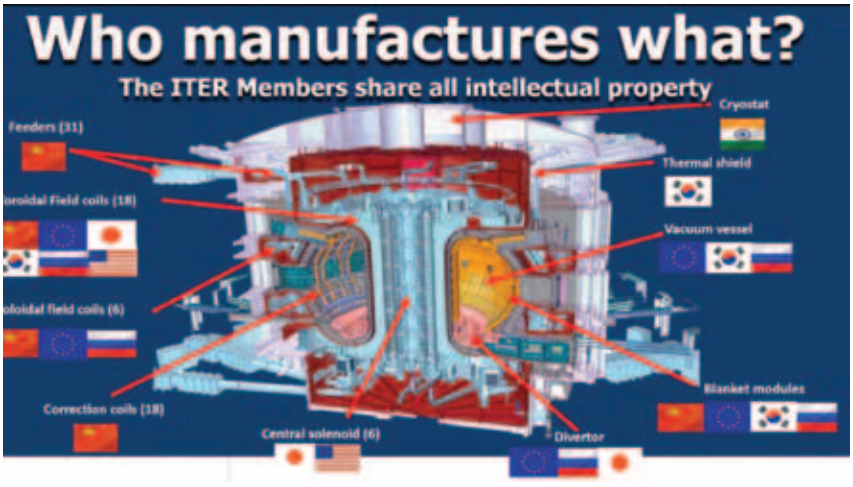


'In-Kind' Production of Components

The complexity of the management is related to the decision of this "in-kind" sharing of all the manufacturing of the components, and to the requirement that ITER members will share all intellectual property.

In the cutaway image of the tokamak, you can see the vacuum vessel, which is the torus, embedded in the magnetic cages, and all the different components that will be in what we call the "cryostat" because the temperature needs to be quite low for the superconductive coils: –270 degrees Celsius. In all of this work, big progress is now going on, with many manufactured components on their way:

• China has manufactured one of what we call the "poloidal field coils." This coil is now complete and has



been transported to the ITER site. It now has to be checked before final positioning within the tokamak.

• In India, the "top lid" of the tokamak is now complete and will be shipped to the ITER site.

• Japan will also deliver the cage coils, the vertical field coils, toroidal coils that I mentioned before.

• Europe also is producing vacuum vessel pieces as well as Korea. And indeed we have the first vacuum vessel sectors. There are nine sectors. The first one has now arrived safely on site and is fully compliant with requirements.

• The U.S. and Russia are providing materials.

On the ITER site, the largest pieces, which couldn't have been transported, are on their way to being completed. They are [four of] the "poloidal field coils." The largest one is 24 meters in diameter. It was not considered viable to transport them from another country. So this is why we experienced during this last month the quite massive arrival of many components. Some coils and some equipment which is now on site and ready for assembly. We are now preparing all these different components, including these first poloidal field coils which have arrived on site, in order to be able to assemble them.

To do that, we have to have all the civil engineering works ready to accommodate the equipment. Many buildings are on their way to being completed and finished in order to accommodate the equipment. As of now, 70% of the total work, from design to first plasma, has been completed. And since we have been progressing quite well, during the last five months, reaching on the order of 70%, we feel that we are on track to achieve the challenging goal of first plasma in 2025.

We are preparing now for machine assembly due to the fact that the civil works are so well advanced and the components being on site. This summer, we moved what we call the "cryostat base" as well as the lower and upper cylinder, which are large boxes of 30 meters diameter and 30 meters high, to the tokamak "pit," i.e., the building where the plasma will be fusing. The large cryostat base, lifted nearly 50 meters above the ground. It has since been deposited on the tokamak base earlier this week (Aug. 31). Very impressive and a big challenge, because of its large size and the precision with which we have to position this equipment—a precision below 5 millimeters.

We are really ready to go now for the first pre-assembly, the pre-assembly of the vacuum vessel, on site, as well as the toroidal field coils with the assembly line and we are now commissioning all these different sequences to be sure it will be safe and of high quality.

First Plasma by 2025

I hope I have convinced you that hydrogen fusion is on its way to becoming an option for the world's energy supply. There is a large benefit from it, but there are still a lot of challenges to be overcome in order to demonstrate it. We feel that it will be possible, after first plasma in 2025, to go on for full fusion power ten years later, in 2035, and by the year 2040-2050, to have made all the needed demonstrations such that the utilities could then consider using this technology and substitute it for their large consumption of fossil fuels to produce energy, to produce electricity in complementarity with renewable energies. Indeed these two technologies could complement each other very well. One is massive and fully predictable, and the other, as you all know, is diffuse and intermittent. So, we have an option for the future.

Dr. Stephen O. Dean

Achieving Fusion Power: Where We've Been, and How We'll Get There

This is the edited transcription of a pre-recorded interview of Mr. Dean, presented as his opening remarks to the Schiller Institute conference on September 5. Mr. Dean is the President of Fusion Power Associates.

Schiller Institute

Dr. Stephen O. Dean

Q1: *Could you describe the history of the U.S. fusion program and its achievements?*

In the 1970s, tokamaks were invented and demonstrated first in Moscow at the Kurchatov Institute. It was so attractive that the whole world started building them in various sizes. Progress was very rapid, and the U.S. built a facility at Princeton called the Tokamak Fusion Test Reactor, and Europe built a facility called JET [Joint European Torus] that is still in operation. Both of these achieved fusion conditions. So, the world was ready to move ahead very rapidly in the 1970s from these achievements.

The U.S. Congress actually passed the Magnetic Fusion Engineering Act of 1980, saying that the U.S. was ready to spend $20 billion in order to have a fusion power plant on the grid by the year 2000. So, we were ready to go and do that. We were planning to build a facility like the present-day ITER [International Thermonuclear Experimental Reactor] in the 1980s.

But Congress never provided the money to implement that Act that was passed by Congress. So, things slowed down, and in 1985, Reagan and Gorbachev got together and said they would build it as an international project, and all the rest of the world then joined in on that. That became the ITER venture that's now coming to fruition soon. ITER has been a prime example of how successfully the world can work together to do something like this. Of course, as you know, it's being built in France right now. [See the presentation to the Schiller Institute conference by the Director-General of ITER, Dr. Bernard Bigot, also in this issue.]

Q2: *What have been the consequences of the cuts to the U.S. fusion budget over the decades?*

The real momentum for fusion and the really big facilities for fusion are all being looked at elsewhere. For example, in Japan, a huge, new fusion experiment called JT-60 Superconducting just came in operation this year. Its construction is just being finished. In Europe and the UK, the JET experiment is still running, where the U.S. Tokamak Fusion Test Reactor got shut down. So, we're totally dependent right now on the international effort for what the timescale of bringing fusion online for electricity is. The U.S. does not have a commitment right now to actually build anything like a power plant or a prototype power plant, although we have a study going on right now by the National Academies looking at what's called a pilot plan as a goal. But

it's a goal, it's an idea, but it's not yet agreed to by the government that the U.S. is actually going to do it.

So, you have to look at our budget as just being our budget; just a small contribution, maybe less than 20% contribution to what is really a world effort. In all the countries of the world, the scientists are working very closely together. If it's China, or Japan, or India, or Europe, all of them know the same thing. All of them are ready, depending on their government policies, to step forth.

In China, for example, the size of the program has been expanding rapidly. The number of people working on fusion now in China exceeds the number working here, and the same way in Europe. So, we're just a small part of the world effort, and it's really the world effort now that you have to look at, and the world facilities that are being built, to judge how fast we are moving.

Q3: *Is it important to have a robust domestic fusion program in addition to the international level?*

Well, you can't have a successful international program unless all the parties have a robust national program, because they all have to have enough smarts and capabilities to contribute their weight to the international venture. And they all have to be prepared to capitalize on the successes of the international project to move their own programs forward. It's important that each country has a plan of its own, how to step forward beyond ITER to the power plant, because the energy markets, the electricity markets in each country operate very differently. So, it's important for every country to decide what they're going to do beyond ITER that best prepares them to make fusion a success in their market.

Q4: *Could you give us a sense of the scope of the work being done in fusion around the world today?*

One of the interesting things I think that's happened in the last several years is the emergence of a bunch of small companies that are being funded mostly by private money. I think that's happening because ITER is making people feel that fusion is real, and ITER is making people think, well, maybe there's a way to do it faster or cheaper than what it's costing ITER, because we're all smarter now. So, we have now the phenomenon really of more than a dozen of these small companies around the world. Most of them, I think, are in the U.S., but they're [also] in Europe and the UK.

Also, small companies that are getting sizable amounts of money and have very ambitious plans. Some of them—for example, Tokamak Energy in the UK, a private sector company. It's a variation on the tokamak, it's not the conventional tokamak, but it's a smaller, improved tokamak called a spherical tokomak. I visited there in March, and they've already built an experiment, and they've already got plans to go beyond. And the Culham lab in the UK also has an experiment of that type, and they're all working together. Princeton is actually bringing into operation in a couple of years a bigger tokamak of that type, the spherical torus. That's in competition with the conventional tokamak, and right now the leader in that area for getting to power is Tokamak Energy in the UK.

There are other companies that are following concepts that are not tokamaks at all, like TAE Technologies in the U.S. TAE is using a variation of a concept called the mirror concept, or the field-reversed concept. They've built two generations of machines, and they have good funding. They've got plans to bring online a demonstration power plant in the next 10-15 years that would not look like a tokamak at all. It's behind the tokamak scientifically, and it's behind the tokamak in achievement so far, but it's moving fast, and it's being built on a physics basis that's been around for quite some time.

I was going to mention that the tokamak and these other concepts are based on tokamak-like physics, or mirror physics, mirror-confinement physics.

There's a whole other approach to fusion called inertial confinement, which is based mostly on lasers. There's a little company in Germany called Marvel Energy which is looking at ways to capitalize on developments, breakthroughs, in laser technology to try to move that whole area along faster. That's based on some of the work that's going on at Lawrence Livermore [in California] on the biggest laser in the world called the National Ignition Facility. There are programs in the U.S. that support that in Rochester and the Naval Research Lab, but there's this little company in Germany at Garching called Marvel Fusion that wants to take all of that and move the whole thing faster with these petawatt lasers which aren't being used in the conventional inertial confinement.

So, there's a lot of innovation going on, there's a lot of progress in all of the different areas. As I say, there's a dozen little companies. There's even a company in the U.S. called Zap Energy which is going back to one of the very original concepts that people tried in the 1950s on fusion called the Pinch. It basically looks like a fluorescent light, but instead of a few amps of current down

the tube, it puts a million amps of current down the tube. These were always unstable when you tried to do that, but they've got the idea that if you just put a little twist on the pinch as you make it, it won't go unstable, or at least it won't go unstable very fast. And maybe you can get enough fusion out of that.

That's an extremely simple idea, but if it works, and you can keep it stable for a long enough time with that geometry, it's extremely simple. One of the things electric utilities are looking for are technologies that aren't so complicated that they've never used before, that they've got to figure out how to make them work on a very reliable basis to make electricity for months and years on end without having to do a lot of maintenance.

Q5: *If we did have full funding and support of the U.S. domestic program, how might that affect the timeline for achieving fusion?*

Well, in the United States, it would affect it tremendously, because if the money starts to come in, in the quantities we envisioned, escalated to today's dollars, what that would mean would be that the Congress and the U.S. government are committed to building the facilities necessary to do this quickly. So, building the facilities that you need, and building them quickly, and having the money to do that makes a total difference in the schedule. I still have no doubt that if we got that money, we could be doing this in 15-20 years.

There's also a management issue. Right now in the U.S., the fusion program is being funded as a science program. That's like when we decided to go to the Moon, astrophysics was a science program. But you had to build up a whole infrastructure and management commitment to go to the Moon. So, what we'd have to get in addition to the money, would be a management structure that was committed to getting to a power plant. That is not in the psychology right now of the fusion management at the Department of Energy. Along with the money, you would either have to have a whole new agency, or you would have to have the Department of Energy set up a whole new wing to make a firm commitment to manage this thing through to the end.

Mr. Dean is reachable at fusionpwrassoc@aol.com or www.fusionpower.org.

Michael Paluszek
Nuclear Fusion–Propelled Missions to Mars

This is the edited transcription of Mr. Paluszek's presentation to the Schiller Institute conference on September 5. He is the President of Princeton Satellite Systems.

Schiller Institute

Michael Paluszek

Today we're going to talk about nuclear fusion–propelled missions to Mars.

Direct Fusion Drive (DFD) is a nuclear fusion rocket engine for deep space operations. DFD does not produce enough thrust to take off from a planet or moon. In this talk we present a transfer vehicle that uses a high-thrust nuclear thermal engine to depart the Earth, then, using DFD, leave Earth orbit and go into orbit around Mars. We're going to talk about two types of nuclear reactions: *fission*, which is splitting atoms, and *fusion*, which is combining atoms

Direct Fusion Drive is a new type of rocket engine, made of a fusion reactor powering a plasma rocket. It's different from many other nuclear fusion technologies, because this single fusion engine can generate both propulsion and electricity to power its payload.

Here's how it works:

The DFD engine is made of a linear array of coaxial magnets with a pair of smaller, but stronger mirror magnets at the ends. A fusion region is centered within the magnet array, while cool plasma flows around it to extract energy. This fusion region is about the length of a surfboard and holds very hot plasma that spins like a motor. Antennas surrounding the engine create a novel radiofrequency heating mechanism, which is tuned to particular fuel ions and creates a current in the plasma. The plasma ions get pumped up with increasing energy cycles until the ions become hot enough to fuse.

Once the ions fuse, they create new, very energetic particles called fusion products. These particles follow paths that take them in and out of the cool plasma layer as they orbit the magnetic field lines. With each pass, the fusion products lose energy, until they get captured by the open field lines, and shoot out the back of the engine. This takes just a few milliseconds.

The mirror magnet at the end of the engine converts this electron thermal energy into ion kinetic energy, creating thrust, just like a regular rocket nozzle. Extra heat from the fusion reaction is converted into electricity, providing power for scientific instruments and communications.

The fuels or reactants used are deuterium and helium-3. The main reaction, therefore, is deuterium plus helium-3, which produces helium-4, the kind of helium used in helium balloons, plus a proton. Most of the power is in this reaction. We also get side reactions, which produce tritium and neutrons. Neutrons damage the walls, but we fortunately don't have that many of them.

Figure 1 shows the properties of a Direct Fusion Drive Engine.

The Specific Power is a very important parameter, because it shows you how much power we get per unit mass, and that's going to determine how good an engine it is. The Efficiency is how much power goes from the fusion reaction into the thrust. The Fuel Tank Fraction is particularly important because it ultimately limits how much ΔV you can get with a given engine, with a given Exhaust Velocity. You'll notice the Exhaust Velocity is very high, at 300 km per second. A typical hydrogen-oxygen engine, like that used on a rocket like the Space Shuttle, has about 4.5 km per second; a Hall-Effect thruster has 20 km per second. The Fusion Power from a typical engine is 1 megawatt (MW).

Figure 2 shows you the breakdown of the mass for the engine in all its components. To the right is a flow diagram of where the energy is going. The Rotating Magnetic Field (RMF_0) and Radio Frequency Drive drives the fusion reaction but also waste energy and *Bremsstrahlung*, which is X-rays, and Synchrotron Radiation. All this is fed back into the engine, and some is lost as waste heat to the radiator.

FIGURE 1

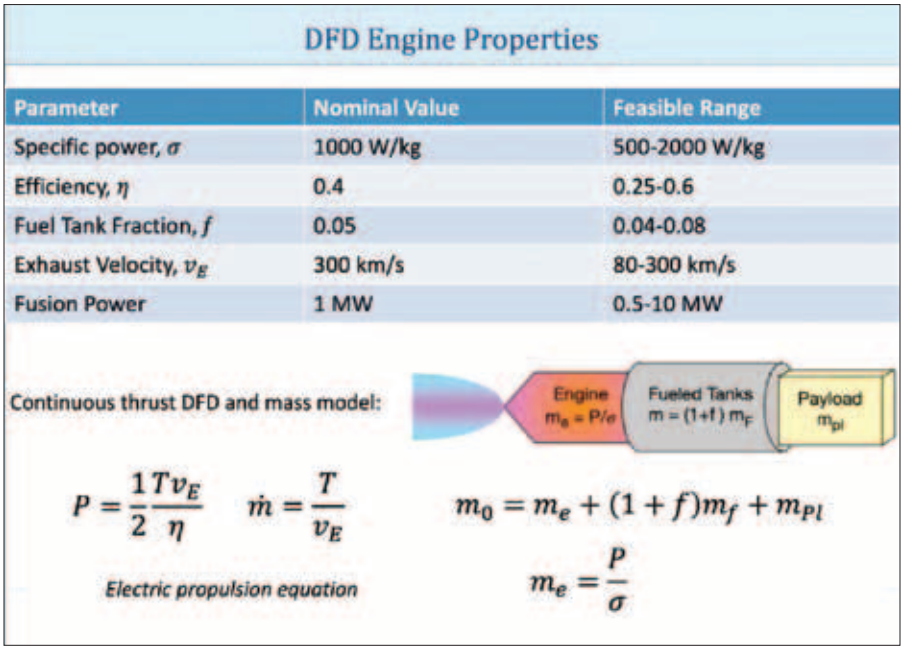


FIGURE 2

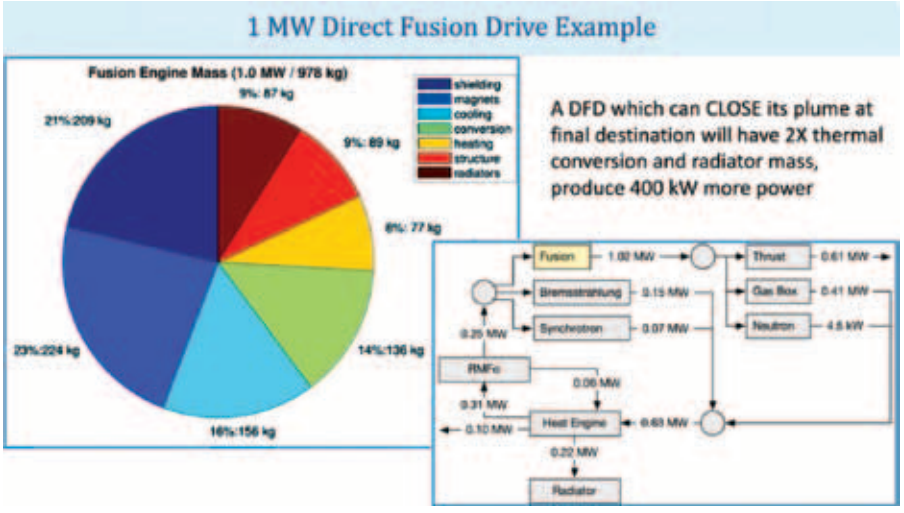
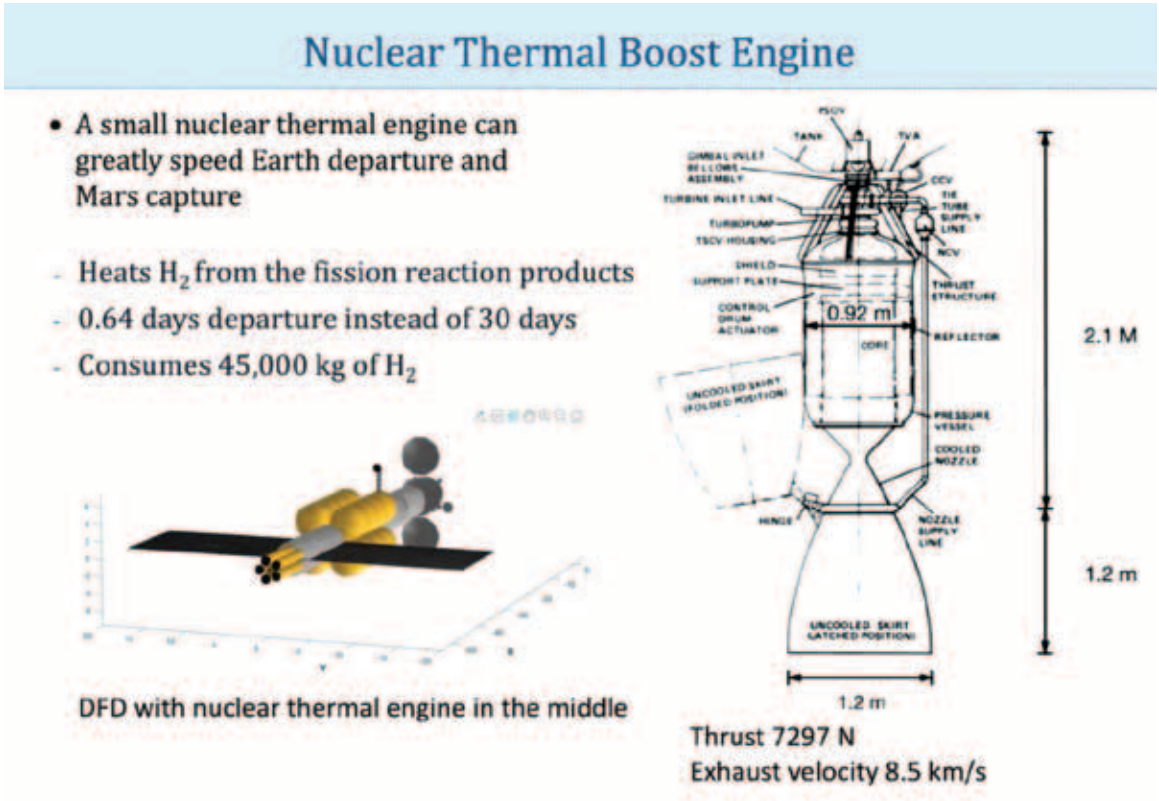


FIGURE 3



Space Travel Is Faster with DFD

Now, a fusion engine can get you places a lot faster. We can get to Jupiter in one year, Saturn in two, and Pluto in five. The NASA New Horizon mission took about nine years to get to Pluto, and it couldn't go into orbit. With DFD we could go into orbit, which enables all sorts of new science.

We depart the Earth and then leave Earth orbit for Mars a short time later. We then wait almost a year on Mars, on the surface, doing experiments, and setting up new technology and new habitation for future travelers, and then we return to Earth. The whole mission takes very little time, much less than it would if we used a Hohmann transfer orbit, which is what you would do with chemical propulsion.

We depart from Earth orbit in a spiral and it could take up to 30 days. So, one idea is to use a nuclear thermal engine, which produces ten times the thrust to get us out of Earth orbit. So instead of taking 30 days, it's only slightly more than a half-day. On the other hand, because the exhaust velocity is much lower, we consume a lot of hydrogen. **Figure 3** shows a nuclear thermal engine developed by NASA. Its thrust is 7,297 newtons, which is quite a lot. The exhaust velocity, however, is only 8.5 km per second, about twice that of the hydrogen-oxygen engine that I mentioned a moment ago.

So here's the idea of the Mars mission: We can get there in 100 days, which is a lot better than the six months a chemical rocket would take. And you can see, we could deliver 30 metric tons, that's about 30 tons, and we show some of the parameters we use in our analysis. Now, we haven't built the engine, so these are hypothetical and based on analysis. But you can see our thrust is much less than that of the nuclear thermal stage.

Besides propelling us to and from Mars, we can also use Direct Fusion Drive as a surface power source, because it is also being developed for power generation. You can use this engine to power bases, delivering a megawatt for scientific experiments, manufacturing, mining, and industry, on the Moon or on Mars.

To reach Michael Paluszek at Princeton Fusion Systems, go to http://www.psatellite.com *or* map@psatellite.com

Dr. Sergey Pulinets

An Approach to the Relationship Between Science and Politics

These are the prepared opening remarks by Dr. Pulinets for his live presentation to the Schiller Institute conference on September 5. Dr. Pulinets is a Principal Research Scientist at the Space Research Institute of the Russian Academy of Sciences.

Schiller Institute

Dr. Sergey Pulinets

It is a great honor for me to participate in such a representative forum, which actually discusses the fate of our civilization, which is currently exposed to real dangers that could lead to the destruction of human civilization as such.

As a professional space scientist, I would like to start with the cosmic factors affecting our planet. Particular attention should be paid to our luminary, [the Sun,] whose behavior has baffled many scientists. Its activity during the last solar cycle turned out to be unexpectedly low; in fact, we had the opportunity to observe the weakest solar activity cycle since the beginning of instrumental observations of the Sun. If in the maximum of the previous cycles there were 150-200 sunspots, which characterize the activity of the Sun, then in the current 24th cycle the number of sunspots at the maximum has barely exceeded 95.

Usually, long periods of decreased solar activity are associated with cooling on our planet, as it was during the Maunder Minimum, which lasted from about 1645 to 1715. Since November 2019, when, after a long hiatus, the first spots appeared on the Sun, a new, 25th cycle has begun, and, apparently, 2020 will show how the situation will develop. Will the Sun return to normal, or should we wait for a cooling, despite all the forecasts and the actually observed global warming?

While we are observing a gradual increase in solar and geomagnetic activity, the Sun continues to amaze us. We are, starting from August 17, in a state of continuous magnetic storm for the third week. It is small, but of such duration I have never seen it in my entire rather long scientific career. Therefore, we need to increase activity in solar research. In this regard, I would like to welcome the initiative of NASA to start developing a new solar project, HelioSwarm.

I know that many are inspired by astrophysics, problems of the origin of the Universe, interplanetary flights, the exploration of the Moon and the planets of the solar system, but it seems to me that in planning space research, one should first of all take care of our planet, because now the question is literally about the survival of mankind.

Areas of Argument

What are the most relevant areas I would like to highlight?

1. Placing weapons in space

Recently, there has been a dangerous tendency when countries ignore agreements on the peaceful use of outer space and begin to organize a space command, space weapons and systems for their use. This critically lowers the threshold of a new world war, which with the available technologies can very quickly end with the destruction of our civilization. Therefore, not only politicians, but all of humanity, including the participants of this forum, should make every effort to prevent the development of a situation that would actually allow placing weapons in space.

2. The problem of climate change and space research

We observe an ever-increasing number of global cataclysms; fires and floods alternate without interruption, and we see that humanity is not coping with this problem. And part of this problem is the inability of sci-

ence to explain and predict these phenomena. Despite the increasing number of remote sensing devices, a person remains just an observer, only with the best equipment, since the paradigm of modern science, based on narrow specialization, turns certain groups of scientists into blind people, feeling the elephant from different angles. The problem of interaction between geospheres, which Academicians Vernadsky and Laverov spoke about, remains on the sidelines, far from mainstream research. And while this situation continues, we will again shrug our shoulders after the next cataclysm, passively observing the melting of ice and permafrost.

3. The problem of earthquake prediction

I would like to dwell separately on the problem that worries me personally. We are talking about the problem of earthquake prediction. We have developed a technology that makes it possible to carry out a short-term forecast (for several days) of destructive earthquakes. A physical model of the formation of precursors was developed, a number of monographs and hundreds of articles were published, papers were reported at all possible international conferences of the highest level, patents were obtained in the USA and Russia, negotiations were held with the Ministry of Emergencies in Russia, FEMA in the USA, and in Japan.

The results have been practically demonstrated using data from various spacecraft on a global scale, but it seems that solving this problem is not beneficial to those in power. All our efforts go like water into sand, and people continue to die, buildings collapse, and then the ministries of emergency situations begin to heroically pull the remains out from under the rubble. And in this case, we can say that this is not a problem of science, but the relationship between science and politics.

4. Green energy

Recently, the number of phantom phenomena has multiplied in the world, among which the so-called green energy can be attributed. Everyone is shown pictures of clean cities in which electric cars drive. Let's turn to the numbers. According to a report by the International Energy Agency (IEA), even if the share of electric vehicles in the world grows 15 times from the current number, it will reduce global CO_2 emissions by only 1%.

In turn, IEA Executive Director Fatih Birol said that electric vehicles saved 40 million tons of CO_2 worldwide in 2018, equivalent to a decrease in global temperatures of just 0.000018° C—or just over a hundred-thousandth of a degree Celsius—by the end of the century.

But does the use of electric vehicles actually reduce CO_2? Let's think about where the electricity comes from to charge the batteries of electric vehicles. Electricity is produced by power plants, most of which are thermal, i.e., they burn oil products, producing an enormous amount of carbon dioxide. If we take into account that the efficiency of this entire chain of bringing energy to a car battery is much less than unity [less than 100%], then when this energy is produced, much more carbon dioxide is released into the atmosphere than if this car simply used an internal combustion engine.

But that's not all. In the production of batteries, metals such as lithium and cobalt are used, which are not so abundant on our planet and are found only in some countries. For example, in Chile, "lithium mining uses almost 65% of the water resources of the Salar de Atacama region, one of the driest desert regions in the world, to pump out brines from drilled wells." UN experts note that one ton of lithium requires a million liters water. This "contributed to environmental degradation, landscape disruption, soil pollution, depletion and contamination of groundwater," the UN report says.

Along with lithium, cobalt is another key component in electric vehicle batteries, and two-thirds of all cobalt is mined in the Democratic Republic of Congo (D.R.C.), the UN said. The United Nations Children's Fund (UNICEF) reports that about 20% of the cobalt supplied from the D.R.C. comes from artisanal mines "where human rights are continually abused, and 40,000 children are employed in extremely hazardous conditions for meager wages."

But that's not all. You all know that the batteries that you use in your gadgets cannot be disposed of with ordinary waste, but must be taken to special recycling centers. There are billions of these small batteries. At the same time, UNCTAD experts estimate that over the next decade, sales of electric vehicles will grow to 23 million units, thus, in just four years, the battery market is expected to grow by more than 700% to $58 billion by 2024 from the current level of $7 billion. And batteries don't last forever.

Now imagine the industry for recycling these batteries. How much energy is required for their utilization. And how much carbon dioxide will be released at the same time. Electric cars are a mirage for ordinary people and lovers of beautiful pictures. Most likely, it is necessary to direct efforts to the production of hydrogen-fueled cars, which exist, but for some reason are not produced on a mass scale.

People have told me that electric cars are not all there is to green energy. There are also wind generators and solar panels. I will not go into details here. I will say that both sources depend on external weather conditions not controlled by humans. No one can guarantee you that the weather will not be calm for a long period of time or that a dust storm will not cover the working cells of solar panels with sand. You need a reliable supply, not the California crisis that led to blackouts this year due to extreme heat and fires. Even such simple things, such as that the maximum solar electricity is generated during the day, but because most people come home from work in the evening, there is a surge in consumption, the system cannot cope.

Conclusions

There are plenty of other arguments, but let's move on to the conclusions. No one disputes that green energy helps preserve the environment, but it does not provide the main conditions: reliability, safety and continuity of production. It can be used in small farms, on farms, in remote places where it is not profitable to extend power lines. But it cannot and should not be used to supply power to hospitals, schools, critical infrastructure, military units.

According to the Schiller Institute conference program, it is clear that at this conference a lot of attention will be paid to thermonuclear energy. There was enthusiasm with the start of the construction of the ITER reactor in France, but this is still only a prospect for at least a decade. If we want to solve the problem now, then the only possible way out, I think, is the massive construction of reactors based on fast neutrons. They are already there, they are safe, and they leave no nuclear waste. They will solve many problems, including in countries with undeveloped economies. They can be used to operate desalination plants in regions with a lack of fresh water, and most importantly, the stability and uninterrupted supply of electricity.

Dear Sirs, our conference is taking place at a time when humanity is passing a turning point in its development, when the level of turbulence has reached a critical point in almost all countries. And the main thing in such circumstances is making correct and balanced decisions. It is not enough merely to accept them; they still need to be conveyed to people, and one of the main tasks is to convey this information to as many inhabitants of our planet as possible, because only then they can be implemented. Let me wish us all the best in achieving this noble goal.

Paul Driessen

Will We Allow Eco-Imperialism To Block Development?

This is the edited transcription of the pre-recorded remarks delivered by Mr. Paul Driessen to the Schiller Institute conference on September 5. He is a Senior Policy Advisor to the Committee for a Constructive Tomorrow (CFACT). Subheads have been added.

Schiller Institute

Paul Driessen

Let me share some important thoughts with you, about lethal eco-imperialist policies that are being imposed on billions of poor people in Africa, Asia, and Latin America by rich, powerful, callous radicals in developed countries.

The chasm between modern, industrialized nations and still-impoverished countries is as shocking as it is unnecessary and intolerable. But the reasons for that chasm—and what can and must be done to eliminate it—are readily available for anyone who wants to discover them, for anyone who wants to use that knowledge to dramatically improve lives and living standards in all those still impoverished countries.

Impoverished countries need freedom to function, create and build responsibly, under reasonable, responsible laws and regulations.

They need to eradicate diseases that kill people and make them unable to work for weeks or even months.

To do that, they need doctors, nurses, modern clinics and hospitals, clean water, insecticides, medicines—homes and buildings with doors and window screens to keep disease carrying insects out.

They need abundant, nutritious food—through modern agriculture and the seeds and other technologies that produce more crops, from less land, using less water, with less backbreaking labor, and are able to survive locust and other insect plagues.

Perhaps more than anything else, they need *energy*—especially *electricity*—abundant, reliable, affordable energy from coal, natural gas, nuclear and hydroelectric sources.

Those countries need to recognize that expensive, intermittent, unreliable, insufficient energy—from millions of wind turbines, billions of solar panels and billions of backup batteries—requires a hundred times more raw materials, mining, land use, habitat destruction and wildlife decimation than those now hated coal, gas, nuclear and hydroelectric sources.

Each of these steps and components creates jobs, incomes, prosperity, health and better, more productive lives—that multiply and multiply over time.

In fact, all these things are fundamental human rights.

I'm talking about the fundamental human right of access to these modern technologies. The fundamental right for all human lives to be improved and blessed the way ours have been. The fundamental human right to never be denied access to these technologies.

A Dark and Evil Force

So what is holding these impoverished nations back? Inertia and inaction, sure. Corruption, certainly. But there is another factor, a dark and evil force throwing roadblocks in their way.

That dark, evil force is the veritable army of rich, powerful government agencies and non-governmental organizations—NGOs—that lie, pressure, harass and intimidate families, businesses and entire countries into doing nothing, into rejecting modern technologies, into settling for minuscule improvements in their lives and living standards only at the margins.

These pressure groups use their vast wealth, prestige, power—and control over trade, loans and technology transfers—to perpetuate poverty, disease, malnutrition and death. It's eco-manslaughter.

And yet they get lionized and even canonized, for supposedly protecting Mother Earth. The NGOs enjoy tax-exempt status and global prestige, because the horrific human and environmental costs of their actions are mostly ignored by news media, celebrity, human rights and other supposed watchdogs.

Maybe even worse, they are financed by taxpay-

ers—and by super-wealthy, supposedly charitable foundations—many of which got their billions of dollars from fortunes made in the same industries and technologies that they now deny to poor families and countries.

What they are doing is akin to denying cancer patients access to chemotherapy, because *they* are concerned about possible side effects. They would rather see the patients *die*, than allow them to suffer hair loss or depressed immune systems.

As though it's *their* decision, instead of the cancer patient's.

But it's even worse. Because the supposed side effects of the modern technologies that these powerful NGOs, government agencies and international anti-development banks are denying to impoverished families and countries are mostly exaggerated or fabricated.

They exist in their imaginations, computer models, press releases and fund-raising appeals. Not in reality.

These pressure groups won't even let families get Golden Rice—which could prevent 500,000 children from going blind and 250,000 from dying every single year from Vitamin A deficiency and malnutrition.

These radical agencies, foundations, banks and NGOs are committing crimes against humanity. They are perpetrating and perpetuating millions of deaths every year—millions of poor, dead, dark-skinned parents and children—at the hands of mostly rich, white radicals in wealthy developed countries.

These cold-blooded eco-imperialists should be condemned for crimes against humanity and racist eco-manslaughter. They should lose their funding and tax-exempt status.

They should be banned from college campuses and polite civil society. They should be hauled before the UN Human Rights Commission and International Court of Justice.

All of you at this conference could help make this happen. You could turn this dark, evil paradigm on its head. You could help bring a new birth of freedom, health and prosperity to dozens of countries—and billions of people—around the world.

I hope you will join me and my colleagues in making it happen. Thank you.

Follow Mr. Driessen on Townhall.com, WattsUpWithThat.com and CFACT.org.

Ramasimong Phillip Tsokolibane

LaRouche and the Development of Africa

This is the edited transcription of Mr. Tsokolibane's greetings to the Schiller Institute conference on September 5. He is the leader of LaRouche South Africa. Subheads have been added.

Schiller Institute

Ramasimong Phillip Tsokolibane

My name is Ramasimong Phillip Tsokolibane. I am proud to be the leader of the LaRouche movement in South Africa. On behalf of my nation and all of Africa, I send greetings to each and every participant in this urgently important conference and pray for the success of our deliberations.

When I spoke to you last May, I urged that the greatest powers devise plans to send immediate and massive aid to my country and all of Africa to help us overcome the ongoing global coronavirus pandemic. I asked that President Trump make good on his promise to stand by Africa and do all that he could to secure a better life for Africans through economic development aimed at lifting our people out of poverty.

This sentiment was communicated by First Lady Melania Trump in an October 2018 tour of several African nations focusing on the plight of our children.

Poverty Kills, Just as Surely as a Policeman

There have been reports in the international press that the COVID-19 pandemic may have spared many Africans, pointing to lower-than-expected official infection and death rates, including in my own country. I believe that the official numbers are vastly understated because of the severe

lack of viable healthcare systems and the absence of testing.

As that great lady, Schiller Institute Chairwoman Helga Zepp-LaRouche, has said, we must build up an extensive modern worldwide health security system, as no such system currently exists. This applies to much of the so-called advanced sector, including in the United States, and it is certainly true in Africa. We need more doctors. We need more healthcare workers. We need more hospital beds and treatment facilities. We need access to medicines and personal protective equipment (PPE).

And, when developed, we will need access to vaccines and antiviral therapies. *We cannot pay for this. We should not be asked to do so.* We need a special global health Civilian Conservation Corps type of program to help us accomplish this as Helga proposes, and we needed this yesterday.

The reason we now know the numbers of COVID cases are understated is because the main vector in the spread of disease is poverty. Africa, in a state of enforced underdevelopment imposed by the global British financial empire, suffers from widespread poverty. So, this virus is killing Africans in large numbers, even as we speak today. *We cannot allow this condition to stand.* This must be among the urgent matters to be discussed at the summit of the Permanent Five United Nations Security Council member nations proposed for next month by Russian President Vladimir Putin. *That summit must take place.*

I call again on President Trump: Make good on your promise to help Africans.

The 'Better Angels of Our Nature'

As I look at the anger and frustration in the streets and cities of America today, I see many rallying around the slogan, "Black Lives Matter," but does not a black life threatened with death coming from poverty and disease in Africa, or anywhere else, oppressed by a global financial oligarchy that seeks death for those they consider useless eaters, matter just as much as a life threatened by the armed brutality of police? I hear nothing about that from my black brothers and sisters in the United States.

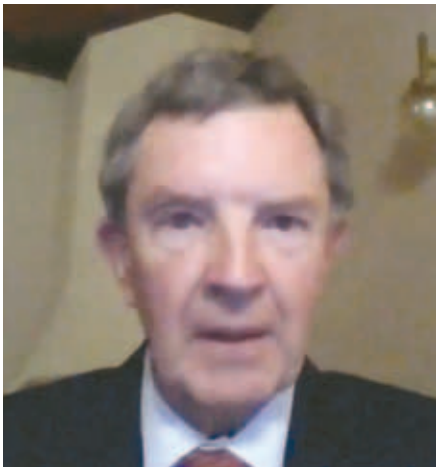
All citizens, everywhere in the world: We must join together and express with equal clarity and certainty our moral courage and outrage at the murderous intent of Wall Street and City of London bankers, whose policies kill Africans, and the outrageous, unacceptable actions taken by police in America.

I appeal to what your greatest president, Abraham Lincoln, in his first inaugural address, called "the better angels of our nature," to find the pathway for justice of all men, for all women, for all humanity. I believe that pathway for justice is embodied in the policies of Lyndon LaRouche to create a just, new world economic order to give all of us the opportunities to rise to our creative potential as human beings. In our pursuit of that happy future, I foresee success. Thank you very much.

Dr. Kelvin Kemm

Nuclear Energy in South Africa, and in Africa at Large

This is the edited transcription of the opening remarks by Dr. Kemm to the Schiller Institute conference on September 5. Dr. Kemm is CEO, Stratek Business Strategy Consultants, and former Board Chairman of the South African Nuclear Energy Corporation. Subheads have been added.



Schiller Institute

Dr. Kelvin Kemm

I am Dr. Kelvin Kemm. I'm a nuclear physicist from Pretoria in South Africa, from the company Stratek Business Strategy Consultants. I do work over a wide-ranging number of fields not only in the nuclear, but all sorts of businesses where we have to look at solutions that work for us people who live in Africa.

Believe it or not, Africa is larger than the United States, China, Europe, India, and Japan added together. South Africa alone is the same size as the whole of Western Europe. The distance from where I live in Pretoria to Cape Town at the southern point of the country is the same distance as from Rome to London. We often find when we are

travelling in Europe and we talk to Europeans, and they talk about something being a long way away, they mean 100 kilometers. We think nothing of driving 100 km to a meeting and then driving back. To us, a long way is 500 kilometers or more.

'Solutions' Must Work in Africa

So, we have to think: "How do we find solutions that work for Africa?" So many of the European solutions are *assumed* to work, and we in Africa are very guilty of this ourselves. We hear somebody saying, "There's a television system, and there's a telephone system, there's a so-and-so system that we wish to import." So, we say to ourselves, "Oh well, let's have a look. It's working in Germany, or it's working in France or Switzerland." Then we discover that the distances for them are 20 km between radio masts or something. For us, it's going to be 200 km or more for it to work in the same way. So, quite often, we put a look and say, "What is it that we must do?" And the challenge is, start thinking for yourself, and thinking under your own conditions.

We build dams here in South Africa, and dams that hold drinking water. The dams are designed to last through a five-year drought. In the UK, if it doesn't rain for a couple of weeks, they start to worry about drought conditions and water shortages. Here, it's years that the dams are designed for. So, the nature of the approach is just very different. Many people from the First World are going to many African countries and telling them, "Wind and solar is the answer because it looks like it works in my country in Europe." That is a dishonest thing to do.

The Medicine of Nuclear Power

One needs to look and say, "How would Zambia, Botswana, the Congo, Mozambique, and so on, satisfy their electricity needs, and what is going to be beneficial to them?" South Africa is predominantly dependent on coal for power; we are one of the few countries of the world that is blessed with vast coal resources, which we use for our own electricity. But we export a lot of coal, too.

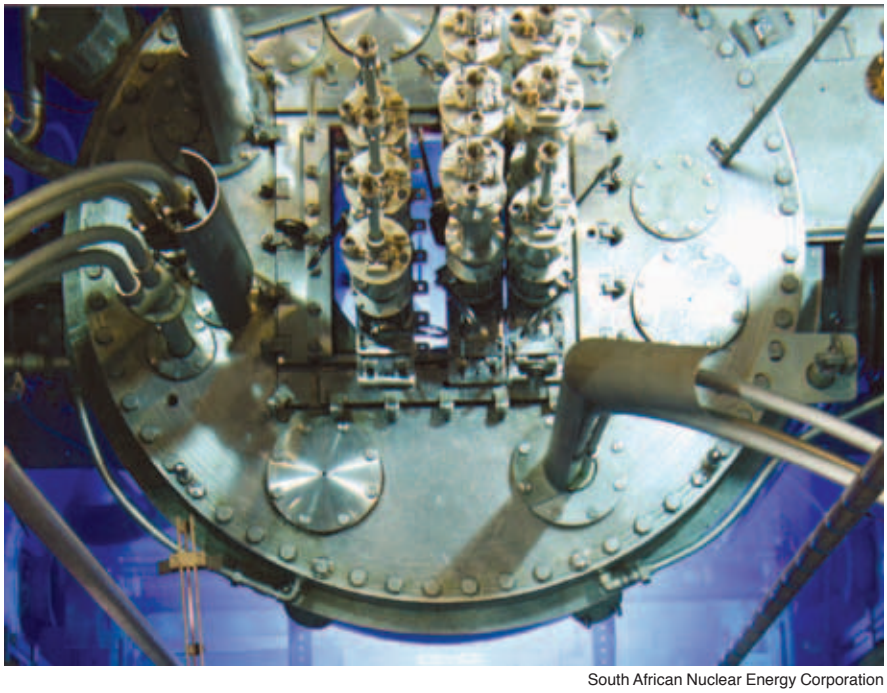
But the coal is all clustered in the northeast of the country. As I indicated, the distance from where the coal is—which is further away from the south than Pretoria is—the distance from the coal to Cape Town, so to speak, is like Rome to London. It's not practical to move the electricity all that way. That's why the Koeberg nuclear power station 50 years ago was conceived of as being down in the south. Koeberg is nearly 40 years old now, and has about [audio loss], so it has a good number of years to go.

We have plans now to build more nuclear power stations around the coastline of the southern part of the country. The coastline—because, number one, that's where we need the electricity to come up from the south; and also because the sea is there to provide large-scale cooling for a big nuclear power station. Nuclear power is the answer for most of Africa, if not all of Africa. Not necessarily big 3,000-megawatt power stations, but for example, small power stations like the South African plans to develop what was known as the Pebble Bed Modular Reactor, the PBMR, which is 100-200 megawatts in size, versus a Koeberg size station, which is 2,000 megawatts in size.

The Pebble Bed Modular Reactor was designed by South Africans in South Africa to take into account our conditions. For example, it was designed not to need a large body of water for cooling, so it is cooled by gas. It can be placed inland, where some of the mining activities are, some of the huge mining activities that need a lot of power. Why not put a nuclear reactor close to the mines? The South African mines underground have hundreds of kilometers of road underground. There's shops underground; there's education facilities for the workers; there's trains that go past, and so on. So, a lot of power is used in these mines.

If one looks at other African countries, *they all need nuclear power,* and a number of African leaders have spoken to me personally and indicated that that's exactly what they need. Because the majority of African countries are not blessed with fossil fuels; they don't have large reserves of coal or gas or oil. So, they need electricity. Electricity is what advances people. It's just not honest for some of these extreme Green people to come along and say, "You're doing the right thing. You're carrying water from the river in a bucket. That is the way to continue living in harmony with nature." I've had some of these Europeans telling me that type of thing to my face. Or to say to a person, "You're using a wooden plow powered by one ox. That is the right thing to do. Do not invest in a tractor, because then you need fuel, and you'll have oil, and you'll produce pollution." That's just not right.

So, we've got to look at what are the real solutions for South Africa as an economic leader of the continent, but then also for the rest of Africa as well, right away past the Equator up to the north. Numbers of African countries have really indicated that they want to go nuclear. Countries like Zambia have started with a project to build their first nuclear reactor that will be used for training purposes. Other countries have indicated they're doing the same. Further to the north, Egypt has started with nuclear power, and so on. So, I would not doubt that you're going to see a lot more in the future.



South African Nuclear Energy Corporation

South Africa's SAFARI-1 is a production reactor for radioisotopes used in medical diagnosis and treatment. It provides perhaps a quarter of world production of the major radioisotopes, including molybdenum-99, iodine-131 and lutetium-177. Shown here is the SAFARI-1 reactor core.

The Power of Nuclear Medicine

Nuclear power is but one aspect of nuclear technology. There's much more than that. For example, nuclear medicine. South Africa has become a world leader in nuclear medicine, and we now export nuclear medicine to over 60 countries worldwide. Nuclear medicine is wonderful. It's used primarily as a diagnostic at the moment. It's by far the best way to detect cancer and some other diseases as well. It's as simple as being injected with a nuclear tracer that goes into the body and is designed to gravitate towards the cancer. There's various formulations, and the medical doctors know which ones to use, depending on what they're looking for. The nuclear medicine will then show, very early on, whether the person has cancer or certain other things. Far sooner than many normal diagnostic methods are able to detect.

Bearing in mind the large distances that I've already mentioned, it's possible to put up nuclear scanning centers way out in rural areas, far away, and have somebody like a nurse present to be able to do the scanning. It is not necessary to have a medical doctor at each one of those scanning sites. They are all then linked by internet to centers where there are medical doctors trained in the field who can then give the diagnosis. So it's possible, for example, to have a scanning center in Tanzania, or in Uganda, or in Kenya, or in Botswana, and have somebody scanned there, and instantaneously have the scan sent through to Cape Town or Pretoria to be diagnosed and the answer sent back to the medical doctor in Uganda or Tanzania, for argument's sake, who is treating the patient, and then work from there.

Of course, what is desirable is for African countries to train their own nuclear professionals. Many people already exist in African countries, but there's huge potential for many more. There are training programs in South Africa. In Pretoria, for example, we already have African trainees in the program—radiographers and medical doctors from other countries.

So, this is an opportunity for Africa to become a world leader in nuclear medicine, which we already are in the distribution from South Africa. South Africa could supply the nuclear medicine to anybody who needs it.

Panel 2: Discussion Session

The following is an edited transcription of the discussion session during Panel 2 of the Schiller Institute conference on September 5.

Before taking questions from the audience, the panelists were given a chance by the Moderator, Megan Dobrodt, to respond to what they had heard so far from the other presenters.

Jason Ross: I thought that this panel was a really profoundly inspiring image of the future that we have gotten from the expertise that is here on nuclear power, on fusion nuclear power, on space science. I saw in the YouTube chat, people were saying, "Wow! Why didn't I know about this? Why isn't this the top thing on the news?" when they heard about how huge ITER is and the international cooperation that makes it possible.

I had a question for some of the other speakers which maybe we can take up now or later, which is to what extent fusion is an engineering versus a science problem. That is, to what extent do unexpected outcomes in fusion experiments create the next generation of fusion experiments? When we create these tokamaks or these other devices, how much of what happens is a surprise to us, versus how much is what we would expect, confirming the knowledge we already have?

Dr. Bernard Bigot: The development of hydrogen fusion from my point of view is both a scientific and engineering issue. We have to assemble all these components in very precise conditions. It has never been done before, so really, engineering as a capability is absolutely decisive. But we are exploring, I would say, *terra incognita*. Never in the world has somebody been able to have a burning plasma, a self-sustained plasma. At 150 million degrees, there will be some turbulence, some different events. We know it will exist, but have never had the experience on this scale. So, from my point of view, it is both, the need for science development as well as for engineering.

Dr. Stephen O. Dean: Thanks, Bernard. We all admire you all over the world for the job you are doing on this incredibly large, complex construction project. We're looking forward to the day when we're actually studying the plasma.

I would just add or perhaps expand on what Bernard was saying. Fusion and fusion science and engineering are in many ways not dissimilar from the history of science and engineering and technology over hundreds of years. We're at the very early stages of learning how to do this, and we have to expect that the first thing we do is not going to be the last thing that we do in terms of improvements and finding new ways to do it, and finding new understandings, and so on. When ITER operates, and when fusion is really there in the laboratory, it's really the beginning of probably a couple of hundred years' worth of things that you can't even hardly imagine. Just like you can hardly imagine our cell phones today, a hundred years ago.

Dr. Kelvin Kemm: It's important to note the advances that have been taken in nuclear developments. The fusion machines, the advanced tokamaks, the space engines that are going to enable us maybe to get to Mars. There are great advances being made in nuclear and far-advanced nuclear—fusion and so on. In the meantime, a lot of work has been done on things like small modular reactors, advanced-generation reactors and so on. There mustn't be brakes put on the development of these nuclear solutions and their deployment into countries like African countries.

What I noted from Dr. Pulinets is that we've got to look at our planet now, we've got to look at a lot of the politics of society. There's the potential of global cooling coming, with which I agree; it's indicated by the sunspot activity. But what we find is, there are psychological and social pressures being exerted to put in wind and solar to supposedly saving the planet from carbon dioxide. Yet indications are that the little bit of global heating that has been detected since the time of President Abraham Lincoln is probably due to magnetic activity on the Sun and is not actually due to human-induced carbon dioxide at all. Scientists have got to much more get in contact with society at large. We need to get the politicians to listen, and we need to try to be realistic. This is very difficult.

Dr. Pulinets pointed out this move towards electric vehicles, for example, and quite correctly, to my mind, said, it'll probably generate more CO_2 to produce an electric vehicle than to just use the petrol [gasoline — ed.]. There are also the sociological effects of children being used in the lithium mines, the cobalt mines, and

so on; and this is not noticed. Paul Driessen made mention of this, of the chasm between rich countries and other countries.

It's just not reasonable for African countries to be told they've got to stay in an archaic state because somebody in the First World thinks they've got an answer which probably is suspect anyway—this carbon dioxide argument. He made it quite clear that people are not realizing what's going on. The death rate from malaria, for example, is high in Africa because DDT has been blocked from being used. There's a lot of human cost going on. We somehow need politics and we need sociology, and we need people like the bankers to pay more attention to scientists. The scientists may be able to speak their language and explain to them what it is that we need.

There are nuclear solutions along the way, and I feel the fusion researchers are at the leading edge at the moment. But trailing behind that is the practical solutions that can be employed today, such as Pebble Bed-type reactors, gas-cooled reactors that are ideal for deployment in African countries and many other countries around the world as well. So, I think it's very important to listen to Dr. Pulinets' arguments about the politics and the sociology and science coming together to find adequate solutions. thank you.

Dr. Sergey Pulinets: I'm happy that what I am talking about found a common language with representatives from Africa. And I forgot to say that if we look at the total cycle of mining of the metals for the accumulators [storage batteries] for cars, then we should think about the utilization. We know that all the small batteries which we have in our phones cannot be disposed of with normal waste; we must take them to special places.

Now, imagine how extensive a technology we will need to handle all the batteries from electric cars. We will have to develop a special industry to deal with these accumulators. The number of these cars is growing to a geometrical extent, and it will create a large problem for the environment.

Michael Paluszek: I've enjoyed listening to all the speakers.

A question for Dr. Bigot: *With the beginning of the assembly phase of ITER this summer, French President Macron made a speech in which he said, "There are times when the peoples and countries of the world choose to overcome their differences, to rise to the historical challenge of their times. The launch of the ITER project is one of such moments. ITER is a promise of peace." From your perspective, Dr. Bigot, what does Macron mean that ITER is a promise of peace?*

Dr. Bigot: On July 28, we were very pleased to hear the views expressed on the ITER project by the heads of state of the seven ITER members, as well as on the significance of the start of the assembly phase. French President Macron stated very clearly that the world needs energy; energy is life. Without energy, there is no biological life, nature, or economic life, or social life and development.

The world's energy supply is not well distributed. Some countries have quite favorable resources of fossil fuels; some others have quite favorable conditions for renewable energy. But many have difficulties ensuring a long-term national energy supply. Fusion uses a raw material, seawater, and a very tiny quantity of lithium, both of which are widely distributed. So, with fusion we will avoid competition and confrontation as in the past when people tried to get energy from some other part of the world. It was the reason that we are developing hydrogen fusion, and as it now agreed, fully shared among all the people. The intellectual property will be fully shared with all ITER members and more broadly. It could be a breakthrough for long-term peace for the world, if I correctly understand the meaning of President Macron's statement.

From a science professor at a college in New Jersey: *We have already employed fission in space missions. Besides propulsion, what other uses would fusion bring to our space-faring society? For example, could fusion aid in* in situ *resource utilization?*

Dr. Paluszek: Fusion can be used just like fission for both power generation and propulsion. Fission is interesting, because one option for fission propulsion is nuclear thermal, which can produce fairly high thrust. Fusion typically is going to produce—the technology we've looked into—would produce much lower thrust. It's only really suitable for in-space and fairly slow missions. But both types of reactors can be used for Mars bases or lunar bases. NASA is pursuing fission right now, because the technology has been developed to a fairly high level of development in the Kilopower Program.

Fusion is quite a bit off in terms of time; you're talk-

ing about 15-20 years before you could use fusion technology for the same kind of thing. I imagine that the first application of nuclear power in space will be either nuclear-electric, which is being proposed for some missions, or also as power for bases on the Moon or Mars.

Ross: One thing on resource utilization that comes to mind is how both fission and fusion differ from using chemical power or solar power, with respect to what you would need on another planet: That's the processing of materials. We're trying to essentially use the crust of the Moon or Mars and extract the resources from it.

It's difficult to pull metals apart from oxygen that's combined with them chemically. Here on Earth, we use coal to do that; both to provide the heat, and the carbon is able to pull out the oxygen in the form of carbon monoxide and carbon dioxide. We're not going to be using carbon for that purpose on another celestial body. Having a very intense supply of energy means that it is possible to find another way of separating the metals from oxygen so that we could more effectively make use of that on another celestial body.

A question for Dr. Kemm: *Had fusion been available as a power source by the 1990s, what do you think the population of the planet and the continent of Africa might be by now?* [Audio problems delayed Dr. Kemm's answer until later in the discussion.]

Dr. Bigot: The development in Africa, and everywhere in the world, is definitely depending on energy in order to develop, for example, hospitals and medical things. I am pretty sure that if there were easy, safe, clean energy in Africa, everywhere in the world, the development of Africa would have been much safer and much steadier. But it's very difficult to predict the population because it is dependent on development, education, and also individual behavior. My understanding is that it would have been much safer development if they had had more reliable sources of energy.

Question: *How can we go to Mars or even to the Moon when we're facing a major constraint, which is to be able to cross the Van Allen radiation belts?*

Dr. Pulinets: It's a problem, but we can select the trajectory of the space vehicle to pass in the polar regions where the magnetic field lines go inside the magnetosphere, and between them, we can send our space vehicle. Essentially, this was the way our polar missions were sent to the Moon. Yes, the radiation belts are a problem, but it is possible to select the special trajectory of the space vehicle to avoid danger to the astronauts.

Various partner nations' contributions to ITER are in the form of manufactured components, such as magnetic coils, vacuum vessel pieces, and so forth. Today, there seems to a trend of placing sanctions on companies from some of the nations involved in ITER. Has this impacted ITER, and if so, how have you dealt with it?

Dr. Bigot: Seven nations have signed the ITER Agreement, with a total of thirty-five countries joining forces because they know there is no alternative option for them to develop fusion. Since I have been involved in the ITER project, whatever political debates happen among the members, ITER has not been impacted. They all realize that they have to preserve fairness among them in order to succeed. So, for the time being, I have not experienced any difficulty about what you said, about the banning of some companies. So far, it has never happened, and work has been proceeding in the best way.

The ITER project is a good illustration that when there is a common understanding among all the nations and the political leaders, that there is no alternative option for them but to join their forces, sincerely, so that work can be done. From my point of view, it's a very good example for many other issues the world is facing, for example, about food, medical, disease, all these things. I ask you to pray to preserve this type of cooperation in ITER, as well as in many other fields.

Dr. Pulinets: Scientific cooperation has always prevented military conflict. We remember the Soyuz-Apollo common space project between the United States and the Soviet Union. Now, we are many countries working on the medical vaccine against COVID-19, and so on. It is very nice to hear of a large scientific project which unites different nations, even if they have some conflicts in different issues. For example, China with India, and so on.

A question directed to Dr. Dean, Dr. Kemm, and Dr. Pulinets: *What about a 15-year program for building a new design for a nuclear fission plant, including*

Pebble-Bed and thorium designs, moving to fission-fusion hybrids, and then fusion at the point of feasibility? As better technologies come online, we discard the old, but we evolve from fossil fuels as much as we can. We can, if we wish, use as much oil or coal as we want, because we have a vision of where we are going.

Dr. Dean: I think the development track that was just described is a possible track, except for the last point you mention. Which is, we can then use as much fossil fuels as we want, because we have a carbon problem into the atmosphere that needs to be dealt with in the next several decades. But in terms of the technology path of coupling fission and fusion, and then going on from there to pure fusion, that is definitely a possible development track. It is not a track that either fission people or fusion people seem to be pushing for. They each like their own separate tracks, but it has definitely been looked at from time to time, and it is technically a track that could be followed.

Dr. Pulinets: I think that in addition to development of the traditional nuclear power plants, you probably know that in Russia we developed fast neutron reactors. The advantage of these reactors is that they can use all radioactive elements which remain after the first reaction. So, there is no waste after elaboration of products inside this reactor. It is a completely pure technology. Before we reach essential results on fusion, we can use instead these fast neutron reactors.

Question: *How does the increase in scale change the internal plasma confinement geometry of the fusion reaction? Does the ITER design take the unknown variables of this very complex process into account?*

Dr. Bigot: The ITER design has been developed during nearly 15 years. It was based on the decision of President Reagan and Secretary Gorbachev to launch a large international research cooperation. So, the physicists, based on many years of experience, including in the U.S. as well as in European tokamak, decided to shape the plasma as a D shape, which offers the best stability as well as the best way to collect energy. For a large plasma vessel like ITER, as I mentioned—it is over 800 cubic meters—this shape is very well suited. On some other design, maybe the shape could be different. There is not a single way to proceed, but from my point of view, this selected shape for the ITER tokamak is appropriate for the size we have right now.

Dr. Dean: I think there are some things which were developed over the years from dozens of tokamaks of various sizes. So, there's a lot of back-up from a lot of experiments from small to larger tokamaks that have gone into the optimization of the ITER geometry.

Dr. Bigot: We are fortunate now to have what we call the modelling, simulation. With a large computer and appropriate software, we can model very well the plasma behavior. So far, with this modelling, nobody has found a better shape for the ITER than the one we have selected.

But as a research program, certainly if there are some changes, we will accommodate, we are able to accommodate. It is a research project to optimize the fusion capacity in order to offer the best option for the world energy supply when we will have completed the research program.

Ross: The ITER is enormous; it's an international project. Space is an international concern. There's one space and it's for all of us. I was wondering, Dr. Pulinets, if you had any thoughts about if there's a conflict between the military use of space, and then, civil uses. One of the fields I know you've been studying a great deal, Dr. Pulinets, is earthquake forecasting using the ionosphere. Is there a big conflict between these two uses of space? Do you have any concerns about the militarization of space?

Dr. Pulinets: No, I don't think there is a conflict between these directions inside the same country. Every country has its scientific program of space research and some part of the military program. But when we go to the international scale, here appears the source of conflict because we are developing technologies which give possibility to change the orbit of space vehicles and to approach different space vehicles. Everybody feels a threat that somebody could do something with his vehicle. I think the only way, is to develop wider international cooperation, to make common projects.

For example, our Space Research Institute put several devices on the European mission to Mars which is working now. We put devices on the mission to the Moon. Russia launched a regular telescope and had two devices from Germany. This is the way. Then, the sci-

entists meet together, do common work, and this is the best way to avoid the military conflicts. To avoid these conflicts, we should create good agreements on the peaceful use of space. Unfortunately, recently the United States left some of them, and this creates an unstable situation.

A question for Dr. Paluszek: *My question is on the implications of Direct Fusion Drive (DFD) for Artemis, the Gateway, and Moon villages. Where does DFD stand in relation to these projects?*

Dr. Paluszek: That's a great question. Remember, Direct Fusion Drive is many years off, so if we're landing people on the Moon by 2024, 2028, it really won't be ready to support that. One architecture where DFD could be valuable is as a transport of materials. If you wanted to move a lot material between Earth orbit and lunar orbit, and had enough time to do it—in other words, it was not a vehicle with people on it, because you would not want to expose them to cosmic rays for long periods of time—then it would be a way of moving a lot of mass so that we could expand lunar settlements. But at the moment, it's really not in a position to support Artemis as it's going on now, which is pretty much following the Apollo template.

A question for Dr. Paluszek: *Your design is quite small, compared to ITER. And it obviously has a slightly different purpose. Do you think that work being done on fusion for space propulsion and space power could help make advancements for the development of fusion here on Earth?*

Dr. Paluszek: Absolutely! The work being done on ITER helps us; we read all the technical papers and all the plasma physics. The areas of controlling the plasma in ITER are directly relevant to us. Any time you look at an area in plasma physics, whether it be our machine, which is one type of configuration; there are mirror machines, there are stellarators, everybody benefits. Anytime you look at something from a slightly different point of view, you may discover new things. We're always talking to people who work on tokamaks, the plasma physics lab, they have a different configuration, the national spherical tokamak experiment. We're constantly exchanging information and ideas with them. The more people there are working in this area, the better off everybody is.

Two questions from Berlin: *When will the first fusion power plants be finished for using electric energy? When will mankind settle on the Moon and Mars?*

Dr. Dean: We do get the joke: "Fusion has always been 30 years away, and always will be." It's taking a while, and it's going to take a while longer. My personal opinion is that we don't really know. I think it could be done in 15-20 years, and it could take 30-40 years. We're all watching to see how ITER goes, and we're all looking at a bunch of—as I mentioned in my talk—a bunch of ideas to see if we can get fusion with something a little smaller that might be able to be built faster than ITER. ITER has really advanced the capabilities around the world to make the kinds of equipment that any fusion machine in the future may need. So, it certainly allows any idea that people have, for moving faster to a timeline goal more doable.

The truth is that right now none of the countries have a commitment for any kind of a timescale to say, "We're going to have fusion on the grid by such and such a time." You will hear various advocates of various concepts, especially in the private sector, say that in 10-15 years they'll be making some electricity, but that's sort of about the fastest you can imagine doing it. But it could well take longer.

My personal opinion is that maybe by the year 2045 or 2050, there will be at least one fusion reactor putting electricity on the grid. But there's not going to be a hundred of them. A few fusion reactors are not going to make a dent, percentage-wise, in the world's energy needs. So, even when you have the first one, say in 15-20 years, it's going to take decades before fusion is making 30% of the world's electricity.

Ross: Did it have to take this long? Steve Dean just brought up this joke that fusion is always some number of years away. Why is that a joke? In other words, was that correct when it was said, say 30 years ago? Were those estimates unavoidably wrong, or was this just a lack of a commitment to make a breakthrough that could have already happened by now?

Dr. Bigot: If I may comment to Steve. From my point of view, ITER is a very sizable piece of equipment. It takes nearly 25 years with seven ITER members, which represent quite a large share of the world industrial capacity, to build it. So, it took quite a long time in order to assemble this large coalition.

From my point of view, this is the first question—people know from the beginning that we need quite large equipment in order to be able to demonstrate the feasibility of hydrogen fusion.

Second, the quality of the work which has to be done in order to ensure the condition for this burning plasma is quite strict. For example, just to manufacture one of the nine vacuum vessel sectors, which are double-walled stainless steel pieces weighing more than 450 tons, nearly 20 meters high, by the best company in the world, took nearly six years.

We are now passing a point where the feasibility of this development is quite predictable, to achieve a first plasma by 2025, but still it is a challenge. After that, we will proceed according to what we call a staged approach, where we will complement the installation in order to have, for example, the recycling of the fuel and also the breeding system of the tritium. In this way, we are complying with our goal of full fusion capabilities by 2035.

My belief is that engineering capacity and industrial capacity will take over as a result and develop fusion power more rapidly than some people believe. That's why I am fully online with what Steve said a few minutes ago. By the middle of this century, we will be at a turning point where this technology will have demonstrated its capability or not. If it has demonstrated its capability, it will be developed very rapidly. We cannot sustain burning fossil fuel as we do now. So, we know whatever development is available in energies, we will need a complementary way of producing predictable, massive power.

In the past, it was right that fusion was always 50 years ahead, because we have not taken the proper measures. Now, I do believe we have taken the proper decision to move in a steady way to demonstrate the capacity of hydrogen fusion.

Dr. Pulinets: On the second question, about the Moon and Mars. It is connected with the previous one about radiation belts. It is not a problem to bring the people to the Moon and Mars, because it was already done. But still remains the problem of the long stay of people on the Moon and Mars; it is solar radiation. We have not enough good measures to protect people from radiation. So, I suppose the main problem will be not the transport of people to the planets, but to protect them from the solar radiation.

A question for Dr. Kemm: *How is it that South Africa has been able to secure such a vastly different standard of living than other nations in Africa? Why has South Africa been able to develop nuclear power while other African nations haven't? Is it because of the historic economic advantage, a conscious fight against supranational institutions like the IMF and other efforts to impose constraints on development?*

Dr. Kemm: I think that's a difficult question to answer. One of the things was, of course, that the Cape sea route was very important since the late 1400s, when Portuguese explorers first rounded the Cape on their way to India. So, there was a lot of economic activity that occurred around Cape Town.

Because of the importance of that, the British moved in, the Dutch moved in, the French moved in; there were a whole lot of people that came into South Africa. Some of the early Dutch settlers were only interested in settling on farms and having their cows and their crops. They were very religious people who left Holland.

Two internal republics deep in the country were formed; one was called the Transvaal and one was called the Orange Free State. There was a rural lifestyle there, based on farming. Then fortunately or unfortunately, depending on whose point of view you look at, diamonds were discovered in one, and gold was discovered in the other. That attracted the business people, the industrialists, and that ended up in the famous Boer War at the end of the 1800s, into the early 1900s.

Interestingly, Russia came and fought on the South African side, and so did the United States, and so did some French people. There was a famous French general who came and fought for South Africa.

There was this complete mixture of people, and this was to do with the discovery of the wealth. I think that catapulted the country forward a lot. It didn't happen to some of the African countries that were deeper in. Then over the years, South Africans have shown a lot of initiative, and we've been frequently isolated and so people found their own solutions.

South Africa is, I think, the third oldest nuclear country in the world; we were in on this very early. The South African Atomic Energy Corporation, the nuclear energy corporation, was established in 1948. The Atomic Energy Commission in America was established in 1946. So, we were only two years behind. Nuclear has been going for a long time here, and there's just been a lot of interest. Even now, there's a youth

nuclear society of a couple hundred young people who see nuclear as a career option.

Part of what we see here, is this unreasonable attack by extreme Green organizations trying to prevent African countries from getting into nuclear technologies. Not only African countries, many countries, supposedly to save the planet. It does not appear to be the case at all that the carbon dioxide produced by mankind is actually the problem, as Dr. Pulinets pointed out.

Part of what we need is, we need society to listen much more to scientists. We need scientists to talk to society. There's been a traditional divide there. Scientists talk very technical language to each other. They think they're reducing the language sometimes when they go from post-graduate level to just under-graduate level. But that's still about four or five years ahead of what the average member of the public can understand. Then it's the politicians and the people holding the money like the bankers, who are the ones who largely determine where a society goes.

So, I think it's terribly important that science must much more explain to society what's going on. Things like tokamaks, things like nuclear-powered engines for space and so on—that's the leading edge of thinking which one of these days will lead to nuclear reactors on land which supply power for the lights in the street. It's this sort of thing that is going to advance society, and that's what we need to get right. It's important.

At the moment Africa desperately needs more electricity, and they've been told to go for things like solar and wind options, because that's supposedly in the interest of the planet. But it plain and simply isn't. As Paul Driessen pointed out, it's killing people here in Africa. They're dying because they do not have fundamental electricity deeper in Africa. Many of the countries there are 15% electrified, for example. It's immoral to tell them they can't get more electricity.

At the moment, it looks like one of the best ways to do it is small, modular reactors of various types, of which the South African PBMR and another variant, the HTMR-100 that has also been developed here—a simpler version of the PBMR—are solutions for Africa and elsewhere. So, we need to put those solutions into operation.

We can't be held back because somebody else's politics are holding us back. I think countries like Russia—I've been to Russia a number of times—they have very similar problems to us socially. You see it in South America, you see it in Indonesia, you see it in India. There are many countries that are in the same position. We have a very advanced First World element to South Africa, but on the other end, we have people living in mud huts. We better bridge this divide. That is the situation faced in many parts of the world, and it needs attention.

A question for anyone on the panel: *How could the development of fusion power affect mankind's ability to deal with the dangers of asteroid and comet collisions with Earth—what is sometimes called the Strategic Defense of Earth?*

Dr. Paluszek: A fusion rocket will allow you to intercept an asteroid earlier, and the earlier you intercept an asteroid, the easier it is to push it, so it won't hit the Earth. So, that's one of the potential advantages of fusion technology. You can also do it with other kinds of technology—nuclear thermal, nuclear electric—but fusion would allow you to do it.

Dr. Kemm: I think what's also important there, in dealing with something like fusion and so on, it's the leading edge of thinking, and you need to encourage the leading edge of thinking.

We've been hearing for a while about this fourth industrial revolution. What the fourth industrial revolution is, is to take the tools at your disposal and see what ideas you can come up with. If you've got more tools at your disposal, whether it's fusion technology or more advanced fission technology, also better telescopes and mechanisms for looking into deep space to detect asteroids and so on when they're still far away, the navigation to get there very accurately. All of that needs to come out from the advanced thinking which needs to be encouraged.

Once you have much more information at your disposal and more tools to deal with it, then you can go out and get those asteroids early. Because what happens with the asteroid if you detect it early enough, with a small deflection, you can send it away. But if you get it too late, then even if you blow it up, you still effectively [allow the fragments to] blast the Earth with a shotgun blast.

We need to be able to advance technology generally, and that means fusion thinking and many other types of thinking should be encouraged. Because that's where the Earth is leading, where the gulf becomes even greater between what the scientists understand and

what the public understands of what the scientists are trying to tell them. So we need to be aware that that gulf is dangerous if we don't make efforts to inform people of what's going on.

Ross: I have a question for Dr. Kemm. If fusion had been achieved in the 1990s, what would Africa look like today?

Dr. Kemm: I think if fusion had been achieved, of course, we would have been able to produce incredibly cheap electricity in great volumes. In South Africa, nuclear power today is the cheapest power by far, but there's political resistance against it.

But certainly, if fusion had come about in the 1990s, for example, such that it was economically viable—and you could place them wherever you want to and get fuel, which is effectively from seawater—those problems would have been solved, and it would have led to very cheap electricity. That should be an objective to try and get the cheapest possible electricity that we can, that's as distributable as much as possible. Because that enables people to think and to come up with solutions to solve the sociological problems which we have.

When we get people now, as Paul Driessen said, who come along and say, in the interest of the planet they're going to put the brakes on development, it just causes many more people to die.

In fact, I believe that if many more coal-fired power stations were built in Africa, it would *reduce* CO_2 emissions. That sounds back to front. The reason why, is that there are tens of thousands of people who have cooking fires outside informal dwellings, and they just burn wood, charcoal, dung, anything they can get hold of. That's producing a lot more atmospheric pollution and a lot more CO_2 than a controlled, high-efficiency, coal-fired power station.

One has got to look scientifically at what are the solutions for mankind, and we ought to stimulate all over, which includes the physics of tokamak development and toroidal devices one way and another. And fusion and so on, because it's that leading-edge science which eventually becomes the economically viable science that goes into everyday devices. So, we need to encourage all of it.

Ross: The whole platform overall of electrification. Leaving CO_2 aside for a moment, if you talked about air pollution in terms of having an immediate effect on human health, building coal-powered plants in areas that don't have electricity, *of course* reduces air pollution. Certainly, experienced air pollution, compared to a fire in your home? That's a lot of pollution right there.

Dr. Kemm: This is why nuclear is a solution for Africa. There are too many people who see big nuclear as being for the advanced First World, and it's not the case. Building pebble bed-type reactors, small modular reactors of 100 MW even down to 10 MW—there are designs for 1 MW. I believe there will be nuclear power on Mars, for example. There's not any other alternative. So, going for small nuclear, and understanding that nuclear is the future.

I'm convinced that in 100 years' time, 200 years' time, children will be taught, "Way back at the beginning of the 2000s, when mankind wasn't sure about the transition to nuclear." Just like now, we look back a century and say, "Good heavens! Horse-drawn carts in London and places like that gave way to trams and motor cars." These were all considered hare-brained schemes. Wooden sailing ships gave way to steamships. All of these at the time were massive transitions in the psychology of society. I believe we're right in one of those now. We're in a psychology where we've got to understand that nuclear is the right answer.

You find, for example, false impressions that are there around the world. Look at Fukushima. At Fukushima, *not one single individual was killed by nuclear radiation;* not one single individual was *harmed* by nuclear radiation. No private property was harmed by nuclear radiation. People died because of forced removal, because they had heart attacks when they were forced to move out of their houses in a hurry. But nobody died from nuclear. So, Fukushima was not a nuclear accident; it was a conventional industrial accident as happened at the oil refinery down the road and has happened at the airport and the shopping center and many others.

Chernobyl as well; the same thing there. The total deaths in Chernobyl were something like 50. But the figures that go around the world in some circles are thousands and millions, and so on. The psychology that's created to be anti-nuclear and is effectively anti-progress is huge. Dr. Pulinets mentioned that type of thing very much.

I've talked to many senior politicians and bankers, and often I walk away appalled at their lack of understanding. Then I say to myself, "But what have we told them?" You find bankers haven't the faintest idea of how nuclear works. They vaguely read about it in *Fair Lady* or *Vogue* or something like that maybe, but they really have little understanding. This gulf is getting

bigger. The gap between somebody talking about toroidal fusion devices, tokamaks, and so on, and then talking to some person in the pub—it's huge. We've got to address that problem; otherwise, there's a scare reaction. People say, "I don't understand it, so I'm opposed. Let's block it." We can't allow that to happen, so we better much more talk to people and get them to understand what's going on.

Nuclear medicine was mentioned earlier. South Africa exports nuclear medicine all over the world, to over 60 countries. There too, when you say to people, "I want to deliberately inject you with some radioactive material," a lot of people get scared. You must explain to them beforehand, that it is very mild, it all disappears within a few days, and it's highly beneficial. But the whole system at the moment of medical aid and so forth, doesn't make that easy. The system can be very easily deployed, and where it is working, it's working exceedingly well.

But we need to really go out and do a much bigger campaign to explain to people why these things are so important and why they have to believe in them and believe in the scientists such as you fellows who are here today that know what you're doing. But it's difficult to get ordinary people to understand what's going on.

Question: *What would be the advantages of moving to helium-3 as a fusion fuel? And what are the prospects of mining helium-3 on the Moon?*

Dr. Bigot: Helium-3 is also one of the possibilities for fusion, definitely. But as you know, it is a very tiny quantity in the world. So, if there are larger sources of helium-3, yes, it could be an option, replacing for example tritium. It has been demonstrated on some of the sites. But, so far, there is not. So, yes, if there is an easy way to get this material from the universe, it would be interesting. I know some people are thinking about that.

Dr. Paluszek: Our design uses helium-3, but our device is much smaller than ITER. And a lot of the advantages of helium-3 reside in smaller designs. One of the problems with the helium-3 deuterium reaction, well, that has no neutrons. You do have [some neutrons from] side reactions. The other problem is that you have to get the very high temperatures. The Tokamak Fusion Test Reactor [at the Princeton Plasma Physics Laboratory] reached about 50 kiloelectron volts; you need to get closer to 100. So, that is a problem which deuterium-tritium does not have as much. They don't have to be heated to quite as high a temperature.

But as pointed out, the supply of helium-3 on the Earth is very small. If you were to use it now, I suppose you could actually burn it in a reactor. You're talking about 100 MW of power, which is a tiny fraction. Perhaps valuable for some very high-value applications, but not for general power.

In terms of helium-3 mining on the Moon, there is helium-3 in the regolith; it would be expensive and complex to mine, as an economic problem. What is the cost to get helium-3 back from the Moon to the Earth? No one really knows; there have been a lot of studies, but they're just speculative.

Also, the gas giants have helium-3 in their atmospheres, and that's another possible source. But again, it's something where people have done a lot of paper studies, and they're good quality studies, but until you actually start building the technology to do these kinds of things—to mine the Moon, to go to the gas giants and extract helium-3—it's all very difficult to know whether or not it could have a major impact on fusion energy development. Right now, the D-T [deuterium-tritium] approach is good, because deuterium is widely available, and tritium can be bred. So there is an ample supply of those fuels, and that's why all the mainstream fusion efforts are using D-T.

Dr. Dean: I think the subject was thoroughly and correctly just covered.

A question from a young person from the Bronx, New York: *I want to suggest that we have a panel like this, which can be several hours long for young people, just on this question of energy and the direction of the future. I have talked about the idea of a space Civilian Conservation Corps, which means space research centers built inside the Bronx where I live, and other poor areas. This should be done all over the world. But young people need to get on a Zoom platform with many of you and ask questions. Will you do this?*

Dr. Kemm: Yes, absolutely. This is the type of thing that you do need to do. This is what I've been saying, and I've quite a lot gone around to various schools and places like that, and chatted to people. What you find are some very well-meaning people who have got such incredibly misguided ideas. It's not that they're trying to be negative, it's just that they so don't understand something that we take for granted, that they come to such incredibly false conclusions. People believing that radi-

ation is something like honey that will drip down off a table onto the floor, or something. You try and explain that it's got to go in straight lines. That one actually happened to me, and there's numbers of others as well.

You just cannot believe what people believe, the lay person. You say, "Who told them the truth?" And we don't. So, I think it's very important for these young people to get this. Because what do we see on the other side, like with the extreme Greens, to put it bluntly? We see school children marching in the streets, telling they're not going to survive to the end of their lives of their natural generation because the planet's going to collapse, and so on. So, there's a lot of problems like this.

I think space advance is going to go a lot faster than we think. If you look at the SpaceX rockets that have been launched now—there's one going up about every 10 days. They've been made to reverse down. Just a few years ago, if somebody had said, "Imagine a vertical rocket that takes off, goes all the way up to space, and then reverses backwards and lands on its own legs on the place that it took off from." You'd say, "No, that's science fiction; that's not going to happen." But it has.

The Mars Starliner has launched a couple of test flights now. It comes back and lands. That's going to go to Mars, and it's designed to carry many people. I think we'll see a Mars base in no time. I think we'll see the mining of the Moon; we'll see the mining of asteroids. The gas giants may be supplying helium-3. I think a lot of these things are going to come about.

Just cross your mind back only a few years before GPS on your cell phone. If somebody had said, "Do you know about GPS?" I knew about that when I was student, but that was aircraft carriers with two-meter diameter antennas aimed at satellites. Multi-million-dollar systems for an aircraft carrier. If somebody had said, "You can have GPS in your car," I would have said, "No, that's impossible. You'll never be able to do that; it's beyond good sense." But we do it today.

Emails, so on and so forth. It's unbelievable what we now accept as reasonable, which only a few years ago completely wasn't reasonable to the man on the street. We as scientists know that in the not-too-distant future, the next 5-10 years, there are other things which are going to come about which sound now completely unreasonable; let alone what's going to happen in 20-30 years' time. There are things we can't even believe are going to happen. Even more reason to keep the research going on fusion, tokamaks, toroidal, all sorts of devices, and any ways like this, too. Because things are going to happen that you just can't conceive of now.

So, yes, we need to chat to young people and say, "Try and use your imagination to try and understand what we conceivably have in the pipeline. Because it's there, it's coming."

Dr. Bigot: Reacting to what the young fellow from the Bronx said, I do believe we need much broader education efforts. And these new electronic devices offer us a unique chance to share directly the ideas of the ones who are now in charge of developing some research for preparing the future of the world, with the young generation, to motivate them to consider science—as it was stated a few minutes ago—a real asset for the world to overcome the difficulties we face. It's why I am pleased to see all the speakers today spending four hours of their time and answering questions from the public. Maybe this will be widely broadcast and produce new motivation.

As part of the ITER organization, I receive a lot of requests from the younger generation. Every week, I pick one or two of them, and I offer a 15-minute Skype call with me. I can say that these calls are usually very interesting.

Dr. Dean: I'd just like to add that Bernard is to be congratulated. He's in the midst of a very difficult construction management task, and yet he has shown so much willingness to broaden out and make opportunities available to young people through his internship programs and various other things like he just described.

In closing, I would like to say that I've enjoyed the few hours here that we've had together. Hopefully, we can all keep in a little better communication together as we go forward.

Dr. Paluszek: I think it's important that young people get involved in science and technology. It is the obligation of everyone who is doing research and development of it, as we all are doing, to make sure that happens. We hire a lot of interns, and we find interns are a great source of enthusiasm, and oftentimes really great ideas. We talk to elementary schools, middle schools, so this is all an excellent thing to do. The important thing in general is to make sure that the people are educated consumers of the information they get so they can make decisions, so they can support technologies or things that are good for society. And they're able to make their own decisions, because they're getting all the information.

Dr. Pulinets: I support Professor Kemm; we should make wider scientific outreach to young people. We should bring these ideas to young people. They need to understand what we are proposing. This is the first thing. Secondly, we discussed energy, how to support human life on our planet. We see the perspective for fusion is only the middle of this century, and we have discussed what to do during these 30 years between today and the middle of the century. Again, I want to support Dr. Kemm on that. Nuclear power is the only possible alternative to thermal power plants and the use of oil, coal, and so on. This technology is safe and will provide the energy to different countries, especially for Africa, which needs this energy.

The last thing is that we should develop the wider scientific cooperation like ITER. We have many areas for such cooperation in physics, medicine, space, and so on. We should provide a force to organize this widest international scientific cooperation. Thank you very much.

Ross: I'm very happy with the request from our young person in the Bronx, I'm happy to help in any way I can on that. Look, something very bad happened 50-60 years ago, through the 1960s, between the time of the assassination of President John Kennedy, the assassination of other leaders, the creation of a total shift in culture. A projection of the past, some of that was correct, but much of it wasn't. A tendency towards thinking that development is a problem; that the Earth is imperiled in a dramatic fashion; and that the way to fix these things is to hold back on technological progress; or that science is creating problems, or development is creating problems.

In fact, it's exactly the opposite. As Kelvin Kemm discussed the use of dung and what have you, for fuel, that's very bad for the local environment inside your home if you're burning wood in the middle of it. The worst kinds of conditions, as described by Paul Driessen, in terms of resource extraction, of children working in cobalt mining, the poor conditions for that in the Congo. These are relatively poor areas. Whereas, in areas that are more developed, you find in general a much cleaner living situation; a much improved one.

Progress was really hijacked as a concept from what it used to mean in the 1940s and '50s, which was getting power out to people; getting power out to farmers; bringing electricity to the world; ending colonialism and imperialism at the end of World War II. President Franklin Roosevelt intended that he was not planning to defeat the Nazi and the Japanese empires to let the British Empire just keep doing its thing. He totally opposed that. He said, "We're going to free all of these colonies, including yours, Winston Churchill."

In now saying, "We've gone too far, let's go back," the effect of this has been, especially on the poorest people within the United States and especially around the world, the withholding of energy sources that can make their lives much better. This is unconscionable and has to be rejected.

Achieving international cooperation on big things like ITER is great. We should be doing it on so many broader levels. The Chinese Belt and Road Initiative that Helga Zepp-LaRouche described in the first panel, the big push towards cooperation and infrastructure with neighbors. Where is that sense of huge infrastructure advancement in the United States or Europe right now? We don't have them in the same way, and we would benefit so much from these broad projects, from dramatically increasing the funding for science, for space.

The optimism that creates, from seeing new breakthroughs, seeing these new developments, from seeing poverty eliminated from year to year around the world, will be a balm for people, and I think it is a very important part of reconnecting around what it is that makes us human: The shared ability to make improvements in the lives of literally everyone on the planet. That is the kind of real direction to create, to displace this promoted tendency right now to break apart people's identities into small pieces, to look for micro-aggressions, all this kind of stuff that we're familiar with.

Part of what makes that possible is an education system that puts too little emphasis on recreating discoveries; that focusses more on assessing people with just countless tests; assessing people based on having the right answer to questions, and not really having the time or the freedom to say, "Let's go through and let's remake a discovery. How did Eratosthenes discover that the Earth was round, and measure it? How did he do that thousands of years ago? Let's do that in our school now, with another school." That's something every kid should go through.

Is the Pythagorean theorem true? The geometry isn't hard, but it's almost never done, so people just get this habit of thinking they know things, when really, they don't. The real problem in that is that acquaintance with the discovery process itself is something we really need to cultivate in young people to have the most fruitful next generation of scientists and thinkers and people who are able to understand and appreciate what we have in common as human beings on this planet, and what sets us apart from the animals.

II. The Truth of Man and Nature

February 21, 1998

What Is Physical Economy?

Lyndon LaRouche presented the following speech at a seminar in New York City on Feb. 21, 1998. Subheads have been added.

GFDL/Xvolks

Authorized by Jean-Baptist Colbert, First Minister of France, in 1666, the Canal du Midi in southern France was an early physical-economic work of a government that was built to promote the general welfare of a nation.

In principle, we should know that physical economy is peculiar to human beings. No animal is capable of physical economy. But, economy obviously has existed as long as people have existed, because physical economy is essentially the relationship between man and nature, based on a consideration which exists only in man, and in no animals: the power to make discoveries, typified by what we call today discoveries of principle in physical science.

However, the knowledge of science, the knowledge of physical economy, belongs to modern times, for reasons which I will indicate. It emerged by stages in Western Europe, toward the end of the Sixteenth Century, and during the Seventeenth Century.

What is generally called economy, wrongly, in most textbooks, is actually a study of methods by which economies have been administered. Because, for a long period of time, all societies which were organized societies, had methods of administering man's relationship to nature, in matters that we consider today subjects of economy. But there was no science which explained how man interrelated with nature, and no science of administration, which studied the relationship between man and nature.

What developed in Europe after the Fifteenth Century, developed as a result of the creation of the first modern nation-state, or the first approximation of a modern nation-state. The first nation-state as such developed in France between 1461 and 1483, under Louis XI, and for reasons I shall explain. Then, following that, in England, in Germany, and in France especially, during the Sixteenth Century, there were various efforts to understand how the new form of society, and the new form of national economy, changed the way in which society related to nature.

This generally came to be called *cameralism*, which developed toward the middle and latter part of the Sixteenth Century. Out of cameralism, there came

a revolution in the last quarter of the following century, the Seventeenth Century, when the first science of physical economy was actually presented. As a matter of fact, what can rightly be called the first scientific economy was developed as physical economy during that period.

These discoveries were made by Gottfried Leibniz, who of course is the father of much of all European science. Leibniz began writing about physical economy in 1671, while he was based in Mainz, Germany, and continued to do this work from 1672 on, when he was, for a period of four years, a student under the protection, or a collaborator under the protection of Minister Colbert of France, and the French National Society of Science, where he was first associated with Christiaan Huygens, another famous scientist. From that time on, until his death in the early Eighteenth Century, in 1716, Leibniz was massively involved in the development of a science of physical economy, and in questions of administration related to that.

Portrait by Johann Friedrich Wentzel

Portrait by Ivan N. Kramskoi, 1878

Gottfried Wilhelm Leibniz (left), the father of much of European science; and Dmitri Mendeleyev, the great Russian scientist, who conceived and constructed the Periodic Table.

He is famous for his relationship to Czar Peter the Great of Russia. The first attempt at developing a modern economy in Russia, came from Leibniz, on the basis of Leibniz's advice to Peter the Great. For example, at St. Petersburg, there was established one of the many academies of science which were developed by Leibniz. In Russia, in various periods after that, the development of economy was associated with Russia's science, physical science especially. For example, in the late Nineteenth Century, one of the most important economic thinkers in Russia, was the famous Dmitri Mendeleyev, who is otherwise known for the Periodic Table.

The Land-Bridge

Just let me interpolate here one point about Mendeleyev, which pertains directly to the Land-Bridge. The first idea of the Land-Bridge came from the United States. It came in the middle of the Nineteenth Century, and particularly during the period between 1861 and 1876, when the government under President Abraham Lincoln, during the period of the Civil War, pushed the development of transcontinental railways to connect the Atlantic Ocean with the Pacific Ocean. The subsequent orientation of the United States toward Asia and

Union Pacific Railroad Company

Map of the Transcontinental Railroad route as of 1879, the model for European and Russian efforts to span the Eurasian continent.

China, in particular, came as a result of this.

In 1876, Japan had already entered a period of industrial development, under direct U.S. direction, the so-called Meiji Restoration development in Japan, which is the basis for the modern industrial structure of Japan. In 1877, Germany, which already had a very close relationship with the United States, picked up on the same principles of development which had occurred in the United States between 1861 and 1876.

Remember that at that time, the United States was closely allied with the Russia of Czar Alexander II against the British. From the 1850s, the Crimean War period, until 1905, England, the British Empire, was the total enemy of Russia. Until 1901, the British Empire was the enemy of the United States. So, Russia and China, after the Crimean War, under Alexander II, had developed a close relationship. With the defeat of our enemy, Napoleon III of France, France also became friendly to the United States again.

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Helga Zepp-LaRouche (right), with associates Jonathan Tennenbaum and Mary Burdman, at the Eastern Terminal of the New Eurasia Land-Bridge in Lianyungang, China, in 1998.

Later in the century, Sun Yat-Sen of China, who was educated in Hawaii, who was also an enemy of the British, and the British were enemies of his, developed a plan for the development of China, based on railway and other development, based on the American and European model.

So, during this period, from approximately 1877 on, leading thinkers and influential thinkers in France, in Germany, in Russia, in China, Japan, and elsewhere, were moving for a transcontinental railway connection, like that which had been successful in the United States, in going from the Atlantic to the Pacific. The issues of wars, the underlying causes for two wars in Eurasia during this century, were the efforts of the British to prevent the development of such a land-bridge. So that, when I proposed a land-bridge approach in 1988, anticipating the collapse of the Soviet system then, and as Helga and I and others worked on this with Jonathan [Tennenbaum], for example, to extend this further, to the Pacific, many of our ideas were original. But the basic concept of the Eurasian Land-Bridge was not original. It was based on these precedents, from the Nineteenth Century.

So, these were the kinds of ideas which came out of this process. And Leibniz was, in a sense, the originator of this approach to global economy, including his famous papers and studies on the question of China, which he did at the beginning of the Eighteenth Century. So, it was out of Leibniz's views, these views of physical economy, that these developments occurred. The opposition in Europe, came from the opposite faction.

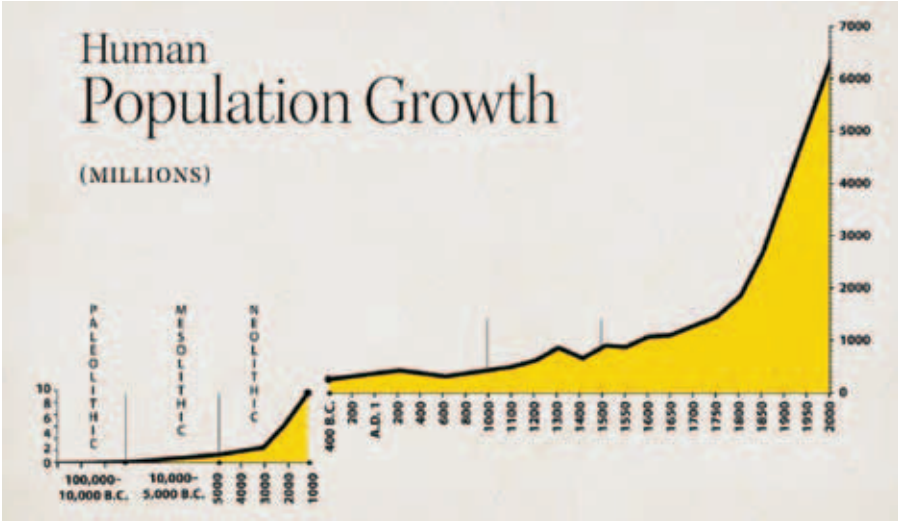
More Than 6,000 Years

Remember that if you're talking about relations with the civilization that came out of Western Asia and Europe, and then later the United States, you're talking about a period which is about 6,000 years old, actually longer, but in terms of history, about 6,000 years old.

Originally, in this part of the world, as in every known part of the world, society was divided into "upper" and "lower" people, a two-tier society. A very small upper group, less than five percent of the total population, who used the lower people, who were over 95 percent of the population, like human cattle. They were not considered full people, full, true people, but they were used as talking intelligent cattle. They were not developed. They were expected to do as their fathers, their grandfathers had done before them. This was called the oligarchical system, as it was known in Babylon.

This system continued from Babylon, the Persian Empire, the Roman Empire, the Byzantine Empire, and European feudalism, where this two-tiered society existed, oligarchical society. In Europe, in ancient and

medieval times, you had two classes which were the predominant oligarchical classes. One, were landed aristocrats, powerful landowners, who owned much land, and owned the people who lived on the land. The second group were people who engaged in financial speculation. They were financial parasites, a parasitical class. Europe went through a great crisis—I won't go into that whole history, it's not relevant here—but through a great crisis, over the effects of these two combined classes, the landed aristocracy and the financial aristocracy.



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Beginning about 3,000 B.C., and rising at an ever-increasing rate, there has been a great growth in human population, because the material conditions of life have been constantly improved to support this growth.

Today, as a result of developments of the modern history, the landed aristocracy has almost disappeared from Europe, from European civilization. But the other aspect of feudalism continues, the financier aristocracy.

What happened in the Fifteenth Century, which is a whole subject in itself, was that there was a revolt, in the attempt to create a new form of society. The basis for the new form of society, was derived from a Christian principle. The Christian principle is that all men are the same, all men and women are the same. They are made the same, and each has a creative power, which may be developed differently in different people, but by their nature, human beings are all the same, are all equal. And therefore, it was wrong and unjust for 95 percent of the population to live as cattle, under the domination of a handful of powerful feudal lords and bankers, or financiers.

The center of the issue was this. If man is good, if all persons are good because they can be educated and developed, then *all* persons must be educated and developed. If they are educated and developed, they must be given the opportunity to do the kind of work and live the kind of life that fits this education and development. And so, there was an effort to create a new society, in which society was obliged to protect these two principles, the improvement of conditions of life through the development of everyone, all children, and through providing the children, as they became mature, the opportunities to do something good, and to be of benefit to society. No longer should man be like a cow, or a horse, or a pig, to do the same thing, and end up the same way as his father, grandfather, and so forth.

The Nation State

This effort, which was not a complete success, but a beginning, occurred with France, with Louis XI, between 1461 and 1483. It caused a great struggle, an internal struggle in Europe, which goes on inside European civilization to the present day. At first, the powerful landed aristocracy and the financier aristocracy, attempted to crush this movement, which is the period of wars of the Sixteenth Century in Europe. Eventually, over the centuries, the landed aristocracy was defeated. But another part of feudalism succeeded: the financier aristocracy, which is typified by the British Empire and London, and what it represents in the world today.

So, throughout the world, we have two forms of society generally, since that time, wherever European civilization has had an effect. We have forms of society which are struggling to create national economy, that is, benefit to educate all people, and to provide progress within the nation for all people, and to provide these forms of work and life which fit people. At the same time, we have, on top, in most parts of society, a financier parasite class, which wishes to keep the national economy down, or suppressed, or destroyed.

Now, here's where national economy, where physical economy begins. If you look back in history, or at prehistory, and you compare man with great apes, and

you study man from the standpoint of the methods of ecology which are used for studying animal populations, or monkey populations, during the past two million years on this planet, in the conditions of life which existed, if man had been a great ape, not man, but something that looks like man, but is a great ape, the population of mankind would never have been more than several million individual persons.

But we know that before—2,000 years ago, the population of this planet had reached over 100 million persons. By the middle of the Fourteenth Century and the beginning of the Fifteenth Century, the population of this planet had become over several hundred million persons. Today, after the beginning of the nation-state and national economy, the population of this planet is over five billion persons. And China of course is a part of this, and the growth in the population of China is significant, because you can see that as modern European technology and civilization touched China, China's population expanded, particularly the underclass people had more opportunity, or more of them, to participate in growth. And there was a great growth in population, because the material conditions of life were improved, to allow for this growth.

So, the question is: where does this growth come from? All through the existence of mankind, the human population has grown. No animal can do that. Why? Because human beings change the way they behave toward nature. It takes a smaller area to sustain an average person, because of increases in technology. The standard of living of each person working, increases, because each person, even with a smaller land area, is more productive.

Where does this come from? This comes from discoveries, which are typical of scientific discoveries, but there are other discoveries, like artistic discoveries, which have a similar effect.

Education and Creativity

So therefore, by fostering the education of children, of more children, increasing the quality and quantity of education provided to children, increasing the period of education, so that people did not go to work when they were still children, but could continue to study, we increased the amount of knowledge of principles of nature and principles of art and statecraft in the population. So, instead of people being like pigs, or cows, living, acting like their grandparents, or parents before them, or ancient ancestors, people were able to progress from one generation to the next, through knowledge, and through acquiring knowledge, and through developing new knowledge.

The larger the percentile of the total population which is so educated, the greater the knowledge of the whole population, and therefore, the greater the rate of development. *And this relationship, of the mind of the individual to man as a whole, and to man's behavior toward nature as a whole, is the science of physical economy.* That's what it means, and that's what it's meant, since the time of Leibniz.

EIRNS

By fostering the education of more children, increasing its quality and quantity, we increase the amount of knowledge of the principles of nature, art, and statecraft in the population. Here, youth at the LaRouche Academy in Bogota, Colombia, are engrossed in a study of geometry, September 26, 2011.

Now, Leibniz's study of work, from the beginning, from the first two important papers he wrote in 1671, already addressed this question. For example, in one paper dealing with the question of wages, he emphasized that the income of the worker must not be a mere minimum, a minimal subsistence. But the income of

the family will bear upon the cultural development of the family, and therefore will shape the potential productivity of the members of that family. The higher the standard of living, the higher the level of culture, the more potential productivity these people represent. Therefore, wages, in a sense, have to *increase,* in order to permit families to improve their life, improve their productivity. And therefore, in increasing wages, we must know the difference between those increases in wages which will be beneficial to mankind, and those increases in wages which will be useless. More money for prostitutes does not improve the life of society, even though some people in society today seem to think so.

So, our great challenge, therefore, is to understand exactly what it is about the mind of the person, and this relationship of the mind of the person to the society and to the land, to the physical—which defines the potential for human progress. Obviously, the problem exists in China today. How can we, given a limited land area, with a large concentration of population in certain parts of the area, and low concentration of population in other underdeveloped areas of China, how can we allow the population of China to increase, by increasing man's power over the total land area of China? Typical problem.


UNESCO/C. Bablin, 1958


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Bertrand Russell (left) provided the conceptual guidance for Norbert Wiener (center) and John von Neumann (right) to develop and deploy the tools of Cybernetics and Systems Analysis to destroy the idea of a society that exists for the benefit of the people.

This is the problem which all societies face, in one form or the other. How can we increase the standard of living, how can we improve the life expectancy, how can we change the composition of cultural activity in the family, to make a higher quality of human being? How can we eliminate drudgery, emphasize the use of the mind, not just physical labor, to improve the future of mankind? And how can we find happiness in our time, by doing that? This is what Leibniz emphasized: the principle of happiness. Not pleasure, but happiness. To know one is a useful person linking the past to the good future, is to be a happy person, because you know your life is necessary. And a person whose life is necessary, and who knows it's necessary, then others can agree that person is a happy person. A normal human being.

Increasing Mankind's Power

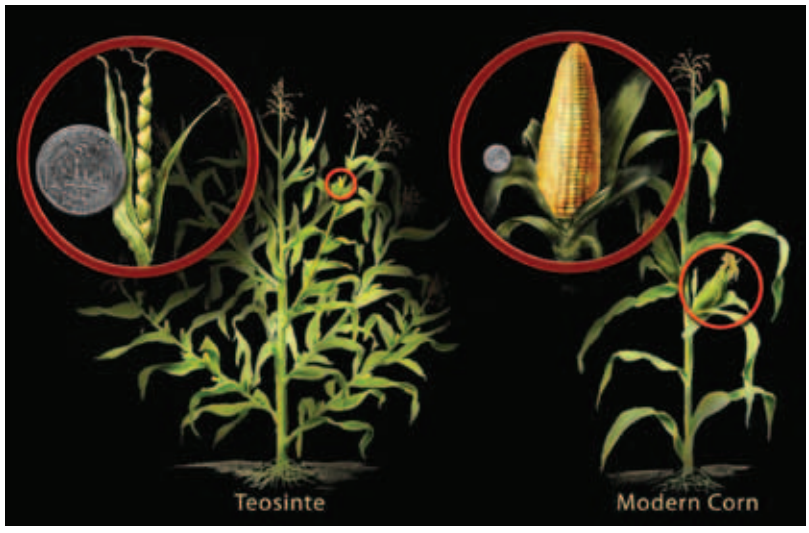
Now, I got into this, into the economics as such, after World War II, after I came back from military service. And, at that time, in 1948, a book was circulating, a book which my previous education assured me was a hoax, incompetent. The book was called *Cybernetics.* It was written by a fraud, a hoaxster from the Massachusetts Institute of Technology. His name was Norbert Wiener, and he is today the world-famous father of a fraud called "information society," which is a fraud. It does not work. It's not true. So, I recognized the fraud. I saw this fraud as a danger, because it's a false conception of man, a false conception of man's relation to nature. So I dedicated much of my time to preparing a refutation of this book.

So I came then to a second book, which is also a fraud. The second fraud was *Systems Analysis,* which was written chiefly by a fellow called John von Neumann. Systems analysis was initially, mainly, developed around the ideas of economics, political economy. And this was the same fraud as Norbert Wiener's fraud, exactly the same hoax. This is not accidental, because both Wiener and von Neumann were trained by the same person, Bertrand Russell of England.

Now, Russell, if you read his writings, you would understand Russell. Russell is a perfect example of an oligarch. And his writings—he hates modern society. He's dead now, of course. He worked hard to earn his

death. And his view was that modern society is bad, because it makes life unpleasant for British aristocrats. These people were against scientific progress. Russell especially hated the United States. He said, "How can I, who was born in Victorian England, when England was a great empire, where my family was among the ruling families of the British Empire, how can I stand to live today in the middle of the Twentieth Century, when the Americans are dominating the world?"

The essential thing, which has always been the problem for us in the world, and the United States, is that these people wish to maintain a two-tier society, in which a small group of the population, less than five percent, rules the world, or work as bureaucrats, administering the cattle from the top. And these people were always determined to destroy the idea of a society which existed only for the benefit of the people. They were opposed, especially, to educational policies which train people to think scientifically, or to think in terms of Classical culture, Classical artistic culture.



NSF/Nicolle Rager Fuller

"We took wild plants, cultivated the ones we liked to eat, and made them better to eat." Shown on the left is wild teosinte, a Mexican grass plant, considered to be one of the parent plants of modern corn, shown on the right.

They wish to keep the majority of mankind as a farmer wishes to keep his cattle: fat, edible, and stupid. You see an animal breeding: how did we get animals on farms? We started with wild animals. We picked the kind of wild animals we liked to eat, as we did with plants. We took wild plants, and we cultivated them, the plants we liked to eat, and made them better, better to eat. We took the cows, who were wild and nasty. You see wild cattle today, on certain parts of the planet. They're very wild, they're very difficult to deal with, very unpleasant. They're not very obedient. So, when we bred cows, we bred them to make them stupid, obedient, to give a lot of milk and a lot of meat. And we bred them so they would give the most amount of meat for the amount of grain they ate.

Power and Happiness

And the oligarchical system did the same with people. They would encourage people to breed, to make strong people, like cattle, people who were not too intelligent, who were not educated, who were taught to be obedient, so that they could work, like good cattle, for the masters.

So that's the struggle, that's the conflict. And that conflict is key to understanding physical economy as an idea. Once you say that all people are capable of scientific thinking, by virtue of their birth, all people are capable of discovering space and exploring space, they must be educated, because of what they are. They must do work which fits what they are. And since they are all going to die, each, we must allow them to do something good for the people who come after them, and we must protect what they do that is good, for the benefit of future people. Once you accept that, you say, "That must be wrong. We must form society to obey that law"; which means you have declared war against the continued existence of oligarchical society, and you've started a war between those who want this kind of society, and those who prefer the other kind of society.

Now, if you belong to the first group, who believes that all people are equal in this sense, then your concern is, "How should society be run?" It must be run according to the nature of the individual person, which is this mental capacity for discovering the laws of the universe; to mastering the discoveries of previous generations before them, to become a person whose mind has all history in it, in the sense of these ideas, as in a great scholar or a great scientist.

Therefore, we are interested in finding out what the laws are, which enable human beings in society to increase their power over nature. The other side says,

"yes, we want the knowledge, the technology, but we don't want too many people to understand it."

So therefore, it was natural that once you had states emerging in Europe, in which a few thinkers had much support, that you began to form national economies, national economies which were committed to the educational development and new kinds of employment, that this concern would come to the surface. And you find the eruption of what is called modern experimental physical science in Europe, and the emergence of new ideas of administration of economy, new policies of education. And the ideas of physical economy began to emerge naturally under these conditions.

Look at the impact of European civilization on the world, since the Fifteenth and Sixteenth centuries. For example, in the Fifteenth Century, the level of development of technology in China and that in Europe, were about the same, as the great maritime explorers and astronomy in China show. But then, the revolution in Europe meant that the development of science and technology in Europe leapt ahead. And suddenly, European civilization, which had merely been one part of the world, now became an increasingly dominant part of the world.

So the history since then, of the relationship of Europe to the world, is a history on the one side of the benefits of the spread of this culture, including its assimilation with Chinese characteristics, which is the way it happens among most people. They assimilate a culture into their culture, adopt it, use it, for their benefit.

Europe and China

But then you have the other side, typified by the imperial systems of the Eighteenth and Nineteenth centuries, which is a reflection of the conflict in Europe itself between national economy and financial oligarchy. And, for various reasons which I won't go into right now, we have come to the end of that. We have come to a special historical condition, where no longer can these two forms of society live on the same planet. And the great financial crisis which has erupted in Asia [in 1997], is the beginning of the end of that system, of the two types of economy.

From that standpoint, therefore, we can understand and trace physical economy. There are two things that have to be considered in physical economy, two kinds of ideas, but really they are the same, or they're two branches of the same.

On the one side, there are ideas that pertain to the relationship of the society, per person, to the physical universe. That is, how many square kilometers are required to sustain an average person? What is the standard of living of this average person, physically? What is the productivity, physically, of this person, on the average?

The second area, is the area of Classical art. The term "Classical" in this case means a Greek standard for the term "Classical." It means Classical in the sense of Plato, in which you say that art is governed by a principle of reason. It is not an irrational inspiration, but there is a knowable principle involved in art. And we can find traces of art, as far as we know them, of Classical art, or roots of Classical art, back into 6,000 years ago. So these are the two branches.

The first branch is simple, in one sense. It's simple to understand. It's called experimental physical science, in modern terms. It covers everything: biology, mechanistic systems, astrophysics, everything of that sort. Mankind makes a discovery of a law of nature, of a principle. We prove this discovery is true, by something like an experiment, what is called a crucial experiment.

Now, when you construct an apparatus to test a scientific principle, the apparatus you construct, can then be used to guide you to make new kinds of things, products and processes, production processes. Now, you bring that new principle into changing the way you do things, the way you practice, the way you work, and the way you design products. And you find that for the same amount of effort, you now can do more, that your products are better, that the power of man per capita over the universe has increased.

But society is not a mere collection of individuals practicing science. For example, take the very concrete point, to understand this: Can a person using their senses, see the mind of another person working? Can you see the mind working to produce a valid discovery? You can not. This involves an area called *ideas*: things which are true, but which you can not see, touch, feel, with the senses.

The Science of Paradoxes

How do you study science, for example? The student in the school is given a problem. The problem is a difficult problem, which the student must work out. Among the many problems the student is given, are re-

ports that a certain person made a discovery, a discovery of a law of nature. The students, at a certain point in their education, are asked to repeat for themselves the act of discovery made by this famous person. So when the students re-enact a great discovery, they have thought as the great discoverer did centuries or more before. They then have re-lived the act of thinking of that person, that discovery.

For example, if you have a system of education, in which you don't ask students to do that, you tell them merely to learn the result of the experiment, these people will pass the examinations, but they won't understand anything. This is true at all levels of work, and everything else. If you put a person to work, how well is that person going to work? You say "Well, he will do what he has learned."

Now, some of you have been involved in administration, or observing the administration of projects. And you know from painful experience that doesn't function. On every level, you require some degree of creativity from the people working in the project, beyond just learning. For example, every poor peasant was born with the same mental capacity as a person who is educated. You take a poor person from a farm, from a poor farm, you put them in an industrial project. How is the project going to succeed? You require more than the person understanding what to do. The result will depend upon to what degree that person has developed the ability to solve problems, to make things work. Ingenuity.

Why does a person solve problems like that? I can tell you my studies, and my own experience, and the experience of others in U.S. industry. People solve problems because they enjoy solving problems. A person who is angry, who kicks the machine, who breaks the tool, is not going to solve the problem. He will fail you. He will become extremely angry, break things, curse at people.

The person who is a supervisor of workers, when they frustrate him, he becomes angry with them, and says stupid things to them. A good manager is one who enjoys helping people to learn to think creatively. He'll say, "We must do this job." He will be harsh in demanding the result, but he will be loving in assisting them to find the way to solve the problem.

So therefore, the important thing in society, is this developing the individual to love to do what it is they do well as human beings, to make discoveries. For example, when you bring a toy home, you have a young child. And you bring a new toy, or you bring a new game for that child to play. The child at first is frustrated. They don't know what to do with this new toy, or how to use it, or how to play this new game. But then, when the child, particularly a young child, discovers how to solve that problem, a play problem, the child is very happy. And the people around him, usually the parents, are also happy to see the child solving the problem.

EIRNS/Stuart Lewis

"A good education system produces creative, innovative people who solve problems, who are not simply angry at things that don't work, but who find ways to make them work." Shown here is Lyndon LaRouche (left) in 1994 with Norbert Brainin, first violinist of the Amadeus Quartet. Helga Zepp-LaRouche is visible beyond them.

What Makes Us Human

So, this *happiness principle,* of using the mind to solve a problem, is the thing that makes for good work, and makes for creativity. You can not buy creativity; you must inspire it. So a good education is not an education which beats people into learning how to obey. A good education is one which forces the child to meet the challenge of solving the problem we know that child can solve. And the victory is joy.

I'm sure all of you have had the experience of work-

ing at a job which is very monotonous: the same thing day after day. It becomes very boring, very frustrating, to repeat the same action over and over again. And people in these work situations like variety, to break the monotony. They will sometimes do things differently, just to break the boredom.

So, the normal condition of the human being is to be happy, in the sense of true happiness, which is the happiness of an old man who dies with a smile on his face, who says, "my life was necessary. I came here, I did something good. It would not have happened if I weren't there to do it. Therefore, my life was necessary." The old man dies and says, "I have good children. I was necessary to make these good children." Happiness. Happiness in life is to do something each moment, which contributes good.

So, if you look at every baby, every child, and say, "that is a good person, a good child," and you educate that child, with the idea not merely of getting a certain technical result, but using that task to make that child happy, because that child will experience the sense that they are something special, because they have this power in their own mind; if you want a good education system, that's what it must do. To produce creative people, innovative people, who solve problems, who are not simply angry at things that don't work, but find ways to make them work. This is also a reflection of art inside science.

In fact, in no case have I known personally a great scientist, who was not also involved in Classical art. Because the spiritual aspect of art is necessary for the spirit of scientific work. And let me briefly explain what I mean by that.

The most famous forms of art we have, are divided into what we call plastic arts, such as sculpture, architecture, painting, and the arts such as music and poetry, or the great literary works, the dramatic works that come from that. For example, poets and poetry are very old, the oldest thing we know, essentially, really, in terms of art, is Classical poetry. Every Classical poem, like every work of art, has in it a problem. And every great poem is enjoyed, because it is a reliving of the act of solving the problem which that poem presents.

Rembrandt van Rijn

"No one can see, or smell, or touch, or feel, the thinking process by which another person develops an idea." Here, Rembrandt portrays the empiricist Aristotle, who knows nothing of the creative mind of the blind poet Homer, whose bust he contemplates.

Great Art and Greatness

We talk about principles of social behavior, for example. Generally, these can be represented by great dramas, or great poems. The same thing is true in music, the same is true in plastic art. What we are studying, is this most important of all problems, that we are a society, not a collection of just individual human beings. Yes, we use a language, which, in each society, tends to be a common language for that people. But language is not what makes a society work by itself.

The most important thing is what I said before: that no one can see, or smell, or touch, or feel, the thinking process by which another person develops an idea. In physical economy, the most important things are ideas like scientific discoveries. The most important thing is: if one person makes a valid, scientific discovery, how can we cause that act of discovery to occur in the mind of another person? You can not use information theory to do that. Information theory is a fraud. *You must*

enable the other person to repeat the discovery you've made.

You see that in any classroom experience. You see people are studying a principle of science, in the same class. In a good science class, 15-17 students is good, because the interactions are there. And you see, one by one, the faces of the children in that class, begin to realize that they have understood the principle. And they can then demonstrate to each other, that they've all had the same experience. They've all shared. Those who made the discovery, all now share it. Because they know what happened in the mind of the other.

So the most important thing in society, is, how can we enable one another to understand what we think? This is essential for science and technology, it's essential for everything. How can we have law? Shall law be something which is made simply because some people agreed on certain words? Or must law be a principle, like a scientific principle?

If a person goes before a legal court—suppose a person is accused of some crime. And they are called before a court, to be tried on this accusation. So the person who is being tried, knows they are not guilty, they are falsely accused. What is the problem with the person who is accused? The person says "I am innocent. I know I am not guilty. How can I convince the judges that I'm not guilty? How can they come to a true"—not "how can I persuade them," not "how can I bribe them," not "how can I deceive them?" But "how can they discover the truth, as I know the truth?"

On the other side, look at the mind of the judge. The judge has a person before him, as an accused. How can the judge know whether the person is innocent or not? What must he evoke from the accused person, or from witnesses, to determine whether that person is innocent or not, or guilty?

Not by the Senses

So, in both cases, the problem involves minds, a mind whose functioning can not be seen by the senses. And the same principle we use for discovery of scientific principle, as in classrooms, or we teach scientific principles, apply in every aspect of society. What's the most important thing in running a state, not just in law, or not at the trial. The most important thing is: how do we develop ideas which are true, and then how do we convince the people that these ideas are true? Not by deceiving them, but by causing their minds to recognize the truth.

And therefore, art—and if you look back at the history of all great Classical art of all great cultures—I'm sure you can do this in China's culture—you find, embodied in the culture, many things in Classical art, which help to communicate what otherwise can not be communicated in words. It's called *metaphor* in English: the art of contradiction. Where two meanings contradict, what is the truth that lies between the two meanings that contradict, when both meanings seem to be supported by evidence? That's scientific method. That is also the method of Classical art.

And thus, that is the essence of physical economy. The object of physical economy, is to perpetuate and develop a form of society, which meets the requirements of human beings. Not just the physical requirements today, but the requirements which flow from the fact that each of us will die.

If each of us will die, what, then, is the meaning of our life? The meaning of our life is what we are doing while we live, that is going to benefit humanity in the future, and do honor to people who came before us, to whom we are indebted.

How can we make such a society? And therefore, how can we understand how the mind works, how minds can work with each other, and discover principles which we can then cooperate to use, to make the condition of mankind not only better by these standards, but also to deal with the universe?

Someone will say, they go to astrophysics. And they say, "You think you are doing well." And they will say, "Well, maybe three billion years from now, the Sun will blow up. Then what happens to humanity? What was all this about? There could be other catastrophes. You may have some object come and strike the Earth and destroy life on Earth." So that obviously, whatever these problems are, the destiny of man is to provide the conditions under which mankind can continue to exist.

We must, therefore, develop. And we must, therefore, not only develop, but we must provide people happiness in the process of contributing to development. That's what physical economy is, which has many technical implications, but I've tried to concentrate, for this period, on the principles, the historically determined principles involved.

COVID-19 Vaccine Result Possible by Early to Mid-October

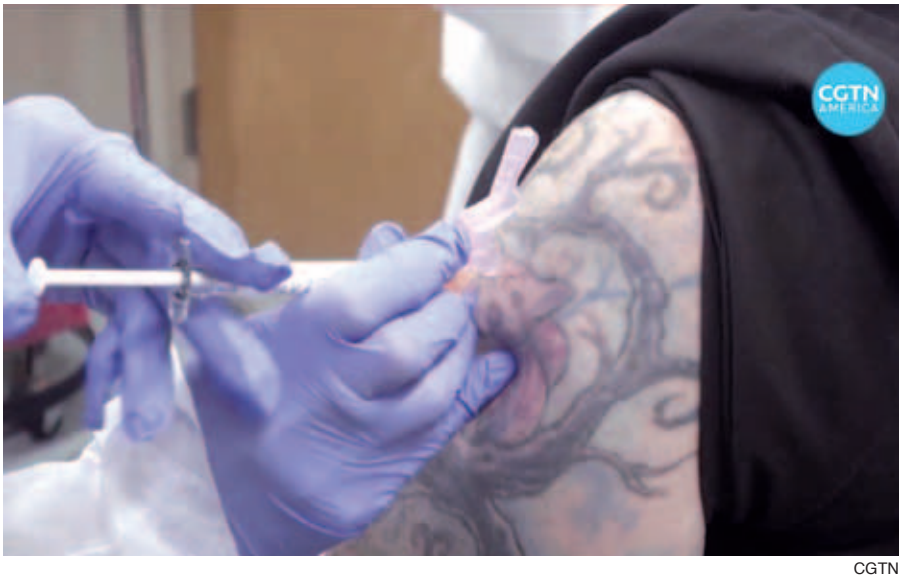
by Ned Rosinsky, M.D.

Sept. 12—On September 7, National Public Radio put out a vaccine coverage story entitled, "How Can You Tell If a COVID-19 Vaccine Is Working?" The coverage includes an interview with Holly Janes, Ph.D., a biostatistician at the Fred Hutchinson Cancer Research Center in Seattle. She stated that the trials currently underway are event-driven studies, and said, "An event-driven trial means that the primary analysis of the trial happens when you get enough events."

The article explains that by the term "events," "Janes means laboratory-confirmed cases of COVID-19 disease. Janes says that the trial now underway aims to get at least 150 events among the trial participants." That is, the trial is completed when you get enough events.

The COVID-19 Phase 3 trials do not have a time endpoint, such as 3 months. The trials are run until a certain number of participants get COVID-19, enough to make a statistical comparison between the vaccine group and the control group. The trials are also tracking the number of people who get hospitalized for COVID-19. That statistical comparison will indicate if the vaccine is efficacious, and how efficacious it is.

Note that these trials are being conducted under randomized controlled double-blind conditions. A randomized controlled study involves comparing the test treatment with either a known treatment or a non-treatment placebo, called a "sugar pill," in which each subject gets randomly assigned to either the test treatment or the placebo. A double-blind study requires that neither the researchers nor the subjects know who is getting the test treatment or the other treatment/placebo. A controlled double-blind study combines both of these features. The controlled double-blind requirements are implemented to minimize bias in the evaluation of response to the treatment by the study clinicians. It is only after the study is terminated, when the results are documented regarding each test subject, and the comparison between the groups is analyzed, that the blind is broken, and the researchers find out who got which treatment.



CGTN

Moderna and Pfizer have begun Phase 3 trials and expect a moderately effective COVID-19 vaccine by early to mid-October.

Trial Period Depends on Efficacy of Vaccine

How long should this take? The U.S. has recently been identifying approximately 45,000 new COVID-19 cases daily, out of a national population of 331 million, which calculates to 1.36 new cases per 10,000 population per day, or 1.36/10,000 per day. In a test cohort of 30,000, which is the planned cohort size of each of the Moderna and Pfizer Phase 3 studies, the number of expected cases would depend on the efficacy

of the vaccine.

For example, if the vaccine were not at all efficacious, all 30,000 subjects in the study would be at risk, which would calculate to 30,000 x 1.36/10,000, or 4 new cases in the 30,000 participants per day, or 120 per month.

If the vaccine were 100% efficacious, there would be only 15,000 people at risk, the people in the unvaccinated placebo group, which would predict half of the 4 cases, or 2 new cases per day, totaling 60 per month.

If the vaccine were moderately efficacious, say 60% efficacious—which is good enough for FDA approval, which requires at least 50% efficacy—then approximately 84 new cases per month would be expected.

Moderna and Pfizer have been recruiting and vaccinating study participants since July 27, 2020. Moderna is now at or very near its target of 30,000 participants, and Pfizer reported they were at 23,000 participants as of September 3, so they have both been vaccinating and testing participants for all of August.

There are other factors which would tend to increase the rate of new cases or "events."

First, Moderna is targeting high-risk populations for recruitment into their study, so their event rate should be considerably above the national average, in some populations more than 4 times the national average.

Second, it is widely acknowledged that the actual rate of COVID-19 is significantly higher than the reported rate, due to lack of comprehensive testing of the population.

The study participants are expected to be tested whether they are symptomatic or not, to be sure to pick up the non-symptomatic cases, so the event rate will be higher than the currently reported national rate, and much closer to the actual rate in the population.

A Moderately Effective Vaccine by Early to Mid-October?

Although there are no publicly available accurate measurements of the increased rate expected from targeting high risk populations, or the increased rate expected due to the actual rate in the population compared

to the usual estimates based on current testing, these numbers would imply approximately 150 "events" for Moderna at least by or before early October for a moderately effective vaccine, and for Pfizer, which is slightly behind Moderna in recruitment, by two weeks into October.

The earlier Phase 1 and Phase 2 studies of the Moderna and Pfizer vaccines showed a very high rate of efficacy, as estimated by the immune response of the test volunteers. There was nearly a 100% response of antibody production, with antibodies generally at the level of people who have previously had the disease and recovered.

Fred Hutchinson Cancer Research Center
Holly Janes, Ph.D.

In the general population it would be expected that the immune response would vary due to a number of factors, such as age, genetics, the presence of other diseases, stress level, and nutritional status. It is well known that a similar set of factors is associated with the severity of COVID-19 when people are infected. That is why a large, broad-based Phase 3 is important.

Possibility of Emergency Use Authorization

Given the current, extreme emergency situation of the state of the epidemic, with approximately 1,000 people dying daily in the U.S. from COVID-19, it would be a prudent and justifiable policy for the Federal Drug Administration (FDA) to issue an Emergency Use Authorization to allow the vaccine to be used broadly in the population when the number of cases is reached, as indicated above.

The FDA has a Drug Safety Oversight Board (DSOB), which requests unblinded data from drug research teams. The DSOB typically checks the progress of ongoing studies approximately every 2 months, to gauge efficacy and monitor for adverse effects. In the case of the COVID-19 studies, the DSOB is likely tracking the Phase 3 studies much more frequently due to the national emergency.

Taking the above possibilities of efficacy as examples, if the Moderna vaccine were at or nearly at 100% efficacy, then if approximately 2 new cases per day of COVID-19 were found for somewhat more than 30 days within the study population of 30,000, the FDA would know which arm of the study had the cases.

If all or nearly all the cases were in the non-vaccinated group, and if there were an acceptable level of adverse effects, the DSOB and FDA could decide that there was sufficient justification for an Emergency Use Authorization.

Conversely, if the vaccine were only mildly efficacious, such as 50%, then there would be 3 new cases per day, and the FDA would know which group these came from, 1 from the vaccine group and 2 from the placebo group. After a month there would be 75 cases total. The FDA could then decide to wait longer, to get a more accurate statistical estimate of actual efficacy.

Who is Dr. Holly Janes?

The above estimate by Dr. Janes of the number of events needed to complete the COVID-19 vaccine studies is based on her long experience and her expertise in the vaccine research field. She holds a Ph.D. in biostatistics from the University of Washington, and she is working on the design and analysis of vaccine studies, with particular expertise in HIV prevention and vaccine science. She also develops and applies statistical methodology for evaluating biomarkers for risk prediction and optimizing treatment decisions. She is an Affiliate Associate Professor, Biostatistics, at the University of Washington, and a member of the Graduate Faculty, Biostatistics, at the University of Washington.

She has research interests in statistics design and analysis of vaccine efficacy trials, HIV vaccine development, clinical trial design, and pediatric vaccine trials. Her current projects include providing leadership for the Statistical Data Management Center of the HIV Vaccine Trials Network, statistical methods for HIV prevention efficacy trials, statistical methods for human challenge studies, and statistical evaluation of biomarkers for making treatment decisions.

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