

## Paleo Solution - 327

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Robb Wolf: Hi folks Robb Wolf here, another edition of the PaleoSolution Podcast. I'm super excited for today's guest. He is Professor Sean Carroll, an internationally acclaimed evolutionary biologist who is the author of several amazing books which I have essentially bronzed and made centerpieces of my home. These include "Remarkable Creatures," "The Making of the Fittest" and recently released "Serengeti Rules." Professor Carroll, how are you doing?

Sean Carroll: I'm doing great. Thanks for having me.

Robb Wolf: A huge honor to have you on the show. Professor, could you give folks a little bit of your background and how you've found yourself in this kind of nexus of evolutionary biology research in the science education that you've done via your books.

Sean Carroll: Sure. I grew up as a kid in Ohio and I liked wildlife. Probably more of the wildlife I saw on TV than I saw at my door and I think I got inspired and interested in nature and animals and I became a biologist. But I wound up indoors as a biologist. Ironically, I work in the lab and really studying life at the invisible scale. How do genes work, how do bodies get made and asked some big questions about and how body parts have evolved and how really the great sort of diversity of the animal kingdom came about? But that's sort of my connection to the great outdoors into the bigger world and over the course of several decades as we made a lot of progress and understanding big questions about, you know, where the animal kingdom came from and how was it made. I've shared some of those insights in a variety of books.

Robb Wolf: That's great. It's ironic that the initial passion that you had for the outdoors and nature basically sequestered you in the lab. I've found a little bit of a similar path myself so it's ironic how that plays out. We should have probably been park rangers or something.

Sean Carroll: Yeah, I think if I had, for example, the opportunity as a kid to maybe do fossil hunting. Maybe do a little Paleontology probably I would have...I've had such Paleo envy that I think a lot of buddies that are Paleontologists that I think that would have steered me in a different direction but it's been a great run. Really almost all my free time, vacations with family etcetera, we aim for jungles, reefs, deserts, badlands, savannah, etcetera.

So I'm generally relaxing out in those places unlike some of my friends who have to work in those places.

Robb Wolf:

Right, right that's true so you do keep...you're allowed to keep that as least part of your leisure time and not just completely all your work. That's great. So Professor Carroll a cornerstone of the Serengeti Rules and I guess a lot of the work that you've looked at is talking about this concept of regulation and sometimes nonlinear characteristics of regulation. Could you talk a little bit about that both the macro level? Like in your book, you start off talking about regulation from an ecology standpoint and then it's almost like a microscope going from high zoom to low zoom and you ogle in and start looking at regulation on the physiological level.

Sean Carroll:

Let's actually start there. When I say everything is regulated and that's sort of where the general themes of the book. Certainly, of interest in the realm of your world and your listeners which is...our body is probably have maybe 30,000 different substances and the amounts matter. Some things are incredibly abundant and that abundance matters and some things are incredibly scarce like some of the hormones we make, for example, are present in really tiny quantities but they're very potent and the amounts matter. And we know that because when things are off, we genuinely feel that we don't feel well. We don't feel right and if we're not...if we have the wrong amount, for example, or too little insulin we call that diabetes. If we have too much cholesterol, of course, that can gum up our arteries and lead to heart disease.

So the amount of these substances matters and genuinely the body has evolved pretty interesting mechanisms to buffer change in either way and to sort of maintain a tight range. The discovery of those mechanisms that are used to maintain the ranges and I'm talking about everything. Salts in our body, fats in our body, proteins in our body, hormones etcetera. Understanding those mechanisms has been crucial inside into both human health and human disease and how we managed certain diseases and that's been a huge investment and a lot of progress over the last 50 or 60 years.

Robb Wolf:

Professor Carroll, I'm fascinated by evolutionary tradeoffs. So a really robust immune response can help protect us against infectious disease and potentially cancer but an overly robust immune response can set us up for autoimmune diseases and potentially accelerate the iatrogenic process. Could you talk a little bit about those evolutionary tradeoffs and how the regulation plays into that?

Sean Carroll:

Well the immune system is highly regulated. It's an incredibly orchestrated thing and it just turns out that my PhD is in immunology studies. My first deep study was of the immune system and highly regulated, as you described, it's fantastic that it has this capacity to essentially recognize any invader, any virus, any bacteria, any parasite and mount a robust response that generally clears things from the body in a modest amount of time. That's why we get over illness. That's why most things don't last more than five or six days at the worst. But that process, when I say regulated, the magnitude of that response has to be regulated and the specificity because, as you said, we can have such a response that we start destroying our own tissues.

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So part of the immune system, the regulation that happens within immune system is to suppress responses against things that are ourselves and that would react essentially with ourselves. Autoimmunity is the breakdown of that regulation. So whether you're talking about Lupus or Multiple Sclerosis or Crohn's disease or things like that where there's lots of autoimmunity and really, I would say, this is one of the black boxes of human disease. We know what's going on but we really don't understand how it's come about, what's triggered it in much detail.

So the breakdown of...the general theme is the same, breakdown of regulation of the immune system is problems for us. Normally, the immune system is so beautifully regulated that response is mounted and then it's sort of self-limiting. Through a sort of feedback mechanisms, it quiets down, our fever goes away, inflammation goes away, etcetera so all those symptoms were familiar where they're mounting a defense. You might ask, why does my fever go down, why does some...the lump in my lymph nodes change, etcetera? It's because there's just there's a sort of forward process that's regulated. There's also the dampening down once the threat has been met and normally those things do get damped down properly.

Robb Wolf:

A couple of thoughts here. One of them is just...maybe your perspective on the discordance theory, changes in the environment, changes in nutrition, circadian rhythm and whatnot that could play a factor in human health. And then I guess somewhat specific because I have couple of a two-year-old and a four-year-old daughter so within this regulation story, every once in a while the kids will get a cold or a pretty good fever. I really want to give them a little bit of Motrin or something to knock that fever down so they can sleep and feel better.

But then I'm not a PhD and immunology but I've spent a bit of time in immunology circles. I know that there's a critical component to that that

immunological response playing out in a specific way and suppressing those cytokines and the kind of inflammatory process can be problematic. So I guess one question like, how concerned should we be about over regulating from our side of things with pharmaceuticals that process and then maybe some thoughts also on just the general idea of discordance theory and our modern degenerative disease situation?

Sean Carroll:

Well let me start...let me go back to one of the stories I tell in the book. I tell a story of a Harvard physician named Walter Cannon who came up...really coined the general idea called homeostasis, this idea of the body buffering change. He had a really nice way. When he was introducing this idea in 1920s and he had a really interesting backstory and that he was around at the beginning of sort of x-rays and as a student studied how food move through the body was the first he kind of look, look inside the body at such fundamental processes. And then later served in World War I, even when he was a father of five and in his mid-40s. He was so compelled to go over there to deal with the problems of shock in soldiers that he volunteered to go to frontline hospitals to try to work on it. So a very interesting person and a very generous human.

He came up with this idea of homeostasis and when he was talking to fellow doctors he said, "The body has all these mechanisms and really the job of the physician is to sort of step in when the body is sort of failing, is unable to buffer things back." It's to kind nudge and help the body back towards the normal range. Now, how you actually implement that either for yourself or for your children or other people you are responsible for...I think there's a wide range of opinion and mine is not necessarily better qualified than anybody else. We do get sick and in some cases that sickness is serious. It could be debilitating. It could be a spiral downwards and if medicine can step in and halt that, I think we're all interested in that happening.

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In other cases, things like childhood infections...most colds are not anything to be too worried about. But there's a lot of viruses flying around that can be...and bacteria that are very dangerous can be very dangerous to newborns. It can be very dangerous to other vulnerable kids. And the experience, for example, with vaccines is that we've prevented an enormous amount of childhood mortality and childhood various sort of handicaps that can have evolved in childhood, blindness, for example, from measles and all that through vaccination.

Now, you brought up the case of kids got a runny nose or an ear infection, it's a 101 temperature and feeling lousy and unable to sleep and things like that. A lot of things over the counter are basically treating

symptoms. They're not interfering with the body's mounting a specific immune response. That's why what they have is generally going to clear up. So a lot of things we're doing are sort of making ourselves feel better or just feel less worse I guess I would say. And not necessarily interfering with the long-term health in terms of our ability to counter the same infection if we encounter it later. I know that's a long winded answer but I'm careful to not to want to give any kind of blanket answer of...I guess one of those, here's your scientific answer and you're familiar with that. It depends.

Robb Wolf: Right, right.

Sean Carroll: I think that one of the hardest things about sort of science education for the public and medical education for the public is there's a lot of messages out there and the messages are short and it's sort of...yes, they sort of need to be a little bit longer, a little bit more nuanced. And then you feel like you could be making a better decision for yourself or for your loved ones.

So I guess as in any given situation, you're just going to have to look at the data or obviously rely on a physician. And those physicians are guided by the professional societies that guide their practice and that they meet with regularly and for which they're repeatedly board certified and things like that. I think those are some of your general choices. It's an awfully big burden. I'm sympathetic to this in a variety of ways and I've raised my kids now into their 20s. They're on their own. They're going to have to make these decisions for themselves and for their own kids.

But I'm sympathetic that in a world where now so much information's available in our fingertips and a lot of that information's conflicting or confusing that to put that burden on everybody. What's the best thing I can do for my kids and what's the best thing you know? I think that's an awfully heavy burden. In many ways if people asked me friends or neighbors asked me it may seem like a cop out but I'm going to say talk to your pediatrician because...and also that person is going to know your kids and going to see them repeatedly and you're going to develop some sort of relationship with that person and that they...the messages from the media are awfully confusing and sometimes outright contradictory.

Robb Wolf: Which usually indicates that like you said, there's a point of nuance there that can't be encapsulated in a sound bite. We're pretty lucky that our pediatrician is an M.D., PhD and his PhD is in immunology and so I get to talk shop with him a little bit. And I asked him similar question and I said, "So you know what's this tradeoff between like Motrin and kind of

knocking the fever response down a little bit versus better sleep.” And he thought for probably good 30 seconds and he said, “Well, clearly if the fever is getting too high then we want to address that but then beyond that at some point your sleep is probably going to benefit the health of your family as much as everyone else.” So, yeah.

Sean Carroll: Can I just say is there any evidence of a downside in that situation. In other word is their...if there’s enough experience with something, do we know that –take Motrin as an example. Does it really interfere with the development of long-term immunological memory against whatever the kid is fighting and I’m not aware of any evidence that it does.

Robb Wolf: Right.

Sean Carroll: The fact that the infection is clearing up is not due to the Motrin. It’s due to the immune system clearing it. So and that’s good sign in terms of long-term health.

Robb Wolf: Right. No, that’s a fantastic answer. So maybe a little bit of a peripheral look at this stuff. What are your thoughts on this general idea of the discordance theory of western degenerative disease? This is something that is really fascinating to me within the evolutionary biology story and I’m just curious what your thoughts are on that?

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Sean Carroll: Yeah, I don’t think my thoughts are incredibly original but I’ll share them anyway.

Robb Wolf: Please do.

Sean Carroll: The perspective I have comes...I know a fair amount about the history of our species. I have been...I have several Paleontologists as good buddies. I know a fair amount about what we know about the genetic history of our species and I’ve even been to Olduvai Gorge in East Africa and that’s part of those experiences of what inspired the latest book.

So I think the perspective of understanding...we’re an animal and I know this is something you talked about. We’re an animal that had a diet, a course of varying diet as we’ve spread out across the world over millennia and eating different foods and then farming for ourselves and collecting what was available and how we...fish and meats and all this sort of thing so we would...it’s a fundamentally scientific truth that a lot of animal’s physiology is in tune with their diet and a lot of their diet s in tune with their physiology.

Now, you look at sort of industrial food practices particularly, pick a time but things are really different now than they were just a century ago. That time scale is incredibly rapid for biology. The changes in what's available to eat and how that food is made, that's a really radical change. We all know that, for example, massive amounts of cheap, easily available fructose is having a huge effect on our physiology, our body mass, our, in fact, regulation of our body size.

So the perspective there is that when sort of the environment changes faster than our biology can evolve and adapt, things can be out of step. And I think there's a lot, there's a general validity to the idea that a fair amount of modern ills whether that's asthma, obesity, various degenerative diseases, autoimmunities to a certain degree are products of creating an environment that is not the environment that we evolved in. I think there's a lot of validity to it. What you...how you take that sort of concept and apply it, obviously, there's going to be a lot of diversities of opinion there. But I think there's fundamental validity to that idea that we are, you know we're a bipedal primate that's created its own environment now relative to living in a savannah ecosystem.

Robb Wolf:

Right. I forget the professor's name he was at Emory University and he talked about culture actually creating one of our most rapid evolutionary adaptations in the form of sickle cell anemia. That basically that's when culture slash and burn created these open areas of standing water and this increased the anopheles mosquito load and so it increased malarial load and it pushed the...I think our inevitably one of the fastest but also greatest penetrance of a genetic adaptation that we've seen in history. So we reached the point where even our own culture and our own innovation is starting to shape and fore our own genetics.

Sean Carroll:

Oh that's certainly for true. I mean in terms of recent adaptations and I think evolutionary biologist would think anything in the last 10, 000 years is pretty recent because a lot of other aspects of our body and physiology are shared with the rest of the animal kingdom and are really deep but just things as you say, thing like sickle cell which is that mutation has been selected by the malarial environment. There's other mutations that affect red blood cell physiology that are a result of selection because of malaria.

But even in our diet, we know that the pastoral lifestyle in drinking of milk evolved at least twice in human cultures. We can see that signature in DNA of populations. And again both the archeological and genetic evidence says, "That's pretty recent." So there's a fair amount that's happened in the last thousands of years with farming and things like that.

But of course, I think a lot of the acute interest now is not just what early civilizations did but what our current civilization is doing with respect to diet and the environment.

Robb Wolf:

Right, right absolutely, definitely key area of interest for me. Professor Carroll, could you go over the general rules of regulation that was a really fascinating section of the book?

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Sean Carroll:

Well, here's what we mean by regulation is that, generally, the way two things can interact is that something can increase the amount of something that's made or decrease something that's made. Or the making of something can feedback and sort of dampen down the making of that product. So we'll just call that, that's positive regulation or negative regulation or feedback regulation. Now, I think we have that feedback is a concept that people generally get that it's sort of a system that as it moves along, the state of the system feeds back on itself and that determines how much output there is.

Then the last one is something we see that's widespread in biology and I describe it more in the forms of formologic which is doubled on negative regulation. I'll put it to you this way. When you see car rolling down the street, you figure that somebody has got their foot on the gas. You don't really think that somebody released the brake but releasing a brake, inhibiting a negative control is something we see very often as the logic in nature, in our bodies and out in ecosystems. I go through examples of that in the book several times because often the leap, the conceptual leap and understanding something and scientists understanding something was kind of overcoming our bias that when we...as I said when we see a car rolling, we think of...the simplest explanation is somebody's pushing it or stepping on the gas. It's a positive effect, right, that's making it go not that you're inhibiting the negative effect of the brake and it just turns out, brakes are really important biology.

A lot of things are essentially are under the control of brakes and to get them to go you, got to release the brake. and that's true for example the multiplication of our cells which is really fundamental in terms of keep making and maintaining our body. Then in disease, a lot of the problems, if we say something like cancer are when the brakes are broken. When the brakes have been essentially cut by, for example, by a genetic mutation. So these basic rules of regulation are positive control and negative control and feedback control and then there's double negative control. It's amazing that describes the relationships of a lots of things from sort of the society of molecules inside our cells, the society of cells



that make up our organs, the society of organs that run our bodies and really the society of creatures in any given ecosystem.

Robb Wolf: I'm glad you let it in that way. I hope I'm not going off in the weeds too much. But I'm thinking about keystone predator or keystone species that seems like a really critical point in this regulation story on an ecological level. Could you talk a little bit about that?

Sean Carroll: Sure. So what I do in the book is I talk about these major discoveries and their discoverers. I'll try to tell stories. It's a much better way to talk about science than going to a chalkboard and starting with jargon. Generally, these are stories of people who went out in the world to try to figure out how the world worked and they discovered surprising things and especially surprising things that turned out to be general. Keystone species is an idea that came from experiments, outdoor experiments done by zoologist Bob Payne on the Pacific West coast, then in Northwest coast.

The observation was he wanted to know what role predators played in ecosystem and the bias at that time was that predators they're kind of like ornaments on a Christmas tree. That all the organization the system was sort of from bottom up that the plants gathered light from the sun and the plants grew and then whatever amount of food was there, was food for the things that ate plants and all the herbivores. And if there are enough herbivores around maybe there'll be some carnivores that ate them.

But what Payne discovered was he went to this tide pool type system in the Pacific coast and the top predator he observed were the starfish, this big starfish that would envelope and eat mussels and barnacles and snails and things like that. He thought, "Okay what happens if we take the starfish out of the system?" He went to one set of rocks and would literally throw this...peel the starfish off the rocks and throw them back out in the ocean and on adjacent set of rocks he just leave them intact and he drove back and forth to the ocean every month and repeated this experiment and he saw the effect very quickly.

The effect was, well see whether...people think it's surprising. It's surprised him for sure which was and he sort of think of predators eating a lot of things that...lots of things that were being eaten would flourish. But as it turns out...essentially the system collapsed and that all the diversity that was there...different types of plants, different types of animals, eventually collapsed almost a simple monoculture of mussels. It took over the whole space.

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The reason he came up the idea of keystone that comes from roman architecture. The keystone is the stone at the top of a roman arch where, if you take that stone out, the arch collapses and his idea was if you take the keystone out, the community collapses. So he learned through these experiments that predators at least in some cases played this role where they regulate the stability of that community that they're in. If you remove them, the community can collapse and it turns out when you look across the world, predators can play a really important role in the whole health of a given habitat.

Very soon after his observation, Jim Estes, who met Bob Payne and that inspired his experiments, discovered that sea otters play that role in the Kelp forest of the Pacific Ocean. This is one of the stories that blew my mind. I'm like, "What?" We see these playful little sea otters right and we have saw all these in the pictures and sort of banging on sea urchins under chest or whatever and it turns out, they're incredibly voracious predators because they spend all their time in the water and they need a lot of food to keep that motor running. They eat for example a lot of sea urchins. Well, as they were almost exterminated across the Pacific Rim during the fur trade down to maybe as few as the thousand animals.

Sea urchins just carpeted the Pacific coast as they rebounded which you say rebound where the Kelp forest. And what happens was it's the sea otters...by eating the sea urchins which in turn eat the Kelp. They regulate the amount of sea urchins and if the sea urchins are kept in check. They're there but kept under a modest number, the Kelp flourish. You get these tall Kelp forest and that's habitat for fish and other types of shell creatures and that's where eagles feed on fish, etcetera, etcetera.

So the whole diversity of the system depends upon this Kelp habitat existing and that's depended upon sea otters keeping the sea urchins in check. And so it's this kind of connection unexpected and really surprising connections that have changed our thinking of...have changed our view really of how nature works and in this case predators regulating the plant eaters which in turn allows the plants to flourish and that when we upset that balance bad things happen.

Robb Wolf: Right and completely nonlinear, you couldn't have predicted that type of stuff, yeah.

Sean Carroll: Yeah and we've got a lot of situations on land and in the water where we have taken out predators or taken out other kinds of keystone species. I mean another type of keystone doesn't have to be a predator. Think of

bumble bees. Bees as pollinators. They have a huge influence on the diversity of the communities they're in. So when you lose these creatures that have a big impact on other creatures, systems can really collapse. We're learning that again and again.

Robb Wolf:

Yeah and this maybe gets off and do some controversial area but there seems to be a little bit of a battle between this idea of shifting people towards a largely plant-based diet which in my mind means raw crops and intensification and oil and all these type of stuff. And then there's some other folks out there that are really advocating for the use of large grazing animals to maintain the health and viability of one third of the earth's land masses which are grasslands.

Then it's a pissing contest to pick of epic proportions and I feel a little bit like a crazy person suggesting that wow, maybe we should have camels here in the desert areas of Reno. Because at one time this was a grassland in this sage and scrub brush that we have wasn't actually a climax species. We had I think four species of camel, a couple of different types of elephants. There's still some pronghorn antelope but those were predated by a North American variety of cheetah which now they don't have that animal there. So you've got a very compelling story from this kind of plant-based diet scenario that is against the...confined animal feeding and production what not which is incredibly, energetically demanding and ecological damaging and then you feel a little bit like a crazy person suggesting that we need actually more animals but they needed to be managed. I don't know if you're familiar with Allan Savory from the Savory Institute. They try to re-emulate the predator-prey interaction moving these large groups of herbivores over an area and yeah.

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Robb Wolf:

I know about that work. I also know folks currently working in Kenya, understanding the effects of grazing of large animals and can they emulate essentially the native African wildlife with some of the domestic wildlife. There is...I don't want to issue a blanket agreement with some things that are asserted. There is some evidence lacking in particular places but there's also evidence in favor that this is an idea certainly worth exploring, worth testing, rigorously in seeing... and it may depend of course on which habitats. The dessert is particularly controversial because the dessert itself is a habitat that to our eye kind of...and it looks barren but it turns out there's a lot going on there.

We have to be careful about imposing...I'm not going to say just the aesthetic but our sense of what is natural or productive on given places.

We just have to be careful and we can do this with the best of intentions. We can still make mistakes so...and this is...

I know it's not a very specific answer. It's not a very actionable answer but I also want to kind of give us a little bit of a break. Because the things that I talked about in the Serengeti rules are many of these discoveries have only unfolded in the last 50 years. Some of them have only become widely accepted perhaps in the last 15-20. These are things we just didn't know about how the world worked. While, our population is booming into the billions and we were developing ever more intensive and productive farming methods and industrial fishing and all these sort of things. So we got to sometimes forgive ourselves a little bit for what we don't know.

Now, when we do known and meaning no means there's enough evidence and there's enough consensus around that evidence. Well, then we have I think an obligation to add...

Robb Wolf: Add some gears.

Sean Carroll: ...yeah, more intelligently so in some cases I think we have to sort out what more do we need to know and in other cases what do we need to do to change our habits. That's obviously a very general thing that I'm saying. But that's the caution when you talk about the pissing match is that there's probably elements of truth in both camps but absolutism isn't going to work in either case. You're going to have to be...it's going to be more nuanced. I think...I would say in all the things I've probably come to learn by middle age, we like black and white. We like yes and no. We'd like to have a code to live by but nature is a little more complicated and unfortunately some of these things are going to be grayer and not applied uniformly everywhere. It's just not the case.

Robb Wolf: Right. That's a fantastic point. I guess I do the best I can to make this as much of an informed decision around things from these evolutionary biology perspective. But to your point we have a very imperfect understanding of that so what our assumptions are of that today maybe quite out of date within a day a week, a decade so it's important to have some reservation there.

Sean Carroll: Yeah, I think it's not to do nothing. It's act in the best information that you can find but be prepared that some of that information might change. It's just the nature of the scientific enterprise that often we're excited by new ideas. We're excited about new ideas that have some evidence behind them. But the settling process of what is sort of

appealing about an idea and what is rock solid and bankable, we have to discover that over some time and just throughout, especially, I would say biology because there's no laws, right? There's only kind of tendencies in biology and so we're trying to figure out these tendencies and apply them as wisely as we can for our own health and we'd like to be applied...I'd like to see them applied for the health of the planet but we're a little behind even that, yeah. Hence with the book. But we got to be prepared that thinking is going to evolve with new data and so we don't want to get too rigid. We got to be ready to accommodate new information as it comes along.

Robb Wolf:

Right, right, now I'd love that and this is maybe a poor analogy but when you're strapping into an airplane and the stewardess is telling you the list of things that you've heard a thousand times. And like if there's a cabin depressurization, put your mask on first and then put the person next to you, put the mask on them. But what I've noticed is that when people improve their individual health and then they pop their head up and they start kind of looking around they're kind of like, "Okay I feel pretty good now. Now what do I do next?"

That's where I've been really interested and passionate about this kind of sustainability story and exploring it from this evolutionary biology topic. You really get into that quite a lot in the afterward with Serengeti Rules via your rules to live by. Could you talk about that a bit and kind of expand them what that material is?

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Sean Carroll:

Well, yeah, let me just talk about maybe a general view point of the book and you can point me down the lanes that you want me to travel. But in general one of the themes of the book is look we've started to find out a lot more about how the world works and this is the world that sustains us and I'll just take sort of a simple example.

I grew up on the ledge at the edge of Lake Erie in Toledo, Ohio and I never stepped foot in Lake Erie. I never swam in it. I never fished in it. I never ate any fish that came out of it. So that was my childhood experience because it was kind of an industrial toilet and a lot of lakes that I saw subsequently in my life were by July or August they're choked with algae and I just kind of took that as well. That's the way things are. But it turns out just a little bit of understanding so that our ecological principles. That's not the way now and not the way they are but it's not the way they have to be. Our lakes could be much more productive in terms of things we like, fish, swimmable water, fishable water, portable...

Robb Wolf:

Drinkable water.

Sean Carroll:

Drinkable water. Fish front property, water front property etc. with some changes in habits. So when I...in the book I do talk about some far away and magnificent places like the Serengeti but that's not where we all live. We all live around local woods and forest and farms and lakes and things like this. And it's a lot about look around saying, "This is the stuff that we need to sustain this." We have demands. Humans have demands that needed to be supplied, water, food, right, healthy space etcetera. So understanding that we've learned enough about the way nature works to manage it differently. That's one of my most important messages. I guess when I get into the afterward is I draw in some examples from...let's just call a little longer history than the last few decades anyway and in terms of global, in terms of how do we conquer some things in the past.

I talked about the small pox eradication effort, a disease that was killing millions of people every year and maiming many millions more. We tackle this in the 1960s in an international effort that involved countries that were at each other's throats in terms of geopolitics. I mean the Russians and the Americans work side by side in smallpox eradication. They went into countries that were otherwise hostile, got their cooperation, got troops on the ground. I don't mean army troops but I mean volunteers on the ground working and all sorts of places to conquer something that even the most optimistic people didn't think could be conquered.

If you look at something like smallpox eradication, I mean there's just a lot of I guess I would say encouraging and somewhat optimistic lessons in there about our ability to work together to create a better world, to do some things collectively that are hard but they're in our joint interest. And that's why I highly look at ecological health. It's hard. It does involve changing some habits but it's absolutely in our joint interest and one thing I would want to say is that we can't wait for all the countries around the world to agree and sign a treaty and enact everything.

This is actionable at the very local level. This is about making nearby woods or ponds or lakes or the area around you a bit more productive, a bit more ecologically healthy. And let's see the turtles and the frogs in those ponds or let's not fret when our dog runs into the water and we worry, "Oh my god, what's he ingesting and he's going to die that afternoon."

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So there's things that we can do on a local scale and I think there's things that we can do on a regional scale that will add up and they're not huge. They're not hugely expensive. They're not necessarily even hugely

controversial. They're just generally not known that it matters. Right now somebody asked me that I worked with here. She's headed to Florida in two weeks and you may have seen the news that the coast lines of the Atlantic side of Florida is a green sludge. It's pretty disappointing but I mean this is pretty predictable that we're flooding our waterways with phosphorous and nitrogen.

We understand why that happens. We understand why there's algal blooms on Lake Erie as I grew up with and there's now algal blooms and sludge all over Florida. We understand this stuff and now that it's happen everybody I'm sure either in Florida or going to Florida is incredibly upset and disappointed but it was entirely preventable. Maybe we have, it's human nature perhaps maybe we have to see what can happen before we start thinking about how to prevent it from happening again. But other places should look at what just happened in Florida and say, "Gosh, I don't want that to happen here. What's going on that might have us at risk?" It's a bit of a change of a mindset.

One of the people I quoted in the end of the book was Pope Francis. I was stunned at this in cyclical that he issued in the summer of 2015. It's brilliantly written and very powerful about the ecological health the planet. It was essentially a message to the whole world. It's heartening that someone in that position thought that that was great enough priority to talk. I certainly hope that these voices will start up and people will realize that this is the place we depend upon and we all have a joint stake in its health.

Robb Wolf: Right yeah. Apparently Mars is not an immediate for back up.

Sean Carroll: Yes Mars I feel very confident as a scientist and all my scientific colleagues that Mars is not an option and goodness we would...if Mars becomes an option, we better takes in better habits to Mars than we have here. That would not be...we do not need to export some of these habits.

Robb Wolf: Right, I completely agree. Well Professor Carroll. It's been a huge honor having you on the podcast. Where can folks find you and your work on the internet?

Sean Carroll: Yeah, so I've an author website at [seanbcarroll.com](http://seanbcarroll.com). There you'll find links to books and articles and films that I'm involved in and educational resources and things. My fulltime job these days is that to help sort of the National Science Education Effort while I maintain a laboratory at the

University of Wisconsin. We're just trying to get good stories about science and scientist out into the world.

Robb Wolf: That's great. Well, I love your work. Really a huge honor having you on the show today and I look forward to hopefully meeting you in real life someday.

Sean Carroll: Thanks so much I look forward to it too.

Robb Wolf: Thanks take care. Have a great day.

Sean Carroll: Thanks.

**[0:42:24] End of Audio**