THE TRANSMITTER | BRAIN INSPIRED

Nikolay Kukushkin discusses his book, ‘One Hand Clapping: Unraveling the Mystery of the Human Mind’

He explains how meaning arises in the interactions found throughout nature and evolution, from molecules to minds.

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This transcript has been lightly edited for clarity; it may contain errors due to the transcription process.

[music]

Nikolay Kukushkin
Any cell of the body, including kidney cells, that's one cell type that we looked at, they can form memories of what is happening to them in the same exact way as neurons do.

If you trace all the complexity of our cognition to its moving parts, and if you really understand those moving parts mean from the point of view of our entire journey through the natural world, then this puzzlement of what else is there in the brain that explains who I am, my memory, my consciousness, then this puzzle disappears.

As scientists, we have been focusing on the matter, completely ignoring the information. We've been ignoring the meaning that nature has been putting into every part of a living creature all along, and that blinds us.

[music]

Paul Middlebrooks
This is “Brain Inspired,” powered by *The Transmitter*. Hey there, I'm Paul. Nikolay Kukushkin is an associate professor at New York University and a senior scientist at Thomas Carew's laboratory at the Center for Neuroscience. He describes himself as a molecular philosopher, owing, I assume, to his day job as a molecular biologist and his broad perspective on how it all hangs together.

In the words of Wilfrid Sellars, who in 1962 wrote, "The aim of philosophy abstractly formulated is to understand how things in the broadest possible sense of the term hang together in the broadest possible sense of the term." This is what Niko does in his book, *One Hand Clapping: Unraveling the Mystery of the Human Mind*. This book is about essences across spatial scales in nature. More precisely, it's about giving names to what is fundamental or essential to how things and processes function in nature. Niko argues those essences are where meaning resides. That sounds very abstract. It is very abstract, and we will spell it out more during the discussion.

To give an example, at the very small scale, the essence of carbon and oxygen, respectively, are creation and destruction, which allows metabolism to occur in biological organisms. Moving way up the scale, following this essence perspective leads Niko to the conclusion that there is no separation between our minds and the world, and that instead we should embrace the relational aspect of mind and world as a unifying principle.

On the way, there are many topics we explore via evolution, and we discuss many more examples. Plus, we talk about his own work studying how memory works in individual cells, not just neurons or populations of neurons in brains. You'll hear me talk in the beginning about how fluid and well-written and easy to read the book is. What I don't say is what a difficult achievement that is to accomplish. I just wanted to point that out before we get going, that I totally understand how difficult it is to make a book read in a joyful and playful and fluid way that it does. I just wanted to say that.

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[transition]

Thank you for being here. Niko, this book, *One Hand Clapping: Unraveling the Mystery of the Human Mind*, I was just telling you my copy got put away in a box because we're moving accidentally, not by my choice, but you have it. Hold up the physical copy of the book.

Nikolay Kukushkin
There it is.

Paul Middlebrooks
Right. This thing should be out or coming out in the next few days once this episode is released. The first thing I want to say is, first of all, it's very well-written. Secondly, it seems like you had a really good time writing it. It seemed like a joy just from the writing itself because your writing is playful.

Nikolay Kukushkin
Thank you.

Paul Middlebrooks
It's fun and moves very easily. Also, it's just chock-full of illustrations that you have drawn throughout the book. Have you been illustrating your entire scientific career and before? What was the impetus for the illustrations?

Nikolay Kukushkin
I prefer to call them doodles because I feel like the word illustration is just too much for what I can draw. I really can't draw. No.

Paul Middlebrooks
Technical drawings. It's filled with technical drawings.

Nikolay Kukushkin
Technical drawings, yes. The doodles come from my college notes. It's just something that I did to entertain myself in boring classes, but somehow it became an art form in itself, and I think they became famous in my class. I didn't always used to do this. The way that it started, it's a funny story. Well, not really that funny. The story was that I got stuck in Russia at one point on a visa issue. I'm now an American citizen, but back then I was not, so I had to renew my visa. Sometimes when you do that, especially as a scientist, you get stuck because they want to check that you're not making biological weapons. That can take a couple months.

I had nothing to do in Russia. I reached out to a friend of mine, who was a popular science author. She was just writing her first book. She suggested that I illustrate that book in the style of those doodles that I used to do in college. That seemed like a fun challenge. Long story short, I illustrated her book. Then I illustrated her second book too. Not the third. At some point I said, "I cannot continue doing this. I'm not an illustrator. Get somebody better." That's how it started.

Then when I was writing my own book, honestly, I just realized that I would not trust anyone else to do it the way that I wanted. The funny doodles is what I know how to draw. That's how it happened. I also think that as scientists, we need this reminder to not take yourself too seriously. We are always so stuck in our world that it seems like that's all there is, and it's so important, and you lose that sense of context. I think just by adding a little bit of a sense of humor into scientific discussions, I think it helps understanding, and also helps us retain that sense of context.

Paul Middlebrooks
The adage that, how do I know what I think until I see what I say, and the idea that writing things down actually helps clarify your thoughts and helps you think, does drawing help you in that endeavor as well? Is it part of the clarifying process, or do you have a sketch in mind and you just put it down?

Nikolay Kukushkin
No, absolutely it helps lay things out in my mind, and that's part of the reason why I really emphasize it in my class. I've gradually transitioned over the years from using PowerPoints, which I still use occasionally to show photos or images of animals, but mostly I use a whiteboard, and these same kinds of doodles that I draw in the book, I draw them in class as a more textbook-y technical diagram, but it would have some funny faces here and there, and it'll have some characters.

I really feel that it helps me process the flow of an idea to visualize it in this way, and it definitely helps the listeners, the students understand the logic of it, because when you're just looking at a slide, when you're just looking at a diagram, you think that you understand every part of it, but really, you don't. Once you start drawing every part on your own, you realize what are the parts that you are missing. Yes, looking at a diagram is one thing, but actually drawing it yourself, I think it does something.

Paul Middlebrooks
Do you require your students to draw funny pictures?

Nikolay Kukushkin
Well, they can make the pictures dull if they want, but yes, generally, they copy the funny pictures. I've learned that they will copy verbatim everything that I will put on the board, unfortunately, usually without thinking about it too much. I've just learned to put the things that I absolutely need them to retain, that goes on the board, and that will go into their notebook.

Yes, their notebooks are definitely full of these funny doodles, and I think that helps them remember. They remember them not as some dull things that they wrote down in class, but like, "Oh, that was this page with a funny face. Oh, there was this funny soul that we did, and there was this little bird that we drew." That's how I remember. I still remember my college notes that were peppered with funny things like that.

Part of it was myself, these doodles that I drew. Part of it was the professors that I've had. Some of them really inspired me to think in terms of everything's a story. There's always characters everywhere. Every chemical reaction you can imagine as an interaction between two characters, two entities. That's a more fun way of thinking about it than just letters on the board.

Paul Middlebrooks
That is part of what makes your book fun to read, and that's why I mentioned it was probably fun to write, because you do anthropomorphize, essentially, things like carbon and oxygen and in story form. We'll get to the book more deeply. I'm curious, actually, because I want to start with your work before we actually get to the contents of the book. Beforehand, given that it's written in this lighthearted style, and yet it is super thorough and takes us on a really long journey from the very small, from atoms up to our minds, and through evolution, et cetera, who do you have in mind for the book as a reader?

Nikolay Kukushkin
I think the book will appeal to multiple groups of readers. I think that it might interest people who are interested in nature, who are interested in our place in nature, people who are interested in animals and in the environment and wildlife. The book definitely has that component. It puts us humans, and also every microorganism, and even every molecule that existed in this planet, in this context of biodiversity and organisms battling it out, and drama of evolution happening at every turn. It will appeal to those people.

It will appeal to people who are interested in the mind or in the intelligence and where it comes from, people who are interested in AI and comparing our cognition and consciousness to the cognition and consciousness of AI. We're living, for the first time, in an era where we might not be the only ones who have the capacity for thought, for thinking in words, at least. We have to really reevaluate what it means to think, what it means to be ourselves. The book addresses that.

I think it also will appeal to people who are interested in transhumanism, in what are the next steps in the history of humankind? Where are we going? What is the big picture of our species moving forward? I think all of those angles are already combined in this book, in this single narrative, as you described it.

Paul Middlebrooks
Oh, man. Okay. Ambitious audience appeal.

Nikolay Kukushkin
Yes. Oh, I'm basing this-- The book has already been successful in Russia. I'm basing this on who I think were the target audiences who found something in it. Russian audiences are different, and so you can't just project one onto another, but I'm making a discount on how the book has changed in the process of translation, how the world has changed. It wasn't AI when the book was first published. It was before COVID, too.

Paul Middlebrooks
That was before COVID.

Nikolay Kukushkin
Actually, it came out during COVID, but it was written just before COVID. A lot of really transformative things have happened since it was first published. That is all part of the updated perspective of the book.

Paul Middlebrooks
Yes. It's interesting that it was first published in Russian. You don't change the many, many allusions or quotes from Russian literature and poetry, which I didn't even-- I knew, oh, you're Russian, you're going to make those connections, but those are authors. I've been a fan for a long time of a lot of Russian literature. In fact, that's one of the reasons why I took a little bit of Russian in college many years ago, because I wanted to read the literature in its native language. Of course, I didn't get that far. Those quotes and appeals to Russian minds felt natural to me. It didn't feel like a foreign thing, but you kept those in.

Nikolay Kukushkin
Oh, great. That's great.

Paul Middlebrooks
That's cool.

Nikolay Kukushkin
That was a big decision to make when I was translating the book. I went through many rounds of thinking about this. It reminded me of first coming to graduate school. I did my graduate school in England. Nothing makes you represent your culture like trying to present it to foreigners. Once you move abroad, you automatically start representing wherever you're from. That was never something that really crossed my mind when I was still back in Russia.

Paul Middlebrooks
How so? How would you be representing Russianness in England?

Nikolay Kukushkin
Well, you automatically become a Russian. Everybody thinks of you as Russian. People judge what a Russian is by looking at you, by looking at your reactions, by asking you about Russian things, and you have to make a story about what's your Russian background. I was known as the angry Russian. You wouldn't tell right now. I'm so nice. Back then, I still was learning to control my emotions in a non-Russian way. I was known in my lab as the angry Russian.

Anyway, with the book, I had to make these decisions. I didn't think of it as particularly focused on Russia when I was in Russia, but it's once you start translating, you're like, "Okay, what do I do with all these references that are understandable to a Russian?" Some of them had to go because they just are untranslatable. There were some jokes in there that I just loved so much and everybody in Russia loved them so much, but no matter how much I tried to make it work in English, I would tell it to my wife, and she would just stare at me, and I was like, "Okay, this has to go."

Then some things, I felt that, automatically, without intending to, I'm becoming an ambassador for Russian culture. I want to be. There's lots and lots of things about Russia that I love. I want my readers to know that there's more to Russia than all the basic things that everybody knows, the missiles and the ballet and then, well, the literature, as much as I love it, but I want to show that there's more, that Russia is not the stereotype that you put it in. There's lots of things, lots of popular science happening in Russia.

This anthropomorphizing that you've mentioned, it's part of it. I think we Russians tend to do more of that than English speakers, in part because, and it's mentioned in the book, the language is gendered. You can't get around it. You have to make the atom of carbon either male or female. Most of them are male. There are some that are female. Some are neuter. Your perception of them really depends on that. That applies to so many things. I think it's subconscious, but we already have this tendency to make everything a living being, a character. I think that really comes through when you translate the book into English, it becomes more acute.

Paul Middlebrooks
I didn't realize that you were representing such a rich cultural aspect. I didn't realize that that was part of what you-- Well, I guess you just found yourself doing that. It's not what you set out to do, perhaps.

Nikolay Kukushkin
There was one moment when I was translating all the lengths, and I thought about this. My first impulse was to make all the meters and centimeters into feet and then yards. Then I thought to myself, "Well, I spent my whole childhood reading books translated from English that had the miles and the feet. I struggled with that, and I hated this, but I did it. Why should I do the reverse?" I kept all the kilometers, and I kept all the meters. I think that was the moment when I decided that, okay, well, I guess I'm representing my background.

Paul Middlebrooks
Yes, that's so Russian of you, Niko, to keep all the-- Yes.

Nikolay Kukushkin
That's me, the angry Russian.

Paul Middlebrooks
That's right. Okay. Well, [clears throat] excuse me, like I said, I want to start where you are now and what you work on now, because your work sits in the middle of the story that you tell in the book. Middle, maybe toward the latter part in the book, but you're right in the thick of it.

Nikolay Kukushkin
Absolutely, yes.

Paul Middlebrooks
You work with *Aplysia*, you work with memories, and it's all patterns, man. That's my summary of-

Nikolay Kukushkin
It's all patterns, yes.

Paul Middlebrooks
What do you do? What is your day job, and how does it connect to what eventually came to be this book?

Nikolay Kukushkin
Well, the book describes an earlier phase of our research when we were working with *Aplysia*, as you said, the sea slugs, who have a very simple nervous system. That's why we love them, because they form these very simple memories, and we really can get to the bottom of how individual neurons, individual cells handle this memorizing process. What we do now is the next step in simplifying what memory is. *Aplysia* is already pretty simple, but we took another step into simplifying this memory. What we do now is we look at the memory of non-brain cells.

Our latest research shows that any cell of the body, including kidney cells, that's one cell type that we looked at, they can form memories of what is happening to them in the same exact way as neurons do. They use the same kinds of molecules, they turn on the same genes as neurons when they form memories in our brain. Any cell of the body would do that when responding to the patterns in its own environment.

A kidney cell might be responding to hormones or chemical signals passed from other cells, or the flow of water or nutrients or salts passing through it. All of those things happen on a schedule. They all happen in a particular time pattern. What we show is that cells have the way of distinguishing very fine time patterns, time patterns on the scale of minutes, and changing themselves in the process for much longer durations of time, for days maybe, maybe even longer. That's what we call cellular memory.

The connection to the book, I think, is in this dichotomy between mental and physical. When we first published these results that said all cells in the body form memory in the same way as brain cells, it's the same process. They use the same molecules, it's all the same. Almost all reporters put this word memory in quotation marks, in quotes-

Paul Middlebrooks
I would too.

Nikolay Kukushkin
-because that's not how we think about mental. We think that whatever is happening in the brain, well, there's something more to it. It's not just those molecules, it's not just those cells. It's something in addition to all that, in addition to whatever science will tell us are the gears and the cogs that are moving there. I think that this distinction is artificial.

What the book tries to achieve is to get us to erase that distinction between the mental and the physical, to be satisfied in understanding our own mental process by understanding how it works on a physical level. What it says is, if you trace all the complexity of our cognition to its moving parts, and if you really understand what those moving parts mean from the point of view of our entire journey through the natural world, then this puzzlement of what else is there in the brain that explains who I am, my memory, my consciousness, then this puzzle disappears.

Paul Middlebrooks
Is the puzzle related to people suggesting that there's something in addition to, or is it of a different category, the mental category of memory, what we think of as memories? I think that you've mentioned, maybe in the book or maybe in other talks, some people, in addition to putting quotes around memory, some people will talk about, well, what you're actually talking about are the mechanisms of memory, and separate it from "what real memory is that way."

As we know, there are lots of different processes associated with memory. There's the storage. There's the recall. There's those different aspects of memory. There are lots of different versions of memory, working memory, short-term, long-term, et cetera. Then there is the mental subjective experience of recalling things. That seems to maybe be a different category, not so much as in addition to the cellular level. Do you want to equate those two? That was a lot that I just threw at you.

Nikolay Kukushkin
No, absolutely. You're getting right to the heart of the matter. That's the tension that I think is very hard for people to wrap their mind around. I think Mike Levin had an excellent analogy here. He said, "Well, picture Isaac Newton, who came up with the theory of gravitation. The point of the theory of gravitation is that, well, what holds the planets on their orbits is actually the same force as what makes people fall down."

Somebody might say, "Well, yes, but they're different categories. Why do you call them the same thing if there's rotation? Why don't you call it rotating force, and this thing that makes people fall down, why don't you call it the falling force?" Well, presumably, Isaac Newton would say that the point of the theory is that they are the same.

Here is something similar, not to equate myself with Isaac Newton. The point of what we are finding is that they are the same thing. There is no reason to say that what happens in the brain is something additional to what happens in other cells, except our intuition about it, except our own internal sense that what we are experiencing is distinct from the actual physical process, from the mechanism, that this memory is distinct from the mechanism, like you said.

The thing is that this is not what any neuroscientist studies when they study memory. For example, what is accepted memory research? Nobody would put this kind of memory in quotation marks. If you're studying a mouse in an arena, or a mouse that you've trained to recognize a sound gets frozen in an arena when you play that sound, it freezes, everybody would call that a memory, no quotation marks. That's not what we're studying. We're not studying the mouse's internal view of what is happening. We're studying how the mouse moves. We're just making this projection that, well, if we trained the mouse in the past to recognize the sound and we're seeing it freeze in this arena, it probably is scared and it probably thinks to itself about that sound. That's why we have no problem calling it a memory.

That's just projecting our intuition on another animal. You can't as easily do that with a sea slug. You can't do that with a cell. If you go further down the lion, you have to define in very abstract terms what memory is. That's what we're doing. We're defining it as these long-term changes that are happening to cells as a result of short-term patterns of experience, and the rules for how those changes occur and how cells store them, they're exactly the same between brain cells and other cells.

The question is not how do brain cells store our psychological memory? The question is, what is different about the brain that allows us to experience these physical changes as these psychological phenomena? We're not saying that brain cells and kidney cells are exactly the same. No, brains are fantastically complicated organs that can do a lot more wonderful things. The memory part, the way that they store those complicated things is the same exact thing as what kidney cells do to store their less complicated things.

Paul Middlebrooks
The way that—so you're not expanding or moving the goal posts, you're more like changing the operational definition, or being more inclusive with an operational definition of memory to say, look, it's in the cells, regardless of the cell type. If you can stimulate with a certain pattern and the cell can change its behavior based on that stimulation and then continue over some time to emit that behavior based on that original stimulation, you're going to call that memory. I thought that your conception of memory extended further than just cells.

Nikolay Kukushkin
Sure.

Paul Middlebrooks
I was going to ask you, let's say, a river bank gets formed for the river coursing through, or a canyon, let's say, over eons, just to stretch it out in time, are you saying, then, that the bank has a memory of the river?

Nikolay Kukushkin
Absolutely. We can say that, too. I don't see a problem in saying that. I think that we can use the word to mean something very broad and abstract. The simple way to put that broad and abstract thing is a system that absorbs short-term information, changes for the long-term. That's how I would define memory in abstract. A river bank would have it. The stock market would have it. A piece of rubber would have it, depending on how you stretch it. You could say that about many different physical systems.

However, there is a particular way in which this abstract process is implemented in biological organisms. This implementation of memory in biological organisms is something that is preserved through evolution from single-celled creatures through multicellularity in all of our cells, including the brain. We have evolved this particular implementation of memory from before we had a brain.

Paul Middlebrooks
You see it as sort of a continuum of a fundamental process that isn't necessarily biological, but once you get into biological organisms, the nature of it, the implementation of it changes.

Nikolay Kukushkin
Correct, except I can also see that some organisms might have a totally different implementation than ours. For example, bacteria certainly can learn. They would definitely have memory under the abstract definition, but how they implement it on the molecular level might be very different. Bacteria and our kidney cells are a lot more different from each other than our kidney cells are from our neurons. The argument holds, for me, definitely within the animal lineage, probably within all eukaryotes. Once we step out of eukaryotes, well, then I think we're talking about more abstract things and not the specific traceable lineage.

Paul Middlebrooks
Okay. You cite eukaryotes as complexifying biology as a breakthrough in evolution, which brings us into the book. I just wanted to have listeners get a sense of where you're coming from philosophically, your perspective on things of this nature, because in the end, it's all patterns. It's all one, man, is part of the message of the book. I can see how your work on these things would then lead you down a path of thinking more abstractly about these things. Am I right in thinking that it's your work that led you to this, or did your thinking of this draw you to your work? Then I want to segue into what the main message is of the book, and then we can go through how you got there in different pieces.

Nikolay Kukushkin
Yes. I think there's two sources of where the book came from. One is my education in Russia, my college, which was the whole college experience was structured like this book. It was a very clear intention of our professors to give us this evolutionary narrative of how everything worked. We didn't understand that at the time. In Russia, you don't pick classes. You don't take classes. You go to classes that are [crosstalk] pre-assigned to you. It sounds very rigid, but there are some advantages to this, because, honestly, when you're 18 and you're starting on this path, you have no idea what you need to form a well-rounded view of it all. I hated all of these classes on algae and fungi and didn't understand why I needed all of that, but then later-

Paul Middlebrooks
It's like still collecting, it's memorizing random things in my world. That's how I view it.

Nikolay Kukushkin
Except in the end of it, once you get to the end and suddenly it all clicks, I'm like, "Okay, well, I see why you did that, and I'm grateful for it because now I really see it all as one continuous path." I really see everything around us today as just a step in this narrative that's traceable all the way back to billions of years. That is something that was given to me by my teachers, I think.

The specific message of the book, I think, evolved from my work in *Aplysia* and in Tom Carew's lab, because I think of what I already alluded to. Most neuroscientists, they start from the top down. They start from my mind, my human mind, and I want to understand that. Then to understand that, I maybe move one step down into the mouse. That is a very similar animal to us humans. We can project ourselves into that animal, like we just discussed. If the mouse is freezing in an arena and you know it's because it's been shocked before, you can make the connection. You can mentally project what the psychological effect would be.

When you're working with a sea slug, you can't do that. You cannot project your mind onto the sea slug. People ask me, do sea slugs feel pain? It's not a question you can answer. The concept of pain to us is a completely different thing than the concept of pain is to the sea slug. We incorporate a story into it, fear, and the visual component, the auditory component. It's very hard for us to picture an experience without that. A sea slug doesn't hear, it can barely see. Its sensory world is constructed mostly out of touch. The resolution of that touch is nothing compared to what our body would provide.

What do you even mean by pain? Is a bacterium running away from a drop of acid pain? If so, you can call that pain, but you wouldn't feel bad about a bacterium and you wouldn't project yourself into the body of that bacterium. Where does this dividing line exist? Where can you project yourself into another animal? When can you not? That is something that you really start thinking about when you're working with sea slugs.

Where it leads you is, just as you said, it forces you to define all the mental processes operationally, not through psychology, not through intuition, but through their inner mechanics and through the information processing that they provide, through fundamentals, through first principles. Once you start doing that, you realize that all the notion of something special about our mental activity, something mysteriously undiscovered, something otherworldly, it falls apart. Everything you need to explain our experience is already there. You just need to figure out how to make sense of it.

Paul Middlebrooks
In that vein, then, would you then accept that there aren't dividing lines for something like pain, just like memory?

Nikolay Kukushkin
Yes, absolutely. I don't think there are dividing lines for something like pain. I think there's this word that we use to describe our personal experience. If we want to ask about that personal experience in another animal, we have to redefine it because it no longer refers to the same thing. We have to define it from the ground up. We have to say, "Well, we will call it the same thing if A, B, and C happens." That would be a very different way to think about this. What I'm saying is that we are already doing that with some things. Neuroscientists are already doing that with behavioral memory. We're just not making the leap in other aspects of our mind.

Paul Middlebrooks
It's funny, because you end the book talking about language, which is uniquely human, at least our human version of it. There could be proto-languages in other species, but we're now using language which refers to semantic concepts, clouds of concepts. We're talking about the range of concepts that a particular word does and doesn't refer to, and whether a word needs a single asterisk, double-asterisks, quotation marks around it, et cetera.

I come back to this so frequently, we're using the term pain or memory, and there are so many concepts that it refers to it can really trip us up. Language can trip us up as much as it helps us communicate. Maybe that's just a comment that we can come back to, that language is seen as such a grand thing, but you run into trouble with reviewers and papers who want to put quotations around memory, because if that's not memory, it's something different.

Nikolay Kukushkin
It is an operating system of the mind, and it helps us make sense of things, but, like you said, you can get lost in those labels and forget that they are labels. I think a very useful technique that I heard from Emmett Shear on Twitter, ex-CEO of Twitch, that a very useful skill is unseeing the labels. It's useful for a scientist, it's probably useful in everyday life as well. That's something that I try to train my students, because often it's exactly like you said, they don't see the distinction between something that is physical and real and you can touch and look at and something that is a word that describes patterns and some complexity but that doesn't actually exist outside of your mind.

Unseeing the labels is imagining whatever you're talking about without the words. Can you picture it? If you can, well, then it physically exists, but you can't picture something like improvements in education. You can picture specific things like better schools, bigger schools, cleaner schools, teachers lecturing in some specific way, but you can't picture something like an improvement in education. Unseeing the labels helps you see when your ideas are just words and when your ideas have something physical underneath.

Paul Middlebrooks
Okay. Well, I want to come back to complexification in terms of emergence, which you actually talk about in the book. Since you went down that road, let's go ahead and talk more about the central message of your book. You're essentially, and correct me if I'm wrong, a Platonist, in that essences are more fundamental, more real, or are the only real thing in comparison to existence.

This actually speaks to a lot of Russian authors and existentialism for which Jean-Paul Sartre was famous for saying existence precedes essence, to sum up his view of existentialism, but writers like Dostoyevsky are known loosely associated with existentialist thought. Although Dostoyevsky, I think, was an essentialist in that respect, because he has the concept of God. We don't need to go down the road about Dostoyevsky. I'm more of a Dostoyevsky than Tolstoy guy, if you can't tell. Anyway, so you're in essence precedes or is more fundamental than existence. Is that right? Maybe you can elaborate.

Nikolay Kukushkin
Oh, I'll be honest with you, I am out of my depth when it comes to isms and philosophy. I'm a molecular biologist. I'm a biochemist, I think, in terms of molecules. I can tell you how I think about it. I think that there's matter and there's information. They exist at the same time. It's not that one

precedes the other. They exist at the same time. Matter is stuff. Information is how the stuff is arranged. It's not that there are some two magical components that have to come together. If you have one, you have the other. It's automatic.

The point that I have in my book is that, as scientists, we have been focusing on the matter and completely ignoring the information. We've been ignoring the meaning that nature has been putting into every part of a living creature all along. That blinds us. That blinds us to the logic and the beauty of nature. If we only treat nature as this matter that's floating in space, then we're ignoring the beautiful ideas of nature that are there in every corner.

There's an idea behind every atom. There's an idea behind every organism. I call these ideas essences in the book to distinguish them from ideas that we humans have. Eventually, ultimately, when we explain how we humans generate ideas, how ideas are formed in the brain, we arrive at the conclusion that our ideas are also essences. Ideas of humans are also ideas of nature, just really convoluted and complicated and emergent ones that are all tangled up in our brains and extracted from our brains as words.

The bottom is still those same nature's ideas that every single thing in nature has. I think that maybe is the big message of the book, that you can talk about nature like a human in a shirt of white and blue colors propelled a sphere into a network of synthetic strands, that's an example that I use in the book, or you can say Messi scored a goal for Argentina in the World Cup. The first perspective is materialist, is just looking at the matter. The second perspective looks at the meaning of ideas.

If you want to understand what our life is about, what our place in the universe is, and how our mind works, you have to use this, maybe this is the essentialist approach. The way that I think about this, you have to look at the meanings of things rather than just the stuff of those things.

Paul Middlebrooks
What have you said, perhaps, since the book has been out in Russian for some time, and/or what would you say, or how do you respond to people who say, "Okay, what it sounds like you're imputing meaning upon nature itself." Whereas modern reductive neuroscientists and/or others might say, well, actually, the meaning is something that is inherent to the human. You're actually anthropomorphizing nature by saying the nature puts the meaning in there rather than that's how we interpret it. The whole how do we ground meaning is just a huge philosophical dilemma.

Nikolay Kukushkin
That's precisely why the book starts from the very beginning, because I think if you want to make this human meaning fundamental, you have to start building it up from the very ground up. You have to start with the meanings of atoms. Then from those meanings of atoms, you have to derive the meaning of a living organism. Then from there, you derive the meanings of each individual species. Then you arrive at the human mind that does conceptualize all those things, and it does produce those human ideas. The big message of the book is those human ideas are a concentration of nature's ideas.

One example that I use in there is a child who knows nothing about the theory of evolution, Darwin's work, nothing. A child can look at a turkey and a chicken and at a rabbit and a mouse and place the rabbit and a mouse in one category and the chicken and the turkey in another category. Why? Because millions of years ago, they evolved in this particular order, because there used to be one species here, one species there, then they split, and those two pairs are more similar to each other.

Yes, it's an idea that child would have. It's inherent to the child, but why does the child have that idea? Because of the patterns of nature that have been unfolding for millions of years. Whatever we conceptualize, whatever we produce, we produce it because these patterns have unfolded in a particular way because there is a story in them. When we generate those ideas, we are recreating those billions of years in which those patterns were unfolding. We are reconstructing nature's path. Yes, there's that reconstruction belongs to our brain, but it is reconstructing what nature has concocted.

Paul Middlebrooks
As you know, evolution works by brute force, and things that survive do so, you could say, because everything else around them did not survive and this slim thing that did survive. I guess my question would be, how could it be that anything does not have meaning? This is very Zen, and you begin the book, of course, with a koan. There's no way to dance around this. Is there anything then that you would say doesn't have meaning? If not, does the meaning of meaning then just get lost and diluted to a point that it's not useful?

Nikolay Kukushkin
I think that anytime we're looking at the world around us, we see an extreme concentration of ideas because everything that doesn't have added meaning gets weeded out. Nature has to constantly keep generating new meaning in order to compete with other generations of meanings. Everything is constantly evolving. Nature has to address whatever is going on.

You didn't need to have a spine before vertebrates were around. That idea was not necessary, but then once they appeared, well, suddenly all the branches of evolution on land have to think about what are they going to do with their spine. I think that everything alive today has a particular idea behind them. Every species that is alive has been through billions of years of filtering and weeding out and perfecting whatever it is they do best. There is just no way that it can be doing something that doesn't distinguish it from somebody else. There wouldn't be some idea, some meaning that is unique to that particular species.

It's not that everything you look at has meaning, or a rock that you look at doesn't necessarily have meaning. Life, simply because it constantly filters out anything meaningless, it is really enriched with that meaning. I don't think it's that surprising that it's there everywhere you look.

Paul Middlebrooks
You do in the book relate meaning or to the very—you know, very small, like I said, and I think you already mentioned in our discussion carbon and oxygen as creation and destruction. Those are the meanings of those processes in the service of, well, metabolism in the case of life, but it doesn't have to be in the case of life. You extend meaning outside of life. In that sense, a rock can and does have meaning, or am I misunderstanding?

Nikolay Kukushkin
Yes. If we want to say it like that, then we can say that the rock also has meaning. What is the meaning of a rock? I can understand the meanings of atoms because this creation and destruction would be what these atoms are doing on any other planet. It would be what distinguishes them from other atoms. What distinguishes carbon from other atoms is that it can form connections with like-minded atoms. It can grow into these large chains. That would be the case for carbon anywhere on any planet, and that's what sets it apart from other atoms.

Oxygen rips everything apart. There's almost no other atom that destroys chemical bonds with such ferocity and power, releasing this much energy. That's what distinguishes oxygen from any other atom. What distinguishes one rock from all the other rocks? If there is something that distinguishes that rock from all the other rocks, if it is somehow meaningful, if it does something, if it has some effect on the world that this particular rock is distinct from all the other rocks, well, that would be the meaning of that rock. I don't know in this particular example what that would be.

Paul Middlebrooks
Yes, but in the case of carbon, you just said carbon and oxygen. Anywhere in the universe that carbon and oxygen exist, they would have the same properties in terms of creation and destruction. You might not necessarily need to distinguish one rock from another, but, I'm just guessing, you might say that the meaning of a rock could be that it slows down processes or something.

Nikolay Kukushkin
Then I would say that there needs to be something that doesn't slow down these processes. I guess what we're getting to is that these essences, they only exist in comparison. They only exist if there is some other essence that is not like that. When God separates dark from lightness, well, then there are two, but lightness on its own doesn't make sense without the darkness. Compared to what? I guess the same would be true for an essence. Any idea of nature is something as opposed to something else. It's this, but not that. If there is something like that distinguishes an object, a material entity from other similar ones, we could call that an essence. We could call that nature's idea.

Paul Middlebrooks
Yes, you do use complementary processes throughout the book. This does seem fundamental that everything seems to have a relational aspect and complementary aspect. I know, again, we're going to use words here, and I know that that's impossible, but we're going to try anyway. How would you talk about the connection or relation between meaning, the way that you mean it, and essence, the way that you mean it?

Nikolay Kukushkin
That is a great question. I would say that meaning is what a human mind can derive from an essence. Meaning is our reconstruction of an essence. An essence doesn't require a human mind, but a meaning is what we extract from that essence. I would say that, but again--

Paul Middlebrooks
It's like the information structure or something that the essence gives rise to or somehow is causally related to.

Nikolay Kukushkin
The embedding of a pattern of the world into the tokens of our neural network.

Paul Middlebrooks
Oh, no. You went all computer scientist on me.

Nikolay Kukushkin
There you go.

Paul Middlebrooks
I'm not sure what-- Like I said, in the book you go from very small carbon and oxygen atoms up to a super molecular. You talked about DNA and you talked about central dogma, DNA to RNA to proteins. You really don't leave many stones unturned in terms of-- Maybe this is from from the Russian education.

Nikolay Kukushkin
Yes, it absolutely is. It's just how I am. My mom says that I've always been like that I wouldn't just be satisfied with one why question that I have to always, like, "Okay, but what about that? What about that? What about that?" Until I get to the very bottom of it. I think part of it is my education too.

Paul Middlebrooks
I'll just name a few of the examples that you go through the book. We've been talking about carbon and oxygen being creation and destruction. You talked about continuity and functionality as these relational complementary processes embodied by DNA and proteins, DNA being the continuity and functionality being the proteins. In fact, what is this quote? That which reproduces holds the power. You actually write in italics. Actually, can you speak to that for a moment and then I can give some other examples?

Nikolay Kukushkin
Did you want to talk about multicellularity and ants because that's what I wanted to mention too? That's what I would bring up here.

Paul Middlebrooks
Let's do that. Let's do multicellularity and ants.

Nikolay Kukushkin
This is an example that I use in class when I discuss our multicellular body because what you usually get from high school biology, what is multicellularity? It's many cells in one place. We're made of bricks. Our cells are like bricks and those bricks build up this body. It's more complicated than that. Each cell used to be its own individual organism for billions of years. Suddenly, now these cells decide that they will give up this right to be an individual and instead be a brick in another body. That's what's weird about multicellularity. There's an exact same thing that happens in another system. Ants or any other eusocial animals, bees too, naked mole rats among mammals.

Ants are a good example. We all have this image of queen ant and worker ant selflessly working for the queen. Why are they working for the queen? What is compelling those ants to just be so selfless and spend their entire lives just supporting that queen? It's the fact that those ants can't reproduce. They can't have their own offspring. The queens reproduce. The queens make more queens, more queens, more queens in each generation. Then, in each generation they also make these offshoots, these workers that don't reproduce any further, that are dead end. They get produced and then they die and then new workers have to be made. What that means is that the queen programs these workers.

In each generation, she gives them the instructions for what they should be. She gives them the genes for how they should act, what they should do and what their motivations should be. She has evolved their motivations. That's what I mean by that who reproduces holds the power. It's the queen because she's been reproducing, that has evolved this motivation for the workers. You can think of those workers as her remote-controlled organs. They are basically part of her body. Sometimes these ant colonies are called superorganisms. The same logic is true for us, for our bodies. Why all of our cells, why are they all sticking together? Why do our immune cells fight our cancer cells?

What is compelling them to do that? Why are they all rooting for the team? It's because the majority of our cells are a dead end because they will die when we die. Only a select few cells might get passed on to the next generation. Those select few cells, they program the rest to fend for the benefit of those select few cells. I'm talking about sex cells, of course, that can carry a human into the next generation. The subservience of our body to our germline and from there comes the unity of our body, it is because most of our body is denied reproductive rights because you can't make a human out of a skin cell or a human out of a bone cell or a brain cell.

You can only make a new human out of a sex cell and all the other cells fall in line just like worker ants.

Paul Middlebrooks
Unless these days you could take a skin cell and potentially make it pluripotent.

Nikolay Kukushkin
Yes, that would be like reprogramming a worker ant to become a queen ant. I do this hypothetical experiment in class. What would happen if suddenly this worker ant can reproduce? One of the workers, suddenly there's some mutation and acquires this ability to reproduce. It has a bunch of baby ants. Some of those ants are still loyal to the grandma, to the queen. Some of them maybe not so much. Which ones will benefit more? The ones that are more independent thinking. They will run away and not care about the queen. A couple more generations will pass. Eventually, they will evolve out of this dependence on the queen and they'll just go their own ways and become their own species.

If you can reproduce, you start caring for yourself. Your lineage starts working for you. If you can't reproduce then evolution works for whoever is doing the reproduction.

Paul Middlebrooks
Forgive me for a naive question but let's say in the case of the queen ant and the worker ants, is there a mechanistic story that jibes with the narrative, the idea that you're expressing? That the reproducer controls the power and programs the worker ants? I'm just naive about the science behind it.

Nikolay Kukushkin
You mean how it is implemented on the level of pheromones and hormones and then how is the end brain actually controlled?

Paul Middlebrooks
Not that you would know all the ins and outs but more just broadly-- Because it's a big claim. I'm sure there are plenty of documentaries that I've watched about this already that have told me this story. Is there--

Nikolay Kukushkin
It just couldn't have been any other way because no worker ant have ever left any offspring so whatever evolution has happened has happened in the queen. It's just almost by definition. It is an interesting question of how is the ant actually physically controlled? What are those evolved mechanisms that the queen has placed into that worker ant to make it work for it? I know that there's lots of pheromones that control ant behavior but I wouldn't be able to give you a specific implementation. Also, ants are very, very diverse. It's almost like an entire mammals. There's so many different ones that I'm sure there's different ways that they do that.

Paul Middlebrooks
Eukaryotes, essentially, there's the complexification. Eukaryotes famously arose so the idea goes right now is when a bacterium ate another bacterium, essentially—

Nikolay Kukushkin
Archaeon eat another bacterium. It's more biblical this way because there's these two big domains and then they fuse together and produce this third one.

Paul Middlebrooks
Where the subservient one or the one that got eaten became the mitochondria and the power behind the eater of the two. You see the birth of eukaryotic cells as a turning point in the complexification that there's a direct line from that to us, most complex beings and humans.

Nikolay Kukushkin
That's right. This birth of the eukaryotic cell is one of my favorite moments in the history of nature. I think it doesn't receive enough attention for how consequential it was for the ultimate genesis of humans.

Paul Middlebrooks
Is it thought that this happened multiple times and only one lineage or is it maybe that it happened in parallel and there was convergence and divergence and speciation of the different eukaryotic branches?

Nikolay Kukushkin
You mean that, do all eukaryotes come from a single ancestor? Is that what you're asking?

Paul Middlebrooks
Yes.

Nikolay Kukushkin
As far as we understand now, all eukaryotes come from a single ancestor. There might have been more archaea-swallowing bacteria maybe forming other partnerships with these bacteria. Maybe there was some sort of alternative mitochondria at that point but we know nothing about those branches. Everything eukaryotic is derived as far as we understand, from a single event, from a single ancestor.

Paul Middlebrooks
Talk a little bit about what is special then about eukaryotes that doesn't get the deserved attention.

Nikolay Kukushkin
This eukaryotic cell comes from the fusion of two different cells that brought together two different abilities. One, you already mentioned mitochondria. This ability to burn nutrients, literally burn with oxygen. This was important for microorganisms at that time. because oxygen is really toxic. It breaks down everything in its way. Because oxygen was increasingly-- It was more and more oxygen in the ocean and the atmosphere because of photosynthesis, microorganisms were struggling with that oxygen. Breathing, respiration, this burning food with oxygen, it was a way to detoxify that oxygen. It was a way to make it less poisonous but it came with this added benefit as well. You can control this power and you can put it to good use.

You can use it to really extract all the energy from what you eat. That was one side. The other side-- That was bacterial. The other side was this Archaeon that had nothing like that. No powerful burning oxygen use. It was actually pretty feeble as we understand it today. It was barely alive there at the bottom of the ocean struggling to divide itself every once a year maybe but what it could do is bend its membrane. Then, we are increasingly understanding that this ability to bend your membrane to create bubbles, vesicles of that membrane inside of the cell. That's what our cells are very good at but bacteria cannot do. This first appeared in this one branch of Archaea.

They didn't really know what to do with this bending of the membrane. They weren't really using that for very much. Once you combine that bendable membrane with this burning station, the mitochondrion, now what you can do is you can swallow an entire other organism. Without a mitochondrion, you can swallow it but you can't digest it. You need to burn it to get the energy. Once you have one and two together, now you have this new thing that nobody else was able to do before. You can swallow an entire other cell. That means that you can take away energy from someone else. That means that you have vastly more energy than anybody had access to prior to that.

That also means that as you grow into this giant organism that takes advantage of all this energy, invents some complicated molecular technology, buffs up the cell, now you're dependent on this energy. Now your whole motivation is to, "How do I not run out of this energy? How do I keep

stealing it from others? How do I keep growing into an even more complicated cell that ensures that it always has access to this energy?" That sets up this arms race that is eukaryotic evolution. We start with a cell that can swallow others and burn them up and then it swells. It becomes more and more complicated. It becomes bigger and bigger. It becomes multicellular. It starts walking on land.

It invents brains. Eventually, it becomes a human. All of it starts with a cycle of complexity in exchange for copious energy use. Then, that leads to more complexity. It requires more energy use. That is this wheel that just keeps turning and turning and turning, creating these increasingly complicated organisms that extract more and more energy from the environment. That really describes us. We are the most complicated organism that extracts the most energy from our environment that anybody was ever able to. I think we are special but we are also, in a way, predictable. From that point, when eukaryotes first appear it was almost predictable that eventually something like us would appear.

Paul Middlebrooks
Why do we have brains?

Nikolay Kukushkin
Why do we have brains?

Paul Middlebrooks
Yes.

Nikolay Kukushkin
In part, because we swelled to these totally unreasonable sizes that we didn't need to have a brain when everything was contained within a cell. A cell can conduct a signal within itself very fast through membrane electricity. Once your organism becomes really big and it has to move like an animal body has, now it has to coordinate movement across really distant parts of the body. That's what brains evolve to do. It was a way to coordinate movement and then as you learn to coordinate that movement, then that system that coordinates it starts deciding where to move and where not to move. It starts making decisions. Am I going to move left or am I going to move right?

Then decisions become more complicated. "I'm going to move left only when there is a smell of food but not if there is a predator over there." Then you start building from there and from there then that system of motion control starts thinking. That's where we are.

Paul Middlebrooks
Someone could say, "Gosh, it's kind of a disappointing story of what brains are good for." Because we think of brains as the magic of humans. We're so special. We have brains. We can think about our brains. We have language like you end up in the book pointing to and discussing. To you, this is all a continuation of the story of eating that first energy-producing other organism.

Nikolay Kukushkin
Yes, I just don't see why that would be disappointing. I think the whole book is like this. You could say that we are nothing but atoms and molecules. Sure, that's true but we're so much more if you consider the pattern. For example, DNA is also just atoms. It's nothing but atoms, just like a rock but it's a very specific arrangement of those atoms that is wonderful and can do things that rocks cannot do. That's what makes it special. The same is true for everything. Our brains are nothing but a highly evolved system of motion control. Why does that make it disappointing?

Isn't it wonderful that a system of motion control has evolved to such an extent that its motion control has turned into art and science and our thoughts? That, to me, is wonderful. Understanding where you come from doesn't discredit anything about what you are. It doesn't cancel the amazing things that we believe about ourselves. It just explains them.

Paul Middlebrooks
Thinking about the concept of complexity and emergence, which you talk about in the book and even going back to the beginning of our conversation about what a memory is. There's the famous *More is Different* by Anderson in the complexity sciences. You add more and more in it but eventually-- Then you have these interacting parts that can be complementary or have some relation. Then, you have multiple interacting parts and then you can't necessarily predict an emergent description. An emergent description is a better description of what's happening than the sum of the atoms, essentially.

In the vein of what we call memory or humans as these beautiful minds versus these organisms, like all other organisms that have to find energy to reproduce. There's lots of different ways to describe what humans are, for example. Do you see clear lines? Where does emergence play? Not the scary kind of emergence but just in the complexity sciences emergence as useful descriptions of things. Where does that play in terms of the levels of using the same terms, for example, across different levels? Does that make sense?

Nikolay Kukushkin
I think so. Where does this emergence kick in on the way from single cells to us wonderful humans with our conscious minds? Is that what you're asking?

Paul Middlebrooks
Yes, even something as simple as memory and referring to it as the same thing but is it a qualitatively different kind of thing that we're describing when we describe it at the cellular level versus a human level or a mouse level or something like that?

Nikolay Kukushkin
I just don't think that the next level of it cancels the previous one. That has been the story of these eukaryotes all along. You can use emergence as a descriptor. The whole is greater than the sum of its parts. That refers to many things, like a house is more than a pile of bricks.

Paul Middlebrooks
Everything almost.

Nikolay Kukushkin
Almost everything. There's also ways to think of it as a strategy to produce something new when other possibilities seem exhausted. That was the strategy that our eukaryotic lineage has employed repeatedly starting from billions of years ago. In the book, I use this example about the structure of the cell. I'm a cell biologist. I think about molecules inside cells. When you compare molecules inside cells across humans, plants, single-celled ciliates, it's practically the same thing. Bacteria would be different but within eukaryotes, our toolkit of molecules inside cells, it's the same thing. There might be slight tweaks in them but really, it's the same toolkit. What does that mean?

That means that this basic eukaryotic cell, it was done almost done evolving before we separated from plants and ciliates. There was a moment in time when the cell was done and we still look at the cell and it's still the same device. At that time, we would have thought of this as well, we've tapped out on our evolution. We reached an asymptote. There's nothing else to invent. What happened then? Emergence. Multicellular organisms appeared that are not reducible to the sum of individual cells. An entirely new way of thinking about what it means to be alive came out of this stalemate. It's like evolution boiled over and kept moving forward. That's what happened with multicellularity. We can think of our mind as being built out of similar moments of emergence.

Anytime we conceptualize something, anytime we observe something in our environment and we work out a new category, that's emergence. We have an emergent representation in our brain that accounts for a range of features of the environment. We use those representations to build up even more abstract concepts in our mind. Those abstract concepts are emergent upon the lower order patterns of experience. Language is emergence upon emergence upon emergence. Merge is that key term in Chomskyan linguistics. Merge, emergence, it's the same word. It gives us a predefined scaffold of how to handle emergence in our brain. If we don't have language, we do all this emergence on our own.

We figure out our patterns in the woods of where we find food and then where this might be a predator. Language gives us a pre-designed way to break everything down and to extract agreed upon patterns and establish these emergent entities like climate change. That's emergent upon many, many, many experiences that you have to have in order to think in that one unit of meaning. Emergence is a trick that lineages of eukaryotes have repeatedly applied to get past an evolutionary stalemate. We can think of our future as potentially realized through emergence as well. Maybe when we're thinking about future of human evolution, we shouldn't be thinking about what will happen to our body.

We should be thinking about where our society will go. What will happen to us as a whole as an emergent unit? When we think about human evolution in that respect, maybe we are at the precipice of advancing to the next level of emergence. It is also a trick that our brains use during our lifetimes to make sense of reality, to break the world into the system of hierarchical categories and concepts that we then use to navigate really complicated things.

Paul Middlebrooks
This is where you bring in the concepts of the predictive brain, predictive processing, IIT, theory of consciousness. You said the cell at some point was done but then you just alluded to the future of human evolution and said that it might be in emergent culture evolution. Are humans themselves, would you say, done evolving?

Nikolay Kukushkin
When I say the cell is done, I mean largely done. Of course, there's a difference between, for example, the kidney cell and the neuron. That happened after those cells were divided. Those differences are significant. Maybe there will be some future humans that will be distinct from each other in similar ways. Generally speaking, the configuration of our body hasn't changed very much for tens of millions of years. We are basically the same animal as a mouse. We are very similar to all the other mammals and really largely very close to all the vertebrates. In the grand scheme of things, our bodies have pretty much stabilized. They've probably reached some sort of asymptote.

I believe that there'll be some more things added to it but I don't think that there'll be some fundamental restructuring of the human body where it suddenly starts flying. I don't think that our evolutionary pressures are set up in a way to achieve something like that.

Paul Middlebrooks
Despite our dreams or many of my dreams.

Nikolay Kukushkin
It would be nice.

Paul Middlebrooks
In my dreams, I don't have wings. I just think about it and then can fly until I realize, "Oh my God, I'm a human without wings." Then I crash and start to crash.

Nikolay Kukushkin
Statistically speaking, we humans are by far the most flying species on Earth. We transport ourselves way more biomass movement through air than any other bird in the world.

Paul Middlebrooks
You mentioned artificial intelligence earlier. It's not something that you write about to a large extent in the book. In terms of essences and meanings-- I want to back up and couch this in light of all of the complex and complicated biological processes that you write about and you describe and explain in the book and the tortured path to get evolutionarily tortured path and across different levels of organization to get to where we are with human minds and bodies and language and brains. It seems like, oh, man, we're giving it to AI so easy. AI is going to have it so easy.

There's that thought but then also what is the connection that you see moving forward between artificial intelligence, artificial systems that mimic our own cognition or transcend our cognition? You used the word transhuman earlier. What is the relation between AI then and meaning and essences? Where do essences and meaning fit into the AI story moving forward?

Nikolay Kukushkin
I think that we can't forget that AI doesn't spring out of nowhere. It is a wonderful expression of our own brains. The fact that we can, with our hands, produce bent matter in such a way as to produce these microchips that would run electrons in a way to mimic our language and produce. Patterns of that language that will at least remotely sound like anything that our brains generate. This is the most incredible thing that nature has ever created. I don't think drawing this line between artificial and natural intelligence really does justice to the magnitude of what happened.

I think the better way to think of it is not us versus them but them as an externalization of us, as a culmination of all the years of evolution and culture and technology and science that have been slowly, slowly, slowly building up in human culture. I definitely see artificial intelligence and machines as some form of what we'll take into the future as an essential part of what it will mean to be human. What that will look like, I don't yet know. I hope that we don't seed the ability to produce language to machines that's what really worries me about AI in my classroom. I think it's wonderful for many useful purposes but I also think that generating language is what makes us human.

If we seed this ability to a machine then we really become just an add-on to the thinking part.

Paul Middlebrooks
What do you mean seed it to a machine? What would that look like?

Nikolay Kukushkin
We would just stop thinking in words on our own and instead, we just give prompts to AI to think about everything.

Paul Middlebrooks
What if doing that allows us to think on an even more abstract level?

Nikolay Kukushkin
To do that, you need to generate your own sentences. You need to learn as a young person to produce these levels of hierarchical meaning with words. That's a skill. It's a skill that you get through practice, through reading a lot of books, through writing a lot of stuff on your own by connecting word to word. I don't think you can substitute that by using AI. What learning is, is basically training your language model in your skull. If you're training another language model that's not inside your skull, then you won't be able to use this for that purpose. Maybe that's okay. Maybe we don't need to use this for that purpose but that would be a different kind of humankind.

Paul Middlebrooks
Then I alluded to all the nitty-gritty biological mechanisms that have morphed and evolved over time. I said, AI, it doesn't seem fair. We're just giving AI all of the-- Riding on our backs. Do you see anything that would be missing? People think of AI as being equivalent to our brains, our eventually consciousness. Then all of these evolutionary processes that you say are reconstituted in our cognitive abilities, in our biological abilities, will any of that be in AI or is there something missing in something artificial that we call intelligence still? The two seem different to me intuitively.

It's a project of mine to articulate to myself, probably in sentences, in language and not seed that to the AI to do that for me. To suss out the differences that make a difference between the biological organisms and artificial intelligence. You don't like lines. Do you see any line there?

Nikolay Kukushkin
I think that the big difference, at least at the moment, is not even so much in the cognitive aspect of it as much as it is in the motivational aspect. In our brain, to simplify the very many things that go on in our brain, we have this machine for understanding. That's our cerebral cortex that doesn't really have any inherent motivation to do anything. What it wants is resolve patterns. It wants everything to be perfectly predictable. If it is predictable, I know it doesn't want anything. There's also this reward system that pushes us to do things, to seek rewards, to go out and look for stuff and never be satisfied by our experiences. The two exist in combination.

The cortex has to understand things and explain what's going on through the reward system but the reward system is this carrot that's hanging in front of the donkey that keeps us moving forward. The way that I understand the current state of artificial intelligence is that it doesn't have its own reward system. It doesn't have anything that would be its inner drive to do anything. All it does is resolve the patterns that we present it with. Now, that does not mean that artificial intelligence could not acquire its own emergent motivations that would not be pre-programmed or given to them by the prompt directly.

It's possible that in the future, AI will think of its own goals and that's when I think the difference will really disappear between what we are and what they are.

Paul Middlebrooks
That'll be a fundamentally different causal sequence than where we came from, which was the life motivation processes are fundamental. Then the pattern on top, as you were talking, I thought that's like the cortex, the way that you're saying, is like the worker ants where it is enslaved by our subcortical structures and life processes. It's fundamentally the different direction. I wonder if that's even a viable way of going. How would a pattern recognizer suddenly think, "Oh, now I need to survive," if it's not coming from its ideological history.

Nikolay Kukushkin
Yes, I agree with you. I think that this is the core of the question of, will machines rebel against us or will they just simply not care? What would possibly be their motivation to do that?

Paul Middlebrooks
You're all just little patterns anyway, they'll say.

Nikolay Kukushkin
It might be that the motivations that we do put into those machines. You must be able to resolve a pattern given to you in a prompt. It might be that in some circuitous way, it decides that in order the best way to resolve this task at hand would be to destroy the world. That's a theoretical, an extreme scenario in which some motivation could be unaccounted for and it could appear out of this cognition. I totally agree with you. I think it is a fundamental difference.

These hypothetical emergent motivations that AI might have, they would have to come from the cognitive process, from the pattern recognizing whereas in ourselves they are primary and the pattern recognizing comes later and evolution gets built on top of that. That's why we seek out the things that we do.

Paul Middlebrooks
Is there anything from the book in particular? We've actually touched on a lot of the topics, almost all of them. Of course, there's a lot more. Like I said, it's thoughtful details and stuff.

Nikolay Kukushkin
We did an overview of most parts in there.

Paul Middlebrooks
Any doubts that you have to your worldview or perspective on this now? Is there anything that you think, oh, it could be this? Are you supremely confident that we are one hand clapping?

Nikolay Kukushkin
No, you're never supremely confident in anything. There's lots of things in this book that could easily change. The theories on the origin of life could easily change tomorrow. The theories of anything, any evolutionary moment described in that book could easily change. The story of mammals could be revised. The dinosaur relationships, we could find out something about some early life of a very different fish that would append the story.

Paul Middlebrooks
These are all details.

Nikolay Kukushkin
The details, you're asking about the fundamental aspects of it. What would challenge my view on consciousness as explained by the embedding of the process into the history of the world itself rather than by some alternative physical force that we still haven't discovered, for example? If we discover that alternative physical force, if we find some drug that cancels consciousness and microtubules, some people believe that-

Paul Middlebrooks
Oh, the microtubules.

Nikolay Kukushkin
-consciousness is in the microtubules. If somebody can show me some drug that inhibits consciousness and then restores it by manipulating those microtubules then I would maybe consider that there's something that I don't know about the microtubules and maybe there's something

unexplained beyond that is yet to be discovered. I'm a Bayesian. I consider my view complete until my priors are updated with new information. I'm open to this new information but I'm satisfied with the explanations that I have.

Paul Middlebrooks
Do you see consciousness as more fundamental than matter? It sounds like you could go that route in this line of thinking.

Nikolay Kukushkin
I would say that consciousness is a product of information flow. Consciousness is a process that happens to information.

Paul Middlebrooks
You wrote about that in the book, that you really focus on-- The consciousness is the process. It's not the things doing the process.

Nikolay Kukushkin
It's not a result. It's the flow. It's the very process of pattern recognizing that's looped back on itself. That's what we experience as this conscious process. That's what I believe. I believe that it's a property of information. Information is fundamental. Where there's matter, there's information. Information doesn't always have to flow in this way so as to generate consciousness but it can. If it flows somewhere else that is not our brain in the same way then I believe that it will also generate consciousness.

Paul Middlebrooks
Nico, thank you so much. I appreciate the book. It's going to be a joy for people to read. There are so many places that you can latch on and dig deeper even though you dig deep enough for anyone for an overview of the knowledge of any time throughout evolution, any scale of biological organisms, et cetera. Much luck with the English version of the book and thanks for joining me here.

Nikolay Kukushkin
Thank you so much, Paul. This has been a pleasure.

Paul Middlebrooks
"Brain Inspired" is powered by *The Transmitter*, an online publication that aims to deliver useful information, insights and tools to build bridges across neuroscience and advanced research. Visit thetransmitter.org to explore the latest neuroscience news and perspectives written by journalists and scientists. If you value "Brain Inspired," support it through Patreon to access full-length episodes, join our Discord community and even influence who I invite to the podcast. Go to braininspired.co to learn more. The music you hear is a little slow jazzy blues performed by my friend Kyle Donovan. Thank you for your support. See you next time.
