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Gene Editing and the Future of Personhood | William Hurlbut & George Church

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The Veritas Forum

George Church, Harvard Medical School and Bill Hurlbut, Stanford University Medical Center discuss the risks and opportunities of gene editing at a special event hosted by The Veritas Forum and moderated by Ross Andersen, a senior editor at The Atlantic. The Veritas Forum: Gene Editing and the Future of Personhood Please like, share, subscribe to, and review this podcast!

Transcript

Welcome to the Veritas Forum. This is the Veritas Forum Podcast. A place where ideas and beliefs converge.

What I'm really going to be watching is which one has the resources in their worldview to be tolerant, respectful, and humble toward the people they disagree with. How do we know whether the lives that we're living are meaningful? If energy, light, gravity, and consciousness are a mystery, don't be surprised if you're going to get an element of this involved. Today we hear from Dr. William Hurlbut, who is the most important person in the world.

I'm Dr. William Hurlbut, a neurobiologist at Stanford University, and George Church, a geneticist, molecular engineer, and chemist at Harvard Medical School discussing gene editing and the future of personhood. Moderated by Ross Andersen, Deputy Editor of The Atlantic. Right, George Bill, please be with us tonight.

I was thinking earlier about how we ought to start this conversation, and I know that we're going to get into the nitty gritty of the ethics of this conversation. I'm going to get into the ethics of this really transformative technology later. But first I want to open on a note of wonder by asking you a personal question, which is sort of where were you, and do you remember where you were when you first heard about CRISPR and that this was possible, and what were the sort of your immediate reactions, what sort of imaginings kind of leapt into your mind when you heard that? George.

Right, well, it was slow dawning, actually, in part because we had been working on genome editing since I started my lab in 1986. So, to me, CRISPR was just another way to edit. I know that's unfair.

And I knew about it as a phenomenology where I also do computational biology, and it was just a repeat. It was the so-called junk DNA of the genome. And so, you know, I had more respect for junk DNA than the average person, but nevertheless, it was junk because it was repetitive, it was not conserved, and we didn't know what it did.

So, that was sort of in the more than a decade ago, but then we didn't really jump onto it as a technology until 2012. And do you remember when you first sort of glimpsed its potential? I mean, I'm sorry, I'm giving such a vague, it was kind of a gradient. I'm still not sure I see much potential in it.

That's interesting. Phil, how about you? My background is very similar to George's. I was trained in medical school by Paul Berg and a variety of people who were involved in early efforts to do gene editing.

And so, it was on my radar very early. But when CRISPR became clearer and through the literature, it became obvious we had a tool that was easy to do. It was easier, more precise, cheaper, and it was the beginning of a spectrum of genomic interventions that would have a potential dramatic effect on science and medicine.

I would say, first off, that above all, I think it's a revolution in the lab, and its clinical applications will follow from that, and those we can talk about more specifically. But it's opening up the ease of doing research. Great deal.

How about just zooming out from CRISPR as a particular technique, and let's go to gene editing in general. If you were to, and I know you aren't historians of science, but you are some familiarity with the recent history of biotechnology, how do you situate gene editing as, like, how transformative is it relative to DNA sequencing, for instance, or previous innovations along those lines? Well, I've been involved in both of those, I suppose. We brought down the price of sequencing from \$3 billion to less than \$1,000, and it's more or less \$0 to the customer now.

So I think that's a very dramatic change, and it's very hard to edit without being able to read. If you ever tried it, you'll know what I mean. So I think that's a bigger revolution, personally, and I think that editing, you can do editing essentially by synthesis in some cases, or it's hard to do editing without synthesis, so that's another revolution.

Both of those revolutions tend to get eclipsed by CRISPR, and I'm not even sure it's that much cheaper. I mean, if you go out and buy CRISPR on the market, it's about \$500. It's simply by almost all the previous editing methods, about \$500.

So nevertheless, it is a revolution. There is a revolution going on. There's no doubt about

that.

It won't be very clear, and it involves reading, writing, and editing. And that whole cluster of things is exponential, and it's alarmingly fast, faster than the computer revolution. And it's a very, very long set.

Well, I certainly agree with all that. This is a synergistic process with lots of factors adding in, including artificial intelligence and computer power of analyzing what we get. And it's -- CRISPR, George says, "Do all those other things?" Yes, I think it maybe will be historically looked at as a kind of a hinge moment, though, when things went into sort of hyper speed and science and medicine in the discoveries in biology advanced at a much more rapid rate.

CRISPR basically gives us the tools of inquiry, as I said, and interventions such that finally the promise of genomic intervention -- and it's more than editing, by the way, this has been implied -- CRISPR allows operations at many levels of genomic operation, including on the RNA, as well as the DNA. And this gives -- you can change genes, but you can also turn genes on and off in their expression. And so this is a very versatile tool, and it's going to advance our understanding of a great deal of natural development.

One thing we all need to understand and take account of is that 20th century, we did a lot of studies of molecular biology and understood the basic ingredients of human life in the 20th century, rendering the era of developmental biology, and we're going to understand how organisms are knit together both in health and in sickness. And that's going to give us amazing new tools. I have heard -- I'm not an authority on this, and George can confirm this or correct me.

I've heard that our current armamentarium of pharmacologic interventions target about 250 protein sites, and by any reasonable calculation, there would be probably, what, tens of thousands of potential sites to operate on. So as we gain knowledge, we're going to look back on this era as just the tiny beginnings of our interventions into life and especially human life. If I got that right, George? >> I think that's roughly right.

>> He knows a lot more of the science than I do. >> Yeah, George, you're a resident fact-checker. >> Yeah.

>> I appreciate it. [Laughter] >> Let's talk about gene editing a little more specifically. We've been talking kind of generally about its potential right now.

I want to move to sort of give us the landscape of specific applications that are ongoing, that are in the lab, or that even appeared in scientific papers, or that you all know from the rumor mill are imminently going to appear in scientific papers. And then give us some of the sort of far-out thinking for the next 10, 20 years as to what these techniques might be able to accomplish. So I'm a broadened, just a tiny bit, so we don't have to say

Chris Bergness or really, but you can change developmental -- you can advance the developmental biology to the point where you can transplant organs.

And we've done that mainly in pigs, where you have to make multiple edits, about 80 different edits to the genome, in order to get them close enough that they're good organ donors. And so that's moved into preclinical transplants now at MGH here in Boston. Another one is aging reversal.

That's something where we have a list of about 300 genes that are known to be involved in either longevity or aging reversal in mice and other organisms. And you can extend the life of the mouse by a factor of two. And you can reverse all the markers of aging that we know of in a few days, essentially from very old to embryonic and anything in between.

And so we've converted those into gene therapies, which are quite a few gene therapies that are in clinical trials. And these will be going -- these are in clinical trials now in dogs because people care about their dogs. And then a few years from now we will be doing them in humans.

So those are two examples -- transplants in aging reversal, because many of us will die -- most of us in industrialized nations will die of diseases that do not kill 20-year-olds, about 90% of us. So that's an important category. As someone who's currently at their physiological peak, does that mean I could like press pause? Or reverse, or pause or reverse.

I realize you wouldn't want to go back before your peak, but you could hypothetically do it. Maybe I want to experience the climb again. Yeah, that's exactly there you go.

It's the journey. It's the journey. Bill, talk to me a little bit about the thoughts that pop into your mind when you think about someone who is in touch with sort of the cultural, the philosophical, the theological implications of these technologies.

When you think about human life spans that are radically longer, or certain stages of life which previously have been sort of short seasons or 10 or 15 year runs, being extended by decades, for instance, what sort of changes and cultural transformations are we into? Are we in for it if we have a world like that? Well, being from Silicon Valley, I'm getting used to all this. But here's the thing. The question that you just asked, George, what's this going to affect? I would say it's probably going to affect every, ultimately, every biological parameter of human existence.

And I think it's going to play out in sort of like the app store on the iPhone that it starts out with the idea that there'll be a few little useful things, maps and a few things. And then in a period of years, maybe decades, but it's the scheme of things, that's not long. We're probably going to have hundreds and maybe thousands of applications of

biological interventions that we can't anticipate today.

There's a strange process by which things become clearer that you didn't even know were there. I mean, it's the way it works. And so, for example, somebody today emailed me about the possibility of turning on the genes that are related to the effects that Botox produces in its application in cosmetic surgery.

And then they had some other ideas for doing basic skin interventions that would be cosmetic and effective. And these were ideas that I hadn't thought of very deeply. And obviously, there are many ways to go in and do things.

But when it comes to issues like reversing aging or even forestalling or occluding aging, that's a very heavy laden concept. I mean, we need to ask ourselves larger questions about what the meaning of such interventions would actually be. At the founding of the Society for Regenerative Medicine, William Hazeltine said just bluntly and overtly, the real goal is to keep people alive forever.

And I debated this guy named Aubrey de Grey. You know Aubrey de Grey? Very well. I debated him in the Civic Center in San Francisco, in a forum put on by the Chronicle last year.

And Aubrey de Grey says that if he can just live 35 more years, he's confident that he will live to be a thousand, because in those intervening years, the advances will unfold so rapidly that he will achieve what he calls, the Society will achieve what he calls longevity escape velocity so that the advances will come faster than the aging process. I doubt that he's right on that, by the way. Maybe this is my skepticism as a physician, but I have a certain sense that these will turn out to be much more complicated processes to intervene in that are imagined.

Although we can hear from George about what's happening with animal models and I give us some hint, but maybe just some hint, because the animals may be different with regard to aging than humans at some levels. But yes, at the deepest level, we want to ask ourselves the fundamental questions. What is the source and significance of the natural world? How do we relate to the integrated and deeply interdependent processes of the natural unfolding of the world and our lives embedded in it? And in what ways does that circumstance, our natural circumstance provide the foundational frame for our optimal physical, psychological and spiritual meaning as human beings? We've talked a little bit this week about human flourishing as a goal, really, of a human life.

And just to add some specificity to this conversation, again, if -- imagine -- let's not get too radical, let's just say 200-year lifespans were a thing that biotechnology of some kind can help us achieve. Could you imagine -- now you could imagine that might lead in the short term to inequality as a various sorts. I often think about how it might make the loss of a young person just unbelievably tragic in a way that maybe we don't experience yet.

But also might it open up new avenues for human flourishing, new -- what does a hundred and sort of 70-year marriage look like? What sorts of artworks can someone create across a hundred years? What sorts of science could someone like George do if he had another -- I mean, George will be with us a long time, but if he were to live to the year 2100, do you see positives in that kind of world? I see a lot of positives. I mean, I also worry about it. I mean, you need to worry about things like overpopulation, so yeah, I think, you know, sometimes you worry that we won't be creative as old to our people.

I know a lot of older people that are a lot more creative than some 20-year-olds. But part of it has to do with where you -- how comfortable you are with your history and your future and things like that. And also, if you're reversing aging, you should be reversing all the processes that might ossify or de-osify you.

So, you know, I think there's great opportunity for both pessimism and optimism, and it's up to us to nudge the right direction. And the pessimism for you on this particular question of aging is mostly like matter of the enthusiasm and concerns. Right.

I mean, we need to be cautious about that. But even about, you know, power structure and money and things like that. But I think the power of money is probably a little easier to solve.

If you put our mind to it, we can make technologies. We brought down the price of sequencing, you know, three, ten million fold. We can probably do that with aging.

We're starting with dogs just to kind of demonstrate that. That can be very inexpensive. But in terms of now, Thuzian, I think we need to get off the planet for a whole variety of reasons.

Some of us back up the earth, and maybe that would be a partial solution if we can bring down the price of that. So, George, there's often a distinction made between life span and health span. And some of these interventions may keep us healthier until we kind of get to the edge of the cliff and then drop off.

That's the way, by the way, it was figured out in Brave New World where they were very healthy until the last 30 days, and then Huxley hadn't go off the edge. That actually happens in super-centenarians. People make it past 110.

Do you intend to die quickly? So that would be proven in health span. Do you have any evidence from your studies with something other than mice, which are designed probably by nature to die young because they are otherwise getting by predators. But do you have evidence that large, fairly long-living creatures can have their life span extended? Well, certainly the average human life span is twice what it used to be.

So that's one piece of evidence. The other one is if you look among mammals, you can find pairs of mammals that have tenfold differences in life span that are otherwise

closely related. So, for example, the bowhead whale is the longest-lived mammal.

It's 200 years already. So 200 years is reasonable in the mammalian lineage in that regard. The naked mole rat will live ten times as long as they're at.

So you could say, you know, the naked mole rat live better or something like that. They have pretty horrible life. They have such high CO₂ concentrations as they all huddled together that they've changed their pain sensors because there's so much acid in their skin.

So they wouldn't be in favor of extended longevity. They have voted with their genes. They live a long time.

They roll into the rats. So I don't know. I mean, I think there's no physics that says we can't live a long time.

And I think I tend to agree somewhat with Aubrey on this point, not all points that our technology today is so much more amazing than it was when I started graduate school. And 30 years from now, it will be hard to even for us. Most visionary people to imagine what it's going to be like because it's such a steep exponential.

So as a general rule, just so that you've got a perspective on this, the kinds of things you read about and what they do with roundworms and mice and so forth tend to advance as an age of even things like caloric restriction, which you probably all heard about, tend to go down as you get to larger, more complex beings. It's less than in dogs than in mice and in monkeys and less probably less than humans. And it may very well be that humans are already optimized at some level for kind of a balance of their purposes, including aging purposes.

Now, that doesn't mean we couldn't extend life somewhat and employ tools that nature simply can't deliver in the coordinated coherence of normal development. But it does raise questions about what's good for us, as you mentioned. When I was on the President's Council on Bioethics, we did a book called *Beyond Therapy, Biotechnology in the Pursuit of Happiness*.

And it was a very fascinating study. And one of the chapters in that book is on ageless bodies. And while we were doing this, I did a little calculation that if you figure a generation span is about 25 years now, it seems to be a little older.

But that's, let's say, 25 years. And say everybody, because of all this advance, lived to be 150 years old, then the newborn baby would have 64 great, great, great, great, great grandparents, 32 great, great, great grandparents, and so forth. They would be so separated by genetics, they wouldn't really be that related because you divide your genetics in half every time.

There's a generation. And second, they'd be unrelated at some level. When culture, I find it hard enough to keep up with my Stanford students.

And so, and they probably couldn't remember each other's names. So it would certainly change the meaning of family at some level. And there are many social issues.

I mean, I think we don't need to be rigid about that. We can handle those social issues perhaps. But there might be personal issues that were very different.

For example, it's possible that given that kind of longevity, we'd be more afraid of dying than we were in past centuries. I once talked with a woman who was 104 years old. She was really great.

She was ambulatory. She was cognitively with it. And she said to me, "Well, the happiest years of my life have been since I turned 80 because after that I stopped worrying about dying young." [laughter] But then she got a little wiser and she said, and it was pointed to hear it, and she said, "But my husband died 56 years ago.

All of my children have died and some of my grandchildren have died." So what does it do to life? Does it change the character of life? And at the foundation of these matters, we need to keep in mind our deepest questions about what we think our lives are for, if you will. And I'm not saying that we have to be rigid about that. We maybe don't know completely what our lives are for.

But I know some of what I think my life is for, and it doesn't all comport with every possible scenario of biological intervention, even if it serves my physical being. I want my life to have a meaning that is consistent with my values, that serves others around me, that is a sort of divine pedagogy where I learn to understand the nature of the source and being of my existence. And do you, are there particular, I mean you were just enumerating a few sort of possible ways that extended life spans could come into tension with those values, but are there more, it still sounded to me like you were open to the idea that on balance, it might actually allow for greater forms of human flourishing? Are there, putting aside that, you know, let's grant the premise that we don't know yet whether this is possible in humans, or maybe George knows, but the rest of us don't know? And just say, in an imaginary world, could you find it conceivable, or do you think, have you done some calculation in your head where you say, actually I've looked at the trade-offs and the bads that way that good here, and we should sort of stick to the normal human lifespan? George, how about you, have you had those thoughts in this process? Oh, I worry about everything.

I worry about that. This will give you more time for worrying. Yeah, exactly.

So, this is, if you're worried about your grandchildren dying, you could have new children. You could have a whole new generation of them. Well, not replace them, just

have a new family, you know? They're irreplaceable.

And if you have cultural barriers, you can work at it. You've got plenty of time to work at either learning the new culture or creating a new culture. There's no reason why you can't create the next sensation in music, for example, at the age of 180.

So, I mean, I think we need to expand our minds just a little bit to think that we're not the 180-year-olds of the future will not necessarily be as locked into their ways as 80-year-olds today. Some of them are already quite creative and flexible. Are there aspects of human culture to sort of ask a reverse question of you that you would say, actually I want to put up some barriers around these aspects of the world.

And I think that there's a lot of barriers around these aspects of human culture where biotechnology should not intrude. Well, you know, I think making armies and sociopaths would probably not be in the best interest of society. But that's ultimately a kind of utilitarian argument that it would create more suffering.

Are there things that you regard as just that are so interdisciplinary? Are there so interdependent or have such a high value by being part of pure nature or, you know, Bill is really pointing saying that some of these things just ought not to be tinkered with in general? Is there anything like that for you? Probably a lot. You know, I would say, unfortunately, we're not, we're no longer anywhere near pure nature. 97% of the animals, large animals on the planet are pets and agricultural species and us.

So that's very far from what we consider natural and our lifespan is already twice what it was. And, you know, we wear clothes and we show in rockets and jets and things. It's very unnatural world that we're in.

I'm not, I'm mostly, I think it's positive. I'm not even sure we necessarily have to improve on our happiness. You know, I think if we just had it more equally distributed or so that the happiest people that are happy today are pretty much everybody has access to that.

And again, that might be an economic thing because happiness to me is just a part of what you need to accomplish your goals and values of society. One of the biggest one, I think, is we survive when earth goes down. And it will almost certainly.

So, so, just me back to the issue of longevity and happiness and meaning. It certainly puts one in an awkward position to try to, to in any way defend death. Abraham Lincoln spoke of aging as the bombardment by the silent artillery of time.

It's a poignant phrase. I think most of us would like to live longer and that that would be a fairly natural motion of human intention. The question becomes then how and at what expense or what alteration of the meaning of life.

And George mentioned that we've increased the lifespan significantly in the past century

and that's true. But the turn of the century to the 19th to 20th century, the average lifespan was less than 50 years old. Now, in some of the more developed parts of the places like Monaco and other places, the lifespan is approaching 90.

And it's very possible that even with no biotechnological interventions, we can live, many people can live to be over 100. And certain people might even live to be 120, 130. With no biotechnologies, it's better, better operations within the world understanding what diet and exercise and sleep and lower stress, less social media maybe.

And things can do for us. But here's the difference and that is that these changes in the last century have come about through intelligible operations on the node world. And most of them are not biotechnology in the strict sentence.

They're mostly diet, sanitation, better understanding of what is healthy. And that comports well with human beings involved in their own lives in a positive and constructive way. I think it's a hard point to make.

It's a little abstract. But I think we have to be very careful that we don't turn our lives into something that is not easily understood by ourselves. In other words, we have to be careful that we don't make the transformations of our nature physical and biological as well as mental and psychological into something that's more akin to magic.

And I think for my own life, life has something to do with the given conditions of my life and my operation within the world to try to express the excellence of my capacities to the degree I'm capable of doing so. And it's within that frame that my meaning emerges in part. Now, I don't want to make this too abstract, but if you go to something like sports, we can easily imagine biotechnological interventions in sports that would make you better at something in the sense that you could run faster or jump higher or something.

But it might vitiate the whole meaning of sports and the way it plays for the individual life and the social collective of the sports events. And that gives us a sort of frame of why its human beings are not merely products. They are actual processes.

They have purposes that are played out in the way they live their lives. I guess I'm willing to say that I think the purpose of life and the broadest sense is this kind of experientially based ascent toward a deeper and more profound, which might call magnification of soul, an expansion of self in a way that is consistent with the deepest possibilities in the created order. And there's something about longevity in particular or other biotechnological interventions that you think would profoundly disturb that and not in a short term way.

I mean, I think everyone would agree that if we were to have 200-year life spans, there would be a period of reckoning as there is with so many changes that were currently

undergoing that are technological or otherwise, where we come to grips with how what this means for those of us who are trying to maximize our human flourishing on whatever theory of human flourishing that we hold. But in the fullness of time, we might come to some equilibrium with that. Are there certain constraints that you see today that you think ought to be permanent? Well, do you want to answer first? Or, I won't mean to answer that one.

Well, let me give you an example because we're back to gene editing. Okay? So George and I both know the Chinese scientist, Hijong Kui, otherwise known as JK, that's his nickname. He was at a conference that Jennifer Doudna, who's quote was initiated this event.

Jennifer Doudna and I are working on a project of deliberation and education regarding the implications of the new tools of gene editing. And George is part of our working group. He came to our first meeting and participated in the second one via video.

And the first meeting, JK was there. And we met him, talked to him, heard what he was about. And I'm sure George, just like I realized he was in the fast track toward germline and genetic engineering, although I don't remember him at all.

Well, that's interesting. But in any case, yeah, well, he was a young guy. We just invited him.

You had some very good comments in response. We're all very busy. That was two years ago.

So now JK did this dramatic experiment that was leaked. It wasn't intended to be a public event, but it took place at the end of the day. It took place at the Hong Kong Summit.

And it was like an explosion to the summit. It made worldwide headlines. I was there.

And it was really like nobody was talking about anything else. And because the summit was partly designed for the public image of science, I'm not saying that was the only goal, but that was part of the goal to announce to the world that we know there are serious ethical issues associated with these technologies. And we can handle the regulation of ourselves.

We don't want the government and everybody's frightened scenarios to control the science. And JK's experiment basically was a big embarrassment to the Hong Kong Summit and the organizer, the convener, David Baltimore, Nobel laureate from Caltech, stood up and said, this is this event shows that we have not been able to effectively self-governance. And so the entrepreneurs are our social scientific process.

And he signed it to the lack of transparency, which I think is correct also. Everybody piled on JK with huge criticism and to his credit, George gave an interview to Science

Magazine saying, wait a minute, this is the goal, even if he's gone a little fast, you can say what you said, but I was very happy to see what he wrote, and I know JK pretty well because he came to see me numerous times afterwards at Stanford. And I got to know him and talk with him deeply about what he was doing.

And it's not quite fair to say he's this guy after pure fame and fortune and did it in a corner. He did it talking to many people, and he also has very idealistic goals. He's kind of a touching person actually in the sense of what he wanted to see happen.

But just to circle back to what I was really going to say was, so his experiment was done, seven days later he got an email from an infertility clinic in Dubai saying, hey, we want to take a course from you, we all learn how to do this. And you know, everybody knows where that's going to lead. It's going to do the same thing that the stem cell issue did.

It's going to lead to these kind of edgy clinics all over the world, offering services and advertising services. And the reason I bring this up is because this is one thing I don't want to have happen with biotechnology is for it to become a promoted, aggressive disruption of normal life processes. I do not want procreation to be turned into production.

I don't want to see the normalization of IVF for every new baby that comes into the world. I do not want to see the commercialization of reproduction. And these are very great dangers.

And we speak about the possibilities in science. We need to be alert to what is, you might say, in man in the sense that Jesus says in the Gospels, Jesus himself had needed no one to bear witness to what is in man's heart. And we know what's in man's heart.

There's all sorts of strange and distorted ambitions and appetites and aspirations. We want to be very careful and powers coming into our hands are greater than we've ever had before to intervene in human life. So there are very serious concerns.

I think you don't even have to go to a fertility clinic. They've done polls in the public to the extent that they understand it. They're about 75% in favor of this kind of technology, both in China and the United States.

But put that aside because maybe they need more time to think about it. Getting back to the issue of whether our current health healthy status or doubling of our average age is due to biotechnology. I would argue that it is.

You've said that it's mainly about eating well and exercising, but I think it's also antibiotics, vaccines, surgery, ambulances, all kinds of things that are very technological, and many of which we do not understand. The average personal street does not understand how these things work. In fact, they often misunderstand them, misrepresent them.

If you say almost everything in this thing is magic to most people. GPS, how did that fit in there? And all those satellites inside this thing. We're getting to more and more things which no individual person understands.

Even the world's expert, even the world's most multidisciplinary person, can't explain most of our technology. That's not necessarily something that alters our soul. I think we still care about each other and we still care about the planet at some level.

That extra technology helps us reduce the fraction of people that are in poverty, not necessarily the absolute number, but the fraction. And we can just kind of, the rising tide will float all the boats and we'll get more resources to make a healthier, hopefully more spiritually aware world. But it's hard to be focused on these higher level concerns when you're spending all your time keeping your family from dying of horrible diseases.

Well, I certainly agree with that and you may not understand how your cell phone works. I really don't understand how my toaster works. So it's not the non understanding of those things.

It's what my point was a little abstract, but there are parts of human life that we don't want to treat as though they are just engineering challenges. I mean, I mentioned sports, but it goes beyond that. I think the way a human life unfolds is we probe the world by intention.

We understand ourselves within the context of that interaction with the world and we build up a memory recording of how we relate to the larger world and that's the formation of personal identity or the autobiographical self. And if we are frequently intervening, and I think we're already too frequently intervening in our biology, we disrupt the normal chemistry of identity and personal control of our lives. And it's maybe hard to lay out in clear fashion in such a short forum, but I think it's a very serious concern.

When we did the volume that I mentioned in the President's Council, we spent quite a few pages explaining how the relationship in personal process and meaningful life are serious matters to be concerned about in the age of biotechnology. And part of our lives is not just affecting desired ends, but having an understanding of the means toward ends. Education is one of them, character development of certain qualities, moral spiritual development.

I personally don't want to take a pill to become a better Christian. I want to learn through the pedagogy of experience what it means to be a person. And by the way, jumping back to the goals of longevity and so forth, I was at the dentist a while back.

We all hate that. And the hygienist was saying, "Be sure to floss, because then your teeth will live forever." And I said to her, "Frankly, I don't care if my teeth live forever. I

only want them to live as long as I do." And that's the way I feel about my life.

I would like my life to unfold for purposes that are higher than just the preservation of my body. I would like to live my life in such a way that the meaning of it is a contribution and engagement with the larger world. And frankly, I would like to be like Soren Kierkegaard.

I would like to use myself up so that I would give myself every last ounce of mental and physical energy in the sacrificial mode of understanding and ascending to and magnifying the presence of love in the world. I want to go to some audience questions in a minute, but before I do that, I want to end our three-way conversation here on a note on which George may exceed us all as a bio-conservative. Because I know him to be not just interested in preserving the current natural status quo on the planet, but actually wanting to wind it back to the ice age in some corners of it through his involvement in this project.

I had the pleasure of visiting in Siberia called Pleistocene Park a number of years ago. And part of that would be hopefully to resurrect through gene editing and other fancy biotechnologies, the woolly mammoth. And so I was hoping, George, that you could give us an update here tonight.

Is there like a woolly mammoth in a tank in a lab somewhere here in the Middle East away? Well, I mean, some people are opposed to the speak because they think they had their chance. And I'm not sure, you know, we're just creating opportunities, but I think it's not so much about bringing back the ancient species. It's about bringing the ancient genes to enrich current species.

And neither of those is natural. I'll admit it, except to the extent that we are part of nature and therefore it is natural. We are engineers by nature.

Education is very far from natural. The way we do it now with Gutenberg and everything, all the fancy new stuff that keeps avoids eye contact by looking at books. But with the point of this is to the Asian elephants are endangered species.

They're dying partly because of herpes virus and partly because of their strange interaction with humans. They're in highly populated regions. So this would help them, but also they could help us if the Arctic carbon is in danger, which it seems to be.

So that's a longer story. Your question is whether we have them coming out of our brave new world tanks, and the answer is no, not yet. But we have mostly edits we think we need.

We've developed new methods for we can sequence the ancient DNA. We brought back a couple of ancient genes and they're fully functional and they look like they're exactly what you would expect physiologically to be to form the transport of oxygen and low

temperature, the conductance of nerve sensory inputs at low temperature. So we're bringing back individual genes.

And that may be all we do. We bring back those genes and that gives elephants ability to live at low temperatures again. They're already hybrids.

I mean they have bits of mammoth DNA and I'm just like I have bits of Neanderthal DNA and there's a lot of stuff going on in the past. Bill, do you have any special objection to the resurrection of extinct species? Particularly when you talked earlier about sort of living within meeting in the created order. Obviously these things it's indisputous to whether humans in particular cause mammoth extinctions it seems very likely.

But we certainly cause the extinctions of the vast majority of megafauna during the Ice Age and in the millennia afterward. And it might be that living within meeting in the created order is taking acts of restoration along those lines. Would you would you object to that or does that come into conflict with your values at all? I find George's ideas of bringing the William Mammoth back exciting.

And I think it's I'm with Neil Wilson on this. I think it's absolutely a scandal that we're not taking better care of the natural world and the species are going extinct. I mean where are we as Christians in this very very important honoring the created order? It gets a little more edgy when George talks about de-extinctioning Neanderthals.

I mean that raises them, you don't talk about that? No. Not that it's not usually. It's certainly not working on it.

It would certainly be fascinating but it also raises the question whether it would be fair, whether it would be kind. And I think in the final end all of our technology ought to be governed within the frame of love and real consideration both for human and non-human creatures. [Applause] If you like this and you want to hear more like share subscribe and review this podcast.

And from all of us here at the Veritas Forum, thank you.

[Music] [Silence]