INTERVIEW

Mihai Nadin: Disrupter of Science

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"[My book seeks to] disrupt science in the sense that it gets us away from the myth that doing more physics and chemistry will be the answer to understanding the living and, in particular, the human being."

On January 15th, Dr. Mihai Nadin, an emeritus professor of computer science at the University of Texas at Dallas, joined *Merion West* contributing editor Jonathan Church for a discussion about Dr. Nadin's new book *Disrupt Science: The Future Matters* and the nature of what he calls anticipatory systems. Dr. Nadin is widely revered as the father of anticipatory systems in computing. Throughout his interdisciplinary career, he has written more than 30 books and over 200 academic papers in science and philosophy. Formerly a director of the Institute for Research in Anticipatory Systems at the University of Texas at Dallas, Dr. Nadin's primary research focus is on the nature of these anticipatory systems. In Disrupt Science, Dr. Nadin assesses many of our most pressing societal problems such as the Coronavirus (COVID-19) pandemic and artificial intelligence, while advocating for the cultivation of what he calls "an anticipatory mindset." Dr. Nadin argues that an anticipatory mindset overcomes the shortcomings of a deterministic worldview that one finds in mechanistic science, as opposed to in biological science.

This interview has been lightly edited for clarity.

Thank you for joining me today, Dr. Nadin. To get started, how would you summarize the nature of anticipatory systems?

Anticipatory systems are characteristic of the living. There is no stone or anything that is not alive that performs in an anticipatory manner. The living—in order to survive—have to be anticipatory.

For me, anticipation is definitory of life. Life, in order to survive, in order to exist, has to be anticipatory. Why? Because we live in a world that is in continuous change. And, in order to adapt to the change—in order to be able to survive in a changing world—one has to, as a living entity, deal with possible futures.

One of the things that I thought was very interesting about your book was the way you contrast the nature of an anticipatory mindset, taking into account the future in the context of living organisms, with a deterministic mindset that comes out of the Cartesian tradition—mechanistic science. That's particularly applicable, as you were saying, to the nature of living matter versus non-living matter. So, in physics and chemistry, you can study chemical and physical matter and come up with a model and predict outcomes, based on the accumulation of data from past occurrences. Whereas with living matter, there's inherent uncertainty, which means you have to take into account many multiple possibilities in the future. You have to try to anticipate—as best as you can—potential outcomes.

That leads to my question: What do we mean by disrupting science, particularly in healthcare and in the medical industry? The idea seems to be that it is simply not to wait for things to happen and react but, instead, to try to anticipate what might happen and come up with a plan.

You are getting close to the core of the book. And the core of the book is represented by what I avoided calling the Nadin principle, so I will not call it that even here. But I talk about a very important principle: To react is—by many orders of magnitude—more expensive and unsustainable than to prevent.

So what does that mean? It means that with respect to physical phenomena, we are very well prepared by knowing the laws of physics and chemistry and so forth, in order to deal with the inanimate. We have very good models that we can use in order to look at a bridge and say, "What are we going to do to prevent that bridge from causing trouble?"

Think about the Golden Gate Bridge, for example. In order to deal with what might happen in the world of the inanimate, we have a lot of knowledge.

It turns out that living things are not reducible to physics and not reducible to chemistry. The future of a human person…the future of an individual is such that we cannot infer from past data the possible futures, and this is because those possible futures cannot be—in any shape or form—predetermined through physical chemistry.

Why is that? What is that crucial difference between living and non-living matter that makes the former so much more difficult to predict?

The crucial aspect is the fact that the non-living is homogenous. All electrons in the world are the same. Even in advanced physics, we talk every now and then

about the color of an electron, but, in the end, we know exactly the charge of an electron. We know the dimensions of the electron. We know how electrons interact. With the living, there is not even one element that is the same.

I gave my students—for years—the example of how I evolved from a moment of innocence, when I was told that Aristotle claimed that there are no two blades of grass that are the same. At that time, with the impertinence of youth, I said, "Okay, so what?" Today, I understand that this is a tremendous observation.

In our body, there are no two cells that are the same. And not only that…in the process of reproduction from one generation to the other, there are no two cells that are the same. If we take only the numbers that describe this fact, which is a fact, we realize that for the inanimate, for the world that is not alive, the numbers are high if we start considering the numbers of stars and the numbers of elements and combinations.

But that is nothing compared to the dynamics, not even of a human being, but the dynamics of the monocell. The monocell is a living entity made out of one cell. And, interestingly enough, that cell has a reality that escapes our measurements and escapes our ability to infer from its past to its future.

When you say measurement in that context, are you saying essentially that living matter is such that we cannot really capture it very well in a model?

Let me start by trying to be on your good side and say, "Yes, this is part of what I'm saying." And let me now make your life a little more complicated. With respect to phenomena that relate to the homogenous world of the non-living, we are able—at this moment—to measure them.

In other words, to describe them in a quantitative manner…in a way that is decidable. I'm using here the concept of decidable, as it came from a logician, which is good. And the decidable describes something that we can fully and consistently describe.

At the living level, there is no way that we can describe the simplest element of the living, which is the cell, in a decidable manner. Interestingly enough, if the description goes as it does, for instance, through genetic sequencing, into a great

deal of detail, it turns out not to be consistent; it turns out to be contradictory. The same thing appears to us as we look at the data describing it, as being contradictory.

And, at that moment, we're lost. The living is undecidable. That's why I claim that the living is complex, while the physical and the chemical are decidable.

And that's why I would characterize the living as complicated. The relation between something complicated and something complex is that you cannot reduce the complex to the complicated. Unfortunately, with the Cartesian revolution, we inherit the reductionist idea, according to which I take something from here, and I cut it into pieces.

And, if I understand the pieces, I will understand the whole, which is not true when it comes to the human being, or to any other living entity that we're aware of.

One of the things I read in one of your recent articles, which is really kind of astounding to me, was, over the last 50 years, that there has been a 150% increase in the number of physicians, if I have that correctly, and something like a 3,200% increase in healthcare administrators.

One of the things you talk about is putting doctors back in control of making decisions, in the context of preventative medicine versus just constantly reacting to, say, pandemics. How do we think, then, about this notion of decidability in the context of healthcare?

No cell, no person is exactly alike—the uniqueness of each sort of life entity, if you will. How do we think about this notion of decidability in the practical context of providing better healthcare to people?

I will disclose to you that I'm working right now on an article. I don't know where it will appear because I'm still working on it, but the major hypothesis is the following: We made huge progress in the chemistry represented by the mRNA vaccine, but we don't understand the biology of vaccination. And, as a result, the mRNA vaccine is the origin of the COVID-19 variants.

Are you aware of this idea? I don't think you are because as far as I know, checking

the literature, nobody else came up with this hypothesis. You can expand on that. I'm currently trying to provide the data that shows from the curves, number of vaccinations, variants, where they occurred, that there is a possible correlation. I'm very careful. I don't want to talk about causation.

Now, going back to your question, it turns out that if I take mRNA, and I inject it… ideally, it should go to the same type of cells in everybody. But the body does not act as a machine. The body gets something injected. In some cases, the injected mRNA stays in the muscle where it was injected. But, in other cases, it went to other parts of the body. From looking at your background, I know that you are experiencing one of the most, how should I say it, "criminal conditions," the great "C word" related to cancer. Now, somebody who is undergoing cancer treatment and gets injected with mRNA will produce copies of that mRNA in a different way than somebody who does not have the condition of cancer. In other words, our conditions, if you will look at them holistically, are such that the bodies will not answer the same way.

That's why in the end, the mRNA never proved to be a vaccine. It was never a vaccine. It never prevented anyone from getting COVID-19. All it did is it made COVID-19 easier for some people. But, as you know, some people fully vaccinated and boosted died, so it's not even a healing answer. But it does have a positive effect.

If anyone would have asked me yesterday—and if anyone would ask me today—vaccination or no, I am firmly on the side of vaccination. But vaccination in the sense of a science that understands biology is not what mRNA is providing. And there are a huge number of variants we are experiencing this winter, and we have no idea why and how it occurred.

There are enough details that we know at this moment to say that this new variant is the result of the last wave of boosting.

One of the big topics these days, obviously, is artificial intelligence and where it's going to go. I think it's pretty clear that artificial intelligence is going to be a very significant part of our lives in the future. I think it's probably also the case that no one really knows exactly how it's going to shape up in the future.

And maybe that gets to the nature of anticipatory thinking in terms of trying, as best you can, to anticipate what those effects might be and how to respond. How do we respond to effects, both the pros and cons, the challenges and the possibilities? How would you describe the challenge that artificial intelligence poses to human society, right now in 2024?

My first instinct is always when I hear this question to say, "Have you ever pulled the plug?" And if you went through the experience of pulling the plug, you understand that we are still in the position of pulling the plug on anything that takes energy from the network. In that respect, I am not worried at all about AI.

If I'm worried about something, I'm worried about how human beings interact with tools that can have exceptional impact. And, in that respect, I am as worried as [people were] generations ago. People should have been worried when the great discoveries in chemistry were made. Why? Because it's very nice to have the chemistry that suits our needs. But it's not very nice when you think about the chemistry that led to the killing of millions and millions of people.

It's a similar situation with AI today. There are beautiful things that can be done. But then comes the temptation to start operating in that gray zone between the useful and the dangerous; the distinction is very difficult to make. The fact that our discussion as it takes place now can be picked up by somebody and reproduced in forms in which nobody can say which is the original and which is the copy is one example.

Neither you nor I would like to be in a situation in which we look at an interview that we never had, in which you and I exchange who knows what kind of ideas, and people look around and say, I know both of them. Therefore, they have credibility. In other words, the capacity to lie, the capacity to misrepresent, the capacity to influence people is tremendous.

I saw, unfortunately, images that come out of the Middle East in which, how should I say it, I got totally scared. What can be faked? In other words, it is a dangerous moment in which things can be faked. What is my answer to it? My answer is never to control it. My answer is never, never, never to submit it to legislation and government control. It will become more and more dangerous. It is

already, unfortunately, under government control, most of it. But it will become even more dangerous if we start regulating it.

My answer is educate, educate, educate. I don't believe in the superstition of this, that, and the other. Educate people. Put them in a position in which their judgment is informed by knowledge and not by impression and not by propaganda. It continues to be done even for chemistry and for physics. Remember how wonderful it sounded?

We have a nuclear bomb. We can beat the bad guys. Think about it. It's easy when you know who the bad guys are. Who are the bad guys in our world today? I don't think that we have the answer based on that model.

The title of your book is *Disrupt Science*. What I take away from the book is not so much to run away from a deterministic mindset but, instead, to understand that it's, first, particularly applicable to non-living matter, and, second, that when we're starting to expand into the understanding of living matter and perhaps so much more, we need to disrupt science by introducing this anticipatory mindset. How does that disrupt science?

It disrupts science in the sense that it gets us away from the myth that doing more physics and chemistry will be the answer to understanding the living and, in particular, the human being. And, second, it makes us aware of the ethical condition of everything that we do. There is no ethics implied in the activity of a machine.

Machines do not have any implicit moral values. Anticipatory activity is—by necessity—guided by an understanding of the meaning of our actions. Machines have nothing to do with meaning. They are meant to perform an operation—maybe a simple one or maybe a very complicated one. We, in our actions, are not so much driven by the how I do it, but the why do I do it?

And the "why" question is supposed to become, in my opinion, the major question of a disrupted science. Otherwise, the meaning of life would be only let's do more and more expensive science, and let's go to the next planet, and let's create the next explosion. Then, let's do the next you name it, whatever, without an understanding of why we want to do that?

What is the impact? What is the return we expect? All of these huge experiments cost more and more and return less and less value. And that is something that people need to wake up to: that they return less value because we do not ask the question of why.

When you talk about disrupting science as trying to cultivate this anticipatory mindset, you talk about it in cost-benefit terms. And as you were mentioning just a few minutes ago, too, the costs vastly outweigh the benefits when we start just simply focusing on reaction.

How is it that the benefits of an anticipatory mindset outweigh the costs relative to the cost-benefit calculus of the deterministic mindset, particularly with respect to living matter—healthcare, the COVID-19 pandemic, artificial intelligence, and so on? Given the nature of uncertainty in living matter, why should you necessarily expect the benefits to outweigh the costs? Why should we disrupt science?

One of my preferred examples is the Bar-tailed godwit, which is a little bird. If you read the book, you read the story of that bird that does 10,000 kilometers, over 6,000 miles, on 4.3 watt energy total for the whole trip. And this little bird is able to fly higher or lower with an understanding that when flying higher, there is going to be less oxygen.

Less oxygen has an immediate effect on the metabolism. So the why in this case is a very simple why. That bird wants to make it; the bird wants to survive.

Those birds, because there are millions of them, are surviving. There are some who do not. That's part of the non-deterministic aspect of life.

If you start looking now at the cost of living on the energy of the future, we're undermining our own existence. Our own survival starts being undermined at this moment. It is not that I'm coming with an optional idea: "People, be nice and start looking at anticipation." No. If that were the message, you're wasting time with me. You can say, go take a walk.

I have better things to do during this time. I'm talking about this notion of sustainability that everybody talks about. Everybody tries to milk it for their purposes: ideological, political, and economic. There are people who make money

by using this word that they don't care for. Sustainability is: "Is there going to be a future for us or not?" And, then, there are some people who say, "Why would we need you if we have AI?"

It just so happens that AI still consumes energy that we are producing as human beings. And once we stop doing that, that will pull the plug on everything and goodbye. Even Elon Musk, who is inviting us to prepare to live on a different planet, realizes that, first, we need to survive.

We might start asking questions about exploring space at the moment when sustainability will make that question a justified question. Today, for me, it's not a justified question. For me, most of the science—as we practice it—is not sustainable. And, in this respect, I go as far as to say it's most of the time unethical. The billions that we put into DNA research, reducing the human being to the DNA, to chemistry is wrong, simply wrong. Because DNA is important as part of who we are.

But guess who does the work in the body? The proteins and not the DNA. The proteins are alive. DNA is dead. DNA is chemistry, period. The protein is the living part. And when I say the protein does the job, we claim that we have AI that can describe the folding of the proteins. Unfortunately, my colleagues in AI are misrepresenting things. They are not able to predict the folding of a protein because in the absence of understanding and anticipation, that process cannot be described.

All they produce is an image of how many kinds of folding are possible. That's based on probability. It turns out that the next protein folding is not going to repeat anything. That is the beauty of the living. That's why one of the major things that I'm discussing in the book is repetition without repetition. I raise my hand signaling to you. The first time I raise my hand and the second time I raise my hand, it looks the same. But it's not. Because in the meanwhile, the muscles, every part of the body is learning from the first experience. The second time when I do the same motion, so to say, it's actually a different motion. Try to do it in a different way than by disrupting science. I don't think it's possible. And I'm pretty radical with this point. Why? If I do not articulate it in a manner in which I'm fully committed to, then I'm wasting everybody's time.

It's another interesting thing. A bird that flies 10,000 miles. So what? I recently went down to Pacific Grove again to see the butterflies. And people say butterflies fly 10,000 miles. No, those are three generations of butterflies. In the meanwhile, they start someplace in New England, way up in the north. They make it here to this place in Pacific Grove. You look at this reality of a huge bunch of butterflies hanging on some trees.

That's their survival. They have anticipation. Otherwise, they would not exist. We would not go to see them. So it's an existential problem. The disruption of science is for me an existential goal ■