CONVERSATIONS ON STRATEGY

PODCAST TRANSCRIPT

Darrin L. Frye
"Nanoweaponry and the Resolution Revolution: Making Danger Invisible"

In this episode, Dr. Darrin L. Frye, associate professor of science and technology and innovative futures at the Joint Special Operations University, discusses the profound implications of nanotechnology in modern warfare. He explores the concept of the "resolution revolution," examining how emerging technologies shift battlefields from traditional domains to the microscopic realms of biology, where threats can operate invisibly at a cellular level. Frye explores the potential of nanoweapons to manipulate human cognition and behavior, raising ethical concerns about their environmental impact and the risk of mass extinction. He emphasizes the urgent need for genetic surveillance to protect against these vulnerabilities and advocates for a strategic approach in preparing for the future of warfare. This conversation serves as a crucial call to action for individuals and policymakers as we face an unprecedented era of conflict intertwined with our very existence.

Keywords: nanotechnology, nanobot, resolution revolution, DNA, genetic information

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Stephanie Crider (Host)

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Dr. Darrin Frye is joining me remotely today from Tampa, Florida. He's the author of "Nanoweaponry and the Resolution Revolution: Making Danger Invisible," from *Emerging Technologies and Terrorism: An American Perspective*. Fry is an associate professor of science and technology and innovative futures at the Joint Special Operations University.

Welcome to Conversations on Strategy, Darrin.

Darrin L. Frye

Thank you very much. Great honor to be here. Thank you.

Host

Those of us interested in history, we're aware of political revolutions like the American Revolution in 1775, the French Revolution in 1789, and I know there are also technical revolutions like the Industrial Revolution in 1771. I am not familiar with the term "resolution revolution." Can you explain what you mean by this and give us some background on why it's important?

Frye

Certainly. It's actually hard to even say resolution revolution. But, to put it in perspective, let's go back about 250 years—and you think about what was the technology like back then? Back then, we started in the steam era, where we're using steam for energy. You can think of the steam locomotives. And basically, it was a surge in technology that was mechanized. We're seeing interesting innovations that were helping us kind of automate things. As we progressed

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through time, about another 100 years, that's when we got electricity. And that's really changed everything—where we saw some interesting automotive advancements, where you see the assembly lines, things like that. As we progress another 100 years, or almost 100 years, then we get into the computing era, starting into the modern era, and we started getting computing and things like that. And today, we are probably at the artificial intelligence era. So, we think that maybe this is the fourth revolution.

Now, let's go back about 100 years, and that was with the invention of the electron microscope. For the first time, we could see down inside the body to the nanometer size. Well, what's the nanometer size? That is where we can see the inner workings of our core codes, like the DNA, even the cells of our body, things that were unimaginably small.

And, we'd always been interested in telescopes and gazing at the stars. This is the same exact thing, only in reverse. The same immensity of space in the galaxy is the same—only in miniaturization. This electron microscope changed everything, and we call it almost its own "resolution revolution," where we are now looking at the miniature world.

Host

In your chapter, you talk about a new battlefield. Some of us are familiar with the term "multidomain," which talks about possible future fighting environments like land, sea, air, and space with all services federated—Army, Navy, Air Force, and the Marines—working together in an integrated fashion. What did you mean when you introduced this concept of a new battlefield, and where does it fit into this scheme?

Frye

Well, it is my job to try to predict where we're going to be fighting next. Most of those domains that we mentioned, the multidomain battlefield, are all well-known—air, land, space, as you mentioned. Also, we're looking at other domains that we have to be concerned with nowadays—all the way to the bottom of the sea beds—which is a complete new area. We also can see things like cyber. We have to deal with cyber. So, cyber is becoming, now, its own domain.

I want to introduce a new domain, potentially, and that is the nano. And, with nano you get a whole 'nother set of issues to deal with. Most of the targets in those other domains are visible targets, except for cyber. Cyber is kind of an invisible. Well, this joins that because this is another invisible threat. And, that's what I mean by a new battlefield. Most of the targets that we have today are visible, as I mentioned, but also, we usually target, we call people, "two-meter people." That's the target. Two-meter people. The new battlefield of tomorrow will be targeting two-nanometer people.

Well, that is a billion times smaller than our normal targets. If you can imagine how hard it is to hit a two-meter target, you can only imagine how hard it would be to hit a two-nanometer target. When you talk about targeting at this scale in the new battlefield, it changes everything. We're not talking about deserts, dense urban environments, or even space. Where does two nanometers make a difference? Well, it's right inside our bodies because that's the code, the DNA. That is the scale we're talking about. And the new battlefields of tomorrow are probably going to be those things, such as the cells that make up our body and our brain and our mind, and the codes that help us create, live, and survive.

Host

In the title of your work, you wrote, "making danger invisible." This really violates the idiom of "what you can't see can't hurt you." Can you explain to our listeners what you meant?

Frye

Well, that may have applied one day in our lives. What you couldn't see couldn't hurt you, but it doesn't apply today because, certainly, what you can't see can hurt you—and probably will! When you talk about the nanoscale, it's something we can't really imagine. It's hard for people to get their heads around. If you think about a nanometer,

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what is a nanometer? Well, a human hair is 100,000 nanometers. Your fingernails grow a nanometer every second. But, when you start talking about that scale—the invisible scale, we can't see it—we now are starting to look at what could you do with weapons that are at that scale or not weapons? Well, you can start altering cells. You can alter even the DNA code. This invisible era is so deadly, it's hard to imagine.

We think of weapons of mass destruction. We think of the nuclear threat. Think about that in the old days—in the '40s and so, where we had our students in schools getting under their desk and doing these nuclear drills. Well, now the threat is not external nuclear, it's intranuclear. It's the cells of our body that have a nucleus. The threat is coming from within, and it's an invisible threat. We talk about weapons of mass destruction. These are weapons of mass extinction, which is a whole 'nother level of threat. I don't mean to get everybody nervous about all this, but this is something that we have to prepare for because once we know more about it, it becomes less dangerous.

Host

Leaning into that a little bit more—about our bodies being the battlefields of tomorrow and how dangerous that really is—you noted that another sinister component of these nanomunitions is they can target our brains. Tell me more about this.

Frye

You think about most weapons, you know, we talk about somebody being shot or some kind of projectile. It usually affects the physical organs, you know, your heart, brain, your body. And we worry about injuries on the battlefield, the casualties that usually are bleeding out or something like that, or destruction. Well, we don't usually worry so much about mental injury or brain injury—other than blasts and things like that.

So, when you talk about weapons at this scale, for the first time, you could actually send a weapon to a specific address. And I'm talking about an address in your brain. Our brains are localized into regions, and each region has its own processes. Some is motor function, some is mental function, some is memory, some is balance, things like that. Some is your personality and your choices—your empathy, whether you care about things or not. For the first time, these weapons, or these nanomunitions, can actually be fashioned so they could target any of those areas. So, we could disrupt somebody's thinking ability.

We could certainly injure them or maim them or put them out of business completely, but I think the threat is almost unimaginable in the fact that we could create almost a zombie effect where we don't kill the person. We just make them make bad decisions because we could literally impair their thinking ability or create paranoia, fear, or something that pushes the emotions to make bad decisions.

For the first time, we have to think about a different type of injury and a different type of threat. The problem is it's invisible and you wouldn't even know it's happening. So, you could have an apparently perfect leader that is quite impaired. And so, you could almost see or envision where you could have this person go back into the troops and be a complete threat and nobody would know the difference. So, for the first time, we have to think about things like this. I wish we didn't, but our enemies are.

Host

So, you just described the size of future nanoweapons, the fact they can reach right into our brains, and I feel like there's more coming.

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Frye

The things I've been talking about were you could disrupt maybe even the neuronal process of the brain or the cells of the body. You also can get down to the DNA code. Our DNA, if you're familiar with, is very small. It's down in the 5- to 10-nanometer range. The code has to be read. If there's misreadings or errors, then you get problems. These weapons are the future. Well, once you get to that level, now you can alter the way a person lives, what diseases they might get, whether they become sterile, whether you just want to eliminate a certain population—because each of us has our own unique DNA code and certain ethnicities would be targetable. So, you could literally wipe out females. You could wipe out males over 20. You could alter all kinds of things. The devious thinkers go crazy with this, but it's worse than that. We share our DNA with the living world. We share over 80 percent of our DNA code with cows. So, you can imagine that the humans may be the intentional target, but there may be unintentional consequences as the living world could also be affected by munitions that are targeting DNA codes. There are some people that think that we share 70 percent of our DNA code with bananas and 40 percent with beetles, things like that. Everything along the entire food chain has DNA.

Weapons may not even target us intentionally. They may target somewhere in the food chain. You can imagine the economic damage if our enemies would wipe out the cattle population or knock out all the Holstein cattle so that causes milk shortages. These are weapons of fear. And we might be able to live through a catastrophic species extinction. If we lose wheat, we would probably work around that. But the fear is something that would be much harder to fix. And that's kind of why terrorists are going to really be looking hard at these type of nanomunitions—because they are available and they can produce significant fear, because once we lose trust, we lose a lot. But, I'm concerned about the entire environment, not just the human targets. I'm talking about the living world because it's all related, and we all share so much in common all the way down to our DNA code.

Host

If these weapons are so powerful, and they're invisible, is there anything we can do?

Frye

This is not something we can just hope it goes away. It's a wave. It's here. It's coming.

The good news is that the weapons that are going to be used against us, the same technology can be used to prevent. But, there are certain things we need to do, and I mentioned that in the chapter, that we not only need to work on the science part, we also need to work on the regulations and all of the relationships—try to prevent this from escalating to something that is unrecoverable.

As I mentioned, it's a species extinction. One thing we definitely need to do is we need to know what our ground state is because if we don't know what our own DNA code is at rest, we certainly can't tell if it's been intruded. The repositories of the DNA need to be done immediately. All servicemembers get their DNA taken when they enter the service, but those are not run. Those are just kept in case of an emergency—in case they need to match remains. We need to run all of those and have everybody's code, their base code, documented, and then we need to be checked periodically to see if we have intrusions because we wouldn't know unless it kills us. And, then we could find out perhaps on autopsy, but that would be the only way. And if we didn't have the original code, we wouldn't even know what killed.

These are not only invisible weapons. They leave no trace. We need to look at our DNA codes and storage, keep them secure.

Well, we need to protect our DNA first. This DNA code is your personal address, and it not only keeps you alive and healthy, but it also could be your address of unwanted effect. We need to run the DNA code so we know what

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baselines are.

And then, we need to use the same tools—the nanotools that produce a weapon can also be a repair agent. We have natural repair agents in our bodies, but we just need to amplify that. In today's world, with the new CRISPR technology and some of these technologies where you can do gene editing, combine that with these nanotechnology, nanorobots, we can actually have these nanorobots scouring our systems and cleaning up DNA that might be intruded. Yes, there's a lot we can do and we have to do, but we also need to look at the DNA of our environment—not only our animals that live with us, but also the crops that we produce and the ground that we walk upon.

All these things need to be done. Plus, we need to get our legislators helping us with that—with regulations. And then, we need our commanders and our command and leadership to realize this is what we're up against and prepare the best we can in case of some kind of an issue.

Host

Unfortunately, we're running out of time. I am dying to know, though, as you were doing your research, did you find any surprises?

Frye

I think the biggest surprise was I didn't realize that the problem was bigger than us. I think the thing that surprised me the most was how vulnerable our environment is and how easy it would be to disrupt that environment. And the systems that would be used to do that are not that complicated, but the seed modification could be easily used in a nefarious way.

The technology for creating nanorobots that would affect the brain function could be further away. It's certainly more expensive, so less actors could get to that, but the crude tools that could affect the environment are much cheaper and much more likely to be used first.

The fact is that we don't have any real documentation of our DNA codes, so we wouldn't even know. There are some great people working on taking DNA and running DNA of all the living world. But, of course, you can imagine the amount of species of—let's just say, insects. To run codes on all of those is going to be quite the effort.

We now know the entire genome of the human. We know the entire genome of many, many things. So that's a good start. I think the surprise is the enormity of the problem, the enormity of the vulnerability, but also we need to temper that with the excitement of the possible—what we can do to recover mentally and physically is still significant. So, I think there's more surprises. Another thing is that we talk about nanotechnology as if it's a single entity. When you start looking at the other artificial intelligence and quantum computing, virtual reality, you start mixing these with nanotechnology, we're starting to create a whole new set of technologies that didn't exist before. We're seeing nanotechnology in paints that reduce friction, for example. Or, we're seeing nanotechnology in paint that will make it invisible.

I think there's unlimited surprise. It's fascinating. It's scary. I think those are the main things, is the vulnerability. And, to tell you the truth, I work with [Special Operations Command or] SOCOM, and we look at the priorities of the command and the technologies they're watching. You look at the United Nations, at NATO, all their scientific priorities—nanotechnology is not on any of them as a priority. To me, that was a surprise. And, that's kind of my mission is to take this work and publicize it. And, that's why I'm grateful that we have such a wide audience. And, I hope it can make a difference.

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Host

Do you have any concluding thoughts to share with us before we go?

Frye

I appreciate the time, and I love what you guys are doing. When we talk about the battlefields of the future, I think the one thing I'd like to leave us with is that we are the battlefields of the future. It's not some distant land and it's not some unusual space or anything. We are the battlefield of tomorrow, and we need to prepare for that.

Host

Thank you so much, Darrin.

Listeners, you can download the collaborative study at press.armywarcollege.edu/monographs/967.

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I learned so much from you today. I, truly, I appreciate your time.

Frye

Thank you.

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