Geoffrey West (00:00:00):

Unfortunately, the dynamic of positive feedback and superlinear scaling leads to the speeding up the pace of life. So you have to do things faster and faster, and that eventually leads to a socioeconomic heart attack, and that's the issue. And so how do you get around that?

Nate Hagens (00:00:21):

I am pleased and honored to welcome my next guest, the physicist Geoffrey West to the program. Geoffrey was a professor at Stanford. He was the leader and founder of a high energy physics group at Los Alamos, and most recently he was the president of the Santa Fe Institute. He has been long fascinated with general scaling phenomenon in biology and nature. Today we talk among other things about Kleiber's law, which states that the metabolism or the energy use of an organism scales to the 3/4 power of its size. And we apply that not only to human bodies, but to human exosomatic energy, how much we use in cities and the whole world with fascinating, ominous implications.

(00:01:19):

For those of you that have long followed this podcast, this conversation is a must watch and also enjoyable. Geoffrey's kind of like a wise, kind of physicist version of Gandalf, and I learned a lot. I think this is at the core of what people need to understand about the linkage between human nurture and human nature as biological organisms, how we use energy and materials. Hope you enjoy it. Please welcome Geoffrey West. Geoffrey West, welcome to the program.

Geoffrey West (00:02:07):

Nate, thank you so much for having me. I'm delighted to be on your podcast.

Nate Hagens (00:02:12):

You are an important human to have on this podcast because the Great Simplification at its core is about the metabolism of cities, economies, our culture, and you are probably the most renowned scientists on the concept of metabolism and scale. So I really wanted to get you on and I'm glad we finally connected.

Geoffrey West (00:02:40):

Yes, yes. As I said, I'm delighted to be on, and I'm sorry we couldn't do it sooner.

Nate Hagens (00:02:45):

So I of course have 20 questions just for starters. But if you could, in your lifetime of work at the Santa Fe Institute and elsewhere, you have a very biology systems approach to the world. If we could start with just a flash round of explaining some key concepts in not too lengthy answers, just as a foundation that apply to the theme of this podcast. So let's start with the basics. What is Kleiber's law?

Geoffrey West (00:03:21):

So Kleiber's law is, first of all, it's named after a man named Max Kleiber, who was a biologist at what is now UC Davis in California. And he discovered, I guess is the right word, a remarkable systematic law in biology for what is presumably the most fundamental quantity of interest, not just for an organism, but almost for any system. That is how much energy does it need to sustain itself and indeed to do the activities to function? And that's called, of course, in biology, that's called metabolic rate. Roughly speaking, it's equivalent to how much food you need each day to stay alive. And what Kleiber did was he both gathered past evidence and did some measurements himself of metabolic rate for a whole spectrum of animals, mostly from mice to elephants. And what he discovered was that there was a very systematic and mathematically extremely simple scaling law for how that quantity scaled from the, well, in this case, the smallest mammal to the largest mammal that he could measure at the time.

(00:04:53):

Although he did also have some measurements someone else had taken on blue whales. But what he discovered that was so important was the following. So first of all, you have to recognize to plot a mouse and an elephant on the same graph is a challenge of itself because an elephant is maybe 100,000 times heavier than a mouse. And so instead of plotting it one, two, three, four in terms of grams, the natural way to plot it is by factors of 10. 1, 10, 100, 1,000, et cetera. In which case, on an ordinary sheet of paper, you can get both the mouse and elephant. And when he did that, and that's called plotting it logarithmically, when he did that, he found something extraordinary, that the points lie almost precisely on a straight line, which is kind of amazing because each one of these organisms has evolved by natural selection.

(00:06:01):

So by which we mean that it's gone through this sort of, roughly speaking, arbitrary, chaotic process in competition with every other organism in the biosphere, so to speak. And so it's historically contingent, and that's how we think of organisms as historically contingent, meaning that if you plotted it the way I just described, you would expect, okay, there might be some correlations, but they would sort of be spread all over the graph, each point reflecting, so to speak, the historical trajectory of the organism. Quite the contrary, they all line up beautifully on a straight line. And what in addition that he discovered was that the slope of that line was very close to the number 3/4, 0.75, and that became known as Kleiber's law for metabolic rates.

Nate Hagens (00:06:57):

So if it was so robust across all these organisms of historical contingency, the implication is it functions akin to a natural law, something going on in our planet and with species alive here.

Geoffrey West (00:07:14):

Yeah. So one of the things that you've implied by that is that this, what Kleiber did was of course for some subset of organisms, almost entirely mammals, but later, he and others expanded it across the entire, so to speak, spectrum of organisms from cells all the way up to ecosystems. And they discovered the story is indeed incredibly robust. It applies to any taxonomic group of organisms whether fish, birds, mammals, cells and so forth. And so therefore, it's sort of natural to conclude that this is in that sense, a law of nature. It may not be a law of nature, sort of like Newton's laws with governing motions and so on in the sense that they're precise, because if you look at the graph, each point lies just slightly off from that straight line a little bit. But in that statistical sense, it's an extraordinarily robust law that metabolic rate scales as the language of it, has the 3/4 power of mass across the biosphere.

Nate Hagens (00:08:24):

So as you survey an animal and their size gets bigger, the amount of energy they need to sustain themselves per day scales according to their mass, but not one for one, but to the 3/4 power.

Geoffrey West (00:08:39):

Indeed.

Nate Hagens (00:08:40):

And what is the scientific speculation on why it's 3/4 power?

Geoffrey West (00:08:46):

Yeah, so first of all, let me just say a word about that 3/4, that that 3/4, obviously less than one, so we call that sublinear, and 3/4 less than one means that if it were one, the slope of one, that would be linear, which means if you double the size, you would presumably...

Nate Hagens (00:09:06):

Double the energy.

Geoffrey West (00:09:07):

So you would double, you'd need twice as much food. So this law has this extraordinary consequence that every time you double, you actually save 25%. So there's this systematic economy of scale that goes from the smallest to the largest, and that has profound consequences for the whole structure of the biosphere, including the sustainability of the biosphere, which maybe we can come to later.

(00:09:34):

But going to your question, namely, what is the origin of it? That's what got me into the game because I learned about this scaling law many years ago, and for various reasons started getting very intrigued by it, especially because it's so antithetical to one's sort of naive idea of what evolution by natural selection is going to produce, all this sort of randomness and sort of arbitrariness and quite the contrary, as I said earlier, this is very highly systematic and predictable.

(00:10:09):

And that got me involved in trying to understand it, especially because I learned that there wasn't any generic sort of universal explanation. And I got involved in it, and I came up with this idea, the following, that if you ask what is common to not just birds, birds, fish, mammals and so forth, but also plants, plants also satisfy the same law, which are quite different. What is similar about... Well, the thing that's similar is that they have this huge challenge of having a huge number of components cells. We have

about a hundred trillion inside us, and they have to be sustained, fed in a sort of roughly speaking egalitarian and efficient way. And the way we've done it, we meaning natural selection have done it, is evolved these networks that service cells either like a circulatory system and respiratory systems and so on. And the idea was that I worked on was the idea was that this is universal and that it is the mathematics and physics of these distribution networks of energy, resources, oxygen to the cells that is constraining metabolic rate to have this simple scaling law. And if I could understand it and do the mathematics properly, I would be able to derive the number 3/4 from the properties of the networks.

Nate Hagens (00:11:48):

So between a mouse and an elephant is a human, so the human would be our internal body with a hundred trillion cells would lie on that logarithmic chart between a mouse and an elephant. But what about outside of the body? Our transportation networks in our cities, in our global economy, how does that apply? Because that isn't an animal, that is a social and economic structure built by animals.

Geoffrey West (00:12:23):

Yeah. So yes. So let me just give a little few words about the background to this. So this theory was developed based on networks, just thinking about organisms to begin with. It was actually extended to forests, which is a community of organisms.

Nate Hagens (00:12:46):

Does it apply to forests as well?

Geoffrey West (00:12:51):

Yes, it applies to forests. That's what's amazing actually. It applies to trees, plants, and when you put those all together to form a community, it applies to them. So it was very natural when we extended it to all these things. And we found it was sort of almost a complete theory of the scaling of almost any physiological attribute or trait of an organism and to any of its life history events, like how long you live, how long you take to mature and so on. But then when all that work was done, brewing in the background was your question. Human beings are special. We've done something extraordinary including what we're doing here. We've created this incredible technology once we discovered language.

Nate Hagens (00:13:47):

Which this technology doesn't seem to the viewers, but we are using quite a bit of energy right now with the lights and the internet connection and the embedded energy and all the microphones and everything.

Geoffrey West (00:13:59):

Absolutely. And so it was natural to ask the question, what about the socioeconomic activity that we have created? Which for want of a better word, I like to now use anthroposphere or sometimes I like the word urbanosphere because one of the things that has become very apparent in this last century is the planet is dominated by cities, which is our very manifestation of our evolution from hunter-gatherers to becoming sedentary communities and then forming these massive cities and all the fantastic things and also the bad things that come along with urban living. So going to your very question about, how does that change metabolic rate? And this is a fundamental question. First of all, you have to ask the question about just organisms in their natural state. In their natural state, what I talked about, metabolic rate scaling with the 3/4 power, you have to ask yourself, first of all, what is our metabolic rate? How big is it, first of all? What we call our basal metabolic rate, which is simply the amount of energy used sitting around doing nothing.

(00:15:23):

That number is 100 Watts. But most people don't realize that's 2,000 food calories a day, which is how much food you need to eat to stay alive is only a hundred Watts. You only operate the energy of a light bulb, which is truly extraordinary. Now if you add in your hunting and gathering, so to speak, I mean before we became this marvelous socioeconomic entity, it goes up by a factor of two or three. And that's true across all mammals. That's true of a mouse, it's true of an elephant. If you include their actual activity, it's two or 300, two to three times bigger. So our sort of natural active metabolic rate, and there are still people on the planet that live this way, is somewhere between 200 and 300 Watts.

(00:16:15):

Anyway, so now you ask about us participating as we are here, as you said, using energy to fuel this communication system, to have the energy that was used to make the laptop that sits in front of me, to have this office, this nice office I'm in, to produce all those books behind me, to have an automobile out in the parking lot that I'm going

to go home, I have a home. I have all this stuff that's part of me, we think of as it's actually me and it's you.

Nate Hagens (00:16:49):

It's your exosomatic metabolism.

Geoffrey West (00:16:52):

Exactly, exactly. And if you add all that up and you ask, how big is it? It's not 100 Watts. It's not even two or 300 Watts if you're an American, it's about 11,000 Watts. Our social metabolic rate is about 100 times what our natural basal metabolic rate is.

Nate Hagens (00:17:15):

So on Kleiber scale, 11,000 Watts would scale to what size of an animal? Do you know?

Geoffrey West (00:17:22):

It's about 30, what is it? It's equivalent to about a dozen elephants. That's the number I usually keep in mind. It's about, the blue whale is the biggest mammal, the biggest organism that's ever existed. It's not quite a blue whale. We're maybe 1/2 to 3/4 somewhere in there the size of a blue whale. So each of us on the planet roughly, or each of certainly in the United States, in developed countries are acting as if we were the size of almost the blue whale.

Nate Hagens (00:17:57):

Or 10 to 12 elephants.

Geoffrey West (00:17:59):

Certainly about a dozen elephants, which is-

Nate Hagens (00:18:02):

So that's the US, which is about four or five times the global average, right?

Geoffrey West (00:18:07):

No, it's not even four or five times. It's more like about two to three actually, believe it or not. It's kind of amazing actually. It's not as big as people think. And it depends a

little bit. I mean, getting measurements of social metabolic rate is actually quite a challenge to know exactly what you put in there and what you don't.

Nate Hagens (00:18:30):

Do you include the military? Questions like that.

Geoffrey West (00:18:33):

Exactly. So there's all kinds of question mark, but nevertheless… And this is work that now I am beginning to push very hard on that we need seriously to come to terms with what we mean by that and what that number is and get it for different countries, different cultures, and so forth.

Nate Hagens (00:18:54):

Let me ask you this. So you've been a lifetime scientist and systems analyst. At some point in the last 20 or 30 years, you were working at a computer or a notebook, and you discovered that the metabolism of the average American was a dozen elephants. Did you at that moment, was that disgusting and profound, like, oh my God. Was that a shock to you?

Geoffrey West (00:19:21):

Yes, I think it was at the time because I really was, this was near the beginning of the work, and I hadn't sort of put it all together and I hadn't seen its extent. And most importantly, I hadn't seen its consequences. And this was one way that sort of made me sit up when I realized, when I turned the equation around. That is given, if I take seriously that metabolic rate of 11,000 and ask that question, how big an animal are we actually equivalent to? And seeing how big it is, that already blew my mind. And then beginning to realize that, well, at that time there were 7.2 billion people on the planet, and each one of us in our own way wants to be having a social metabolic rate of over 10,000 Watts. And that is extraordinary. And that brought to home to me, the challenge that we have in sustaining what has brought us so far to this stage.

Nate Hagens (00:20:31):

So not only are we functioning metabolically as a dozen elephants, but that is our global cultural goal is to get to that point or beyond that point.

Geoffrey West (00:20:43):

That's right. Yeah, no, I think that's right. I think that's... Of course, it's even more so those of us, the leading edge of this, namely in Western Europe and the United States are pushing to get more actually. I mean, that's what the economy, that's the paradigm that we're in. It's been an extraordinarily successful paradigm. The discovery and exploitation of fossil fuels coupled with the discovery and exploitation of capitalism and entrepreneurship and the extraordinary creation of wealth. It's been phenomenal.

Nate Hagens (00:21:26):

I understand the natural law aspect of Kleiber's law as it pertains to mice and individual humans and elephants and forests and the like. But if a human system, like a city or an economy, the social metabolism got bigger, does Kleiber's law automatically apply to that? Or is there, on the social metabolism, is there less of a natural law and more of maybe a nature versus nurture wide boundary of possibilities?

Geoffrey West (00:22:02):

Yeah, this is a really important question and not one that's easy to answer. First of all, what you call Kleiber's law strictly only applies to organisms. That's this 3/4. When you look at analogs to social metabolic rate, and they could be proxies like GDP of a city, it could be GDP of the planet, but GDP of a city or the wages in a city or the number of patents it produces in a city, how much innovation is produced, all these are proxies or results of social metabolism. What we discovered was that instead of the 3/4, we see a number like 1.15, which is instead of being less than one, which meant sublinear was the word I used, which meant the bigger you are the less you need per capita in that case, per cell for an organism. When you come to a city, you're exactly the opposite. The bigger you are, the more you need per capita. In that case, per human being.

Nate Hagens (00:23:20):

There's a metabolic positive feedback then in cities?

Geoffrey West (00:23:25):

Exactly. There's a positive feedback. And that positive feedback can be traced back to the positive feedback for the dynamic and the process for what cities were evolved to be namely, to facilitate and encourage social interaction. And so that positive feedback is a result of the positive feedback in social interaction that comes from me talking to you until you talking… This thing that we build on each other and we build ideas.

Nate Hagens (00:23:54):

So it's creating new nodes and each node requires more energy.

Geoffrey West (00:23:58):

It creates new nodes and it creates new ideas. We're continually creating ideas and creating wealth, and that, as I say, has been enormously successful, and that leads to this super linear scaling.

Nate Hagens (00:24:12):

And what about villages or people living in the countryside? Are those smaller entities with 10 houses or a hundred houses different than a big city like Santa Fe or New York?

Geoffrey West (00:24:26):

Well, Santa Fe is a small city…

Nate Hagens (00:24:30):

It's bigger than a few houses.

Geoffrey West (00:24:31):

It's bigger than a small village, that's for sure. Well, the thing is that this is systematic. What is amazing is that the data shows that this dynamic systematically increases with size of the city, because it increases the chance of more interactions, and great cities encourage more interaction. I mean, New York is maybe the prime example of a place where the buzz of the city is visceral and really encourages not only that, it encourages not just interactions, but encourages potential and possibility. And that tends to be absent as you go down in size.

Nate Hagens (00:25:13):

This may have to be a three part podcast because now you're getting into some deep areas that I've speculated a long time. Let me first ask you, do you have an opinion on what Howard Odum called the fourth law of thermodynamics, which is the Maximum Power Principle, which maybe that's related to Kleiber's law, that organisms and ecosystems self-organize to take advantage or to degrade an energy gradient. Do you believe that?

Geoffrey West (00:25:44):

Well, in some form of it, I do believe yes. And in fact, all the work that I do is based on something that's slightly more general than that, in fact. And that is all of these systems evolve towards optimizing something, we'll call it something. So for example, just to go back to take it out of the socioeconomic characteristics to talk about organisms again. So the way the derivation and calculation of Kleiber's law follows from the network theory is that all mammals that have ever existed share the same kind of cardiovascular system that has evolved to minimize the amount of work your heart has to do in order to pump blood through the system, to supply energy to the cells, energy and oxygen to the cells to sustain life. And the idea is that you minimize that in order to gain a fitness advantage by being able to devote more energy in the case of organisms to sex and reproduction and the rearing of offspring, which is Darwinian fitness to project into the future your genes. And so you optimize the structure of the network in order to minimize the amount of energy. And so this is one of a number of these kinds of optimization principles of which Odom's is another one.

(00:27:29):

And cities you could argue have evolved to do two things because they're much more sophisticated in some ways than an organism because they have two pieces. They have infrastructure, which is the analog to your circulatory and respiratory system and all the rest. But they also have something that we've just touched on, and that is social networks. That positive feedback and a city is sort of the integration and tension between those two. And so in the social... Well, let's talk the infrastructural network. You might hypothesize that the thing that's being optimized or as cities evolved was the transport system, whatever it was even if it's just walking. Was such that the structure of the city evolves so that you minimize the time in order to get from A to B, wherever A and B are and you minimize the time and the distance and that's what

you try to do when you go home. You don't take some arbitrary route, you try to a route that is optimal in terms of your time and distance and so forth.

(00:28:44):

The social network on the other hand might optimize in order simply to create interaction. The way the system is to facilitate more and more interactions so that more ideas can come to the surface, more wealth can be produced and so on.

Nate Hagens (00:29:03):

So here's why I brought up maximum power principle, just to mention it.

Geoffrey West (00:29:07):

It's very similar to that.

Nate Hagens (00:29:08):

So if we had a city of 1,000 elephants, that city would largely have the same metabolism of the individual elephants times 1,000.

Geoffrey West (00:29:20):

Exactly.

Nate Hagens (00:29:21):

But if we have humans there are social status pressures, there's moving upward in the social hierarchy, there's novelty, there's discovery, there's incentive. And so I would argue that dopamine in a way is part of the origin when humans are living in proximity like that in large numbers that might explain some of your 1.15 positive extra linear dynamic, which is almost a brain equivalent of the maximum power principle. There's something that we're trying to optimize that's outside our basal metabolism. It's something social which is why there's a positive feedback there.

Geoffrey West (00:30:10):

Yeah, absolutely. No, that's exactly right. And by the way just going back to the biological for a moment, I said you only require about 100 Watts, 2000 food calories a day. But if you took all your cells all that 10 to the 12, 100 trillion of them and just put them aside and asked how much energy does all those cells if they were not

interacting and be part of you. Just lay them out on a table if you could imagine it, you would require 50 times as much food. So you have an extraordinary economy of scale in bringing all this together and your whole body interacting in a highly coherent integrated way and so it is with the city and I'll give you an example. I think New York is about 100 times bigger than Santa Fe in population it turns out roughly, and New York produces... So you might have naively guessed New York will produce 100 times more patents.

(00:31:28):

It doesn't it produces 200 times as many than Santa Fe and you could ask how many patents if we took all of the individuals in Santa Fe or New York and you made them into a guru that sits on the top of a mountain and contemplates the mysteries of the universe. How many patents would that produce? If you took all 15 million New Yorkers and put them on the top of the mountain and so on you know how many patents they'd produce? Zero.

Nate Hagens (00:32:00):

Well, because they no longer care about social status they want to reflect. Yeah.

Geoffrey West (00:32:04):

Exactly. So that's all part of what a city is without passing judgment, good or bad on it that's who we are.

Nate Hagens (00:32:13):

Okay. So if you don't mind I'm going to read out loud to you one of my favorite quotes that was in my academic paper on the Superorganism and I'd like your opinion on it.

Geoffrey West (00:32:26):

Sure.

Nate Hagens (00:32:26):

Because I have a deep philosophical question for you and you're one of the first people that I've had live to be able to answer it. So this is a quote from a book called A Short History of Progress by Ronald Wright. "What took place in the early 1500s

was truly exceptional, something that had never happened before and never will again. Two cultural experiments running in isolation for 15,000 years or more at last came face-to-face. Amazingly, after all that time each could recognize the other's institution. When Cortes landed in Mexico he found roads, canals, cities, palaces, schools, law courts, markets, irrigation works, kings, priests, temples, peasants, artisans, armies, astronomers, merchants, sports, theater, art, music and books. High civilization differing in detail but alike in essentials had evolved independently on both sides of the earth." So my question to you is when humans encountered energy surplus, which was the unspent metabolism outside the bodies in the form of agricultural surplus and eventually fossil hydrocarbons. Was this kind of inevitable? This scaling of cities like almost a cancer that is unfolding?

(00:33:54):

What are your thoughts? How can you explain that quote that I just said from your biological systems background?

Geoffrey West (00:34:02):

Well, I guess I would have to say to some degree it was inevitable. Namely, you might've even extended that because it was true of China. I mean, when Marco Polo went to China he immediately recognized city, right? I mean, and in fact they'd existed way before the cities of Europe that he'd come from. So there's only those three examples and I'm a physicist, a scientist and one has to be careful about extrapolating from special cases or specifics. Nevertheless, the theory that I have expounded of the origin of scaling namely that it has its origins in the networks that support these systems. On the one hand... Let's just stay with cities now for the moment. On the one hand their infrastructural networks, the roads, general transport lines, the supply lines. I mean in modern cities that would be electricity, gas, water, and so on.

(00:35:16):

But those are networks and those are much like biological networks and on the other hand the social networks that we just discussed, the interaction between human beings which is universal. I mean, we may look different and we have different cultures and different histories and geographies. But roughly speaking at the level of which we're having this conversation human beings are pretty much identical across the globe.

Nate Hagens (00:35:42):

We're eusocial.

Geoffrey West (00:35:44):

Absolutely.

Nate Hagens (00:35:45):

Yeah.

Geoffrey West (00:35:45):

So that's who we are, it's in our DNA because we evolved from being bands of hunter-gatherers forming sedentary communities, discovering language and agriculture and so forth and leading eventually to cities and megalopolises that we have now. So here's the thing, the evidence in favor of believing that it was potentially inevitable. We discovered all these scaling laws for cities, namely that and I'll stay just with the superlinear for the moment. If you look at all socioeconomic activities whether the kinds of things I mentioned earlier, wages, number of patents produced, amount of crime, amount of disease, etc. Anything that involved the interaction of human beings with each other and you plot them versus city size, you see these beautiful scaling laws namely on a logarithmic plot straight lines and the slope is superlinear. It's about 1.15, and it's the same for all these different metrics. But what is amazing and relevant to the question you brought up, it's the same pretty much across the globe.

(00:37:03):

That is the scaling of cities within the United States is the same as it is in Argentina, as it is in Spain, as it is in Portugal, wherever. Therefore, it's as if in 1800 people realize, my God, the industrial revolution has come, this extraordinary expansion is going to be happening, we're building cities like crazy. We need an international convention to bring together as to how we're going to design cities and these are the scaling laws which you have to obey and go out there and build your cities. Well, of course none of that happened.

Nate Hagens (00:37:45):

But that never happened.

Geoffrey West (00:37:46):

It never happened. It happened totally organically that Japanese cities, which had nothing to do cities in Portugal I presume or very little and cities in the United Kingdom all scaled in a similar way. Indicating that there was this organic dynamic that is already somehow in their DNA, which is being expressed in the organization and dynamic of city.

Nate Hagens (00:38:17):

I sometimes in my public presentation show a graph of CO2 in the atmosphere from Monte Loa overlayed with all of the convening of parties, Kyoto Protocol, the different meetings and you might say, "Oh, the CO2 is because of those meetings." But the CO2 increase is an externality of the scaling that you're describing.

Geoffrey West (00:38:44):

Yes, absolutely. Oh, absolutely. In fact, I often show a graph of the scaling of carbon emissions versus city size.

Nate Hagens (00:38:58):

I'm so honored to have you because I really care about this not only in what do we do about it, how can we steer humanity to a better place. But it's just so fascinating, it's like a forensic detective story. So it's cool despite the horror of the implications.

Geoffrey West (00:39:19):

Yeah, right.

Nate Hagens (00:39:20):

So in theory though yes humans are eusocial, we have nature and nurture. Our bodies have this metabolic need, but our 10,000 Watts outside of our 100 Watt body that is a social phenomenon. So is there a way that governance or de-growth or something could come up with social structures that have a sublinear metabolic scaling instead of a 1.15? Maybe we could reduce that in the future hypothetically, what are your thoughts on that?

Geoffrey West (00:40:03):

Well, that's a tough question. One I've given quite a bit of thought to without great success to be honest. That is the implications of these scaling laws for future growth

and the future of the planet don't look good. I mean, in fact if you just take them to their logical conclusion it's very hard to see how we can sustain things as they are. So if we just simply continue in the same mode I think we are due for some major collapse at some stage. I hate to be so pessimistic, but it's hard to see how it can sustain itself and it is sort of Malthusian in a way. But it goes way beyond Malthus because that statement includes the effects of innovation. I mean, the work that we've done and innovation plays a crucial role in it in fact. But "all" it does is yes, it postpones the problem till later. But unfortunately, the dynamic of positive feedback and superlinear scaling leads to the speeding up of the pace of life.

(00:41:21):

So you have to do things faster and faster, and that eventually leads to a socioeconomic heart attack and that's the issue. And so how do you get around that? Well, you have to change something fundamental and that's something to do with... If you believe any of this it's to do with social networks and social interaction, which means that it has to be almost revolutionary in the way we interact with each other and form communities and ultimately that's not a scientific question it's a political question. It's a sociopolitical question.

Nate Hagens (00:41:58):

Or a spiritual question or both.

Geoffrey West (00:42:00):

Yes, absolutely.

Nate Hagens (00:42:02):

Because if you took those I don't know what the number you said. If you took the 15 million people in New York that were developing patents and put them in the wilderness somewhere, they would develop zero patents. But then when they came back to New York, maybe they would have a change in consciousness and there would also be less patents and less social striving for competition. Because maybe the definition of their self expanded to include the biosphere and the future and other creatures maybe.

Geoffrey West (00:42:33):

No, I think that's right. Because mostly the baggage we have that is us is mostly material, I mean that's the way we identify ourselves with our jobs and our houses and so on. And at best in terms of human interaction we identify with our loved ones and people very close to us, but we don't identify very much with nature being part of us even though we so obviously came from the natural world. We are part of the natural world, but also that we're all part of each other. I mean, I know this sounds a bit flaky but it's sort of love thy neighbor as thyself kind of thing and we are yearning in order to solve this problem for some spark, some leadership that inspires us to rethink who we are and move in a direction towards it. I mean, it's the image... I hate to say it, I'm not a religious person. I'm not a Christian. But to have a Jesus Christ or a Mahatma Gandhi or a Martin Luther King, someone that inspires the good in people and the collective and somehow we've lost that.

Nate Hagens (00:44:01):

That's where my thinking has been going of late.

Geoffrey West (00:44:04):

It's so weird. I mean, I'm sufficiently old that I grew up in my very formative years as an adult were the '60s and '70s and all the flower children and love and all that which is... But I realized in my old age my science has sort of taken me back to realize that as sort of misguided as much of that was, that sense of love and that sense of being part of the collective and that it isn't just material wellbeing that is going to make you happy. That you need also both for want of a better word spiritual, whatever that may mean to the individual. But you need to feel part of both the natural and social world.

Nate Hagens (00:44:57):

I agree with that and that's really the foundation and the ethos of this channel and here's a profound question. In the same way that an addict can't solve his or her addiction until he or she has awareness. Can we change our metabolism as a culture without realizing that we have a metabolism? I think we have to recognize these metabolic scaling laws that you've been working on. Because if we take that into account it suggests some of our strategies that we're striving for are kind of dead ends, and it might suggest other ones. What are your thoughts on that?

Geoffrey West (00:45:46):

Yes. But I don't know what those are. I mean, as I say… I must say, just going back before that it's very hard not to be very pessimistic until you take it out of the context of materialism and the idea that paradigm shifts and innovation means technology. It needs to also have that idea of a paradigm shift or a re-birthing needs to be something that is socioeconomic and how you do that I don't know. Because I guess my present thinking and I basically said it a moment ago, is that I would love to think that it could be bottom up. But my experience is that it needs to have some top down, meaning leadership and I don't mean enforced on you but you need… I mean, that's why Donald Trump really intrigues me. In the sense that Trump is extraordinary in terms of his charisma and his being able to tap into what I consider the negative parts of this. The parts that encourage you to feel very individualistic, not to feel like you are part of the collective, not to care about nature and so on.

(00:47:17):

It's all part of us, I mean we have all these things. Each one of us contains all this stuff inside us and he in some extraordinary way somehow… What's the word? Weltanschauung. He had this moment that he tapped into this part of our nature, which I think goes against all of this and only encourages us to go further and further and deeper and deeper towards the collapse of modern society. And we need so to speak an anti-Trump, someone with Trump's charisma and ability to sense. Forget about whether he is articulate and intelligence, but he has an extraordinary genius for sensing something.

Nate Hagens (00:48:08):

I agree with you, but let me ask you a scientific follow-up question to that.

Geoffrey West (00:48:15):

Yeah. By the way that was not science what I said, this was me, personal emotive opinion.

Nate Hagens (00:48:21):

But scientifically, is the anti-Trump someone that would exhort and inspire the opposite attributes. Would that individual go against the grain of this metabolic dynamic that you're talking about? This positive energy scaling that we've seen in human history and around the world?

Geoffrey West (00:48:45):

That's the big question. That is the big question. Because another way, a very crude way of saying why the origin of this continuous open- ended growth and superlinear scaling, is that the principle that in our socioeconomic activity, the optimization is that each individual wants more. Greed. Greed being sort of the fundamental driving force, and is that part of our DNA? Is that what's been actually happening? Because by the way greed is not necessarily always negative. I'm not even being necessarily pejorative about it because that greed is also to do better, to run faster, to whatever.

Nate Hagens (00:49:40):

Right. Ambition, incentive.

Geoffrey West (00:49:40):

Yes, ambition and so on. So I use it in a very general not necessarily pejorative sense. So it's using that energy, turning that energy into positive energy.

Nate Hagens (00:49:52):

A lot of this has to do with metabolic scaling laws on energy use, and the other point that we haven't made yet is when energy scales even if we had the ability to scale our continued energy the environmental impact and the materials and minerals and all the other stuff scales as well.

Geoffrey West (00:50:13):

Absolutely.

Nate Hagens (00:50:15):

But I think on the energy sense for 95% plus of our history we didn't have any external metabolism because we were hunter-gatherers in Tanzania. And so I almost think that our fall from grace was when we started to store energy surplus and until energy surplus goes down and stabilizes, we're going to have these issues.

Geoffrey West (00:50:38):

Yeah. Yes. No, that's of course true and I agree with you. But that also leads to something we haven't discussed and something I'm not an expert on at all and that is the source of energy and the idea that of course from a physics viewpoint, there's

enough energy to continue this or ad infinitum almost, namely the energy of the sun. It's clear we use a very small amount, and our problems began… Well, they did begin of course as you say when we created surplus energy especially from agriculture and so forth. But they got amplified enormously in the industrial revolution where we found it very easy not to use the energy that we are getting from the sun, but to use the energy that we got from the sun and is stored on the surface of the earth. And so what we've done since about 1800 is simply burnt the surface of the earth. I mean, that's what it is we're just burning the surface of the earth as we speak.

(00:51:48):

Which by the way you don't have to be a physicist to know that if you're burning the surface of a sphere it's going to get hot and the flows of currents of air and things are going to change. So it's sort of a no-brainer that you're going to change the climate and the system is going to get warmer. So that's one of its consequences. But what we need to do is to change from what is effectively a closed system, namely just the energy that's already here to return ourself once we came to where we have an open system and we're just using the energy of the sun, which leads us, of course, to this whole question about the economics of renewables and the technology associated with it and so on. But in principle, as I understand it from my colleagues who are experts in this, if there were a serious global program, we could turn this over and change everything in a relatively short time. But you'd have to give up so much to do that. It's not feasible.

Nate Hagens (00:52:59):

I want to focus on your core expertise, but briefly, I don't think it's possible because we would have to continually regenerate those constantly. But let's just assume that you're right that it is possible to get rid of fossil carbon and to replace it with renewables. Let's assume for the moment that that's right, don't we still run into the metabolic scaling of the 1.15 if we have the same governance and cultural aspiration?

Geoffrey West (00:53:30):

Absolutely. Absolutely. No, absolutely, and I am very glad you brought that back because that's part of my whole sort of bully pulpit. It is exactly that, is that "just" solving the energy problem or global warming or whatever you want to call it, is not enough because you are going to put yourself back potentially in that situation again.

It goes a hell of a long way if you could, if it's correct that we can release ourselves from the dependence on fossil fuel would go a hell of a long way. But you still have to deal with the social problem or the sociopolitical problem that is sort of underlying this that's coming from this dynamic in social networks.

Nate Hagens (00:54:24):

I want to move to some deeper, more forward-looking questions, but I have a couple more factual ones related to cities. So you said that cities, and you explained why, scale super linearly at 1.15, not 0.75. What about the global economy? Is it a collection of cities from a math standpoint, or how does that map?

Geoffrey West (00:54:51):

Yes, so this is work that still has to be done and it's work in progress and it's something... So to come for it from both directions. One is that you can say, "Look, the globe is dominated by cities." In 20 or 30 years it'll be 70 or 80% urbanized. Certainly by the end of the century it'll be 80% urbanized, which is what all developed countries are, over 80% urbanized. So to all intents and purposes, you can certainly thinking longer term, you can think of the city as the globe, as the sum of all the cities. And that's one way of setting it up, so to speak, mathematically and conceptually. But you could also sort of shortcut that meanwhile by asking, just finding out how much energy is being used globally, how much water, et cetera, et cetera. And then you can think of the globe, the planet as a single entity. Okay, not the sum. It is the sum of everything, but it's also... in the same way that you can think of you as yourself or the sum of all yourselves, and you have to do both of course.

Nate Hagens (00:56:20):

This is our first conversation, so you probably don't know a lot about my work, but I wrote a paper called Beyond the Superorganism, and I believe that global human society, not the hunter-gatherer cultures, but the mass of most of the developed world and those following function metabolically like an energy hungry, mindless Superorganism.

Geoffrey West (00:56:42):

Yes, I'm afraid that's true with the emphasis on mindless, unfortunately.

Nate Hagens (00:56:49):

Mindless in the same way that you said this was inevitable and that we build cities and Marco Polo and Cortez in that sense, we are not, let's plan this. Let's build this out. No, it's like those subterranean ant colonies. There's no architectural plan for those. It's a byproduct of them seeking out energy in the most efficient way for their colony.

Geoffrey West (00:57:18):

Exactly. That's the idea. Exactly.

Nate Hagens (00:57:21):

Okay, so you have proven that cities are centralized units of society that use resources more efficiently, and what about as people start to understand biophysical ecological limits, and there's many people now advocating for more decentralized models. We need to spread out and decentralize and not have central markets and globally interconnected things. How does that fit in with your scaling models? If instead of having a hundred huge cities in the world, we have 10,000 small cities, does that mean we're less efficient and actually have more environmental ecological impact, or what are your thoughts on that?

Geoffrey West (00:58:12):

Yeah, so that's a very tough question. The work has not been done, by the way, and I've not given it much thought til recently, and I've not worked on it seriously, and I've only started thinking about it because of this idea of the so-called 15-minute city, which is... Do you know what I'm talking?

Nate Hagens (00:58:31):

No.

Geoffrey West (00:58:33):

So it's been proposed. In fact, one of my collaborators, a very interesting man named Carlo Ratti, an architect at MIT is one of the proponents, major proponents of this, and that is we need to sort of retrofit cities so that you can do everything within 15 minutes of where you live. That's it. So it's localizing this big agglomeration rather than this sort of old image, which is partially true. That is there's a central downtown

and then there's all these layers going out to the suburbs outside, kind of of almost concentric, almost onion-like.

(00:59:18):

Instead of that, you have lots of these centers, which had been talked about before anyway, but now people are taking it quite seriously and putting numbers to it, like making it sort of this 15-minute idea. Anyway, so that got me thinking about that and indeed naively, and I've not done the work, it does what you said, it would mean that it's less efficient for the collective. That is in the same way that, as I said, if you... Oh, here's an example that is like the one I said earlier.

(00:59:55):

If you took an elephant and you asked the equivalent biomass in mice, so it's the same number of cells except on one side you make all those cells an elephant. On the other, you make it into, and I forget the number, 200 mice or equivalent. And you ask how much energy do they need. The 200 mice, if that number's right, I don't remember the number, but that number of mice requires... I think it's 20 times as much food as that single elephant. So there's extraordinary price to pay. You've got to produce 20 times as much food and you're going to produce 20 times as much entropy, therefore 20 times as much pollution and waste and so forth.

Nate Hagens (01:00:48):

So applying that example to humans, a bunch of small cities with the same population and same resource throughput would be an environmentally deteriorating trajectory?

Geoffrey West (01:01:03):

Yes, that would produce much more so. If you did the same, if you took New York and you made it into its 100 Santa Fe's, naively you would produce much more pollution. You would require much more energy and you would produce less ideas.

Nate Hagens (01:01:23):

So did you know-

Geoffrey West (01:01:24):

That would be the idea.

Nate Hagens (01:01:26):

Did you know E.O. Wilson. He passed away last-

Geoffrey West (01:01:28):

Yes, I did. I did know him. I did know him.

Nate Hagens (01:01:29):

He's someone I always wanted to meet. But one of his ideas endures... And I have all of his books. I only have one of yours, is the idea of Half Earth where humans have half the earth and all the other nature in wildlife has the rest. But I'm just wondering if we just have one giant city, I mean, how would that work? I mean, it wouldn't work.

Geoffrey West (01:01:54):

I don't think that works either. So the other end of the spectrum doesn't work either, because one of the things you discover, which we only touched on earlier, is if you... Because if you start putting together a system, then it turns out you actually need... And you optimize the entire system... And I talked about it in terms of the forest. I said, "We did work on individual trees and then we put the trees together from a forest." It turns out you need a distribution of sizes in order to get to optimize the system, and that's roughly what we see. It turns out that is what has evolved.

Nate Hagens (01:02:35):

Would you call that a power law?

Geoffrey West (01:02:36):

Yeah, that's also a power law. That also works as a power law.

Nate Hagens (01:02:41):

So I often hear about power law in public conversations that 80% of the points in the National Basketball League are scored by 20% of the players. Is this really a robust finding?

Geoffrey West (01:02:57):

Well, it's not robust, but it works very, very roughly. Rule of thumb, the 80/20 rule, as it's called, sort of works. I don't know how close it is, but 80% of the GDP is produced

by 20% of the cities or 20% of the people or whatever it is. And that's roughly correct. I mean, certainly what is the spirit of it is certainly correct.

Nate Hagens (01:03:26):

Well, the spirit of it is what I'm curious about. How can you explain as a physicist, as a scientist, why that happens? Why does that 80/20 rule roughly hold?

Geoffrey West (01:03:39):

Well, that again is the work to show that the optimum structure for optimal use of resources and energy, if that's how the system... As the system has evolved and new things grow, new towns, new cities, and the thing is continually adapting and evolving and minor changes, that arranges itself following a distribution that is a power law and just for the distribution of cities, that's called Zipf's law after a man named Zipf who discovered it also in the 1930s, like Kleiber discovered his law. And most entities do that. The distributions follow roughly speaking that rule and that power law has as its consequence, this kind of 80/20 number roughly.

Nate Hagens (01:04:38):

So let me ask you a difficult, or at least uncomfortable question again, one of these that I've saved for you specifically, if you took a time-lapse aerial view of our planet over the last 50 years, 30 years, a hundred years, it looks a lot like a cancer growth. So there are 200 types of cancer. Do you assimilate the growing form of some city's metabolisms and what's happening in the world to different types of cancers using common descriptors like aggressiveness or speed growth or metastatic? Where does this analogy hold and where does it break down?

Geoffrey West (01:05:27):

Yeah, yeah. I don't know the answer to that. And I occasionally think about it, and it may be that I don't think about it very much because some years ago, I don't know, probably 15 years ago or more, I was interviewed by The Economist about some of this work, and it was about the growth of cities and the growth of what are called informal communities, in the old language slums basically, and the word cancer came up in that context.

(01:06:06):

And I meant it very much in terms of the idea that you have an organism and then which is sort of in a metastable situation. And then at some stage something starts growing inside it, which maybe shouldn't be there or should be there, whatever, but it starts growing. And in that sense, that's how I thought of a slum or an informal community. That's something that's slightly outside of what was the host system. And this thing is growing in a way that is sort of in some way or another violating the rules. And I refer to that as cancer without... And I got into trouble because along with that word cancer obviously connotes something-

Nate Hagens (01:07:09):

Cancer is a physical scientific description, but it's also kind of like a verb.

Geoffrey West (01:07:16):

Yes, it is. Yeah. No, and it carries an enormous weight. So I've been very reluctant to-

Nate Hagens (01:07:20):

But it's a little bit... I hear you. And it just looks like visually similar.

Geoffrey West (01:07:29):

And in fact, I suppose... The question I thought you were going to ask, and maybe it was implied by it, if you were some alien, whatever, taking photographs of this planet over the last a hundred thousand years, it would be for the first 95,000, maybe 98,000, not much would change. I mean, there'd be seasonal changes of course, but the overall structure wouldn't change drastically. And it would look... And then beginning that last couple of thousand years, it would've gone bonkers. It would've been all this stuff started growing on it and taking over, and-

Nate Hagens (01:08:22):

Then the last 30 years, it doubled again.

Geoffrey West (01:08:27):

Absolutely. Just going completely crazy. And you might think of that as a cancer from the outside. I mean, that's not casting aspersion on anybody, except us.

Nate Hagens (01:08:40):

No, no, no.

Geoffrey West (01:08:40):

Us as human beings.

Nate Hagens (01:08:42):

I know. Cancer cells don't like to label themselves as cancer because it's--

Geoffrey West (01:08:47):

No, I'm sure they don't. I mean, I'm sure they're doing what they think... They are doing what's best for them. And by the way, literally cancers are us. They're our DNA. They are us.

Nate Hagens (01:08:59):

So is cancer in a human body an example of a superlinear scaling?

Geoffrey West (01:09:04):

No, but cancer... No, it doesn't actually. What is interesting about cancers is they're left to their own devices, so to speak. That is if the body went on living forever and the cancer just kept growing, it would do what the body did, it would grow and then eventually stop growing. And some cancers do that. They grow quickly and then they stop. There are some, but usually what happens before then, of course, they metastasize. That is they start doing bad things elsewhere and then shutting down organs. And so the terrible things that lead to mortality.

Nate Hagens (01:09:49):

So let me shift this to forward-looking. Given what you've laid out here on the metabolism and energy use of organisms and outside of the body exo-somatically, how would a physicist listening to this program who understands metabolism of cities and the inevitable end of linear scaling because we are on a finite system, the linear scaling of cities, advise government planners on planning?

Geoffrey West (01:10:23):

Well, first of all, let's make it, first of all, local. And I've interacted with many cities. This work, I would be very reluctant to be prescriptive, to actually say I'm not a McKinsey.

But the thing I tell cities is that you should be cognizant of these scaling laws because unbeknownst to you and all your predecessors that have been city planners and builders and so on, and extending cities and so forth, there is this dynamic that is going on in a kind of hidden way. And if you build a city in violation of those scaling laws, you are going to run into trouble. And indeed, the history of building major cities as well as minor ones, but big cities which like Brasilia and Islamabad and Canberra, even Washington DC, building cities de novo, planning cities, I don't think there's a single one that has been successful.

(01:11:53):

I mean, they've always been highly criticized. They don't work. They tend to be soulless. People are very unhappy, dissatisfied. Now eventually, those organic forces of nature take over and eventually Washington DC turns from being a boring city that most people who don't want to go to and live in, to a city that has only happened in the last maybe 20 years or 30 years, become a city that's like every other big city of that size. Exciting, interesting, lots of young people, ideas floating around and so forth. But it took a hundred years to do that, whatever it was. Brasilia is just beginning to turn that corner. It was built in the 1960s and is at last beginning to somehow evolve into a real city. And the point is, what happens is, of course, people determine the structure of a city. You know what it's like, I always give this example because I hang around universities. Typically, they build some new quadrangle or whatever, inner city, and they have the various buildings around it, and then they put in paths going across it to go from A to B.

(01:13:18):

And of course then they open it all up and the students and faculty start using it and some of those paths they use, but many of those paths they don't and they start walking across the grass in a certain direction and they form... Well, that's the sort of thing that happens in a sense. Gradually, the city organically adjusts to optimize whatever it is the function of that... In that case this university is for. So that's what happens to these cities. The city evolves and changes so as to optimize what it's there for and it becomes a real place. So my advice is be cognizant when you do it of those scaling laws because most of the things that are done in the building of new towns and cities is really sort of almost rules of thumb.

Nate Hagens (01:14:10):

So if you followed the scaling laws, you would make some decisions that would prevent disasters 10 or 20 years from now because of the scaling laws?

Geoffrey West (01:14:18):

That's right. They're to prevent disasters and mitigate or at least minimize... I wouldn't say even prevent, I wouldn't be as arrogant to say that.

Nate Hagens (01:14:29):

Okay, minimize.

Geoffrey West (01:14:29):

I would say minimize disasters that are going to occur because of some we decide, "Oh yeah, we should put a park here. We should build this building here and it should be this high and we should do this and that."

Nate Hagens (01:14:42):

So on a national level, the horses already left the barn.

Geoffrey West (01:14:46):

I'm afraid so.

Nate Hagens (01:14:47):

But on a local level, we can maybe take this wisdom and-

Geoffrey West (01:14:50):

Absolutely. Or if you are building a new city, which doesn't happen very often any longer in the United States, but is happening elsewhere, please for goodness's sake, be cognizant of the... And not just of the scaling laws themselves, but of the underlying dynamic that is encapsulated in those scaling laws and to do with social interactions, and also to think about how those fold into the functionality of what you want that city to be.

Nate Hagens (01:15:26):

It's so interesting. I'm taking up a lot of your time, but I want to get to some of the key questions that I had planned to ask you in no particular order. Do the energy use curves of dying societies resemble those of biological creatures dying of old age?

Geoffrey West (01:15:50):

Oh boy. I don't know the answer to that. I don't know. That would be a very interesting question to do some work on actually. I suspect it's extremely hard to get data. One of the things that is very hard in this, which surprised me in this work on cities especially, is difficulty in getting data. The data is out there, but it's all modern data. You'd also like to get data from 1920, 1820, 1620, you know what I mean? Historical data geographically spread around so that you can start to address these very questions.

(01:16:32):

Now, some of my younger colleagues looked into this in terms of pre-Columbian cities in Mexico, for example, where there's a lot of huge amount of archeological data and using that data to show that ancient urban systems actually follow the scaling laws. So that was very encouraging actually. But the question you are asking would be very hard to eke out data, would be very interesting to think what you could use for proxies for the decaying city and what are you going to measure that would tell you about it. I mean, there is data and people have started to look at it, and I haven't followed it very carefully that came out of our work looking at ancient Rome because there you have the buildup and then the sustenance of a powerful, all powerful city empire, and then its decay into the first part of the millennium.

Nate Hagens (01:17:39):

So in your opinion, are we running our governments more like cities or more like companies? And what does this mean for the livelihood of our nations?

Geoffrey West (01:17:49):

That's a question, believe it or not, where we're sort of doing ongoing research. So let me just tell you, I can't answer that question directly. It's probably more like cities actually. But we did ask the question... We asked two questions that have been work done on. One is, first of all about universities, we've asked about, so there was, "Are they more like cities or companies?" Kind of question. I won't go into that. But the question maybe more direct relevance came out of a conversation, which I'm sure

you've had informally with some friend or colleague, where you sit around and you bitch about administration and bureaucracy, and how it's getting in the way and it's destroying everything for us. Why is the National Science Foundation so full of idiots that don't understand-

Nate Hagens (01:18:41):

Yeah. What is the role of that bureaucracy with metabolism?

Geoffrey West (01:18:45):

What is it doing?

Nate Hagens (01:18:45):

Yeah.

Geoffrey West (01:18:45):

What is all that? So we, myself and a colleague, started talking about this, bitching, and then it sort of hit me actually that I said, "You know, is it conceivable that actually these bureaucracies are actually quite efficient and optimized for the collective but are very bad for the individual?" That is at the individual level dealing with it, it just is always seems to get in the way. There's too much of it and so on. But actually if you looked at the whole system and the function of whatever that agency is or that company, or that whatever, actually it's tending towards optimization. So, to cut a very long story short, we, after several attempts at writing little white papers that got summarily rejected by funding agencies, eventually it was picked up and given a very large funding by the National Science Foundation. So we have this big grant to do that and we have some extremely good people, people that work with us. We have someone at Harvard Business School, someone at the Sloan School at MIT and so forth.

Nate Hagens (01:20:04):

So what are you mostly doing with your time now? What questions are keeping you up at night, that are you're fascinated by and want to pursue?

Geoffrey West (01:20:12):

Well, lots of them, too many questions. But the two major things, and by the way, at the same time, unfortunately, because I'm well into my 80s, dealing with health issues myself, my wife, inevitably, and I obviously don't have quite the same energy to stay up till two or three in the morning doing the calculations.

Nate Hagens (01:20:40):

You seem like you have a hell of a lot of energy to me.

Geoffrey West (01:20:41):

Well, I'm doing sort of okay. But nevertheless, so with that caveat, the two things that I'm most interested in, of the many that I'm working on with colleagues, are one that's been a theme throughout all of this work, and I've never really completed it. And that is I have this sort of long-term, morbid interest in aging and mortality, death, and understanding what that process is, and in particular to understand why it is that human beings live of the order of a hundred years. Where does the hundred years come from? And that, in a sense, that's what got me into all this work. Just a side personal comment, that I come from a family of short-lived males. They all die in their 50s and 60s. Occasionally someone manages to reach 70, but so I assumed I would be dead in my mid 60s. And I started to worry about this question, which got me interested in many of these questions that we are now talking about.

(01:21:53):

And I've somehow violated the genetic rule of my family because I'm now 83 and I'm still going. That's interesting of itself. What is going on here with that? That interests me very much. But the other question, which I suppose is related to it in a way, is the whole question that we've touched on, is the sustainability and therefore the mortality of the anthroposphere, this fantastic socioeconomic system that we have developed. So I'm one of these people that don't fear the fact that human beings will somehow go extinct. I don't think that's going to happen, and I sort of don't care. What I care about is that we, socioeconomic human beings, will go extinct. I don't want to lose all this. It's fantastic what we've created, even though it has built into it, in a certain sense, its own demise. Can we save it and keep it going and try to understand that? So we discussed this earlier in the conversation. But really trying to develop a science of the anthroposphere, considering it as an integrated whole, that is the planet is an integrated whole of socioeconomic activity.

(01:23:18):

And I more recently got much more serious about it, because one of the things I didn't say earlier was that, unbeknownst to me, a few years ago, a man whom I did know, named Will Stefan, an Australian, I think he was an anthropologist by training, but Will was, I think, the first person to put together data of material and socioeconomic metrics for the planet as a whole. And he published this stuff, and all of them looked like hockey sticks, of course. They're zooming up. And the data he collected goes back to somewhere in the 50s. And he termed all this The Great Acceleration. Okay. So he left it at that and it became central piece for scientists working on the anthroposphere.

(01:24:17):

Now, I only came across this by word of mouth a couple of years ago, and I was very excited when I learned that this data existed, because then I could go back to what I had been thinking about much earlier several years ago. But I'd stopped thinking about it or so I put it aside, because there wasn't data. And I come from a tradition of physics that is, we do theory, we make models, we create ideas and concepts. Very important to make predictions, to understand what's been done and make predictions that we can test and so forth. But this was devoid of data. So I was left hanging, and I thought sometime in the future there will be. Now it has happened. It's very crude, but enough, and the good news, for me, as a scientist, is I wrote down some equations, which I won't go into, for the anthroposphere and it made some predictions. They're really postdictions because they are for socioeconomic activity, and the data, it agrees beautifully with the data. And so that has given me hope that we can continue this, and really... This is very much scratching the surface of work in progress, that we can really make a serious theory, or put it slightly differently, a conceptual, quantitative, analytic, mathematical framework that we can start thinking seriously in terms of, something I termed in my book, a grand unified theory of sustainability, because we do need to bring everybody into this conversation, and I want to create a framework where everybody can get involved in it, and we can really come to terms with all these wonderful questions you brought up in the last hour or so.

Nate Hagens (01:26:15):

What keeps me up at night is very simple, is how do we save the biosphere and the 10 million other species we share the planet with. But how do we reduce our

environmental impact without the violence and collapse that would require us to tighten our belt? And how to marry those two things? On your first question though, Geoffrey, and we could come back and do a second podcast on this, but just out of curiosity, do you personally use intermittent fasting? And a more important question is, how would fasting and reducing the caloric input as an individual organism affect, consciously having a trump card on your natural impulses at the level of the individual, how would that affect your metabolic scaling and age and all the other things? Do you have an opinion on that?

Geoffrey West (01:27:16):

It would not affect the metabolic scaling, per se, but it would lead to longer life.

Nate Hagens (01:27:22):

Really?

Geoffrey West (01:27:22):

On the average.

Nate Hagens (01:27:23):

You're confident of that?

Geoffrey West (01:27:24):

I'm very confident that if you were to reduce, if you can reduce your metabolism, you will extend your life. Now how much is obviously individualistic, and for some people it may not work very much, but on the average, it will.

Nate Hagens (01:27:39):

So do you reduce your caloric intake?

Geoffrey West (01:27:43):

I don't, actually. I don't... Well, I don't eat very much. I'm old. I don't eat very much. So I went through a long period where I did, and I lost 30 pounds. I was at 180 and I went down to 150 without even realizing it. I was terrible. And I freaked out when the doctor... I went for some... This has got sort of nothing to do with anything, but I went for my annual exam and I was standing there naked, and the doctor looked at me and

said, "Geoffrey, come into the next room. I want you to look in the mirror." And I looked and it was quite sobering, I have to tell you. And I did think, "Gee whiz, I better do something." But I did reduce it to what I was more naturally earlier. I now stay around 165 to 70. So in that sense, the answer's yes, but I am not obsessive about it and it's not part of my consciousness.

Nate Hagens (01:28:52):

I agree with that, and it seems logical and scientifically grounded. The question is how do we apply that from the level of the individual to the level of society?

Geoffrey West (01:29:02):

I think that's extraordinarily difficult, because of, again, the commercial pressures on food and especially fast food and so on. That's another one of these things where, sometimes in my darkest moments, I think there's a lot to be said for benevolent dictatorship.

Nate Hagens (01:29:23):

Yeah.

Geoffrey West (01:29:24):

But I'm such a committed Democrat and naive Democrat. It's ridiculous.

Nate Hagens (01:29:28):

Yeah, those two words are-

Geoffrey West (01:29:29):

You know what I mean?

Nate Hagens (01:29:30):

... don't fit in the same sentence. So I've taken up a lot of your time. I have a few questions that I ask all my guests, and this has been great. I love your work and I've learned some new things in this conversation. So you've thought about and worked as a macro observer at the Santa Fe Institute for a long career on these issues. Do you have any personal advice to the viewers of this program for their own lives, given the

global upheaval and the anthroposphere and the metacrisis and everything else? Do you have any personal advice given your lifetime of experience and wisdom?

Geoffrey West (01:30:08):

Well, I'm very reluctant to give advice. I have to tell you. Just my-

Nate Hagens (01:30:11):

You're a scientist.

Geoffrey West (01:30:13):

Yeah, exactly. My science gets in the way in a certain sense. On the other hand, I'm a human being.

Nate Hagens (01:30:19):

Exactly.

Geoffrey West (01:30:21):

So yeah, I guess it hops on what we talked about earlier. And I try to do it myself and I don't succeed. And that is just be much more cognizant of the fact that I am really part of the community and therefore the community is part of me. I'm carrying that around with me. And the community is everything from my community of colleagues here at the Institute to the community I'm part of, in terms of a city, Santa Fe, part of a community, I am, as part of being an American living in America, and part of being a human being, that we're all interrelated, interconnected. And it sounds, again, a bit hokey. It doesn't matter what side I'm on, but people dying in Ukraine or Gaza or wherever, Syria, that hurts because the thing that I began to realize, in addition to what we've already said, is that, as far as I can tell, we are the only part of the universe that actually cares.

(01:31:39):

It's kind of sobering. I love nature, and I can say all those things about nature that I said about my fellow human beings and community, that I'm... Also, that advice that to recognize that you are part of nature and nature is part of you. That's where we came from, and we're in it together, kind of thing. But there is... But the fact is that nature doesn't care. It does not care. We invented, as far as I can tell, ethics and morality.

We've done terrible things, and we're doing terrible things, but we also do wonderful things. And we need to be conscious that we are the only ones, and that is an incredible burden and incredible responsibility, and we should all be aware of it. So it's me being... We used the word spiritual earlier. I'm not a religious person. I'm not a believer, but that's my version of belief.

Nate Hagens (01:32:46):

I think it's beautiful. We don't have the right to assume that this story is inevitable, and we are the only species able to care. Well said.

Geoffrey West (01:33:00):

We're the agency of care. And that is a hell of a responsibility. We're also, by the way, the agency of understanding.

Nate Hagens (01:33:12):

And we're also the agency of metabolic impact on the hockey sticks.

Geoffrey West (01:33:17):

Absolutely.

Nate Hagens (01:33:18):

All wrapped into one. And that is-

Geoffrey West (01:33:20):

They all interconnect, all of that stuff. The thing I loved about my own work, I have to tell you, is the recognition that all these things which are considered disparate and disconnected, don't have much to do with one another, and put into boxes, actually, turns out they're all interconnected and they all do the same thing, I mean in very generic terms, but they're all manifestations of the same theme. They're all variations on the same theme. And that is extraordinary.

Nate Hagens (01:33:56):

For the record, I also love that about your work. So you have been around universities and young people for a long time. How would you change your advice? What advice

would you give to an 18, 22 year old human who is starting to understand the broader biophysical backdrop of their time?

Geoffrey West (01:34:19):

Well, do science. I believe in science strongly. Be a humanist. Read. Read the great books, and recognize that the two most important things in the universe for human beings are love and understanding. And if you could... I say those, it's not that I've adhered to those. I've tried, but I've failed, of course. But I try to keep those as part of my life.

Nate Hagens (01:34:54):

I can see those right beneath the surface of your science and scaling. I can see those. This has been an amazing conversation. I've never met you before this phone call, so hopefully we can stay in touch and I'd love to-

Geoffrey West (01:35:10):

Sure. Absolutely.

Nate Hagens (01:35:10):

... help you with your work. If you were to come back in six months for a follow-up, what is one topic that, we would just focus on that topic that you're extremely passionate about, that you think is relevant to human futures, as esoteric as it might be? Do you have anything like that?

Geoffrey West (01:35:30):

Well, I would... We've already discussed a lot of it, but I think because that's what I'm thinking about so much recently, is it would be this long-term future of the planet, global sustainability.

Nate Hagens (01:35:46):

Are you writing a new book on that? Are you actively researching that?

Geoffrey West (01:35:49):

I'm actively researching it as best I can. An interesting question about writing another book. When I wrote my book, the one book... I've edited all kinds of things, books and so forth, but to write solo, this book-

Nate Hagens (01:36:06):

Scale.

Geoffrey West (01:36:06):

It's called Scale, which I was a... I'm not a natural writer, in the sense that I labor over writing. I am happy with the book, but I do labor over it. Every sentence is like pulling teeth feeling, which is crazy, unwarranted, but I do it-

Nate Hagens (01:36:27):

On the next one just get a ghost writer. Get all your ideas out and get a ghost writer.

Geoffrey West (01:36:30):

Well, people... Has been suggested. That book, by the way, the book Scale, I was strongly urged by some very, very influential people that I should... Because I was sitting on my butt not doing anything that, get a ghost... In fact, I had some extremely good people willing to write it. And that actually got to me in the end, because I said, in the end, "I can't do that. I'm too much of a control freak."

Nate Hagens (01:36:57):

Yeah. "These are my words. I want them--

Geoffrey West (01:37:01):

Exactly. And I have even thought about it for... Oh, so I said after that, "I'll never write another book again." I put everything into that. There's no way. But two things changed that might make me change my mind. One is I realized that book, in a way, could have been three books or four books, actually. One of the things I tried to do in that book was explain everything, meaning, I didn't want to pull things out of the hat. I didn't want to sort of gee whiz and so on. And the good thing about that now is that if I write another book, I can point to the old book and say, "Look-

Nate Hagens (01:37:49):

The primer's already there.

Geoffrey West (01:37:51):

Yeah, it's already there. Go read those pages. Well, I'm just going to tell you this.

Nate Hagens (01:37:56):

I encourage you to write another book or some version of it, because I think at the core of your work is the fundamental question that humanity faces, which is can knowledge and understanding of metabolism impact our metabolism?

Geoffrey West (01:38:16):

Yes. That's a very interesting way of stating it. Yes, that's exactly right. That's exactly caught it. But by the way, I've got one other thing I wanted to say about why I would write it, and this shows a slightly negative side of my personality, and that is, I know many of the science writers that have been very successful, and I shan't name names. But one of the things I began to realize is that they were sort of writing the same book again, and they get more for it and so on. And I was sort of getting frustrated. Why did they do that? And I thought, "Shit. Maybe that's what I should... I should actually rewrite some of this and so on and cash it." And then the other thing was, I've worked... And it came yesterday, here's my friend Venki Ramakrishnan, who is a well known... This book just came out, Why We Die.

Nate Hagens (01:39:16):

Oh, wow.

Geoffrey West (01:39:18):

And Venki is a wonderful man. He's a Nobel Prize winner, and he's at Cambridge University in England. Lovely man. And he's talked to me a lot about this, and I'm glad to see he, even though I've not written much about it, he referenced me. But I saw that book, and it was, again, one of these things which happens, I think, "Bloody hell, I should have written my book on aging and death," even though there's a whole chapter to it. But people don't notice that. So it's part of this ego, there's this kind of ego driven thing. Narcissism.

Nate Hagens (01:39:52):

There's ego, but there's also emergence, because since you wrote your book, you're learning about interconnected things-

Geoffrey West (01:39:59):

Absolutely.

Nate Hagens (01:39:59):

... that you have deeper insights now.

Geoffrey West (01:40:01):

No, and I should. And that's what I've tried to convince myself. I should take those pieces and use those as points of departure for expanding further. So maybe I'll do that. I don't know. I'm not sure I have the discipline any longer to do it.

Nate Hagens (01:40:19):

I'm sure you're going to do something interesting and productive. Thank you for your lifetime of work and thanks for your time today. And let's please stay in touch, Geoffrey.

Geoffrey West (01:40:27):

Absolutely, Nate. Feel free to stay in touch. And I thank you for all your very challenging, provocative, and interesting questions. I've enjoyed the conversation very much.

Nate Hagens (01:40:37):

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