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## **On Bones and Genomes: What Can Science Tell Us About Being Human?**

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### **The Veritas Forum**

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### **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 in history, don't be surprised if you're going to get an element of this in God. Today we hear from Dr. Praveen Sethupathy, a professor in the Department of Biomedical Sciences at Cornell University, where he directs a research laboratory focused on human genomics and complex diseases. • And Dr. Zeray Alemseged is the Donald N. Pritzker Professor in the Department of Organismal Biology and Anatomy at the University of Chicago.

• A discussion titled "On Bones and Genomes." What can science tell us about being human? Hosted by the Veritas Forum at the University of Chicago. So the meditate here in these next eight or nine minutes is to share a little bit with you about my work. And also just to touch, maybe a teaser on how I think about genetics contributing the answer to the question of what makes us human.

So as John mentioned in the introduction, I'm a genomist. And really to me what that means is since we now have the human genome sequenced, we're now in this phase of

trying to figure out what it means. So I think the analogy that was given at the time of the human genome draft was it is as though an ancient parchment in an unknown language was discovered.

And now we need to decode it. And so for the past one years, since the mapping of the human genome, that's what scientific community in genomics has been engaged with. And that's what I do in my lab.

Fundamentally, if you think about our DNA, the fact that our DNA is an instruction booklet for how ourselves inside of our body ought to behave, then how is it that a brain cell knows how to do something different from a liver cell, which knows how to do something different from a skin cell? What it boils down to is that while the genome contains a full set of instructions, each cell is only executing a subset of those instructions. So that leads to a really interesting question about how, how do each of these cells know which instructions to execute? And we don't have time to get into all of that today, but those are some of the things, the questions that we're interested in answering. And in particular, how of the species' making by the cell go awry during the development of disease? There's one particularly interesting concept that we think about a lot.

The word genome, which is used to report to our full DNA sequence, means a library of genes. But it turns out that most of our DNA is not gene at all. And instead, scattered and littered across our genome are what might be best described as dials or reostats that are involved in controlling the level of activation of the nearby genes.

And while it can be the case that you can acquire mutations in the genes themselves, more often than not, with the kinds of complex diseases that we're struggling with in our society, diabetes, cardiovascular disease, various types of cancers, these are often because of mutations, at least from the connect standpoint, that are occurring in these reostats or these dials. Instead of making 100 units of a nearby gene, perhaps you're only making 10. And so that has really been a paradigm shift in the genetics field in that we're not thinking about complex diseases as qualitative anymore, whether you have the bad gene or the defective gene for that disease, but rather as a quantitative problem, that you're making too much or too little of genes that are really critical for controlling those traits.

So we're interested in my lab in three major disease areas, diabetes, gastrointestinal diseases like Crohn's disease, as well as cancers, liver and colon cancer. So hopefully that's sort of a brief little snippet of the kinds of things that we're generally thinking about on a day-to-day basis. I want to welcome any questions about any of that that interests you now or afterward.

So switching gears just a little bit. What does science say about what it means to be human? As I was reflecting on this and thinking and preparing for today's event, I was

thinking about how a colleague once told me that biologists can be stratified in roughly two categories, and this is very crudely speaking. One would be Lumper, the other would be a splitter.

A Lumper, as the name suggests, would be one who is interested in grouping things as much as possible based on shared features. And a splitter, again as the name suggests, is the opposite. It's seeking increased granularity and specificity and resolution.

But if you make that splitting idea to its logical extreme, it's not particularly useful, right? Because then you really want what the organizing is. But if you take grouping to the logical extreme, you also have a problem, right? Because then you have lots of things in the group with very few shared features. You may not really be able to learn much at the end of the day, right? And so we want to hold those two things in tension as biologists.

We appreciate the impulse in both directions. But in these kinds of questions that are really about categorization, what makes us human? What are the features that define us that distinguish us from other living entities? When we're dealing with these kinds of questions, I think we want to make sure that we're not over grouping and over splitting, right? So that's one principle maybe to be thinking about. Because I think that I'll be able to give more thorough responses to the questions that John will ask, I think what I'll leave you with is just a couple of principles from genetics.

The first is that genetics is, I believe, an equalizer. Okay. Both within our species and across species.

And I'll take a minute to tell you what I mean by that. There have been efforts by scientists throughout the years to stratify human beings, maybe even assign greater value to one group over another on the basis of discernible traits, like your skin color or your hair type. And what genetic analysis has done is blow the lid off of those kinds of impoverished and superficial thinking.

Because if you think about it within species, I might be able to quite readily with a little bit of DNA sequencing identify two Caucasian individuals in the audience today who have more genetic similarity with an Asian individual in the audience today, than they might with each other. That would not be a terribly difficult task to accomplish. It's also an equalizer from the standpoint of across species.

Right. There is a natural impulse to want to define our as humans on the basis of human DNA. But again, genetic studies have really obliterated the ease with which we can hold that view.

Right. And this is because there are bits and pieces of DNA from other species. Um, extant species, but also extinct species.

Right. That are influencing our biology. It's not just that they're inside of us, but they're

actually helping to govern certain traits that we might even think about as potentially.

Um, so I think that that's really important to appreciate and understand because it colors the way that we might think about using genetics to understand what it means to be. When I say that genetics as an equalizer, please understand me. I don't mean to say that there is no variation among us.

There clearly is. Right. And we celebrate that variety.

Right. But what I mean to say is that it is not so easily as many have tried. To draw definitive, clear and immutable genetic lines.

Right. That separate different groups within humanity or that evens. Manatee from other species.

What I'll leave you with before I see the floor to his array is that genetics. You know, it's also. Um, so the best way to put this.

It. More and more analysis in the realm of genetics have taught us that it is simply a starting point. It's where we might start the conversation in terms of biology and how that informs what makes us to be human.

But it cannot end there. And we know that because genetics doesn't determine who we are. It provides us with a template.

A starting point of who we are, but we know that the full expression of who we are is a combination of our genetics and on an environment. There's a really complex interaction that takes place there. That we can discuss more if you're interested.

And so even the genetics itself is highly specific in terms of how it might define a human being. So those are some of the things that I wanted to bring up during the introductory remarks. Thank you.

No, right. Good evening, everyone. Can you hear me at the back? Well, thank you, the organizers and the sponsors for letting me come from my life is actually just behind us next door.

I have not done this type of forum before, but I will assume any errors that come out of my mouth and I'll fix them when you invite me back here next time. I would also really like to welcome Praveen, who was willing to come here to the University of Chicago and share his expertise, but also his perspective on what makes us human. John, you've been working hard on this with Michael and others to put this together, so I'd like to thank you for that.

So what makes us human is a question that one can ask in many, many, many ways. As a matter of fact, Praveen and I are not the only privileged people to answer this

question. As a matter of fact, again, scientists are not the privileged ones, or religious leaders are not the privileged person, and I am in the 7 billion people.

So how do we have that privilege to ask? They do ask that question. Now the question is, what are the different ways and how can we come to a, I wouldn't say consensus because I don't like the word, but to something that would make sense. So when we communicate as members of one species, how can we find a way of articulating that answer so we all can then celebrate each other? I think that's my bottom line.

But let me tell you something about myself and why I have the privilege of being here today. I think if I am here today, it's number one because I'm a scientist, like Praveen, and as a scientist what I do is I ask as much as I can in particular questions within framework. So the moment I am out of that framework, I stop to be a scientist.

So that is one of my guiding lines. I was telling one of, I think it was Michael the other day, if you had a soccer player, and that's a metaphor for me, and you could be messy or an alto. I don't feel like soccer.

The moment you go out of that perimeter, it will be whistled. You'll be stopped. Whatever you may or may or may not be able to do with your ball, you're out.

So I would like to underscore the importance of a framework. That's number one. So first of all, I'm a scientist.

And I'm also a paleontologist, which is the exploration of past life based on the fossil evidence. And as words, plants and animals die, and I've been doing this for millions, if not billions of years. My job is to go out there, find the fossil evidence so we can answer what happened in terms of evolving life at a given time.

I'm also a paleontologist, which is a subset of paleontology that focuses on humans and their ancestors. What does it mean? As elegantly put by Praveen, it's very hard to actually separate the DNA of people here, and even separate us from other species. And what that tells us is we have a common ancestor that's been changing food time.

And if you look close to home, you will have a common ancestor with the chimpanzees, sometimes 7 to 6 million years ago. It appears that we share over 98% of our genetic makeup, genetic material with the chimpanzees. If you go further, look at mice, it would be less.

If you go further and further and further to nan mammals, it would be less. And you can continue to find the origin that connects all of us. But let's focus on the common ancestor between us and chimpanzees.

DNA tells us that we separated from them sometime between 6 and 7 million years ago. So as a paleontologist, again, which is a subset of paleontology, my job is to go out there

and find the fossil evidence so I can establish the different stages of our evolutionary development. And what that entails is that when you find the fossil evidence, and then today you know that humans have many, many unique features ranging from working upright to the symbolic species that we are becoming the only species to be worried about who I am as a species.

I can even go ask ants or cats. I'm very, I'm not visual, but it's very likely that they'll tell you I don't get about who I am if you were to ask them. They do care about who they are, but they don't really investigate that question in a way that we do it in humans.

So sometimes even we fight about that very question because we have diverging views. But what paleontology does therefore is it gives you the fossil evidence so you can look at it being upright worker like you and I, truly using species like you and I, having this big brain like you and I, and the symbolic species that we are, then the question is when did we acquire this key human attributes after we separated from the cousins, the chimpanzees. And therefore that is what leads me to define and to try to define what makes us human.

Because the question what makes us human is contextual. There is no one definition of what makes us human when we know that we are part of the animal world. But what is exciting maybe to many of you is many people ask, we are so unique and there is no other animal that does what we do.

How is that that we are still part of the animal world? Well, I don't want to disappoint you, but that thing that makes you think like that is the symbolic species that you are, and that is your specialty of species. If you think that you are more specialized than a fish, put yourself in the ocean and see who went to survive. Or put yourself in the serengeti parks and you will see whether you will survive like the antilops or the other cats.

So the unique features that we have today as human species that we are so symbolic is an attribute that also had its origins somewhere in Africa, 100,000 years ago, when people started to put jewelry, ornaments, beads, ochres on their body. Why would one put ochres in the middle of their body? Because that's when we started to separate ourselves as individuals. So the human person, which is a topic of this discussion, actually has its origins and we have the archeological evidence to try to see how it evolved.

And then add to that art, music. That is part of the symbolic species that we are. So if you put all that together and ask me how do I contribute to answering the question what makes us human, I contribute by being a scientist, and that is framing my question.

I contribute by being a paleontologist that is finding the fossil evidence. I try to answer the question by being a paleontologist that is finding the human fossils and I have done

my share of contribution for the set. But putting that together, really learn that the differences that we see today, it's fundamentally documented in biology, it's called variation.

So the uniqueness that we each have today, that we see that we are variable, is actually the basis for selection if you were to go to see in other than human animals. So for me, the differences, the uniqueness that you see in each of us, but also as a species, is an expansion in time of that variation that you observed in the animal world and in the plant world. So it's incumbent upon us therefore to ask that question without the bias of knowing that we are studying ourselves.

So we don't tend to actually privilege that humanness, which of course should be celebrated, but know that it has its biological and cultural roots. I think with that I will maybe stop so we can have the opportunity to delve more into the question. Thank you both for sharing those initial remarks.

I just had a follow-up question. Both of you study the origins of the human person in different respects and I wanted to focus a little bit on how specifically your research has been shedding light a little bit or providing some insight on human person. So Dr. Setha Papp, in the past I know you've worked closely with Francis Collins, the Director of NIH and on the Human Genome Project as you mentioned.

Could you share a bit some of the questions that arose, potentially even controversies that arose over the course of that project or even even your own course of your own research, particularly as to how they pertain to understanding the human person. You mentioned sort of genetics being a great equalizer, implying a certain vision of the human person. So I just wanted to see if you can delve further into your research on that particular question.

Sure, sure, sure. So, you know, I think that touches quite nicely on one of the comments that I had made about how we have bits and pieces of DNA from other species inside of us, helping shape our traits and behaviors. So maybe we can delve into that a little bit more.

One of the levels at which biologists have tried to answer this question of what makes us human, you know, to do it at the behavioral level at the anatomical level. I'm going to let Zari handle those. But we've also attempted to do it at the cellular level and at the genetic level.

So what I mean by cellular level is perhaps we could just define as a collection of all the things we find in human cells. So a compendium of all of those things, the machinery inside there, is human. So we have a sticky problem, right, the fact that probably a little bit more than 50%, a little bit more than half of the cells in our body are not human at all.

But they're microbial, right, so they're bacteria, they're viruses, other kinds of microorganisms that populate different organs that gut and the lung and the nasal passageways and skin and other locations. And they end up comprising more than half of the cells in our body. And it's not just that they're there, but they turn out to be vital for the proper functioning of the organs where they reside.

If we didn't have the microbes in our gut, our gut simply would not function the way that it's supposed to, or our proper health. So there's a really beautiful symbiotic relationship here, but it certainly obliterates this idea that we could just define the human and its behaviors by a collection of human cells. But then you can dig deeper and get to the genetic level and say, "Okay, forget about the cells." What if we just said human DNA? But there you have a problem, because scattered across our human genome, if you read it out from left to right, what you would find are these locations where there are pieces of DNA from viruses.

What are they doing in there? And what does it mean to say that a modest approximation of 10% of our genome is of viral origin? Many geneticists with that number much higher. So how does that make us think about what it means to be human from a genetic standpoint? And again, it's not just that they are there, but it turns out that some of those viral DNA pieces in our genome have been repurposed to contribute to the way that we develop in our mother's womb, to the formation of the placental organ that nourishes the baby in the womb, to some of the unique features of the human immune system. Those are all we might even potentially point to as part of what makes us human, and yet it is pieces of viral DNA that are playing really important roles in contributing those features to us.

So I wouldn't necessarily, I don't think that speaks to your question of controversy, as much as it does get at how having the human genome and being able to map with high resolution the cells of our body has opened us up to the human genome. And it's really important to bring us up to a much greater level of heterogeneity in our instruction booklets than I think we knew about it before, but the extent to which it's present there has been revealed to us now in a new way. I would just think thought if I were to do that DNA swab with my saliva and send it out, they'll come back 90% Korean and 10% virus.

I don't know if they'll give those reports. Dr. Alemisig, a follow-up for you. I understand one of the key insights of your work is to highlight the cultural features of hominids, such as tool making and symbol usage you mentioned that the unique features of human beings as a species is a very symbolic species.

So I wonder if you could delve further into some of your own research that expands our sense of the human beings. Yeah, sure. So I think what's coming from genetics is just phenomenal.

We're celebrating DNA today, DNA day to day. But I don't know, maybe 50, 60 years ago,



we wouldn't have imagined that we would be at this point. Talking about the complex nature of the genome that Pervian has the privilege and the expertise to exploit.

But at the same time, I would say that humans, like any other living organism, live in an environmental context. And the environment is going through shape them. And today, actually, humans happen to be also a prominent shapers of the environment itself.

But let's focus on the first part. But maybe it's also a question for Pervian. So when you see that complex nature of the genome and bacteria in all the viruses, could we maybe reflect on that for a bit? And wouldn't that be part of our environment? It just so happens to be hidden in our body as would be the habitat of early humans.

That was the savanna environment, or would be the forest environment, or the very complex environments that we have today. Because ultimately, what is shaping those genetic expressions and turning them on and off is the envelope, and completely agree with you. Maybe when I'm done, you can tell us more about that, because I'm really curious, you know, maybe the epigenetics works that you guys do.

But let me go back to my own territory, to say. The contribution that I made, I think, in the realm of defining what makes us human, primarily comes from the paleoanthropological fossil and archeological record. And I will just point to two examples.

Back in 2000, I made a discovery of what is known as the earliest and most complete child skeleton dating back to 3.3 million years ago. And one of the things, we've learned many things from the skeleton. One thing that we've learned from the skeleton is actually, first of all, we were able to tell how all the individual was when she died, and we weren't able to determine that the individual died at year two, and 2.4 years and four months and five days, we have the techniques today to accurately determine the age of death of individuals.

But I'm not just telling you that to brag about the techniques or the methods, but because of that, then we were able to see how much of the brain was formed at that age, and why is that relevant. If you were to compare humans and chimpanzees, humans are born with a very, not very well developed brain, small brain. Because if you were to try to give a birth to a fully brained individual, you basically kill the mother, therefore the species gets extinct.

So you should respect your mom's and your sisters if you want our species to continue. So what I think the intellectual selection did is, okay, you want to be smart, you want to make your brain bigger, yes? But then you will have to find a solution, and the solution was, okay, we're going to have our babies born before they are mature, and then we will give them care once they are out. That's one secondary altriciality, basically means a continued dependence of the baby on an agardian or a parent.

So based on that analysis, what are chimpanzees you can see them, they are born by the age of 3, 90% of their brain is formed, so they can catch up with the environment very easily. Look at antelopes, they are born, they start running. Don't try with you babies, because myself, I had to deliver my own baby in a parking lot back in San Francisco, and I know how hard that is.

She survived, she was running, she was doing great, she was 10 now. But that moment of relationship that you have with the birth of your child may be exciting, but what evolution did is also, it made it very dangerous. But it also gave us the solution.

So what it did is, okay, you will have your baby born and then you will have a big brain, so you can open hospitals. Smart people like John. So when did that emerge? Thanks to this fossil, we were able to see a hint of that extended childhood back 3.5 million years ago.

And that says a lot about how our behavior changed from the more applied, where there is a fast growing brain even at birth compared to the human condition. Of course, brain that you and I have today did not emerge until 500,000 years ago, and our species didn't come to the landscape until 200,000 years ago. So those stages of development is what I am very excited about.

That's number one. The second one is the emergence of responsible use. And why is that important? When you look at, again, I use chimpanzees, like because they are 98% genetically the same, and they also do many things that are similar to us.

Also, they have similar teeth, they don't have a tail, you know what I mean. They do use tools, but you will never see them pick up a rock and shape it. Because that shaping of a rock is done with anticipation that it's going to be used for some purpose.

And as far as I know, only humans can do that. But not only humans. We have the evidence for shaped stone tools going back to 2.6 million years ago.

A species known as Homo habilis behind a man was able to, maybe a woman did it, but the man took the credits, I don't know. But we have that evidence. So what we did in my work is, well, how come the species that came before Homo habilis didn't do this? And then we found the evidence for actually a genus or species called Australopithecus making, you know, using stone tools to act to carve meat of the bone, to remove meat of the bone in a systematic way.

And for me, that is really the unique relationship that our ancestors started to interact with in the nature and how is that impactful? Well, it's impactful because the moment you have an additional tool in your hand, the relationship that you're going to have with other predators or other species is going to be completely transformable. And for me, that is really the first iPhone. When we jump from iPhone 5 to iPhone 6 to iPhone X, you

name it, we're amazed by the technology that is being included.

But for me, that shaping of that world, so you can use it for some purpose, is the beginning of the technology that would now allow us to go even beyond our planet. So I think the two contributions speak clearly to what makes us huge, as the proficient stone tool user, and then ultimately having the techniques to venture out of Africa that was also out of the topics. Maybe not many of you know, you will not find any prima, out of the topics, unless in a zoo or something like that.

No, they can't. We are a tropical species. If you dare to argue with me, go out when we have bora called here naked and you will see that you don't belong here.

So the fact that we have the sophisticated tools is what made us the species that goes all the way to the temperate zone Alaska, including Chicago. So the fact that I, in my team, of course, I should acknowledge them, of course, contributed to understanding the origin of earliest phone calls and the origin of earliest childhood would be some of the things that would allow me to understand how we became human. Through the course of the institution.

Do you want to stop here? I loved it. Thank you. But with respect to the earlier points that you had made about, you know, how do we think about it as something that's a part of us versus environment.

You actually touched on a topic that is very open and actively being discussed in the scientific community right now, because there are different camps. Some do tend to view the microbiome, for example, that I described as actually a new organ being referred to that way in some of the scientific literature. It's another organ that we have almost, right, whereas others shy away from that and actually think about it as environmental contributors shaping our own host cells, but they just happen to kind of flip inside us.

So it's an active question and I think you could think about it in both ways. Even when it comes to these pieces of viral DNA that are embedded within our genome, you might be tempted to think, well, right there, right alongside all the rest of our human DNA, and how can we think about that as environmental? Well, they get there. They got there because of a special class of viruses called retroviruses that are able to insert themselves into the organelle.

So at one point, right, it was an external infection, if you will, right, that then manifested and a memory of that was retained in our genome. So while it has become internal, it was once an external influence that led to that. And so even there, there's a conversation to be had about, so even kind of blurring the lines of what is really us and what's environmental.

So I think I don't know that there's a right answer to that, but it is an interesting discussion. Wonderful. You mentioned sort of in joke, ingest the first iPhone and they think that part of what makes us human is sort of not just bones genomes and today iPhones.

So I wonder if I can. Yeah, we have a new species. I can't go without my iPhone.

You know, it's a human thing. I have a new species called the Homo festival chi. You both shared a bit about how the research in your fields sort of contribute to the understanding of the human person.

I wanted to shift gears a bit and talk a little bit about the authority and limits of the scientific field. So a question here that our committee had come up with here was science appears to have a contested authority in our polarized age. And at extremes, we have one side, scientism where everything is explained by science and there are popular versions of this where scientific authority plays a dominant role in dictating everything from diet and exercise in our personal lives mediated through the health pages of the mainstream media and public policy and social life, et cetera.

At the other extreme, we are also in a moment exemplified by a deep suspicion of expertise as people turn to alternative sources of authority for everything ranging from medicine to climate science, et cetera. How do you make sense of this current moment and what what what do you feel is the proper role for scientific authority in our public and personal lives? Do you? So, as a scientist, I undoubtedly agree with science is a power for being able to understand our natural world. So those things that are governed by natural processes should be able to study them in an orderly and rigorous and controlled fashion and be able to understand the mechanisms that underpin those processes.

So, when it comes to climate theory motion or, you know, tackling cancer, science is your man or woman, right? Like you, that's, that's where you want to turn. That's where you want to turn to. But science is necessarily agnostic with respect to anything that is outside of the natural realm, right? It neither affirms it, nor I think can it refute it.

I think its realm is in the study of the natural. You know, this is kind of hard to back to many other thinkers and scientists and practitioners, one that's coming to mind ways as scale, who said, there are many ways of knowing and our day to day lives bear that out, right? So, I would ask me to do that. I love my wife, right? I'm not sure that I would feel the offer to you in the sort of bonafide mathematical sense of the word, right? I mean, I think what I would end up doing is relaying to you a set of experiences and having you walk through my life and it would be either compelling for you or not.

So, if you would say, well, it's the explanatory model that is what does that fit the data better than other explanatory models out there. Really at the end of the day, that's what

we do with scientists, right? I don't really think I'm into this with the theme very much. I think actually what I'm doing is gathering evidence in support of an explanatory model, right? Something to explain the data that I see and over time, hopefully we get to a point where we're able to say, look, there are these competing models out there, but I think this one has really won out.

That's something people don't often understand about how the scientific community came to embrace evolution, right? It wasn't just that Darwin proposed his ideas and everybody said, hooray, right? There was a great amount of pushback, right? Anything new has pushback and it was a lot of the scientists that pushed back, right? And it was really not until over a long period of time where it emerged as an explanatory model for the data that we were observing are better than any other explanatory model that came to be embraced by the scientific community. So science has an extremely powerful role to play in helping us understand the natural world in which we reside. But I think we have to think about what Blaise Pascal said that there are other ways of knowing if we were to ask of the heart, a reason, right, for the way that it feels, he said it would be just as absurd.

If we took a proof and we said, hey, give me an intuition for that proof, right? That's not necessary, right? These are different ways of knowing, he said, right? And we experience with regularity different ways of knowing things. And so whether or not there is another way of knowing, another means of acquiring knowledge that is relevant to this question of what makes us human, science cannot say yes. I would not dare to suggest that my work in science has pointed me in the direction of another.

I would simply say, this is as much as science can tell me, but I don't think it does violence to another way of knowing or another way of approaching this question. That's good. So, again, let me reiterate what I said right at the beginning.

I am a scientist, well, I try to be a scientist and ask questions within a framework. I think a scientific question that does not have a framework is English is not my native language, so I have to be very cautious when I choose words. I would say it is not good science for now.

I was going to say flubbrass or something like that. But I think, Jan, you mentioned two important words, authority and limits of science. So, for me, the limits of science should be dictated by that framework within which you're going to have data, methods, as much as you can in paracal, and then pass through the process of scientific method.

As much as we can understand how science has worked for many, many years. That's number one. So, the limits, for example, sometimes are some people will think their fingers at science.

So, science cannot explain climate change, for example. I think it does, but they will say

that. But they would say that the moment science is struggling to venture into the next stage.

I think if you go back 100 years ago, and was to ask the scientist who was struggling to find the cure for small parts, they were exactly in the same situation. We are now in terms of climate change and understanding evolution, you know, but then the moment we go to the next, the idea we cure small part, and then we say we have another challenge. And then say, see, science has a limitation.

Of course, science has a limitation. Do you know why it has limitations? Because science is not a way to find the truth. It's a tool that aims at the truth and is a process.

If you don't enjoy the process, you'll be bored. Like hell. Don't be a scientist.

So, one time we compare science with other approaches that claim to have the truth. I think that's misleading. As much as I would respect the other approaches, the non-scientific approaches, and they have the right to find the truth.

Comparing it to science is not fair, because science never claims that it's a way of finding the truth. If you remember your math, we have something called as some type of something where you draw a line. You can approach, approach, approach, but you'll never get there.

Science is like that for me. It is going to approximate as much as it can the truth. But then the moment we find the truth, it will be very boring as a matter of fact.

So, I think it is good to put science in its own context and celebrate the many strides that science has made things we started to have the scientific approach. And I would remind you that it's not just about this little change from iPhone 5 to iPhone 6 to iPhone 10. That's not it.

Think of the major strides that science has made so that in the West, for example, today we have a life expectancy which is over 85 years. Unfortunately, in other places, we don't have that. So, how are we going to reconcile an approach that has been proven, having to get it, not only in terms of its theory or hypothesis, but in terms of its application and improving human life? If one has an alternative to the process of scientific medicine and how we do it, then let them have their own paradigm and show us if they would come up with inventions or innovations that science has accumulated over time.

So, as much as we want to find other ways of knowing that other way of knowing will have to have its own framework that is comparable to the way we do it in science. One thing I would add is the worst enemy of a scientist is his calling. When you submit a paper, the first thing we do is where is the bad part? I want to reject this paper.

That is the first thing to say. Because we are not satisfied by what we do because we are in a process. So, to finalize, science is a process.

It's not a way to find the truth. But then, as far as I know, it seems to be the way that is getting us closer and closer and closer to the truth. Very close.

Thank you. I'm going to transition to the question answered to the audience, but I have to take advantage of this moderator position by highlighting my own research and disguising the advantage in the form of the question. Let me just take some of the things that I study and the role of foundational commitments and role models and sort of shaping medical students' journeys to become investors.

I just wanted to just briefly understand how you all decide to choose your respective field and who are the role models that really influenced you and maybe some of the foundational commitments that really shaped your career. Can I take one second? I have a very different background. I was born in Africa in a country called Ethiopia.

We don't really have many role models in terms of doing science, especially paleontology or human evolution. We do have very good medical schools and students from their very successful line of that. Growing up, I like any other child.

Well, I was good at science and all that, but let's assume that that's true. My mom said anyway, so that's important. Not going to school was not an option, not doing homework was not optional, but the bottom line is the role models that the type of role models you can find is limited by the context.

So I am where I am, I would say, via serendipity. Just through that, Ethiopia is where we find many human ancestor fossils, so seeing many foreigners coming to the field work, especially having worked at the National Museum of Ethiopia where famous fossils like Lucy and others were. I think that interaction might have triggered to this interest that I have, but really I don't have any special relationship with someone that made me think about what I am doing.

So I would say I am just a self-made scientist and it seems to work so far. I have been employed up until today. But one thing I would say that, once I started to do this work and this business of what makes us human, but to be in the forefront of finding evidence, to be the first person to touch that fossil, it completely changes you as an individual.

Not only because you are contributing to science, but you are serving as an ambassador for almost 7 billion people to touch that potential, potential potential, potential ancestor that could be ancestral to all of us here, actually the 7 billion. So I would say that it has made me humble. It also has made me to think very broadly.

For me, when I see all these different colors, black, white, you know, what I see is unity. I don't see diversity. Diversity is great, of course we like it.

We celebrate it. But the unity would have to also be highlighted. We are genetically, as Praveen will tell you, over 99 plus percent the same, including our bacterias.

But also, we have a common our origin, somewhere in Africa, 200,000 years ago. And whether we like it or not, we have the same destiny. We cannot list out a part of the planet today and be comfortable.

It's impossible. We are interlinked with it. It's very globalized.

So I think if I would say, based on my work, something is we have no choice but to respect each other because we're simply one. I really, really liked the way that you ended that, because I think that's sort of emerged as a theme tonight is this idea that we can have a conversation about what it means to be human. But science from a variety of different perspectives is certainly making it so that we cannot divorce the answer to that question from our interconnectedness among one another in our species.

But also across species, right, and the kinds of symbiotic and dependent, codependent relationships that form that are a part of who we are, right, in a very real way. So thank you for that. I appreciate that.

With regard to the question, I have the extraordinary privilege, as was mentioned in the introduction, to be trained by Francis Collins. He is the director of the National Institutes of Health and has also written a book called the Language of God that some of you may be familiar with. But Francis provided an extraordinary example for me about what it looks like to pursue excellence in science at the very highest level, while always prioritizing people over things.

Francis isn't unique in this. I'm not trying to suggest that there are many wonderful people in the sciences, but he was for me, the first and most impressive example and role model in a field that can be crowded, that can feel a little bit cutthroat, that can feel a little bit doggy dog. Here was a person at the highest level of biomedical science who always put people first.

I'll just share a quick anecdote. There was one particular day when I had a meeting with him about some pitley little paper that I was trying to write. On that day, he had a meeting with Rahm Emanuel, your mayor who at the time was Chief of Staff for President Obama.

Then after that had to go to Capitol Hill to meet with for a hearing. Then had to go to the clinical building on the NIH campus in order to meet with patients and their families who had very, very rare diseases. Then me.

I was palpably the least important thing by a long shot on that day. He never once made me feel like I was. There was a student earlier today who asked me how to approach being a mentor.



I think a lot about the way that Francis mentored me and the way that when he had time with me, he gave me undivided attention. I felt valued. I felt I was an important part of his day, even though, I think back to speaking, I wasn't.

Most definitely the role model that I had. You mentioned Rahm Emanuel's former Chief of Staff for Obama. I know you had an encounter with President Obama when you were in the U.S. It was a very entertaining story, actually, if you could share a little bit about that.

Yeah, I was doing research in Ethiopia and I was asked to show President Obama the apostles that we have in Ethiopia, Lucy, my own discovery and others. He had this Ethiopian his second leg and he was in Kenya first, where he's originally from. No one is laughing.

Anyway, he came in long story short. I asked him if he had found his own, but very certificate he said no because it was in Hawaii, apparently. So I got him relaxed.

And then I told him about three things. This was a framed visit by President for a nation. So I was asked in five minutes to tell him the six million years of history of humanity in the 3,000 history of Ethiopia, and then the, I don't know, over 2,000 history of Christianity and Islam in the country.

Five minutes I had. So anyway, showing him the apostles, I told him that we are all from here and our ancestors are here. So when you talk to this for our social teaching, a common ancestor.

And I told him, it's not just you even candidate Trump at the time is from here. So you guys fight about nothing. We are all the same.

We are all human being. He appreciated that. And then I also told him about the long history of Ethiopia where we had Christianity in 300 AD actually.

Many people don't know that. It's the only country that had never been colonized. So it maintained its tradition.

It's also a country where we have Islam and Christianity living side by side right from the get-go actually the Prophet Mohammed sent his followers to Ethiopia because we had a Christian king who was kind enough to accept them when they were persecuted in Saudi Arabia, the Qur'an, the Goresh people. So all that combined, I outlined the history of Ethiopia, the history of religion of the country and the history of humanity which is dear to me, the President Obama. He appreciated it.

And even though he was there for five minutes, he simply couldn't go. He was there for 20 minutes with me and I ended up writing an article called "My 20 Minutes in Council with President Obama". So John is referring to that.

But I think the takeaway from that meeting is if we are to make a difference in this particular thing to all of us, for being as scientists. There are things that we're going to fight about, scientists fight about everything. It's really important to remember that the unity of humanity has a paramount priority as far as I'm concerned.

And what I told him, he actually repeated it at the African Union meeting. This is talking to one billion people. So in spite of the differences that we have, when we discuss specific issue, yes, we have to be methodologically.

But then we should remember also that we are dealing with a very symbolic species of our business that loves to think about being unthinkable, about imagining about being unimaginable. So putting that together, and then especially when we are in front of people like states, heads of states like Obama, we tell them, we inform them about what is good about humanity. Rather than the divisive things that now are really devouring our culture and our communities and many people.

And that's why actually last week I was at the Vatican giving a lecture in the presence of bishops and many other people about human evolution. They are reflecting as to how they can reconcile their preaching with the advancement of science. You can't ignore stanza research now.

You can't ignore personalized medicine. You can't ignore intelligent design or artificial intelligence and things like that. What you do is you come together and then make sense to the average person understands, yes, scientists fight, but at the end of the day, we are one.

So that was the takeaway with my encounter with President Obama. And President Obama and Dr. Francis Collins, if you are watching this recording, I hope you are proud of this. So we have about 15 minutes to transition now to the audience question and answer.

So at this time I would like to invite any members of the audience to come forward to the mic. And I apologize, I went a little bit over here but if you could just keep your questions brief to the point, you know, and limit to one question, that would be great. I'd like to particularly invite students first to come up and ask the first couple questions.

Is this on? Yeah. Thank you guys for your discussion. Your dialogue is really informative.

I just have a question given the fact that your scientists in the backdrop of a century of genocide and war were questions about what it means to be human. And I was wondering, how does that history and violent history affect the work that you do as scientists and the political nature of what you do? And sort of a corollary question is, what should supplement science given that sort of violent backdrop and the potential for the work that you do to be used and abused? Yeah, passing the book. Go ahead.

So could I attempt to rephrase the question to see if I've understood what you're asking? That all of this work that we've been talking about has been happening in the backdrop throughout humanity of violence and hatred and vitriol toward one another. So what role does science play and what else could it work together with in order to try to mitigate that problem? Is that what you're asking? Yeah, so I think we've touched on some of that today. I think more from Zari than anything else in that so much of what we've discussed and what we have learned and discovered from our scientific endeavors is that the commonality is the kind of sharing the co-dependence, the symbiosis and these are all the things, ideas that have emerged today.

And I think highlighting these points, talking about them not only in the ivory towers but in our communities, right? And in our churches and temples and synagogues and people actually being in a situation where they have scientists in their sphere of influence that they trust, where they're interacting with this kind of information as well. I mean, every time I go across the country and talk about how there are microbes in our body, I mean, when it's a lay community, they're shocked and surprised. And so I think there's more work that we do as scientists to reach out to our neighboring communities and build trust because I think trust matters more than even information.

You can give people information as elegantly as you can, it'll be one ear and out the other. But we have to do the hard work to build trust with communities and then give information, right? At which point it becomes a conversation and a back and forth and people really start with the information that they're being given and think about how that informs the decisions they make, the way that they think and the way that they treat other people. But I really think that science does genetics in particular, as I was talking about, has done powerful work in equalizing, right? I knew of a gentleman who did sort of an ancestry thing and was kind of leaning, leaning sort of white supremacist, right? Who was thoroughly shocked to find, right? That I'm not sure what he expected, 100% pure, I don't know what the... What he expected from the results, but whatever it was, he was shocked and surprised.

And I'm not saying that that's the answer for everybody. Clearly others have gone through that and then found ways to reject that information. But for others, that kind of information particularly provided and explained and interpreted by people they trust, again, really critical, right? Can be transformative.

Can be transformative. So we need to be involved in that process as scientists. I think we complain a lot in our ivory towers about how the people don't get it and Congress doesn't fund us enough and it may all be true.

But what is the work that we are doing, right? To put ourselves out to be able to convey the value of our work, how it actually packs their lives and how it might actually begin to shape their thinking about their neighbor, right? Or these kinds of things that they might

have knee jerk reactions to not do or create problems and tips and struggles with. Maybe it'll help to at least some extent resolve that or provide a healthier framework for discussion. I mean, I'm not trying to be Pollyanna about this, right? So that if we just all talk to each other, then every problem would go away.

But I do feel as though we are increasingly talking past each other. We're living in a very tribalist kind of mentality, right? Where everything's black and white and it's raw here and raw there. When it's being anti-tombreity, I'm all for it, right? But when it's about the human condition, when it's about how we treat one another, I'm not.

I'm not and none of us should be, right? Because there is more that connects us than what divides us. And you've heard those platitudes before, but science actually provides the data to support those platitudes, right? I'll end with one thing, Paul Farmer, many of you may know, famously said that the root of all evil, right, is the notion that some lives matter less than others. And even looking at the scientific data, I think, compels you away from that kind of rudimentary way of thinking.

Yeah, I would just add, I think you were touching on a very important point, sure. Science today is a professor and there is no way we can live without it in my view. It shapes everything that we do every day.

As such, what we can do is be responsible. And this is not just a rosy flower type of painting, it's not. I think John asked about the limits and authority of science.

For me, what comes first is that authority needs to be preceded by responsibility. For example, when we make discoveries that would shed something on, or genetics, on who we are as group of people or species, there is a way that scientists communicate within their role, within their compounds. But the messaging is going to be very critical.

So I think the key word for me is there is a big responsibility in making sure that our messaging is ethical and responsible. That's number one. The second part is, as I said, a scientist's job is to find the fact and how nature works.

Then the policy maker is maybe going to try to use the scientists to propagate their ideology left or right, to convey the message that they want them to convey. I think it's incumbent up to the scientists to say no to that temperature and to stay in protocol as much as they can in that framework that I so much under is called to them. Out of that framework, I am not any different from you.

I'm just arrived and you are John or something. Next question. Hi, thank you guys very much for coming.

I've enjoyed the evening so far. I wanted to challenge the idea that this question could even be answered using a scientific framework because based on your huge expertise, it seems as if the very task forum presupposed that this question could be approached

using scientists. It seems as if the so-called "lumpers" even in a strictly Darwinian sense could find ways that blur the distinctions between species, even between our very complex tools, just seeing that as a product of the environment that's always changing.

It seems as if you guys have been doing, and I don't mean to denigrate, you've got a lot of moralizing. You're saying it's important to recognize the unity of the people. This to me seems like it is on a religious foundation more so than a scientific one.

I really wanted to challenge the idea that you can make any groundwork in this question using a scientific framework. Thanks. I think that's a legitimate question.

Again, I would look at that within the framework of where is that being set? If you were to send a scientific paper to natural science saying that humans are all unified and let's be happy, they were rejected. What I'm saying is relevant to what my brother was asked, how do we contribute or try to minimize damage given the authority that is imposed or invested upon us? How do we contribute to make things better for all people? Then we can have an opinion that is important about what we do. But as I said, however, when we do the scientific work to justify what we say, it has to happen within the scientific framework.

The confrontations are not the same. Reflecting on a topic because of our work is different from pushing an idea that is going to be tested by scientists. Yes, you write the challenge because declaring the unity or diversity of humanity is one could say it's a wishful thinking because we know how complex human beings are, politically, ideologically, culturally, united.

My point, however, is if science was to be relevant in any way, and as I said, the moment I'm out of my framework, I am like you guys, I'm out. I can have any opinion. I would like to support the comments that were made in that context, versus the comments that were made within the framework of the results that are developed based on scientific data.

That would be my answer. Sure. I'll offer two points as quickly as I can on this.

Thank you for the question. So what I would say is that to reinforce that I do see the scientific data, pushing back on the tendencies that we have to divide and separate and assign different values. As I was mentioning really early on, again, as another example, you know, we tend to superficially we tend to divide people by traits that are very obvious to us.

Right. When so there's the black community and the white community and the right brown community. And what genetics has shown us genetic analysis has taught us.

And so, I think that we're able to say or emerging it with other philosophy or anything of that kind. I think it is on its own entirely able to teach that divisions on those superficial

traits is an impoverished way of understanding groupings in humanity. That is arising from the data.

So we might say that it is offering some kind of moral perspective in the way we interpret it in a quiet to our lives. But the data is teaching us, right, that you can have one, you know, individual from one African tribe and one individual from another African tribe that are more distinct from one another quantitatively speaking genetically than one of those African individuals with someone from Poland. Right.

So that happens not infrequently. Right. So it's breaking down these artificial and superficial barriers that we have imposed in our society.

So that's what I meant to say in terms of how it can inform the way that we think about our connectedness and our relatedness in a different way than with just the poor proxies for human divisions that we've come up with like skin color and things like that. The second point that I would make is that hopefully it was clear that while I do think science has a lot to this conversation and hopefully that has come out loud and clear. I would not at all contend, nor does my personal experience convey that it is the only way to think about this question.

I think that there are very complimentary ways. I am a Christian. I'm a person of faith.

And in my synthesis in my life, I have not, you know, I don't hold my faith-based commitments and my thoughts as a scientist in the parts of my brain hoping that they never interact. I genuinely feel as though there is harmony between those. But think about what that word harmony means.

It's not the same note being played in music, right? It's actually different notes but coming together in this really sort of wonderfully consonant way, right? And that's the way that I think about the contributions that science and faith-based worldview, the contribution that they could make to answering this question. We didn't really get a lot to my thoughts on the latter, but I hope that it is clear that that's certainly how I approach it. And again, coming back to Pascal, sort of different ways of knowing.

And I think they can end up being highly complimentary. They could lead us to the same place. My faith-based commitments do tell me about the unity of mankind, right? That there is no Gentile or Jew or no slave or free or barbarian or skivian, right? But that we are all one, right? And so, you know, I certainly think it is possible for these different ways of knowing to converge and they have my own life.

And if I may just interject quickly. So if you were to look into the type of data that Pervene and I explore, the DNA and the fossils, they clearly take all of us to Africa, sometimes 100,000 years ago, number one. Second, the genetics tell us over 99%.

It's the same thing. So when we say we are one, as opposed to someone telling us, "Oh,

you look different, so you're different." I am very confident, scientifically speaking, to say, "Yes, we are not. We want." Yeah.

Now, that one is, however, I realize has a social context. It's the pictures that we have about people. If you had a white person and black person married, the child becomes what? Why? So when we say one, it is because the fossil evidence and genetic evidence suggests that we are more one than we are different.

But then if you were to put statistics, then that becomes a scientific conversation. That is, that was my point. I think this will be our final question.

Hopefully it's a brief question. Oh, well. I wanted to see, I've heard rumblings as an utter non-expert around the concept of beauty, influencing how we understand the biological and evolutionary process.

And so I was wondering if you could make some remarks as to either your skepticism or your seeing of promise in terms of how creatures conceive of beauty and how it relates to this question of what it means to be human. Ooh. That's the lovely question that's almost impossible to cover.

So the concept of beauty, is that the question? Yeah. Okay. If you let me indulge out of my comfort zone, and then if you were to interpret my answer as such, I will say something.

When we do archaeological work, the archaeological work, many parts of the world, Europe, Asia, America's all the way to Africa, we see humans putting, you know, occurs and the beads and other things on their body back like 100,000 years ago. Why would they do that? Could it be that they started to identify themselves as groups? That's number one. Or as tribes, territorial populations, or as individuals.

Or were they done the way we perceive it today to be beautiful and more attractive? I will put that question. But that is 100,000 years ago. I'll push you forward in time and bring you to France, southern France, aside the Cape Side called "Lascaux" dated back to 18,000 years ago.

And we're right in the middle of the Ice Age now. What would you think? An ancient human 18,000 years ago was doing in southern France when we are in the middle of the Ice Age. The first prediction would be trying to kill animals so they can feed themselves, so they don't die of hunger or starvation or cold.

Now, they were fine painters. You can google "Lascaux". And if you are going to tell me those populations did not appreciate nature, at least broadly, and had a at least rudimentary understanding of what we homo sapiens or homo egocentricus considered to be just ours, then I would argue, again, I'm out of my territory as I said.

So I think they had the appreciation for beauty. So what was the that appreciation's implication for who we are today, I guess for me is the expansion and sophistication in time of that symbolic species that emerged at some point in Africa, 100,000 years ago, and became this complex species, asking about what is beauty. And if monkeys or cats or rats ask that question, that would be my quick response or past or long response.

Yeah, lovely response and great question. And it's something that I think about a lot. So I'm afraid that I'm not sure that I'm going to have a pity.

And I think that it's a very important thing to say about this, and here's why beauty separates us from all other species. And I don't know that I can offer an evolutionary explanation for why we find things beautiful. So I think it's a really interesting area of study and one that certainly merits further investigation.

And to me, it's sort of immaterial whether evolution gave rise to this or not, because it is a part of the human experience, right? So the mechanism is an interesting kind of sub question. The way that my faith-based worldview is that God is the author of all natural and supernatural processes. It's not sort of a Stephen Jay Gould.

You've got natural things here that sort of function on their own and then then there's supernatural things for which you need God. And that model as tempting as it might be, is the kind of model that as we find more natural explanations appears to artificially just push God out of this box. And so it's not a model that I personally ascribe to my understanding is that there is an author of all of these natural and supernatural events.

And natural ones happen to be ones that we can use the tools of science to be able to dissect and understand because there are laws that they follow and there's an author that we can understand whether there are laws and orders and natural mechanisms that might help provide mechanistic undergirding for what beauty is to humans is a fascinating area. But all of that being said, ultimately I would say that that is something I feel, you know, I don't know how to talk to a monkey and ask whether it has its own way of appreciating beauty. So I want to exercise some humility because maybe other species do actually have some way of interfacing with this concept, but it's just a little bit different from the way that we do.

But maybe the way that I would end is to actually bring in how it connects to my faith-based commitments. And that is that I believe, and again, I want to be very clear is science doesn't lead me here, right? This is a separate belief that I hold. But that we are that unique, ultimately what makes us human is that we are that slice of existence that gets to delight in existence right alongside the way that scripture says God delights.

God delights in creation, right? It's like, it's almost like we're, and I don't know exactly what it is about us, right? I'm not sure that I can really pinpoint that or say that it is feature X, Y, and Z. And you run a mathematical model and it'll tell you that that'll



explain 90% of why we're able to do that. I don't know, right? But it's one of those things where you know when you see it, but you're not really able to pin it down and define it, which is really what I think we've been talking about all evening. And that's the way that I feel about this concept of beauty is that we seem to have this unique capacity to delight in the things around us in almost exactly the way that we read God delighting in the things that He's made, right? And so there's some kind of specialness and maybe that's part of what the image of God is, right, that we talk about in Christian circles.

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[Music]