Announcer: Bulletproof Radio, a station of high performance.

Dave: You're listening to bulletproof with Dave Asprey. Today's cool fact of the day is that a keto diet may protect your eyes or at least if you're a mouse and probably if you're a human. According to new research published in the journal of neuroscience, switching mice destined to develop glaucoma onto a low carb high fat diet which is the template for bulletproof although it's not always keto, but it protects the cells of the retina and their connections to the brain.

Dave: The study adds to a bunch of other findings that this kind of diet has neuro-protective effects on Alzheimer's, Parkinson's, and ALS. You might have noticed that a lot of the research in my book, Head Strong, about mitochondria relied on research on those three things because when the brain breaks that's bad. When you do things that make broken brains heal, and you do those to brains that are already well, they kick ass more which is the whole idea behind it.

Dave: In the study, they concluded that higher rates of glaucoma in people with diabetes also suggest the potential connection between that eye disease and metabolic stress. The reason I'm bringing this to your attention is that when you make your metabolism work better, your risk of every disease, and your risk of dying from any cause other than a piano falling on your head goes down, and there's no double blind clinical trials on pianos falling on head either but we just know that. Now if you like bulletproof radio, you like what you hear. I would love it if you took a few seconds to go to bulletproof.com/iTunes which will get you right over to the Apple page where you can leave a five star review and say hey, this show is cool. I'd appreciate it.

Dave: Today's guest is Andrew Hessel. Imagine building something like a cellphone or a car or a house and that one thing just reproduced itself. Well that's the idea behind what the human Genome Project-Write or GP-Write intends to do starting with the basics. They want to build a human cell from the ground up and complete with all the DNA that's required to produce more human cells. The idea is that by mastering this technique, we could wipe out disease that we just don't understand yet, because in order to build something from the ground up, you have to understand it in a way that you don't understand when you're looking at something that's already built.

Dave: Andrew, today's guest is a CEO of humane genomics which is a C stage company developing virus based therapies for cancer starting with dogs, and he's also a co-founder of GP-Write or Genome Project-Write which is an international scientific effort working to engineer large genomes including ours. Welcome to the show.

Andrew: Thanks for having me, Dave.

Dave: When I decided I wanted to interview you, I checked you out and GP-Write, the human Genome Project-Write is one of those things that sounds like science fiction and I looked at what you're doing, and you've described yourself as a synthetic biologist which is a set of words that did not exist even 15 years ago. What the heck is a synthetic biologist?

Andrew: What's a biologist? What's a molecular biologist? Synthetic biologist, it's a new field where you don't take apart genomes and try and understand what they do, that's the reverse engineering of biology. It's aspiring to go and design and build genomes from scratch and if you can build a genome from scratch, you build organisms from scratch. The two are completely linked.

Dave: You're starting your work with viruses. But to-date at least in my understanding, no one's ever been able to build a life from the ground up. We have put all the building blocks together but there's some animating force to quote 17th century alchemist or something that makes it turn on, and start working. Have we cracked that code yet?

Andrew: Well, there's a group of people that are trying to crack it at the very low level and build all the cellular machinery from the ground up. But I take a different point of view, and again I speak for myself, not the field. But all life from this planet, from a simple bacterium to all the way to you and me and plants as well have a common architecture when it comes to how the cell operates.

Andrew: So it's essentially conserved even though there's millions of species of animal so you don't really have to build life from scratch. The only difference between these different organisms is really their genomes. The genome with the common architecture, the machinery of the cell can create massive diversity. So I'm not out to create new life forms in the sense of rebuilding architectures from the ground up. I'm just out to reprogram them and make new versions of life forms.

Dave: So you're going to start with a platform that's basically a bacteria or virus or something, although viruses may not really be alive and then rebuilding from the foundations up rather than assembling a bunch of amino acids and fats, and saying there you go, I've got a life form.

Andrew: Well, you can look at it this way. The machinery of life is conserved and has been for 4 billion years on the planet. Think of it as a really powerful printer. All you have to really do to make a new life form is just create, send new code to the printer. So I'm not out to rebuild life from scratch. I'm just out to learn how to program it and make versions of life that do really useful and powerful positive things.

Dave: If you took off your what's possible glasses and project yourself 50 years into the future and you had unlimited resources, what life would you create?

Andrew: Wow. No one has ever asked me that. I tend to be very pragmatic and I tend to work bottom up, so just as a foundation. The thing that I did talking about recently because it's really pragmatic is I've got two young children. One is three and a half, and the other one is nine months. The types of things I want to build are things that just make it easier to support kids because that's what I'm thinking about on a day to day basis.

Andrew: Honestly, I talk about the milk dribble. I want a small fury object with a nipple that just produces milk, so I don't have to make bottles, I don't have to ... I can actually feed the baby, and if it purrs and coos, that would be terrific too. Once it's been drained, this disembodied breast, put it in the garden, it grows into a beautiful flower, so that's one thing I'd like but on a more pragmatic basis, I'm not a much of a homeowner, keeper, maintainer, I would really just like to plant seeds and grow homes. I think that would be totally awesome.

Dave: So now you're entering the world of Cyberpunk, Neil Stephenson sort of science fiction where you have this idea of you plant a seed that would really could grow into a tree that has the components of a house and is alive?

Andrew: Why not? Why chop the trees down and plane them and make lumber when you could just have a large object that's made of wood, it's living, it's photosynthesizing, it's maintaining the right temperature for human in habitation, it just seems like we've got this incredible machinery now, the cell to start working with, and we really don't know how far we can take that machinery in terms of science fiction.

Andrew: We know where it's been limited in terms of evolution in nature but nature's got a different, really different set of objectives compared to human intention. So I'd just like to see how far we can take the cell.

Dave: Are we going to see that in our lifetimes?

Andrew: I think it's going to happen quickly. These things tend to start off pretty slow because you're feeling them out, you're learning the basics, but the beautiful thing about life if you can look at it as a manufacturing platform the way that I do, it's everywhere already. It's universal on this planet. It's deep as you can drill a hole, you'll find microbes, clouds are filled with microbes. Life is literally everywhere, and there's only one programming language and it's been the same language for billions of years.

Andrew: I think the more that we people get into this and start to concentrate their research and development and put it into a community, the faster this is going to snowball. It's like you don't have to go build a new factory. The factories are already there. You just have to learn how to put a design into the factory.

Dave: You're a faculty member at the Singularity University and I've lectured there and I joined faculty position too, even though I've never actually taught a class there and one of the things that they cover there is nanotechnology, and the idea that well, we don't have to make life forms, we can just make tiny little robots that self-replicate and do essentially the same thing that life does.

Dave: But one of the scenarios that we come across there is the grey goo scenario where you make the wrong robot that turns everything it needs into another nano-machine and pretty soon the whole planet is basically lifeless except for little robots trying to eat each other. How do you know that you won't make synthetic biology that just makes organic grey goo?

Andrew: Well, I remember a synthetic biologist. One of the founding people of the field of synthetic biology, Tom Knight laughing at this idea and saying biology is nano-technology that actually works.

Dave: Exactly.

Andrew: When you look at the machinery of the cell, it is nano-scale. But it works with a very different set of principles. I think if you just take a look at bacteria and fungi and other, just single celled organisms. That's what takes complex objects and decomposes them back into the goo that other things grow out of. We call it soil. So I don't really have a fear of creating a biological goo that just turns everything into mush.

Andrew: That's what happens after we die. So I suppose the closest thing to that would be some sort of pandemic where knocks at most life. I think that if that type of thing could spontaneously arise, it would have already have been tried out by nature. I think in general, nature is the most secured technology there is. It is really hard to hack biology. There are numerous safety systems and checksums and mechanisms, compared to computers, it's just not that much of a worry for me.

Dave: That's a fair answer. When I wrote my book, Head Strong, about mitochondria. I delved into the realm of quantum biology which is, you say the word quantum and immediately you've got people with robes and crystals and things like that who are using the term, but it actually is a real term in quantum biology and there are strange quantum effects happening where DNA releases a biophoton per a femtosecond every 40 seconds or so, and we know that mitochondria communicate via lasing, also biophotons, and there's quantum tunneling going on inside there. Do we really know enough to build that from the ground up? Because it seems like there's some things going on in the cells that cellular biologist don't understand yet.

Andrew: I completely agree with you. I look at just an average enzyme. One of these biological catalyst that turns substrates into different products as being almost magical chemist. They do things that organic chemists can only dream of. So we know that they're manipulating matter in ways that we have a lot of difficulty understanding today and even modeling because as you know, some of the effects are quantum that they've been able to tap into.

Andrew: That being said, you don't have to understand all of the machinery of the cell to be able to reprogram it because you just have to move up to the level of DNA code and programming to be able to understand how to build certain structures. The more you can understand in model, the better, but we don't have a unified model of even a simple cell the same way we have a unified model of planet earth as we do with Google earth where we're constantly layering on more and more detailed information.

Andrew: So the cell is clearly a very complex machine, but I think as we start to focus on doing this type of modeling, as we start to really build a field of biology that isn't just a few specialists, that is really like much more like the field of computing, where you get people form basically all walks of life, all industries kind of adding to it. I think we'll start to crack some of the lower level problems below the programming of DNA.

Dave: What's the timeframe you think that's going to happen in?

Andrew: Again these things are all accelerating because again if you look at, if you just look at the DNA sequencing world where the human genome project was launched in 1990 with a $3 billion budget in a 15 year timeframe, it came in two years early and on budget which for a government project almost never happens and that's because the technology of reading DNA advanced so quickly even during those 15 years that they were able to hit their targets.

Andrew: Since the genome was essentially complete in 2003, that technology has only continued to accelerate. At times outpacing Moore's law by over 500%, and it's not over. Today you can go and get your genome, complete genome. Not just sampling like 23andMe. Your complete genome commercially for 18 months for under $1000. What I hear is that it'll be as low as $200 in the next 12 months. If you grant that there's always some caveats, but that's amazing to go from billions of dollars to a couple hundred bucks in a timeframe of under 20 years. So I think we're going to see the same thing on the synthesis side and even on the comprehension and design side as we start applying the latest efforts in computing and in DNA synthesis.

Dave: How is this going to affect our everyday lives in five years?

Andrew: I think that you'll start to see it soonest in the world of DNA sequencing. Already I've been impressed that DNA sequence, DNA testing, let's just look at it as testing has exploded in the last couple of years. It's just taken off. To day you see ads for 23andMe, or ancestry, or national geographic, all the time. They're big sellers on at Christmas time or on prime day. That's amazing.

Andrew: DNA testing has suddenly become something we're a lot more comfortable with. I think what we're starting to see now is kind of a next generation testing industry that's going to explode and not bring in 5 or 10 million people. I think they'll figure out the business model so that everyone can be sequenced in the same way that basically anyone that wants one gets a free Gmail or a Facebook account.

Andrew: I think we're going to see. I think the trend in DNA sequencing is that it's going free and probably will flip to actually starting to pay the contributors in some way, to incentivize them to join. So I think in five years, we're going to see a mushrooming of DNA testing which will bring millions maybe hundreds of millions of genomes online over the next decade and that's just going to be a giant sandbox for accelerating R&D in life science.

Andrew: As well as allowing us, and by lowing the cost of sequencing in general. Allowing us to sequence the world around us, whether it's our microbes or plants, animals, that we share the environment with. So that's going to be the biggest change, and all of that is just feedstock for being able to better design useful biology going forward. But the DNA synthesizers and even the design tools have lagged the reading of DNA and tools for comprehending and trying to figure out what that DNA does.

Dave: There are some parallels from my career in technology. Many people by now have heard of CAD or computer aided design and almost everything you buy today was designed on a computer first so you can look at how it would rotate in space and then it's sent to a machine that makes die parts and cuts it and things like that or cast it. That includes the lid to your ready to drink bulletproof cold beer. That was designed on a CAD machine somewhere, or CAD software.

Dave: And then about 25 years ago, they started taking those tools and saying why would we use them to build structural steel, why don't we use them to design semiconductors, and I did a lot of work in my early career, I'm putting in a company called Synopsys online, which is one of the big public companies doing that and it turns out that companies were spending hundreds of millions of dollars trying to make it more efficient for an engineer to line transistors and the right way to do something, and the visualized on a computer was really powerful.

Dave: Those tools are mostly missing for biology, and you still see biologists talking about A, C, G, and T. But you never see computer scientists talking about zeroes and ones, because they have a language and a design environment to write code. When am I going to be able to tell my kids, hey go take a class using this graphical design tool to build some DNA to do something cool?

Andrew: That is an absolutely great question, and I've said the same things for years. In 2012, I joined the largest CAD company in the world, Autodesk with the intention of helping them build a bio-CAD, and in fact they did a very good job on that front and they have a tool now called genetic constructor.

Dave: There is one?

Andrew: Yeah, they made one. Now there's other groups coming along. One of the more interesting ones is a company called Asimov that really takes the circuit design from EDA, electronic design automation, and directly using that language moves it into biological circuit design that can do really high order logic and it's remarkable so you've hit the nail on the head. The day we can sit there with the design tool and draw the organism that we want, I want a dragon, and let the software figure out the complexities of the cellular and metabolic designs and just hit print, that will be really cool. We're not there yet, but I can tell you that's what the field is aspiring to this century.

Dave: I published a report a couple years ago on my Facebook page about a biologist somewhere, who said there's a problem with a moth that's eating some agricultural crop, and it turns out there's a type of mold that kills the moth. So we just tweaked the mold a little bit. We just added a really strong neurotoxin from spider venom and something else from a poisonous snake to the mold, now the mold kills those moths really well so we let it go.

Dave: I'm not making this up. Now I did a documentary on toxic mold and how we had an incredible expansion of Aspergillus and Fusarium, making way more toxins than before that are affecting human biology at the mitochondrial level and others, even DNA damage. Now if we have the tools you just talked about and we put those in the hands of crackpots like this biologist who said let me solve a short-term problem and create a giant big problem. Do we really want everyone walking around with dragons?

Andrew: Well, probably not. I actually don't worry about the dragons so much as the way you say it, just things like viruses and single-celled organisms that replicate very quickly and are pretty hard to wipe out. I usually say that anything as large as a chicken or a pig, we're pretty good at hunting but when it comes to the microorganisms, we just don't have the right tools for that. So no, you raise a really good point, and this is one of the reasons why I think that the genome project write is just so necessary today.

Andrew: We need to start thinking collectively. I mean humanity, about some of the opportunities and risks with these types of technologies. We've had agriculture for millennia so we know that agriculture is a very good thing, being able to do selective breeding of crops, being able to manage animals and plants and even forests and ecosystems is important for humans to survive on this planet.

Andrew: The tools and the platform of biology from a cellular level is universal, we can't prevent access to it. So we have to start thinking in new ways about how we channel this stuff for good, and how we defended against bad. The problems are very similar to what we've been learning by doing with the Internet. The Internet is the platform, could be used for good or bad. Today most of our lives are tied in some way to the Internet and electronic systems, our economies are tied to it.

Andrew: We know that there's risk but we don't prohibit the system. We've learned how to ... we're learning how to regulate it and manage it. I think we're going to see a lot of the same types of lessons that we're learning in cyber security be applied to biological security. But I like to point out, biological security has already figured out a lot of those lessons. It's a two way learning.

Dave: It's called an immune system.

Andrew: Right, and the immune system is amazing because it's actually a molecular defense against most foreign molecules.

Dave: The bigger biological approach and the one that you and I probably aren't friends with is one that's well-known in computer science. It's called redundant array of inexpensive systems. You might have arrayed hard drive. That means you have five hard drives in case one fails, so the way mother nature designs things. We've got a few billion people. I don't care if a billion of them fail, the other ones will keep the life going.

Dave: If you're one of the billion that failed you probably didn't like that outcome and that's personal interest versus billion year time span biology interest. It's very true, the mother nature doesn't care about you or me or any one person at all. They care about is there enough life to sustain itself, if you can even describe caring to distributed system immersion like that.

Dave: I want to go back. You talked about what will change in five years and it's genetic testing. I sequenced my genome three or four years ago. I've got a big binder with all the stuff. Mostly it said you have a 10% risk of this, and you have an 8% chance that you carry some gene that could make a defect in some of your offspring and you metabolize caffeine this way. But in terms of actionable information, it seems like almost everything is epigenetic, if your risk is a little higher than this then don't do the things that would make that gene turn on.

Dave: How much epigenetics, this idea that the environment around you chances genetic expression. How much of that goes into GP-Write and the way you think about things, maybe instead of editing your DNA, just turn on the lights in the morning?

Andrew: I agree. The field of epigenetics only came after genetics, and it's even younger. So I can't say a lot of that is baked into GP-Write, but I want to be clear, GP-Write wasn't started because we need to make more human genomes. That's not the point. I want to just to give you a little bit of history. The first genome project was founded in the 1980s really as a grand challenge and back then we hadn't even sequenced a bacterium.

Andrew: We'd only sequenced a few viruses, so when a scientist came along and said hey, let's sequence the human genome, it was a big aspirational, really controversial project. Today we realized there's more and more value coming out of being able to read human genomes in many different fields. It's still very early because we don't have many people sequenced yet, and it's still a very specialized field, but it's starting to open up, and we'd never go back.

Andrew: With GP-Write, I was watching the field that is called synthetic biology start. It was like watching the electronics industry start. People were starting to design and build genetic structures, first at the level of proteins, doing that for the bio-tech industry, then metabolic pathways. Being able to string together a number of enzymes to make a high value product using, assembling, essentially changing the metabolism of a cell.

Andrew: There were a few groups, Craig Venter in particular that was focusing on making synthetic, writing the entire genome. So most of that writing is copying. Because if you break the genome, the organism isn't going to grow, and all the money you've made into making a designer genome is going to fail. But it's starting to get to the point where you can do this design.

Andrew: I was watching a number of companies pop up, synthetic genomics being one of them, Ginkgo Bioworks, one of the more successful groups in the field, Zymergen and others, start to pop up and start to focus on application development which is a really narrow specialization of this technology. You have to focus if you're going to do a business. I saw that there was kind of a need for scientist to come together globally to build, to really start thinking well in the same way that reading and genome has opened up genomics and medicine and health and forensics and other things, we really need to start thinking about working together to create a design platform. Not just technologically but in terms of society, for writing larger genomes. Plants, animals.

Andrew: Eventually one day human genomes. But part of by putting the human in front of it because it was originally called the human genome project-write. Putting human in front of it engages humanity. It gets people listening because we're all human. If it's the dog genome project or the most genome project, most people aren't going to pay that much attention. Making it the human genome project-write really got people interested, and then we ended up getting rid of the H and just calling it genome project-write because it's not just about humans.

Andrew: It's about being able to understand and deploy platforms, tools, scientific resources to be able to write large genomes, and to do it in a safe and responsible way. To have standards, to look at the intellectual property, look at the ethics, look at the defense systems, the safety engineering, et cetera. It's about creating this umbrella, and yeah, this is a technology that many people today think is science fiction but it's going to come fast and hard just like reading DNA did, so I think it's just better to get ahead of the curve. I've been delighted by how quickly the project has brought together scientists from around the world to really start this engagement.

Dave: It is a meaningful scientific achievement and it's something that as the guy wrote the definition of the word bio-hacking which has become a field. The reason hacking was important to me is I come from computer science and when a company writes software, you simply don't know what's in there, and what hackers did is this, hey, we're at Linux, you want to see the source code? You want to see what's going on in there, we'll let you do it.

Dave: In a biological system, there's always something that works to grow and something that works to counter that so we have predators and prey that keep each other in balance. I feel like hackers actually keep big dumb things from governments and big companies, private enterprise from doing really evil things, because we actually know how it works, and what you're doing there is either stupid or evil, and it's a requirement as we continue to evolve our ability to edit our own DNA.

Dave: There's an open discussion and that the science is available and it's not only for the military use to create super soldiers and stuff that's actually happening in various countries around the planet today where they're working on little secret programs like that. I'm not talking Captain America, Avengers kind of stuff, but this is there, if you dig around, it's not conspiracy theory stuff at all.

Dave: It's yeah, here's a proposal to see what happens. You can see where that goes if the rest of us don't have access to those tools. But it's all still kind of academic which is my concern here, am I going to be able to use this to edit my DNA? Because I've got some stuff in there that I want to upgrade. Are we going to be able to use the viruses you're using to cure cancer in dogs? Can I just take a couple of those and just upgrade a little bit of my mitochondrial function, change my hair color, I don't know. Come on, give me some good science fiction stuff that's actually going to happen.

Andrew: Well, okay, I'll speak for myself. Again that's all I can speak for on this front. The reason why I focus on viral engineering was is they're the smallest genomes, and most people don't realize the first one was synthesized in 2002, it's been 16 years. In those 16 years only 25 synthetic viruses that I'm aware of had been engineered.

Dave: Including small pox? They've recreated small pox from scratch.

Andrew: No. They didn't make small pox. They made horse pox. A very close relative.

Dave: Got it. Thank you

Andrew: The first synthetic virus was polio. Not the best ambassador for the field but that being said, I've spent the last, I really spent the last 15 years going out and saying well these synthetic viruses are going to be pretty important because viruses are essentially USB sticks for biological cells. They drop programs in. It's not like a USB stick that has a standard port because cells are all different so you get viruses in all different shapes and sizes, but the core functionality of a virus is just to drop new code into a particular cell organism.

Dave: If you think about it, the last I've read and you probably are more up to date on that. 8% of human DNA is viral in origin.

Andrew: Yes. They're deactivated retro-viruses that brought in blocks of code over our evolution. Because otherwise, you only get random mutation in the copying process or maybe a bit of duplication and evolution in that sandbox, but viruses have the ability to bring in fairly large chunks of code and actually incorporate them into the genome permanently so I look at them as the IP packets on the biological network.

Andrew: So they're absolutely essential in evolutionary processes and yet there just wasn't a lot of activity in doing synthetic virus engineering, and I mean the beautiful part about doing synthetic viruses is you have atomic control over the design of the virus. It's not like you're working with a stock of the virus from a freezer, or from an isolate, from Africa, and you have to sequence it just to ... did you pull the right virus out of the bridge.

Andrew: This is where you sit down and can start doing tab on the virus design. Just doing virus fabrication and getting better at it should give the ability for people to create biological apps for virtually any application whether it's to kill a cancer cell or whether it's to add a new feature or function into a human. One of the viruses that I absolutely love is a virus that it's been evolved and selected to have really high efficiency transferred to the retinal cells of the eye.

Andrew: It's part of a project to cure a certain form of genetic blindness. You just replace the code in the retinal cells that's defective and boom, your eye starts to work again. But I love the idea that one day I would just be able to put in code to give myself an expanded range of vision into the [inaudible 00:35:40] or et cetera. So that's possible. Now how do you get to that point in any type of reasonable timeframe? I think self-experimentation is going to be a part of that.

Andrew: I can't see how it's not. The bio-hackers are getting more and more sophisticated but they're also getting ... they're also building much more of a community and generating their own forms of oversight and for the better part, regulation. If they do something stupid, it makes front page news.

Dave: It does, and I feel really strongly around this whole concept of medical or biological freedom, and only one of the founding fathers in the US was from medical field, and he warned there will be great medical tyranny if you don't put this in the bill of rights and all the other business, and attorneys told him you're crazy, and didn't listen to him, that was Dr. Benjamin Rush, by the way.

Dave: When you look forward to where we are now. I think that there's a great argument that says look if you want to create a virus that does wacky stuff to you, that including may kill you. Go for it, as long as it's not transmissible, and there's I think a very firm ethical line there. But right now, you have to leave the US to do the coolest stem cell treatments to experiment with viruses legally unless you manufacture it yourself but if you buy a virus from someone, you want to use it on yourself. You're somehow breaking the law or doing something you're not supposed to do.

Dave: Do you see that changing or do you see some countries having massive advantages like Singapore or India where you can do medical experiments on consenting people who are probably going to die anyway and you could just do it whereas in the US, you might think about that for 20 years while the person waste away, is this going to change here?

Andrew: I think it has to. Whenever I've had the opportunity to speak to government here in the United States. I've pointed out that there are some really strong headwinds, and it's not just the United States, it's the west. In part because there's many reasons, some of them are religious. Some of them are, there's a legacy bio-tech industry that doesn't really want to see new entrants come in that have access to these types of tools that cost a fraction of the old tools, the old approaches.

Andrew: When you start doing self-experimentation, you're going to create a little bit of noise and activity. We saw that when computers went personal. But I don't know how, put it this way. It would have to be really prohibited and restrictive to block this type of activity in anywhere in the world so I think right now we're seeing the proliferation of bio-hacking but we're also seeing some countries and I was in Hong Kong recently by invitation, I'm going to Singapore by invitation in January.

Andrew: These are countries that are really looking at bio-tech as the next big platform. They're making it easier and supporting people to try new ambitious projects and clearing a path to market in a much more progressive way than I'm seeing in the United States right now.

Dave: I have a friend who was going to have children with very severe birth defects, knew it genetically. The guy is very successful so he and his wife went out out of the US and edited the DNA in their own germ line to remove the genetic defect, so their children were born healthy and their children's children have zero chance of having that thing, that had been in his family for a very long time. That's already happening.

Andrew: Yeah.

Dave: I think it'll be normal in 10 years, we're going to have kids, let's just check out our genes and make sure everything is legit. And if it's not legit, let's just do a little tweaking but it's a very fine line because by the way, this one thing, this one gene that we know is associated with very high intelligence and there are actually several genes that way. Why don't we just toss a couple of those in there, and we are going to, whether we like it or not with GP-Write and other project that we're going to fundamentally change the speed of evolution of the human species, and I'm all for that. Do you agree that that's going to happen or do you think that's a good idea?

Andrew: I think it's unstoppable, I'm kind of a fan of Kevin Kelly, and some of his writing, what technology wants?

Dave: He's been on the show too.

Andrew: Yeah. I really believe that it can't be stopped. Once a technology exist, it's going to proliferate. You just want to steer it towards good, but that's not the technology, that's not what technology does, that's what intention does, and so I think we have a responsibility to as a society to use these technologies in positive ways. I think you hit the nail on the head when it comes to understanding, when it comes to giving our kids a leg up.

Andrew: Today we give parents a leg up in having kids with IVF technologies, and these are still continuing to evolve and improve. I think we just crossed the 40 year anniversary of the first IVF baby last July. Today it's pretty much accepted, controversial then, accepted today. Could still room for improvement, let's make it $500, instead of $15,000. Okay. Great. When it comes to editing our genomes, I think if it's so that our kids will be born healthy that's great, and I think you can make the case for that.

Andrew: It's genetic surgery. We use every other type of surgery to make a kid happy and healthy. Genetic surgery is just a new tool. When it comes to giving them, adding genes to them to give them a leg up, I think you just have a slightly higher bar that to ... you have to have the body of work to basically demonstrate that you're not going to break them, and that comes with animal studies and being able to do this type of engineering in animals, plants, et cetera.

Andrew: We get better at those technologies, we become more comfortable with it. But yeah, then there'll be some people that will just try it because the environment is more permissive or they're just not afraid of the technologies, and they'll separate from the pack. They might even be criticized for a while but then as the results start to get better. It's a lesson for everyone.

Dave: As their children becomes adults that are hyper-intelligent and super strong and long-lived and everyone sees what happened, they're like maybe I should have done that. Maybe we want everyone to have this instead of just a few wealthy people.

Andrew: It may not necessarily be a biological fix. Again today we're intelligent just if we have the Internet because like we are, I need the Internet to reinforce a lot of my conversations today. Just because I, my brain doesn't remember the facts. I don't know if I want a brain that remembers facts perfectly because I've met people with some of those savant abilities and they've had, it's hard to move on if you can't forget.

Dave: They also, those extreme intelligences and those other skills usually come with other neurological atypical things, autism, schizophrenia, all sorts of stuff like that.

Andrew: When it comes to strength, that personally never mattered to me so much but then I like heavy equipment and okay, maybe they'll one day we'll have the mutant Olympic games and people will just push these technologies in their bodies in whole new ways. I don't know, but I've had serious conversations with people that are looking, well how do you change humanity so we can better survive in space and not get bone loss or go and live on Mars, and create a society there.

Andrew: I think these things before they happen, you tend to think negatively and then when the situations arise when you need them, you start to apply them in positive ways. You can't really rush it.

Dave: I've had the great fortune to chat with the founders of the XPRIZE. The people who founded the XPRIZE. The first prize for private exploration of space or at least private space travel, and they don't all believe this but I fundamentally believe that if we are going to colonize other worlds, the first place to start is in hacking the human body because we're just too frail for that kind of stuff and if life evolves to survive in certain environments, we're going to have to force that evolution to survive in environments that aren't this one.

Dave: People say that means you're playing God. If that's what you want to call it, okay. But that's not the intent here. The intent here is if I want to be able to survive somewhere or maybe I won't because my biology is already off to the races, but if we want to make people who can survive somewhere else, they're probably going to be a little different genetically than we are, and maybe that's a good thing.

Andrew: Well, I think even before we start modifying ourselves, I had a conversation about this recently on another podcast. I think you have to start modifying the plants and animals that you're bringing to sustain you somewhere else, and so you start building up this understanding of what is a positive change to survive in these new environments, and then we know how to engineer ourselves moving forward for better.

Andrew: I think it's actually hard to sit down and make a change in humans before you build up the support system for that. But yeah, I think it's time that we start recognizing that biology is a really powerful and accessible technology like computing. Computing is what's giving us a lot of the capability to tap into biology and understand it and manipulate it. But I think it's time we start recognizing that this is a, it's going to be one of the foundations for moving forward as a species. We're not going to get rid of computers, I don't think. And I think we're going to start using biology a lot more and the intersection of those two fields is incredible right now.

Dave: It is one of the most exciting times I could imagine to be alive. It's always hard to see how rapidly the changes will come because we always look backwards, and we don't even have a very good 25 year history but you look at the $20,000 mobile phone, $20 a minute to use it, which existed in my lifetime, and the dollar cellphones are all over the planet now. The same thing is happening in your field which is amazing and one of the first applications that we haven't talked about yet is you are making viruses to cure cancer in dogs. Tell me about that.

Andrew: Well, it started off pretty easy. I want to build genomes. My resources are limited. I don't have a bio-tech company behind me. In fact, I was working with Autodesk, so we had design tools. I needed to find people that were interested in making designer viruses and helping them do it digitally and so that's what we did. One of the first people that I worked with was a Stanford researcher by the name of Paul Jaschke, that had experience with a particular virus that infects e-coli bacteria that had been very well studied.

Andrew: That the virus was called Phi X 174 and it was like the second synthetic virus made on the planet back in 2003 so we learned how to make a synthetic antibiotic essentially and then I started wanting to try it in cancer because every cancer is different, we know that just from sequencing. It's kind of an infection of your body with your own cells. I believe that we need to have personalized treatments to beat cancer and viruses just are all, it's a way to drop code into these cancer cells to kill them but it was already a pretty big field in doing cancer fighting viruses.

Andrew: I just wanted to digitize it. So I found a veterinary group that had run a clinical trial in dogs for a type of bone cancer that dogs get. They had already made an engineered virus that targeted these bone cancer cells specifically and run the trial. I just approached them and said how would you like to start doing this digitally? How would you like to design and build the virus from scratch, and just we'll just copy the recombinant virus, the engineered virus that you made is kind of step one but put in a bar code so we can demonstrate that it was actually made from scratch digitally.

Andrew: But then let's learn how to really crank this wheel and take biopsy information from an animal with cancer, make a custom virus and get it into the clinic faster and faster. If it takes two months now, that's too long but let's try and get it down to two weeks and that's where we've been working. And the technology is supporting that approach. The computing and design is getting cheaper. Synthesis is getting cheaper and faster. Certainly all the molecular diagnostics of a cancer cell is getting to be pretty much routine now.

Dave: If you had cancer, would you go do that?

Andrew: If I had cancer, yeah. If I was diagnosed with a cancer, I would absolutely go and start engineering my therapies tomorrow.

Dave: How long would it typically take to do that?

Andrew: It depends on the size of the virus. Right now it's not like computing where the cost per bit is pretty much identical. Right now the synthesized small fragments of DNA. That's really cheap but then you have to assemble the small fragments into longer fragments and eventually to get to genome size. That assembly process today is really inefficient. It's a cost factor. But the virus that we made for dogs was about 34,000 bits of code. 34,000 basis and it was synthesized and assembled and tested in two months.

Dave: All right, so that would be your first step, obviously you'd get diagnosed and look what was going on. But you'd go in and start doing that. Are there billionaires, superheroes, or any other people like that living in caves or invisible jets who are actually probably doing this to save their own lives today?

Andrew: Not that I'm aware of with designer viruses. But if anyone out there that is a billionaire wants to start, call me or if they have a dog. Part of the next step of work is to go and find. We're trying to do this all open source by the way. My philosophy is as you mentioned around Linux. In fact, I wrote a chapter for Tim O'Reilly back in 2005 on open source synthetic biology and a book all on open source computing. It was a little ahead of its time, but I want to see this platform be made to just eradicate cancer and the kind of the next step in the business development is to find high net worth individuals with sick dogs, because we have to keep this open and transparent if we're going to have it really thrive.

Dave: I know because some of them reached out to me but there are some very influential and successful people who listen to this show which is an honor for me just to, anytime I know someone who's really super busy takes some time to listen. I'm like hey, great, must be doing something. But they've reached out and there are people out there who have maybe dogs with cancer, but really if you have unlimited resources and you have cancer, nothing else matters, and you will put all of your resources into stopping that and you don't care about breaking laws, you don't care about breaking rules because well, great, I followed the rules and I died a painful death.

Dave: It wouldn't surprised me if you got a call or two from people here in this episode. This is that self-experimentation. The law says well you have to wait until it's approved but mother nature says you're going to die before it's confused, screw the law. This is just a fundamental human thing, and what I am really inspired by Andrew is that you said this is going to be open source. Because it is entirely unfair that someone with X amount of money is able to go out and access something that isn't that terribly expensive to do, that's probably cheaper than chemo for a couple years. Cheaper than traditional cancer treatments. Yet there are a whole bunch of people who will die from cancer who could do this but either don't have the economic resources or the legal resources to do it. But someone has to do it first, and it's usually going to be the desperate wealthy people because that's how it works.

Andrew: I appreciate that, and it's one of the reasons why I've championed only and of one therapies. In other words, it's just for you. It's not ever going to be made or sold to anyone else. It's just for you. That makes a ton of sense for cancer. It dozen make a ton of sense for vaccines, so a lot of the synthetic virology work has been focused at vaccines but there, you always need to be able to manufacture millions of doses, and demonstrate a very high bar of safety.

Andrew: If you're doing it for someone that has cancer and conventional therapies just aren't working. They're part of the R&D from day one, and as fast as you can iterate your engineering fast you can get it into them and I really do believe that this approach to cancer is going to just change. Just make it a managed disease over the next 20 years, I really believe that. We're already seeing the first personalized therapies in CAR T-cells be approved now.

Andrew: We're moving away from products to platform technologies that can make, pump out personalized drugs. We've got a lot of room for improvement, but I think that viruses and virus like nano-particles that are built from scratch are going to be a major avenue towards this type of therapy.

Dave: This has been a fascinating discussion and I've got one more question for you, Andrew. If someone came to you tomorrow and said I want to perform better at everything I do as a human being. Based on your life's experience, not just your work, but everything you know, everything that's made you able to do the things you're doing, what are the three most important piece of advice you have for me, what would you offer them?

Andrew: Wow. That's a really interesting question. I try and think about that in my own life.

Dave: Yeah.

Andrew: Because I live a very different life than most people. I focus on what's important. If you want to get better at something, you've got to focus. You can't do everything well. What I particularly focus on is just geeking out about the future and trying to find ways to prototype it. I think it's stay healthy because if you don't physically keep your container and your mind in good shape, you're just not going to be good at using that equipment.

Andrew: Probably the next one is go and self-experiment. Go and start finding ways. Try new things to improve your performance. You have to be able to measure it to go and get qualitative data and quantitative data that's convincing to others. But it only has to be convincing to you. But you still have to measure it and find out what works for you. If it's getting the right amount of sleep or diet or micro-dosing or whatever it happens to be. Go and start studying your own body. You are absolutely unique as an individual. You can get some guidance from the mean, but at the end of the day, you're an experiment of one.

Dave: Beautiful advice and thanks for sharing it. Thanks for all the work you're doing. Keep on figuring out what's going on in our DNA and making it so all of us know about it and if I ever have an issue with cancer which I'm not planning on having given that keto mitochondria working, but if I ever do, I'm going to be calling you and saying help me hack a virus, man.

Andrew: Wonderful. Thank you.

Dave: Thanks, Andrew. If you enjoyed today's episode, I would love it if you went onto Amazon and you took about 10 seconds to leave a review that said one of my books was worth reading because if you've read Head Strong, you've read the Bulletproof Diet, you know how much work went into those, and you know that there's stuff in there that you can use, and I'll read the reviews, and it helps other people find the book so do that. Leave a review.

Dave: If you'd like to learn more about Andrew's work or about GP-Write, and you're interested in the field, GP-Write.com. That's GP-Write.com, which has all the information about this amazing project that Andrew is helping to spearhead.