BOOKS AND IDEAS PODCAST

With Ginger Campbell, MD

Episode #47

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Interview with Terrence Deacon, PhD, Author of *Incomplete Nature: How Mind Emerged from Matter*

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INTRODUCTION

Hi. I'm Dr. Ginger Campbell, and you're listening to Episode 47 of *Books and Ideas*. Since this episode is also being released into the *Brain Science Podcast* feed, I want to take a moment to tell you about *Books and Ideas*.

Because the *Brain Science Podcast* focuses on neuroscience, *Books and Ideas* is the place where I talk to people from a wide variety of other fields. But every so often I will put an episode of *Books and Ideas* into the *Brain Science Podcast* feed, just to remind regular listeners that I actually do two shows.

Today's guest is Terrence Deacon, who is the head of the department of anthropology at the University of California at Berkeley. We will be talking about his new book, *Incomplete Nature: How Mind Emerged from Matter*. From that

title you might think that this is an obvious *Brain Science Podcast* topic; but actually our conversation focuses on a concept from complexity theory called emergence.

Long-term listeners may recall that I introduced emergence back in *Brain Science Podcast* Episode 53, when I discussed the book, *Did My Neurons Make Me Do It?* In his book, *Incomplete Nature*, Dr. Deacon sets out to explain how the emergence of both life and mind occurred completely within the known laws of physics, without the need for anything supernatural.

Before I play the interview I need to mention a few things. First, if you are a new listener, don't be intimidated by the topic. All you need to know is within this episode; although you may be motivated to learn more.

On the other hand, some of you may be aware of the recent controversy about Dr. Deacon's failure to cite the work[1] of Alicia Juarrero. I will address this in my closing summary. For now I would like to mention that after investigating this for myself, I feel that it has been blown out of proportion.

One last thing: because of some sound quality issues, I had to edit out Dr. Deacon's description of his work while he was a student at Harvard. While he was there he did experiments involving looking at the parts of the monkey's brain that are involved in vocalization, as well as other experiments related to brain development. There will be a brief musical pause early on, which will be your cue that I had to skip forward in the interview.

And don't forget, complete show notes, including the free episode transcript, are available at booksandideas.com. And you can send me email at docartemis@gmail.com.

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[1] *Dynamics in Action: Intentional Behavior as a Complex System* by Alicia Juarrero (2002)

INTERVIEW

Dr. Campbell: My guest today is Terrence Deacon. Terry, I'm so glad to finally get to talk to you. Welcome to the podcast.

Dr. Deacon: Thank you very much.

Dr. Campbell: I would like to start out by just asking you to tell us a little bit about yourself.

Dr. Deacon: All right. My background is somewhat circuitous, but that's probably reflected in my work, as well.

I began studying physics as an undergraduate student; changed my mind a number of times; ultimately got an undergraduate degree that was interdisciplinary, mostly focused on things having to do with complex systems, as they were called in those days. But I actually became fascinated originally with the work of a philosopher—something I had not focused on as an undergraduate—a man named Charles Sanders Peirce, an American philosopher from the last century; the end of the 19th century, beginning of the 20th century.

And I went to Harvard, accepted into a program where I thought I was going to study his work. In fact, his unpublished work was buried in one of the libraries at Harvard. And I was very excited as a graduate student. Unfortunately, there was nobody really to work with me at the time on that, and I went off and became very much more interested in the neurosciences.

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Deep evolutionary questions were behind all of my work. I began to doubt that we had really understood the evolutionary process behind all of this. In my work in the 1990's—and I wrote a book called *The Symbolic Species*, that sort of summarized a lot of the work I did on language, transplantation, and the evolution of language—since then, I began to pursue the question of *are there more general principles behind this*. And that's what's led to my current work.

Some of it is on the role of what we sometimes called self-organizational processes in development; but also how they affect evolution. And it became very clear to me that simply looking at the Darwinian story in isolation from these developmental mechanisms, as many people had begun to point out, was going to be misleading; precisely because evolution works on developmental processes.

That's what gets modified. And if developmental processes are not themselves just mechanism, but use much more interesting self-organizing, dynamical processes, then we had to find a way to integrate those. This is not new; a lot of people were thinking about this throughout the '90s and into this century.

I began to pursue this at a fairly generic level. My new book, *Incomplete Nature*, is an exploration of what amounts to these issues about what's behind these kinds of processes. As I pursued this, initially thinking I was going to write a book about brains again, I realized that there were questions behind it that I had not answered for myself and that I did not feel were appropriately answered in the literature at the time, having to do with how these two processes—natural-selection-like processes and self-organization-like processes—interact with respect to each other.

So, I came to believe that we had an inadequate theory, at a very basic level, in our understanding of issues like information and end-directedness; and even how we think about evolution needed to be expanded. Not that we were wrong, necessarily, but that we had not covered the whole story. Evolution does not

happen with respect to just stuff; it happens with respect to organisms that have very special kinds of physical properties. And we had not really done a good job of explaining those physical properties (such things as avoiding the second law of the increase of entropy) so successfully; that we had not integrated into these larger theories.

So, that's what has led me to my current work.

Dr. Campbell: OK. So, we look at your CV, and we see that you're the head of a department of anthropology. So, I erroneously—it sounds like—jumped to the conclusion that you would be an anthropologist. But that's just the closest thing to describe what you do, which is kind of a very broad attempt to integrate a lot of different disciplines.

Dr. Deacon: Well, my links to anthropology are two: The first one is that one of the people who influenced me a lot when I was younger was a man named Gregory Bateson. My interaction with him was mostly at a distance, and mostly through one of his later students.

Nevertheless, he made clear to me that the things I'm interested in are general enough to not fall easily into any particular field. And he, as an anthropologist said, *Look, all of the stuff that I have been doing—studying communication, cybernetics, information, things like that—I've been able to do as an anthropologist; in part because anthropology has this kind of breadth of possibility.*

Now what I would say is I think that the field has actually narrowed since that time, and that its acceptance of the kind of things that I do has probably narrowed. I think that will change, but probably not easily.

The second reason that I got into the field is I was interested in what's unique about human beings—human cognition, and particularly human language. And

the evolution of human language does not, itself, fall easily into linguistics, into biology, into neuroscience, but it does fall into anthropology. It has, historically.

So, this joint focus on the nervous system and how it works and how it evolved, and language and what's unique about language (what Charles Sanders Peirce, my original source of insights, called semiotic processes; that is, all processes that have referential and significant relationships), those were things that he was trying to get a general understanding of. And I think until we actually had an understanding of those kinds of processes in general—not just language, but language in its larger context as a means of referring and communicating—this was really an anthropological problem also.

And so, in many ways I saw anthropology as just a place where I could do the work I wanted to do, without too many interferences. And my mentors at Harvard, when I was there—particularly a man named Melvin Konner—appreciated that interest of mine, and the breadth, and let it flower, so to speak, and let me do what amounts to a very rare neuroscience PhD, but in a department of anthropology.

It gave me also the opportunity to build laboratories that had never been built in anthropology, to do really basic neuroscience in a field that had not previously welcomed that kind of work. I can't say that it is a major part of the field yet. I'm hopeful that as this becomes more relevant, people in the field will begin to understand how important it is to understand our evolution in our neurology.

Dr. Campbell: I'm glad we spent time talking about that, because I have a lot of students that listen to my podcast, and some of them are interested in science careers, and it can be very confusing to figure out where to go. And students that are interested in neuroscience, I've been trying to help them to appreciate that there are a lot of different avenues.

Dr. Deacon: Yes. I should say, just in warning, that I do think the fields in general—all of the academic fields—in many ways, although they've been open to this, there's also a kind of narrowing that's gone on in recent times that I think is unfortunate. The good news is that there are also programs popping up all over the place that stand in between (cognitive science programs, and so on); although they each go through their own process of narrowing and trying to self-define themselves, and put boundaries up.

I think there is always space for people doing work, that I think is inappropriately called 'interdisciplinary,' but work that, by following what you need to follow in order to answer your questions, carries you outside of any clear disciplines. So, in studying the evolution of language, you can't just study it in one discipline. You can't get it all straight in the neurosciences, you can't get it all straight in linguistics, you can't get it all straight in anthropology, or in evolutionary biology; you really need to sort of cross into all of those zones.

I think that's one of the interesting things about good questions—good exciting new questions—they typically fall somewhere on the edge of departmental divisions. And so, you can oftentimes follow them up in different departments; you just have to make sure that you tip your hat to what people in that field think is important in their field. So, you have to do a little compromise to do it, but I think there's always a place for good in-the-cracks kinds of research.

Dr. Campbell: We'll come back to that at the end, when I will specifically ask you for your advice for students. I always do that at the end.

Let's talk a little bit about *Incomplete Nature*. Since it is a fairly deep book, I know we're not going to have a chance to talk about everything in the book; so before we start, I'd like for you to give your own brief outline touching on the key ideas. How do you describe your book when somebody asks you about it?

Dr. Deacon: That's a very good question. First of all, I have trouble putting it into a category. It's not science, it's not philosophy; it's got speculation in it, it's got testable hypotheses. It's quite a mix.

Dr. Campbell: It's got history.

Dr. Deacon: Yes, it's got history. And it's an attempt also to try to put in, I wouldn't say simple language, but in language, some topics that are usually done quite technically, and that sort of leave the average reader out. I can't say that I wrote this in a way that any average reader will find easy to read, but I tried to explain everything I could, even if my writing style is not sort of good popularization style.

The book, for me, grew out of the following issues that I hinted at just a few minutes ago. And that is, I came to realize that complex systems theories really contributed a lot to our thinking, but also to recognize that they didn't actually get to the questions that were interesting to us, and that were most pressing; questions that are now big-time bookseller topics, like the origins of life and the nature of consciousness.

I didn't feel that I could write the definitive book on the nature of consciousness. I think there's a lot of work yet to be done. I should say that my publisher pushed me a little bit—especially in the title—to use a word like 'mind' (which I didn't intend to use there, but I think is one of those things that gets people to read your book), and to put a chapter in there named 'Consciousness.'

So, there's stuff in there like that, but actually the book is an attempt to get at something much more basic than that, that I think is behind a lot of the problems we have with these issues. And that has to do really with two things: The nature of what we would colloquially call 'the concept of purpose,' or 'end-directedness.' The philosopher, Aristotle, called it 'final causality.' And the way he described it,

it's that for the sake of which something is accomplished or something is produced.

And 'that for the sake of' is an interesting phrasing because, of course, it implies that there's something like 'self' there, there's something like 'value' there; and it's something that has not been accomplished yet, it's something in the future. So, sometimes final causality is talked about in terms of how the end generates the means.

We talk about that without any hesitation, in terms of human actions, and our own decisions to behave, and to do things. But it does not fit well into the natural sciences, and particularly not well into the physical, chemical, and biological sciences. And really since the 19th century there has been a very strong effort, after Darwin, to take anything like final causality or purposiveness out of any biological talk.

I felt that this was a problem. Not that I think there is some kind of ultimate purpose, or even that evolution is end-directed (the process of evolution, I think is not end-directed), but clearly it has produced creatures like ourselves, that have purposes and have values. These things emerged in the world, and there has to be a story told about how they came about. If simple physics and chemistry don't have these effects, we need to be able to explain them.

Now, I think one of the problems is many people in both the philosophy of science and in the sciences have been at pains to explain them away. And my purpose was not to do that; my purpose was to try to understand how these things came into being.

The book really grew out of a dissatisfaction with the systems theory approach to this, which says, *Oh no, it's just a complex system; it's just self-organized*—like

snow crystals might be self-organized; they produce order, even though they're falling through a chaotic environment.

And I became excited about self-organization, but I realized that this jump to say that self-organization is going to explain things actually did not; because the concept of 'self' is metaphorical in that phraseology, and the concept of 'organization' actually implies something organizing something else. And it's not that simple. I began to realize that, in fact, even the best complex systems theories that I was excited about weren't taking us there.

So, I became really determined to figure out how to go beyond that. And so, I think one way to think about my book is it's a book that says, *Look, to understand the origin of end-directed phenomena, representational phenomena, or mental phenomena, you need to take one further step; you need to figure out what's beyond self-organization that needs to be explained to account for these things*.

So, that's really the intent of my book, to say self-organization is an important stepping stone and complex systems theory is an important stepping stone, but we need to go beyond it*;* not to leave science, in any sense—not to leave the empirical, not to leave the physical—but to really go beyond that.

And it turns out that that was a really difficult step; and I found it really difficult to explain. And my book is mostly about explaining that process, because I think once you understand it, you understand things like the concept of organization differently, you understand the concept of self quite differently, you understand even the concepts of information and work quite differently—all of these things I deal with in the book.

Interestingly enough, what I found is that at least the first few reviewers that have jumped at the book—which have mostly been philosophers of mind—actually

don't even get that transition. They still think I'm arguing about self-organization and complex systems theory, when in fact, what I'm precisely saying is that's not enough, it's not going to take you there, we need to think beyond that.

In the process, I developed a sort of hierarchy of three ideas. The one that captures this difference is a concept I call teleodynamics, or 'end-directed dynamics'—something that we find in living processes and mental processes. But it's not just to coin a term like that, but to explain how it comes about.

Basically my argument is that it has to do with a very special and unusual relationship that can develop between self-organizing processes; and in that process, of generating a new kind of dynamics—a dynamics that is literally directed towards something that doesn't exist yet; that is, an end that is not present.

That's really the challenge of the book; to say, *Look, can we develop a very specifically scientifically, materially sound explanation for how you can go from systems that don't have that kind of property to those that do?* That's effectively the intent of the book.

Dr. Campbell: I'm going to add in here a quote that I wrote down from your introduction. On Page 16 you said that your goal was to "demonstrate how a form of causality depending specifically on absent features and unrealized potential can be compatible with our best science."

Dr. Deacon: That's, in a nutshell, what I'm trying to do; yes.

Dr. Campbell: And we're going to get into some of the details of that in a minute; but I did want to ask you one other basic question, and that is who is the intended audience for this book?

Dr. Deacon: First of all, I did not write it with equations and complex graphs, and so on and so forth, precisely because the intended audience is not neuroscientists, it's not philosophers of science, it's not evolutionary biologists. I realized that the problems that I deal with are really quite broad and general.

In many diverse fields there are people interested in and confused by these problems. It could be as simple as the concept of function in biology. The concept of function is borrowed, of course, from human artifacts. And yet, we apply it to biology; but of course we don't mean that somehow there's a designer that had a function in mind—an end in mind.

On the other end of the spectrum, even as far out as talking about ethical theories and so on, we have this notion of 'value,' 'normativity'—norms of things. There can be positive and negative value, and the good for something or other; or as Aristotle used the term, 'for the sake of' something. That, too, is something that has this kind of absent character. And yet, these are crucially important concepts, and crucially important causal phenomena, as far as I would describe them, in terms of how human beings act. We act with respect to value.

That's an incredible range of diverse phenomena that have something in common. What they have in common is they all have this kind of link to final causality; this link to something that is not present, is not now, is not here, or is just possible, or maybe even just conceivable. And yet a good part of the world, it seems to me, of living and thinking beings is based upon this kind of causality. And it needed to be explained.

Dr. Campbell: As a person who has read the book, I think it's fair to say that this book will reward anybody with curiosity who is willing to put in the effort to read it. I think it's very clearly written. But it is a very nested argument; you're not going to read it at the beach. Well, you might, but only if you're not drinking margaritas at the same time.

Dr. Deacon: Yes, exactly. And I would say that probably the people who have gotten the most out of it have taken their pencils and marked it up, and have put notes in the margin, and stuff like that. I tried not to write it in technicalese, so to speak. I can't say I fully succeeded.

I even end up—sometimes I think wisely, sometimes I think unwisely—inventing new technical terms, because I felt that the terms that existed carried too much baggage, or were just misleading, or simply there was no term for a particular relationship. There are about seven new terms in the book that are characteristic of my work and nowhere else. I'm hopeful that at least a couple of those will make it into popular parlance, so that people really can gain a sort of a general understanding of some new concepts.

I actually think that this is very difficult stuff to think, much less difficult to write or understand. And so, I really hope that what this will do is just get people to think in different terms—get them to say, *Well, there is something outside of this box; I thought it was only in here, but there's more to it than that*.

Dr. Campbell: That's a great lead-in to my next question. You talked about the importance of good questions earlier. Is it fair to say that the key question you're addressing in this book is how to explain absence?

Dr. Deacon: Not exactly. Another way to put it is how to explain why absence matters; and maybe even more explicitly, how something absent can be causally efficacious in the world.

We're so tied to looking at the world as run by stuff—energy and matter—and if there's no energy and matter there, then it can't have any causal influence in the world. Well, an idea, a thought, even the sounds of my voice that are being laid out in English here, can in fact have a causal influence in the world, not because of their material embodiment, but in fact for something of a very different sort.

That is, what I'm saying, if it influences people's thinking, if it alters their behavior, if it gets them to pick up the book and read it, it's not because of anything physically or energetically there in the words. It's actually about stuff that's not there. What will have an influence in the world is the meaning, the significance, the surprise value; all of these features that come with our talk, our words, our concepts, our thoughts.

I also don't think that thoughts are in the head. I think that neural activity is in the head, but I don't think that thoughts are, in the sense that there's some stuff or energy in there. It's like words on a page; the words on the page are not what matters, the words on the page convey what matters.

What matters is not something physical, chemical, energetic. What's so surprising is that, despite the fact that these kinds of things don't have the physical characteristics that should, according to our current theories, cause things to happen—they don't have those attributes—nevertheless, they're remarkably powerful and important, once you get living and mental processes in the world.

So, that mystery about what's absent really caught my attention. The problem is we really don't know how to think about absence. Does that mean nothingness? Does that mean empty space? What do we mean when we talk about that? And probably the hardest thing that I would say to get across in this text is this way of thinking about absence.

I like to give people the really trivial example of the hole in the doughnut. The hole in the doughnut is in a very specific place. It's defined by the dough of the doughnut. But the hole is actually there; the absence is actually present. And we think about, in part, presence and absence as somehow opposites. But that's not what we're talking about here. They can't be opposites.

So, in fact, I begin the second chapter in the book by talking in almost mystical terms, using a phrase from the Tao Te Ching, which begins to say that "Thirty spokes converge to a wheel's hub," but it's this empty space, that is the wheel's hub, that allows the wheel to turn, and therefore for it to have any use at all. It's what's not there; the degrees of freedom that are in a sense not impeding anything—that allow something to happen—that are crucial. We just have not really had a clear way to talk about how that works.

Now, I think it shouldn't be too strange, even for modern physicists to think in these terms. Modern physics is now used to talking about things, that are not there, as being causal. Einstein introduced this notion that the curvature of space-time is responsible for the so-called 'force' of gravity. But precisely what this tells you is that gravity is not a force pushing on something or pulling something. Gravity is a distortion of space and time; the manifold in which things happen.

We, in some frames, are used to talking in these terms. But it just simply hasn't worked its way—we haven't figured out a way to do this when talking about biological, neurological, and mental phenomena. And so, in some sense, absence comes in as something I necessarily have to deal with, because it's precisely what we've ignored.

Dr. Campbell: And you talk quite a bit in the book about what the consequences of ignoring this are.

Dr. Deacon: Yes, I have three chapters—the next three chapters that follow after a chapter that's called '(W)holes'—that sort of introduces this general challenge. I have a chapter on homunculi—that is, the little men that we sneak into our theories, so to speak, that accomplish things that have purpose, function, value, and so on. We basically sneak in concepts that are sort of like little men in our theories—like the little man in the head that's doing all my thinking. The

problem is, of course, that little men in my head have little men in their heads, and on, and on, and on. So, it doesn't get us anywhere.

But there are more subtle ways of getting caught up in that. One of those is something that's called panpsychism. That is, if we can't explain how it is that the material and energetic processes of my brain produce experience, we might be tempted to say, *Well, maybe it's just something that's embodied in all matter and energy, and that brains just are a special sort of collection of this stuff.*

Panpsychism, or some variants of it, say that there's some kind of incipient sensibility (sentience, or consciousness, or feeling) in all physical, chemical processes. That basically sneaks in the question at the very beginning, and it becomes an undefined beginning place that's not much different than saying, *Well, all purpose just emanates from this mind in the heavens.* It doesn't get us anywhere, because it just sort of begs the question.

The other way around it is the one that a lot of modern science has taken on, which is to say, *Oh, well actually nothing has this; not even you. Your experience of consciousness and of self, this is just an illusion; it's just an epiphenomenon. You're just a computational device.* And that computation is all that's going on, and we should just ignore this—explain it away—it's just atoms bumping into each other.

I call that the golem approach—reflecting on this classic Jewish mythology about an active creature that is made out of mud, that doesn't have a soul, so to speak, and walks around in a kind of Frankensteinian way, affecting the world.

Dr. Campbell: A zombie, by today's terminology.

Dr. Deacon: A zombie by today's both mythical and philosophical terminology; where nobody's home, but it's acting. Well, that's what our computers are, of course. I'm afraid to say that that's what our institutions are. They're effectively

zombies, as well; they have sort of a computing life of their own. Now many of them are, in fact, computers—or embodied as computers. And golems, of course, have no meaning, no value, no experience; but as a result, they're amoral.

We live in an amoral world, from that perspective. And I think one of the challenges we have in our own age (that leads to, I think, the challenges of understanding the problems of value), and the reason fundamentalisms are so attractive, is that our modern science and governmental logics exclude value. It's an epiphenomenon; it's just sort of something that's superimposed, like birds flying in and landing in the world, but not being a part of the world.

That's an unfortunate consequence of a very successful way of thinking that science has introduced into the world. But if our best science excludes not only value, but consciousness even, from the world, as just sort of an imaginary falsity, it's even sort of contradictory to think this thought, it seems to me. It leaves a huge hole that needs to be filled, as well.

And our attempts to try to fill it with compromises (like cybernetic compromises, like saying you can see end-directed-like things in guidance systems, because they seem to go towards an end, and if you veer them off, they'll go back towards that end; or your thermostat running your heater, when it gets too cold, it will turn on, when it gets too hot, it will turn off) gives the impression of end-directedness, but clearly there's nobody home. This is a valueless, mindless world that we're talking about in those terms.

So, in one sense I should say I want to ban the homunculi from our arguments, and yet I want to save what homunculi provide. And that's a complicated task.

Dr. Campbell: Yes. One of the points you made was the problem of (as you said, a side effect of a successful method) this banishment of meaning, and the fact that it alienates people. I have a niece who is very intelligent, who wants to

be an artist, and says she hates science. I've always been mystified by her saying that. And after reading your book, I think that maybe I have a glimpse of what she might be talking about.

Dr. Deacon: Well, it's also one of the advantages of being in an anthropology program. There is a lot of science distrust. Now, science distrust has developed for lots of good reasons: the bomb and things like that, that have been used for ill (and I think science can be used, as we know, for good or ill); but also because it is valueless. The value is something just sort of superimposed. As I said, it's sort of like flying in from some other realm of the world; it's not part of the world. And if value is not part of the world, it's not a world that I feel very comfortable in.

What I want to do in that respect—and another way to frame what I'm talking about—is to expand science in such a way that its empirical focus, its testing of precise hypotheses is grown enough, is diverse enough to encompass these kinds of things; that they are not anymore epiphenomena, or something outside of science.

This is a Cartesian mistake that we fell into, in which we've separated these two worlds—the physical world and the world of meanings, and purposes, and values, and even functions, I should say—off from the world. We need a unified world. We need to have an understanding of the world that we live in, as Ilya Prigogine said, that it's not absurd to think that it produced us.

[music]

Dr. Campbell: Now, you mention panpsychism, actually I think quite a few times throughout the book. And it really caught my attention, because I recently interviewed Christof Koch, and in his most recent book he actually comes out in favor of panpsychism.

In fact, I think in the interview I recorded of him he used the phrase explicitly. And I asked him why he was rejecting emergence as an explanation for consciousness. I mean he is actually embracing that consciousness is a fundamental property of the universe, like electric charge. He says that explicitly.

And he says his reason is that it's too complex to be explained by emergence. Do you think this is a reflection of the problems with the traditional emergence approaches?

Dr. Deacon: I do, indeed. I think you've hit that directly.

First of all, the concept of emergence has a very mixed history; and I think that, for the most part, many of the critiques that came out about this concept of emergence are accurate. They actually identify fatal flaws in the concept. I review some of that, but I try to produce a very different conception of emergence; one that is entirely empirical, and one that nevertheless I think is strong enough to deal with these kinds of questions.

In the very beginning of my book I describe our current dilemma—and I think it really applies to the neurosciences—as a Zeno's paradox of the mind. Zeno, of course, produces these various paradoxes, but the one that many people know about is Achilles racing a tortoise.

The tortoise is given a slight head start. And Achilles covers half the distance to the tortoise quite quickly, but when he's done so, the tortoise has moved just a little bit from where he was. Achilles then covers half the distance to the tortoise, and the tortoise has moved just a little bit further. Achilles moves half the distance again to the tortoise, but the tortoise has moved just a little bit further. From that perspective, Achilles can never overtake the tortoise. Well, of course, we know he does.

My analogy here (and it's just a metaphor) is that in the neurosciences we've chased down events in the nervous system further, and further, and further down, and down, and down to synaptic activities, to different parts of the brain being metabolically active at different times, looking for the "neural correlates" of consciousness; something that Christof has been really interested in, following Crick, who sort of got him into this, I think at the beginning—although maybe the two of them just fell together because of their joint interest in this.

But what happens is we find that the more we learn about the nervous system, and we get it more and more precise, it doesn't seem like we've made any headway in getting to experience. That simple thing that we all know perfectly clearly is part of who we are, what we are, is that we have these personal experiences. One of the things that happens that leads people to one of these two views—which I call the 'golem view,' or the 'homuncular view'— is that people just throw up their hands: *It can't be done. We can't get there from here.* And I think it's been because we've been caught in this Zeno's paradox.

Zeno's paradox, of course, was a paradox because it seemed logically necessary. If you follow the logic, there are an infinite number of half-ways that Achilles has to go to to get to the tortoise. But it turns out, of course, to be a complete illusion, because it shrinks down to infinitesimally small; which can happen very, very quickly—an infinitesimally small distance over an infinitesimally small time.

That insight at the beginning tells me that part of the problem we have is that we're looking in the wrong place: again, looking for consciousness in what's there; in the stuff, in the energy, in the neurons, in the synaptic weights, in the patterns of neural firing. And my point is that, in fact, looking at the stuff is like looking at the spokes of the wheel, but not recognizing that the spokes of the wheel have created a hub, and it's that opening that they've created—that they shape, that they identify, that they specify—that is what we've not looked at.

We've just simply assumed that what must be important is the stuff that's there. So, that's sort of the motivation that kicks me off in this, and also tells me why I think that we get stuck. We get stuck on either eliminating ourselves from the world, or imagining that we're there in quarks and gluons somehow. The quarks and gluons story, of course, just basically says, *No, it's a black box; it doesn't need explanation, it's just there. We don't know how, we don't know why; stop trying to think about it.*

Both of these are, of course, dead ends for science. Once you say that it's already there and it doesn't need explanation, then you can throw up your hands and do something else. Or if you say that it's just an illusion, our misinterpretation of the basic physics, and there's nothing to it, that's also a way to say there's no more science to do.

At least I think we need to tell ourselves, *Yes, there's more science to do. We don't misunderstand this because it's just a black box that can't be explained; we don't understand it because we don't understand it. We haven't looked in all the right places; we haven't put our heads to it quite the right way.*

Dr. Campbell: I want to give you a chance to give listeners a glimpse of your proposed steps in the right direction of solving the problem; and I know that might be an unrealistic goal, so I want to hone in on one point that you make to jump in that direction.

You make the point that there's something that happens when we shift from the inanimate universe to life. At that point, there's something that we've got to explain; and that, as I understood it reading your book, is the reason why we just can't say it's just more of the same.

Dr. Deacon: Exactly. And it's like a simple complex systems approach actually doesn't explain either life or mind. And that's part of what I'm after here; and

one of the things that I think will challenge people. And people in the field will probably find it quite a threat to say this, but the basic argument has to do with understanding the concept of constraint—constraint actually is the way I reformulate thinking about absence.

Constraint can be talked about in two different ways: Something externally restricting movement, or change, or structure—like a fence is a constraint, or like a test tube is a constraint. The other way to think about constraint (and this is one that comes mostly out of early information theory) is to think about constraint in terms of degrees of freedom that are, for one reason or another, not realized.

Now, one reason they can be not realized is because of external boundaries. But another reason they can be not realized is because when complicated systems with many parts interact in various ways, sometimes those interactions go in a direction that progressively eliminates some of the possibilities of their interactions in the future. Things become more restricted over time. This happens in what we call 'self-organizing processes.'

But there are a lot of really trivial examples that people understand, I think quite easily, that have this kind of tendency. One of my favorites is snow crystal formation, in which snow crystals, although they're forming from this sort of random accretion of water molecules to a growing crystal, there's nothing about water molecules that says you have to be in this elaborate symmetric hexagonal structure.

Water molecules do form into this, in part because there is some hexagonal-like symmetry in the way the molecules form. But the snow crystal actually is formed by progressive constraints. As crystals begin to grow in a certain temperature, and humidity, and pressure zone, the crystal will grow according to a certain regularity, a certain pattern. But as it does so, it will produce spires, or sheets, or

plates, and those will restrict the positions that the next water molecules can accrete to. And where they stick will restrict where the next ones can go, and so on.

And over time, as these constraints—as these restrictions of degrees of freedom—begin to mount on top of each other, one after the other after the other, billions and billions of times, carrying with them at the same time this influence from the temperature, and pressure, and humidity, where this happens you get these complex forms developing precisely because the constraints—the limitations—have sort of amplified on top of themselves.

This is the way I would describe what is more generically called in systems theory parlance, 'self-organization.' Not that there is a 'self' that's organizing. It's not that the crystal is somehow itself organizing it; it's that the constraints are mounting up. It's something internal. It's not top down; it's not wholes affecting the parts in any obvious sense.

It's that the constraints amplify each other, and so you get restriction, after restriction, after restriction. And when something is more constrained, it's more regular. So, it's a way to talk about organization. So, both 'self' and 'organization' in the term, 'self-organization,' can mislead us if we don't recognize what's really going on is this compounding of constraints.

One of the things that's interesting about processes like this, and one of the ones that's most familiar to almost everybody, are whirlpools that have formed, for example in a stream. A whirlpool in a stream is there, not because the stream is still, but actually because it's continually being disturbed; there's continually new water coming in, and it's flowing by something, and it's being bumped, say by a rock that's in the way, and the water molecules are being diverted off the direct course.

The whirlpool forms because the system is becoming continually perturbed; the same way that the snow crystal as it grows is continually perturbed. This allows constraints to compound with respect to each other. And over time, given the right flow rates and the right kind of interruption of that flow by some object, what happens is a whirlpool will form.

What's interesting about the whirlpool, however, is something really interesting, having to do with its non-solidity, so to speak; the fact that it's not the same thing from moment to moment. It's different water every second. The whirlpool is not something constant of either energy or matter; it's a form that's constant. The whirlpool today is not the whirlpool tomorrow, is not the whirlpool two seconds later.

What's also interesting about a whirlpool is if you now go in and stir the system up again—you stir the water up—it's chaotic for a brief period of time, and then slowly the whirlpool will form again. That is, it has a kind of self re-forming tendency. And a lot of people have hit upon this and said, *Isn't this a little bit like life; it self re-forms itself*. A little bit, yes; but not enough.

And so, what I recognized is that to go beyond this sort of self-organizing feature, what I needed to explain was something about where these constraints come from. In the whirlpool the constraints come from the fact that when water does not flow around in a circular pattern, it actually does more work to get to its end point. Water becomes chaotic; it bumps up into something, it becomes turbulent for awhile. But what happens is it becomes more efficient over time at moving water from the input to the output, so to speak.

This is a process that's called the maximum entropy production principle. Now, entropy is the increase in mess, in one sense, that we find described in thermodynamics; that is things, when left to themselves, tend to get more messy, not more ordered. But when things are constantly being perturbed, that constant

perturbation can in effect do work that organizes that system of processes so that it more effectively kicks off that disturbance.

So, that's why it's called 'maximum entropy *production* principle;' it's *producing* this, it's sending the output out more rapidly in a way that doesn't allow it to sort of build up internally. That's a feature, once we begin looking at it, that's common to all self-organizing processes.

But what I began to realize is that, even though people describe living processes as self-organizing, they don't have this feature. It's patently obvious that they don't because, in fact, over the course of evolutionary time, we have not been kicking off the energy of the sun as fast as it comes in.

A little bit of it has been skimmed off in each eon, and it's been impressed upon complex molecules. It's being stored as complex molecules. Now, today we're rapidly burning up that little excess that was accumulated over the course of the last couple of billion years, in our fossil fuel use. We're freeing it back into the universe.

But what that basically tells us is that life was actually not just self-organizing; it was not just most efficiently kicking it off into space as fast as it came in. But, in fact, it was sequestering a little bit of it and putting it elsewhere, so that there is entropy production potential in fossil fuels. So, I realized that life had to be doing something more than self organizing.

What I discovered as I pursued this more and more, in terms of just sort of basic principles, was what was actually happening was that living processes use self-organizational processes with respect to each other in a particular way. That is, where one self-organizing process produces the constraints—that is, the regularities, the limits of degrees of freedom—that become the boundary conditions that make possible another self-organizing process, which reciprocally

produces the boundary conditions in its constraints that make the first one possible.

And in fact, in the book I try to describe what I would say is the simplest that I could conceive of, of a process that worked this way, in which there were two self-organizing molecular processes that each produced constraints that were the boundary conditions that made the other ones possible.

As soon as this happens, what you have is the constraints that make something occur are now not just extrinsic, they are generated intrinsically; and although they require constant perturbation from the outside, because both of them are self-organizing processes and they give off energy in the process, they also skim it off in the form of generating these constraints that now are completely internal. That is, they have something like a memory for the constraints that make themselves possible.

And I describe a very simple model system that does this. I tried to be as simple as possible, because I wanted there to be no mystery, I wanted there to be no magical force, no homunculus that's in there doing the work; because a system like this, because it remembers itself, so to speak, when it's disturbed, it will create itself. When you take away its raw materials, it will preserve itself.

And, of course, that's what life is doing. Living processes, if they run out of fuel, they try to find it somewhere else. They change their dynamics; they move around, they utilize different sources in order to maintain themselves. And not only do they remember themselves and maintain themselves structurally, but they do so by making copies of themselves.

We've been captivated by the copy-making process when we think about evolution. But the copy-making process is just a side effect, so to speak, of this

process of having internally the ability to reintroduce the constraints that allow you to do the work to make yourself again.

And so, this is end-directed in the sense that now we have a system that internally represents its own end. And it's a very simple system; it's not anything as complicated as life. In fact, the simple system I start with, I call the process "autogenesis"; that is, it generates itself—literally. And I show that this is a necessary feature in order to have end-directedness.

And literally it creates self in a real sense. Where we say 'self-organization,' the 'self' there is just a metaphorical use. Here we really have something in which it re-makes itself, because it contains the constraints that enable it to do the work when necessary—when disturbed—to re-make itself.

You stop the flow of water, or you pull the rock out of the stream, and the whirlpool disappears. It does not re-make itself, because its constraints are all external to itself—even though it recovers itself if you leave all that external stuff alone. Living systems don't do that.

That, to me, showed me that in effect there was a new way to get at issues of information, of significance, even the concept of work and eventually the concept of mind and experience. It's not the *experience* that is in need of explanation, it seems to me, it's *self*. Once you have self, now you have something with respect to which other things happen and other things matter. You have normativity, and you have self and other; you have inside and outside.

In fact, the whole point I'm making here is that, in fact, 'inside and outside,' itself, is not the crucial thing. Having a boundary does not give you self. My consciousness does not have any kind of boundary, and yet the self is quite clear. The boundary is dynamical; the boundary is in terms of relationship.

In effect, what I've done is to say, *Look, it's not that self-organizing systems are incapable of helping us out with this; it's just that that alone is insufficient to explain it*. And that when we begin to think about constraints that are held internally, constraints are things having to do with degrees of freedom that are not going to be allowed.

Molecular interactions that are channeled away from some things and toward others; those are absences. So, in one sense, what's passed on, in a very real sense, when one organism reproduces another, are not its physical stuff (yes, the physical stuff will re-form in the next generation, and the generation after that, and the generation after that); it's, as we say in biology, the information, the genetics. But that information is in the form of constraints. And constraints are absences that are maintained physically.

So, in one sense what's passed on in reproduction (and I think what's continued in a living organism as it persists through its life, and I think is the core thread that ties experience from one moment to the next in our own conscious lives) is this absence; this transmission, and maintenance, and reconstruction of the absence that can make itself, so to speak.

It sounds very esoteric when you put it that way. But as you see, I think you can actually explain the basic logic of it very, very simply. And you can explain it physically.

That doesn't mean we've explained consciousness or experience; it means that we've come up with the first principle that will help us understand how to go to the next level. In fact, I have really only one chapter that really deals with this—three chapters that sort of struggle with it in the book toward the very end. They're very speculative.

They are basically pointers to a new way of thinking about the problem, that get us out of these old difficulties. And they're based upon this one insight: that teleodynamics, end-directed dynamics, is different than self-organizing dynamics —which I happen to call "morphodynamics;" that is, form-producing dynamics, like the whirlpool's circular form.

So, a long-winded explanation, I hope that was in some way useful.

Dr. Campbell: Well, I think you've certainly given us a glimpse into what I think is a highly original way of looking at things; and one that I found very enlightening.

Is there anything else you want to add before we start to finish up?

Dr. Deacon: Well, there are three things probably I should just hint at. One is that I think this tells us something very different about what we think information is. We have, since the 1940's, collapsed information into bits. And bits don't have any meaning; bits don't have any significance. They can; but all we're really doing these days is measuring the bits—how much my hard disk can store. But what's on the hard disk is not information, not knowledge; it's only information if you can interpret it.

So, one of the things that this does is it forces us to rethink the concept of information. And I think it does a very good job of telling us why computing is not thinking; why computers, as we conceive them now, are not doing thinking in any form at all, and have no one at home, so to speak. I call this—though it's not in my book, I describe this as 'dynamical depth.' A computer has no dynamical depth.

The process I just talked about, you need a thermodynamic process to produce self-organizing processes, which are more complex—they have a greater dynamical depth to them, so to speak; there are layers of thermodynamic

processes interacting—and teleodynamics, the one that really is end-directed, is even greater dynamical depth, because it's this complex relationship between self-organizing processes; very specific complementary interaction between self-organizing processes.

Minds and life have extraordinary dynamical depth. But the system I just described is very simple in terms of its physical complexity; that is, the number of parts and how they interact. And what that tells us is that our concept of complexity really has two dimensions, and that we've ignored one dimension.

The concept of complexity has both dynamical depth (that is, processes superimposed upon thermodynamics, superimposed upon self-organification, and so on), and in fact, minds are teleodynamic process, as I call them, superimposed upon components that are themselves teleodynamic (our cells and our neurons)—extraordinary dynamical depth.

But dynamical depth and what you might call—after a man named Bennett —'computation depth' or 'logical depth,' are different things. That is, you can have many more units, many more parts, with very shallow dynamical depth. That's what our supercomputers are; vastly many parts, but they have very little dynamical depth.

In fact, what computing does does not use thermodynamics, except to move energy around. It does not use thermodynamics to produce form and regularity, as do self-organizing processes, which have greater dynamical depth because of that. They can be vastly complicated; but they don't have this kind of complexity.

Living things, even simple living things, have much more dynamical depth than complex computers. But they, in fact, don't have very much complexity at the level of what you might call 'logical depth.' This is also one of the crucial differences. Minds, of course, have both.

Brains of humans have enormous dynamical depth and enormous logical depth. That's what makes us different than a computer. And it's beginning to pay attention to that dynamical depth that I think will be what leads us out of a realm in which we've sort of been locked into these dichotomous ideas about what mind is, what life is, and what matter is.

Dr. Campbell: Even though the 'Consciousness' chapter was speculative, I thought that it did a good job of bringing the ideas of the rest of the book into something that everyone cares about.

If there was one thing that you wanted people to remember about our conversation, what would that be?

Dr. Deacon: I end the book with what I want people to remember; and that is that pursuing science in a serious way to answer these questions will not lead us to a nihilistic world view. This will lead us to a world in which we belong; in which nature has produced us; in which even value, purpose, morality, ethics are really part of the world. They grow out of the world; they're not something separate and superimposed. We belong in this world. And that belonging, I think is important for people to know, and to take away.

Dr. Campbell: Absolutely!

Well, lastly, Terry, do you have any advice for students that might be interested in science careers?

Dr. Deacon: First of all, learn a skill. One of the things about science is that it's built upon techniques and technologies. Learn a skill. Whatever you pursue, learn how to do something in particular, because that is your window into the world; your way to pry yourself into the world, and find out how things work.

The second thing is don't just do one; learn not just one science, one technique. Recognize that it's embedded in a larger realm. And you need to understand that realm, because otherwise you get stuck inside of boxes too easily, in your thinking and your creativity.

And there's one final thing I would say. Don't give up the humanities. The humanities are playing a role that we don't recognize oftentimes; and that is they are playing a role in educating the emotions, educating us ethically. Good science is not in a world that is without value. You need to know how to be in that world, and you need to feel at home in that world.

Dr. Campbell: Thank you. That was a very good answer.

[music]

Incomplete Nature: How Mind Emerged from Matter is quite a dense, challenging book to read, as you probably got a feel for during our conversation. It's nearly 540 pages, just in text, but it is a book that does reward reading with stimulating ideas. I want to review some of the key ideas of Dr. Deacon's interview, but first I do want to make two announcements.

One is to remind you that you can get my new eBook, *Are You Sure? The Unconscious Origins of Certainty*, from Amazon.com in Kindle format. It's a short work, so it only costs $2.99 in U.S. dollars. However, if you want the PDF form of the book, *Are You Sure?*, all you have to do is send me a copy of your Amazon receipt.

If you got the book, I want to thank you, and remind you to be sure to post a review either on Amazon.com or on Goodreads.com, where there is a page for the book, also.

The other thing is I want to tell you about an interview I did recently on another podcast called *The Secular Buddhist Podcast*. My interview is Episode 124. The reason I mention this is that I know a lot of you are interested in questions about what happens in the brain when people meditate, and Ted Meissner, the host of *The Secular Buddhist Podcast*, interviews a lot of scientists who are studying the brain and meditation. So, I hope if you're interested in that, you'll check that out.

So, let's just talk about a few of the key ideas from today's episode. First of all, Dr. Deacon notes that he is not the first person to discuss the problem of emergence. He is especially interested in the emergence of purpose and meaning. I really want to focus on how his ideas are different from those of other recent contributions.

First, he focused on explaining how meaning and purpose have emerged from processes that appear to lack these qualities. It is important that these qualities be explained in a way that allows them to have what he and I assume every one since Aristotle would call 'causal' power. For example, an idea has neither material nor energetic existence; so how does an idea influence behavior?

Deacon talked about the ways that modern thinkers avoid this question: one he calls the 'homunculus,' which is when something is used as a place-holder, and the fact that we don't have an explanation is just sort of ignored; and the other he called the 'golem,' which is when meaning, or whatever, is just denied and it's just called 'epiphenomenal.'

So, why do so many scientists want to avoid this question of meaning? Well, when the idea of emergence was first proposed in the late 19th and early 20th century, it was usually accompanied by quite a bit of metaphysical baggage. This was because they didn't have the scientific tools to really solve the problem. These tools have only emerged the last few decades. They are non-equilibrium thermodynamics, complexity theory, and dissipative systems.

But the root of Deacon's argument is that complexity theory is not enough to explain the difference between self-organizing systems, like a whirlpool, and the purposefulness of a living organism. He points to the essential role of constraints; but, to be honest, it's not clear to me how his use of constraints differs from that of Alicia Juarrero in her book, *Dynamics in Action*[2]—which I did mention briefly in *Brain Science Podcast* Episode 53.

One point he did make was that in living systems the constraints are internally generated, and the organism has the ability to replicate, or rebuild itself essentially from within. But, of course, the living system is not closed, since it is constantly exchanging energy and matter with its environment.

A key feature of Deacon's approach, that he only had time to touch on briefly, was the idea of nested reciprocal layers of self-organization. He said during the interview that he "realized that life had to be doing something more than self-organizing, and that what was actually happening was the living processes were using self-organizational processes with respect to each other in a particular way, where one self-organizing process produces the constraints—that is, the regularities, the limits of the degree of freedom—that become the boundary conditions that make possible another self-organizing process; which reciprocally produces the boundary conditions in its constraints that make the first one possible." That's a quote from the interview which you can get in the episode transcript, if you want to get the context a little bit more clear.

Obviously I haven't read all the literature in this field, but I did go back and review Juarrero's book, and I don't remember her referring to layers of thermodynamic processes interacting. The closest to this approach that I have read was in the book, *Into the Cool: Energy Flow, Thermodynamics, and Life*, by Eric Schneider and Dorion Sagan, which was published back in 2005.

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[2] Dynamics in Action: Intentional Behavior as a Complex System by Alicia Juarrero (2002)

Into the Cool focuses on the idea that rather than breaking the second law of thermodynamics, life is actually a manifestation of that law. What *Into the Cool* and *Incomplete Nature* have in common is their use of the idea of reciprocal processes.

During our conversation Dr. Deacon mentioned that he had coined the term 'teleodynamics' to refer to what he sees as the level of emergence that goes beyond the level of self-organization described by complex system theory. He didn't say this during the interview, but basically his scheme has three levels: the lowest level is the level of thermodynamics, which is increasing entropy; then you have morphodynamics, which is the level of self-organization; and then his level, teleodynamics, which he calls 'the level of the recursive self.'

Now, I want to take a moment to address the recent controversy about Deacon not citing Alicia Juarrero's book, *Dynamics in Action*; which he has said that he was unaware of when he was writing his book. There has been an accusation that he heard her give a lecture in 2007 on the same topic, and there's really no way to know how much he was really listening to that lecture.

However, one thing I did discover when looking at the website that's about this controversy, which is called theterrydeaconaffair.com; there is a detailed spreadsheet from Alicia Juarrero that has over 250 claimed parallels between her work and Deacon's. And I went through this flow sheet—I actually only went through the first 15, because in those first 15 I discovered that some of the supposed parallels weren't even there, and that most of what was in common was common references to a third source, such as for example, referring to duality in Descartes. So, that's why I decided that I think that the claims that he stole her ideas are exaggerated, because although *Dynamics in Action* is an excellent description of complexity theory as it applies to the emergence of life, Deacon's purpose was to go beyond complexity theory.

I will have some links about this in the show notes, for anyone who wants to look at this stuff for themselves. But I think that this situation is unfortunate, because it threatens to overshadow the really interesting question, which is: *is complexity theory sufficient to explain the emergence of life, consciousness, and meaning, as Juarrero contends; or is a third level of emergence, Deacon's teleodynamics, required?* They both appear to share the same goal, which is to show that our world of meaning and purpose has emerged naturally, without the need of supernatural causes.

Finally, I agree with Deacon that it is important that 21st century science make room for meaning. If it doesn't, there will be more young people, like my niece, who reject science. This is a very dangerous trend, because it not only fuels the growth of various fundamentalisms, but it also contributes to a population that is vulnerable to pseudoscience and the various quackeries that it produces.

Incomplete Nature is a thought-provoking contribution to the debate over the role of emergence. If you are interested in learning more, I recommend reading *Dynamics in Action* first, since it provides a concise introduction to the application of complex systems to human behaviors; then read *Incomplete Nature*. I think you'll come away with an appreciation that one could spend a lot of time exploring these questions.

I would love to hear what you have to say about this episode. You can send me email at docartemis@gmail.com, or post something to the *Brain Science Podcast* fan page on Facebook. We also have a Discussion Forum at Goodreads.com and a *Brain Science Podcast* page on Google+.

Also, I encourage you to go to booksandideas.com for the show notes, to get more references, and also to get the free transcript of today's episode. Don't forget you can sign up for one of my newsletters so that you get show notes automatically,

and you'll never miss an episode of either *Books and Ideas*, or the *Brain Science Podcast*.

Next month's episode of *Books and Ideas* will be an interview with Jonathan Gottschall, the author of *The Storytelling Animal*, and a new episode of the *Brain Science Podcast* will be out at the end of July.

If you are listening to today's episode in the *Brain Science Podcast* feed, I hope you will subscribe to *Books and Ideas*. It's the place where I explore a wide variety of topics, often far removed from neuroscience. Both *Books and Ideas* and the *Brain Science Podcast* are free in iTunes, and via a wide variety of podcatching apps, as well as RSS, and even email.

Until next time, thanks again for listening. I look forward to talking with you again very soon.

[music]

[music]

Theme music for *Books and Ideas* is "The Open Door" by Beatnik Turtle. Be sure to visit their website at beatnikturtle.com.

[music]

Transcribed by Lori Wolfson
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