Futures in Biotech, 31: Insy-Winsy, Teeny-Weeny, Big Bang

Leo Laporte
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Marc Pelletier
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Today we're very fortunate to have as a guest Dr. Michio Kaku, because he's someone who can talk about everything, literally the theory of everything. He's a Professor of Theoretical Physics at City University in New York, and co-founder of String Field theory. Now if we're going to have an understanding, a true understanding of the living world it's going to demand that we understand our universe and how it's assembled. You really can't separate out the laws of physics from biology. As these two fields grow we're going to see them get interconnected more and more. Skip ahead 20 years and look at how physics could combine with biology, for example, rather than doing an experiment where you try to cure the cancer in a mouse, what if you were to teleport that mouse, using quantum teleportation. Now that's serious biotech.

He has a new book out, on The New York Times bestseller list. It's called "Physics of the Impossible". So, here's the interview.

I appreciate you coming on. Even though this is a biotech show, we really want to get an understanding of the human existence and without the physics of it we'll know nothing. How can we ever understand who we are if we don't understand that? So let me – I'll ask you a little bit about your early, early, early work in science. In your teens, you prepared – you did an experiment for a National Science Fair – and this is in your book, and it's so much fun. Would you mind telling us a little bit about that project?

Dr. Michio Kaku
Okay, well first of all, when I was growing up I had two role models in life; the first role model was Albert Einstein. When he died, everyone was talking about the death of the greatest scientist of our era, and the fact that he had not finished his greatest unfinished manuscript. Well, I wanted to know what was in that manuscript that he couldn't finish. Years later, and I found out that it was the unified field theory, the theory of everything; the theory that would explain the origin of the universe, the creation of the galaxies and stars, the formation of the earth and people, maybe even the basis of life and love.

The second role model I had was, well, I was watching the old Flash Gordon series on TV, and I realized very early in life as a kid that I didn't have blond hair, I didn't have muscles, however, the figure of Dr. Zarkov intrigued me because he was a man with a sheer force of intellect, being able to create a starship, cities in the sky, Ray Guns, Invisibility Shields, and I said to myself, "Wow! What a deal!" Here's a physicist, just like Einstein, who could change the universe by sheer thought.

Well anyway, so when I was in high school, I decided, this works for me. So I went to my mom one day and I said, "Mom, I would like permission to build a 2.3 million electron volt betatron particle accelerator in the garage." And my mom said, "Sure, why not? And don't forget to take out the garbage." So I forgot the garbage, and I went to Westinghouse, I got 400 pounds of transformer steel, 22 miles of copper wire, we wound the magnet on the high school football field, it was so large; and the magnet was so powerful, it consumed 6 kilowatts of power, generated 10,000 gauss – that's about the same as an MRI machine of today by the way, so that if you walk by it, it would pull the fillings out of your teeth if you weren't careful.

Marc Pelletier
Wow!

Dr. Michio Kaku
In principle, it would grab a pliers from a distance of 4 feet, and it could injure you. As we know today, nurses, technicians get injured all the time when they turn on the MRI machine. Anyway, finally it was ready, I turned it on; it consumed an enormous amount of power, I heard this crackling sound.

Marc Pelletier
Where did you get the power?

Dr. Michio Kaku
From the garage, the garage had 6 kilowatts in the circuit at 220 volts. So, I heard this popping sound and I blew out all the circuit breakers in the house, and my poor Mom would come home seeing the house lights flicker, and she would say, "How come I can't have a son who plays basketball? Maybe if I buy him a baseball – and for God's sake, why can't he find a nice Japanese girl? What's wrong with him?"

Well, because of the Science Fair project, I went to the National Science Fair in Albuquerque, New Mexico, and I met a physicist who helped to build the atomic bomb. He immediately recognized what I was doing, I didn't have to explain to him what antimatter was and what I was doing with my Science Fair experiment. And so he offered me a four-year scholarship to Harvard, and this made my dreams come true. His name was Edward Teller, father of the hydrogen bomb, and later of course he wanted me to design hydrogen warheads. In fact, he even offered me a job, a position at Los Alamos designing hydrogen warheads. But you know, I didn't want to design hydrogen warheads; I wanted to work on something even bigger and that is the Big Bang, the origin of the universe itself. So I turned him down. So that's how I got started.

Marc Pelletier
So you're driven by the most – probably one of the most important questions, or the most important question to – in science.

Dr. Michio Kaku
Yeah, and just remember that quantum physicists have always been fascinated by biology; it was Irwin Schroedinger, the father of the quantum theory who wrote a book called, "What is Life?" And for the first time in history, somebody nailed it to the wall and said that the nature of life is encoded in molecules, that there is a molecular code that contains all the information of life – otherwise, how can life be transmitted? And so, Francis Crick read that book very carefully, and then with James Watson, fascinated by the program laid out by Irvin Schroedinger worked out the structure of the DNA molecule.

So, it was a physicist who then inspired another physicist, Francis Crick to help to unravel the DNA molecule. And then at Harvard, there was another physicist by the name of Walter Gilbert. He did not get tenure in the physics department working on proton, pion scattering; he switched to biology, and won the Nobel Prize in medicine for reading the DNA molecule. So we physicists have always been fascinated by DNA and the structure of life because we like to break things down to the ultimate nature of things.

We physicists of course, have not stopped at the level of protons and neutrons, we want to go to the Big Bang itself and the ultimate nature of matter, which we think is something called String Theory, and that's what I do for a living, that's my day job.

Marc Pelletier
Maybe you could tell us a little bit about String Theory. I have a hard time – I can get down to a nucleotide, I can get down to perhaps the structure of DNA and a protein, but String Theory and the sort of the fundamental structure of an atom and beyond is sort of – that's where I just – that's where I block. And then I block even further when String Theory leads on to the multiple dimensions. Maybe you could share it with me and –

Dr. Michio Kaku
Okay; well, the book is, "Physics of the Impossible," and I have a whole chapter on time travel and interdimensional travel and parallel universes as well as teleportation, Invisibility, starships, UFOs, flying saucers, telepathy, telekinesis. But in the chapter on time travel, I mentioned the fact that you really do need a Theory of Everything in order to settle the questions once and for all, can time be bent into a pretzel; is it possible to punch a hole in space; is it possible to go before the Big Bang? These are questions that cannot be answered within Einstein's theory; Einstein's theory breaks down at the center of a black hole, it breaks down at the instant of the Big Bang, so it's pretty much useless for the kinds of questions that we physicists now would like to explore.

Now today, the leading candidate – in fact the only candidate, there is no rival, is something called String Theory, which simply says that electrons and quarks and particles are not really dots as Einstein thought, as most physicists thought. When you have dots, you get problems; infinities crop up in your calculations, you get factors like $^1/_r$ where r is the radius of an electron; if the radius of an electron is zero, then $^1/_0$ means nothing. So you have all these problems, with the fact that you have point particles. If you replace the point particle with a rubber band, and the rubber band vibrates at different frequencies, then you kill all the problems simultaneously. First of all, you explain why you could eliminate the divergences, the $^1/_r$ factors, because there is no r anymore, because you have a string rather than a point particle. Also, it explains why you have so many particles – you know, we have electrons, quarks, gluons, Yang-Mills particles, W bosons – hundreds, thousands of subatomic particles.

When I got my Ph.D. in Theoretical Physics at Berkeley, I had to memorize the names of all these God darned subatomic particles – thousands of these particles. I would hope that in the future, when you got your Ph.D. at Berkeley, you would simply say, "String Theory", and get your Ph.D.

So the particles we see in nature are musical notes; if the rubber bands vibrate one way, it's called an electron; if it vibrates another way, it's called a quark; if it vibrates another way, it's called a neutrino. So we have a musical analogy. So, the melodies you could play on the string is the laws of chemistry; the harmonies of the string is what we call physics. The universe is a symphony of strings. And then the mind of God; the mind of God that so fascinated Einstein for the last 30 years of his life – the mind of God – we now have a candidate for it, believe it or not; it is cosmic music resonating through 11 dimensional hyperspace.

Marc Pelletier
11 dimensions. So, do you – when you visualize the string, the rubber band, which is a great analogy, do you see it as energy? I mean, at what point – this is beyond energy or matter, right, this is really…

Dr. Michio Kaku
Well, yeah, first of all, the question that's often asked is, what is a string made out of? That's a very interesting question. First of all, it is, we think, the ultimate theory, so it's not made out of anything else, but well, what is it? We're going to first of all, test the periphery of this theory in two months. Outside Geneva, Switzerland, is the largest science experiment ever constructed in the history of Homo sapiens, it is 17 miles in circumference, it is so big, you could put the city of

Geneva inside the machine, it is called the Large Hadron Collider. We hope to slam two beams of protons into each other to create something that hasn't been seen for 13.7 billion years – that is the age of the universe, we hope to create a mini Big Bang, an insy-winsy teeny-weeny little piece of the original Big Bang, and from this we hope to answer the questions: is String Theory correct; if so, what is it made out of; where did it come from? Okay?

Now, we hope to find what are called sparticles with this machine; sparticles are Super Particles, they are higher vibrations, higher notes of the string. We are the lowest octave by the way. Everything you see around you, protons and neutrons and quarks represent nothing but the lowest vibrations; but there are higher vibrations. And so we hope to test this theory starting in two months when the Large Hadron Collider gets turned on over summer.

Marc Pelletier
Are you concerned at all about – ?

Dr. Michio Kaku
No, because well, first of all, all science is based on reproducible experiments, so it is, or it isn't, right? And if it isn't correct, we want to know as soon as possible. If it is correct, then it could be the crowning achievement of 2,000 years of investigation into the nature of matter ever since the Greeks asked the question, "What is the world made of?"

Marc Pelletier
Are you concerned at all though about the re-creation of the Big Bang? There can be a lot of energy released, or is this a micro… I mean…

Dr. Michio Kaku
This is a micro event. Yeah, three days ago in The New York Times, the front-page article was a lawsuit filed in federal court. Two crackpots in Honolulu heard about this machine and claimed that it's going to swallow up the universe; therefore we have to stop it to save the universe. Well, I say, "Hah! Cosmic rays from outer space have energies much greater than anything that we puny humans can create." Mother Nature is quite violent; she can slam two black holes together, and then release a burst of cosmic radiation that rains down on the earth with much more radiation that we humans can create with the Large Hadron Collider. So, it's not going to eat up the earth, because we're bathed with these cosmic rays all the time, and nothing happens. Also, the total energy from these particles probably couldn't even light up a light bulb. So, we're not talking about a great danger, other than the danger to people's psyche.

And by the way, speaking of developments that are going to be affecting us very soon, the Large Hadron Collider gets turned on in two months as I said, and within the next few months, there are going to be more breakthroughs in the area of invisibility, and this has a direct impact on DNA research by the way; has a direct impact on your work.

So, let me explain; we physicists think that – thought that invisibility was impossible; it violates the laws of optics. If we could make an object invisible, then the mathematics says that we could see right inside a DNA molecule; we could see right into the molecular structure of a single gene. Now we can't do that optically today because invisibility is not possible, so we thought. Well, we were wrong; in the future, we may be able to look right inside the molecular structure of a double helix optically. Now, this is revolutionary; all the textbooks were wrong. I used to teach optics at the college, and now I realize that I was wrong too. Invisibility is possible, and so is the possibility of looking inside a DNA molecule.

Now here is how it works; if I have a boulder in a river, water wraps around the boulder, reforms at the other end, and downstream from the boulder, the boulder is invisible; you detect no information from the boulder upstream; as far as you're concerned, there is no boulder. Now, light cannot do that; light has something called Index of Refraction, it bends going around – cannot bend going around a boulder, so, end of story, period, invisibility is not possible. Well two years ago, we were proven wrong. At Duke University, the scientists there created something called a metamaterial with implants, tiny little implants that kick the microwave radiation in a certain direction, and you can make an object disappear under microwaves; we have videotapes of this stuff. This created shockwaves in the scientific community. At Caltech and in Germany, they've even demonstrated that red light and green light can also bend in a way consistent with invisibility.

Now this means that we may be able to see objects much smaller than a wavelength of light, because that's what you were doing; what you're doing is making light bend in waves smaller than the wavelength of light that was once considered impossible, which means that one practical application of invisibility is not simply making Pentagon jet planes invisible, but to peer inside a gene optically.

So this is creating quite a sensation, and invisibility is no longer off the table. I suspect that in 10 years we'll make an object disappear under one color, like red or green, and a few years after that, maybe under the primary colors, the object will disappear, and after that, Harry Potter, watch out!

Marc Pelletier
This is the great thing about this era of science. We're really on the edge of what has always been dreamed about for eons, to being technically achievable, or within that grasp of – it's a process now of engineering, and moving the engineering forward with some…

Dr. Michio Kaku
And another area that will directly impact on what you're doing, is the fact that we can teleport atoms now and I think in a decade or so, we'll probably teleport a DNA molecule. Now, teleport is the way you do it in Star Trek; you see Captain Kirk dissolve, and then Captain Kirk reemerges someplace else; that's called teleportation. We physicists about 10 years ago, used to say, "Hah! That's impossible." Well, we did it. At the University of Vienna in Austria, they were able to teleport the first particle of light called a photon. Now we can teleport individual cesium and beryllium atoms, and the world's record right now is, we can teleport a light from one Canary Island to another over a distance of about 100 miles.

Next, we will teleport across space, to the Space Shuttle. That experiment is now in the works, to teleport to the Space Shuttle, and after that we will teleport to the moon, after 2020. Now, atoms are more difficult, but we can teleport individual atoms; we will then teleport maybe a water molecule within a decade. So molecules will be teleported, and after that, maybe organic chemicals, maybe DNA, maybe a virus – these are things that cannot be ruled out with our present understanding of something called quantum teleportation.

Now, to teleport Captain Kirk is more difficult; he consists of 50 trillion cells – that's a lot of cells. So Captain Kirk can be more difficult to teleport, may take a few centuries, but Star Trek takes place in the 23rd century, so we have plenty of time.

Marc Pelletier
Could you explain a little bit about the subatomic processes that – so they started with a photon, now they can teleport atoms, and actually do photons a great distance.

Dr. Michio Kaku
When you guys take a course in physical chemistry, you learn that everything vibrates according to a wave; that wave is called a Schrodinger wave. So everything vibrates; and if two electrons are vibrating in unison, that is called coherence. Now, if you separate these two electrons, these two electrons are now vibrating in unison, but there's an invisible umbilical cord that connects them; you can't see it, but it's there, where you can measure it; this is called quantum entanglement. So you now separate these two electrons over many, many miles; as soon as you jiggle one, it affects the other – in fact, faster than the speed of light, okay?

Einstein was wrong on this one. The jiggling of one electron affects the other electron faster than the speed of light. However, Einstein has the last laugh; the information transferred from one electron to the other is random information, therefore you cannot send Morse code this way. However, information can be transmitted slower than the speed of light if you have a third particle, that goes between particle one to particle two, and that's quantum teleportation; that's how we do it. We get two photons that are in-phase with each other, separate them, have a third particle that transfers the information from one to two, and that's how we zapped Captain Kirk.

Marc Pelletier
It's amazing.

Dr. Michio Kaku
And like I said, this affects your work because nanotechnology will perhaps be the foundation for quantum teleportation of the future. And nanotechnology, as you probably know, will definitely affect biology as well – in fact, we are going to imitate Mother Nature and create ribosomes, create information like in a DNA molecule, and create atomic machines, machines that have memory, machines that have gears, levers, pulleys. Atomic machines, just like Mother Nature created an atomic machine called the DNA molecule.

Marc Pelletier
In your book, you do classify these technologies. Do you want to tell us a little bit about how you define what is doable and what is not doable and…

Dr. Michio Kaku
Okay; first of all, I'm a physicist not an engineer, and the difference is, physics asks what is possible, while engineers ask what is practical. So if you class impossibilities into three classes; class one impossibilities are actually possible on a scale of decades to maybe a hundred years; they include most of the devices of science fiction – telepathy, psychokinesis, ray guns, force fields, time – not time travel – antimatter engines, starships, invisibility, teleportation, these are all class one impossibilities that you see in the movies all the time.

Class two impossibilities are more difficult; they would require energy comparable to a star; you're talking about time travel, interdimensional travel, faster than light wormhole travel. If they are possible, they are on a scale of centuries to millennia. And then there are some things which are just downright impossible, violate all known laws of physics, like perpetual motion machines and like pre-cognition, or telling the future.

Now, this means that we physicists are beginning to tease apart so many things that you see in the movies that we think are possible today. For example, take a look at telepathy; people would say, "Hah! Telepathy is not possible." But actually we already have certain forms of telepathy in the laboratory. At Brown University, they took a stroke victim who was paralyzed, put a chip in his brain, connected the chip to a laptop, trained the person to move the cursor on the laptop, and this paralyzed stroke victim can now read e-mail, surf the Web, play games, and communicate with you, and he is paralyzed. So you can imagine that in the future, we'll have normal people with microscopic implants with the ability to surf the Web just by thinking about it, okay?

Now also, we can read thoughts to a degree in the human brain; when you tell a lie, it takes more energy than to tell the truth; to tell a lie, you have to know the truth, know the cover up, or the consequences of the cover up. That's a lot of energy. We can pick that up pretty easily on an MRI machine; so, we can even have a dictionary of thought. Certain patterns correspond to certain ideas to within a certain level of accuracy. This will actually be tested in court by the way this year; an insurance company denied a claim to a homeowner whose house burned down; the insurance company claimed that he burned it down himself. And the homeowner said, "Well, that's ridiculous; I'm going to go to court; I'm going to sue, and I'm going to have my brain scanned in court to prove I did not burn down my house." So this is moving very fast, a dictionary of thought; a one-to-one correspondence between certain emotions, certain feelings, and certain patterns that we pick up on an MRI scan.

Then the next question is, well, why can't we read thoughts directly? Well, there's a problem there; the brain is not a computer – most people think the brain is a computer; well, that's not true. The brain is something called a Turing machine; a Turing machine is a glorified adding machine with a central processing unit like a Pentium chip, inputs, outputs, and a programming. Well, the brain has no Pentium chip; the brain has no Windows; the brain has no programming; the brain has no subroutines; the brain doesn't have any of the things that you associate with a Turing machine or an adding machine.

So, what is the brain? The brain is a neural network; it's a learning machine. It rewires itself every time it learns a new task; that's why the interface between a neural network and a Turing machine is quite difficult. So for these stroke victims, they have to learn how to move the cursor on the screen by thinking about it, like riding a bicycle. There are no rules to riding a bicycle; you just have to learn it. Same thing here. So the interface between a Turing machine and a neural network is quite difficult.

Marc Pelletier
I'd like to take a brief pause to thank Audible.com for sponsoring Futures in Biotech. They have over 45,000 titles in the library, which is pretty amazing. If you sign up using audible.com/biotech you get a free book. Now that's a 14-day free trial, that means if you don't like the service you simply cancel and you get to keep the free book.

I'm about to take the family on a long drive next week to Ohio from Connecticut, it's about a 10-hour drive and while the kids get to either sleep or watch DVDs I'd prefer to listen to audiobooks, they actually help me focus and keep my eyes on the road. I'm going to listen to *Born Standing Up: A Comic's Life* by Steve Martin. Here's a clip.

Steve Martin
Simon & Schuster Audio presents to *Born Standing Up: A Comic's Life* by Steve Martin. Read by the author.

Beforehand. I did stand-up comedy for 18 years. 10 of those years were spent learning, four years were spent refining and four were spent in wild success. My most persistent memory of stand-up is of my mouth being in the present and my mind being in the future. The mouth speaking the line, the body delivering the gesture, while the mind looks back, observing, analyzing, judging, worrying and then deciding when and what to say next. Enjoyment while performing was rare. Enjoyment would have been an indulgent loss of focus that comedy can not afford. After the shows however I experienced long hours of elation or misery depending on how the show went, because doing comedy alone on stage is the ego's last stand.

My decade is the '70s with several years extending on either side. Though my general recall of the period is precise, my memory of specific shows is faint. I stood on stage blinded by lights, looking into blackness which made every place the same. Darkness is essential. If light is thrown on the audience they don't laugh. I might have well as told them to sit still and be quiet. The audience necessarily remained a thing unseen except for a few front rows where one sourpuss could send me into panic and desperation. The comedian's slang for a successful show is, I murdered them, which I'm sure came about because you finally realized that the audience is capable of murdering you.

Marc Pelletier
That's pretty hard-core stuff. So, back to the interview.

Would you like to talk a little bit about aspects of the different impossibilities on society, or do you want to – I'd like to talk to you definitely about your thoughts on basically, the central concept of the universe as being a simple equation – you know, you are driving towards a simple one-inch equation.

Dr. Michio Kaku
Yeah, that's right.

Marc Pelletier
You know, I'd like to talk about that, but ask whether or not you – is it possible there be three equations, and that is beyond the realms of our understanding?

Dr. Michio Kaku
Well, believe it or not, we can summarize all the laws of electromagnetism, you know, radar, magnetism, electricity, television, radio. We can summarize that into an equation half an inch long – and it's amazing that a little equation half an inch long, can summarize the entire electric age of today. That equation simply says that the four-dimensional divergence of an antisymmetric second rank tensor equals zero – that's the equation for light. And at Berkeley, where I got my Ph.D., you can buy a T-shirt which says, "In the beginning, God said, the four-dimensional divergence of an antisymmetric second rank tensor equals zero, and there was light, and it was good. And on the seventh day, he rested."

Well, now we have String Theory; String Theory is a vast collection of hundreds of little formulas – no rhyme or reason to all these little formulas. So, when I was young, I wanted to summarize all of String Theory into an equation one inch long. Well, I succeeded; me and my colleague were able to write down something called String Field Theory, an equation about one inch long that summarizes all of String Theory. Now, is that the equation that eluded Einstein? Not quite. Because now we have something called membranes; membranes can also exist with strings. Our universe for example, is probably a membrane of some sort. At the present time, we don't have that one inch equation for membranes yet, but that's what I'm working on; that's what I do in my day job, trying to summarize everything into an equation one inch long.

Marc Pelletier
Will it be, do you think? It's hard for me to really grasp because it's such a completely different scientific process. I basically move things gradually, technical bits and pieces, and you're trying to get a complete, comprehensive view of the universe.

Dr. Michio Kaku
Right.

Marc Pelletier
So, how do you do this? How do you go about trying to figure this one out? Are you – what are the variables, what…

Dr. Michio Kaku
It's not as hard as you think. First of all, we have Einstein's theory of space-time; that equation is about an inch long; it's one of the great equations of the universe, and it simply describes the fact that matter can warp the space around it – very simple idea, very simple equation, but it gives you the Big Bang, and it gives you black holes. Now, the Quark Model, the theory of the atom, is more complicated; we have 36 quarks, we have tons of different kinds of gluons, Yang-Mills particles and so on and so forth. But the quantum theory can also be summarized into an equation about a yard long, okay? It's a messy equation, but you can put everything onto a sheet of paper. One sheet of paper summarizes everything that is known about the universe at a fundamental level. So that's one sheet of paper, okay? One equation, one inch long, Einstein's equation, and the quantum theory, the ugliest theory known to science is an equation about a yard long. Our goal is to summarize everything into an equation an inch long. Now, we think we can do it. String Theory almost gets you there; now we have membranes, so it's more complicated, but my equation almost takes you right there.

So, this is “Reading the mind of God.”

Marc Pelletier
And this will be tested in a couple of weeks, or a couple of months.

Dr. Michio Kaku
Yeah. We think we’ll begin to test it in two months in Geneva, Switzerland.

Marc Pelletier
I’m going to cross my fingers; this could be the great – it is the greatest question…

Dr. Michio Kaku
Yeah. Well, you see, certain fields like English literary criticism get more complicated every year; Ph.D. students ask the question, “What did James Joyce really mean; what did Hemingway really mean?” And Ph.D. after Ph.D. after Ph.D. critiques Hemingway and James Joyce. Physics is the opposite; physics gets simpler and simpler every year, until we can summarize the entire universe into an equation one inch long.

Marc Pelletier
There’s an incredible beauty in simplicity, and our universe, the elegance of it, would be – could be reduced into that one equation. Is it possible that there is two, and that the combination of variables…

Dr. Michio Kaku
Well, you see the idea of unification is actually apparent even in biology; it used to be thought that there was no unifying principle to biology, because we had all these organisms, each one with its own taxonomy, each one with different parts of the body, so on and so forth. But then evolution comes along, points the way to a unifying principle, and now we have DNA, which is reduced to of course, physics; and so, we've reduced biology to a form of physics, such that we do have a unifying principle that allows us to see all of biology emerging from one structure – that’s the way nature works. Well, physics itself is like that in the sense that we have the physics of molecules, physics of light, physics of gravity, and all these equations can also be unified into a single paradigm. And so, it’s not so surprising therefore that biology could be unified with DNA, and that physics can be unified with String Theory – in fact, DNA and strings are both strings.

Marc Pelletier
Absolutely; what about the dimensional aspects of String Theory? Maybe this could be the closing question. I know that there are hundreds of questions that I’m going to be thinking afterwards, but I certainly appreciate your time.

Dr. Michio Kaku
Okay. First of all, when I was a child, growing up outside San Francisco, I used to go to the Japanese tea garden and look at the carp swimming in a shallow pond, and I asked myself a children’s question; what would it be like to be a fish? If you are a fish in a shallow pond, your eyes pointing to the side, you live in a two-dimensional universe; you can swim forward, backward, left, right, but the concept of up, up into the third dimension, up into hyperspace, makes no sense whatsoever. And I imagined one day, there was a scientist down there in the pond, and the scientist fish, would say, “Bah! Humbug! There is no world of up; there is no third dimension. What you see is what there is. What you can measure is what there is, everything else is just fish science fiction.” Well, then I imagined reaching down and grabbing this fish scientist, lifting him into the world of ‘up’, the third dimension hyperspace. What would he see? He would see beings breathing without water, a new law of biology – beings moving without fins, a new law of physics.

Well, believe it or not, today we physicists think that we are the fish. We spend all our life in three dimensions; going forward, backward, left, right, up, down, but anyone who talks about unseen universes, worlds beyond our world is considered a crackpot, a lunatic, a refugee from Star Trek. Well, physicists don't laugh anymore; all the snickering has stopped, because String Theory is now the only game in town; entire university programs are now based on String Theory. Every single physics department on the planet Earth, either has a String group or is desperately trying to learn String Theory – and my textbook, my Ph.D. level textbook in String Theory is one of the main handbooks that people use to learn String Theory for 3rd Year Ph.D. students.

So, we think that if you go to a higher dimension, things get simpler. For example, let's say you're on a mountaintop, a mountaintop on a third dimension, looking down; if you are in the city, the plain, the valley, things look kind of complicated; many cities, many valleys, it looks quite messy. But if you're on the mountaintop, looking down from the third dimension, things get simple, whole, coherent, simple. And that's the lesson that mathematics teaches us; every time you go to a higher dimension, things get simpler in a higher dimension – and when you go to 11 dimensions, everything collapses into a single theory.

Marc Pelletier
Do these other universes which are representations of those dimensions, are they, I suppose, a way to look at it, as you mentioned, like parallel, in that there's 3x3 dimensions plus two extra? This is not the way to ask the question, but…

Dr. Michio Kaku
Here's how it works: we think that our universe – we physicists think that our universe is a soap bubble; we live on the skin of the soap bubble, we are trapped like flies on flypaper, but the soap bubble is expanding, and expanding rapidly. But we now believe that there are other soap bubbles out there; other bubbles, and they pop into existence, they bump into each other, they split in half, so Big Bangs probably have been happening even as we speak; universes have been created.

Now this picture is actually verified – not verified, but supported by satellite data. We have a satellite currently orbiting the earth, the WMAP satellite, it's giving us gorgeous baby pictures of the Big Bang; we actually have photographs of it, some people don't believe in the Big Bang theory, that's okay, we live in a free country, but we have photographs, we have pictures, baby pictures of the explosion itself. Go to nasa.gov, type in WMAP, and you can actually see pictures of the Big Bang. So the theory has been pretty much verified, the Big Bang theory; but, we now can peer into the pre-Big Bang universe we think, because the data is consistent with something called inflation.

Inflation says, there was a very fast expansion at the beginning of time, but it can happen again, and again, and again. Eternal inflation is now the dominant theory of the universe, which says that we coexist with parallel universes, universes that can collide, universes that can pop into existence, and universes that can bud, or sprout, baby universes.

Marc Pelletier
It does offer a sort of, a simpler view, in the fact that how could we only be one – how could there only be one universe?

Dr. Michio Kaku
Yeah. And some of these universes could look very much like our universe. We know for example that electrons can be two places at the same time; in fact, that is the fundamental basis of biology. When you learnt chemistry for the first time, right, you learnt that the electron could be described by a football; you have the 1S, 2S, 3P orbitals, and that these footballs can connect atoms to create molecules, right? Every biologist has to learn this football theory. Well, what is the football? They never told you this; they never told you this because it would upset you; it would really upset biologists if we physicists told you what this football really was. This is not a

football at all; we lied to you. The electron is not [indiscernible]; the electron exists simultaneously in many states at the same time, and it looks like a football from a distance, but it's really a dot that can exist in parallel states simultaneously, multiple states at the same time. That's called a molecule. If we did not have parallel electrons, there would be no molecules, no DNA, and all of biology – not to mention all reality, would collapse.

Now once upon a time the universe was smaller than an electron. If the electron is quantized, and exist in parallel states forming a football, then the universe, once upon a time, existed in parallel states – multiple states, and so once we quantize the universe, we necessarily have parallel universes – and parallel universes in some sense, is the foundation of the DNA molecule. Without parallel universes, there is no DNA. For example, look at it this way; let's say Newton was right, and there are no parallel universes, okay? Then I have a solar system, which you call an atom; if I have two solar systems of hydrogen, bring them together, and they collide, what do you get? A mess. Two solar systems when they collide fall apart. They never create water molecules. Molecules are impossible if you have a Newtonian atom colliding with another Newtonian atom. So the very foundation of DNA depends upon the existence of parallel electrons, which in turn gives you parallel universes. So believe it or not, in some sense, there is a parallel universe where Elvis Presley is still alive – boggles the imagination, doesn't it?

Marc Pelletier
It's amazing; this is a whole new area for me, and the reality of it, changing I suppose our understanding of how the universe works is – or our universe works – you know, it's just fascinating, it's awe. I cannot just feel a sense of awe at looking at this and it's apparent that you've had this incredible – from the early days of trying to build a particle or an anti-matter – what do you call it, a particle accelerator, that you – you also share this sense of awe, and its…

Dr. Michio Kaku
Yeah, that's why I wrote the book, "Physics of the Impossible," because whenever you go to the movies and you see the Hollywood blockbusters, you kind of wonder whether any of these technologies are possible. And I found out that I'm not the only one fascinated by these things because the book just hit the New York Times bestseller list; it's actually number 12 in the country right now on the New York Times bestseller list. Get this Sunday's New York Times Book Review section, and there it is, the only book in history with the word 'physics' in it to make the New York Times bestseller list.

Marc Pelletier
That's amazing. Now, you're got an incredible talent for – and I recognize this as someone who is trying to bring at least one aspect of science into the media, I think we're all drawn to the fundamental question, how's our universe working, and why are we here? And the book really makes that an incredibly fun way to get an understanding of some of these physical processes that are regulating the universe, and making them tangible. And the book is a very fun read; I'll be putting the link in the show notes, so that people can get more information on it; so much fun to explore these different possibilities. Have you always been a fan of sci-fi, or is it that you see sci-fi trying to imitate – art imitating life?

Dr. Michio Kaku
Well, there's a relationship between art and life; if you take a look at Edwin Hubble, the greatest astronomer of the 20^{th} century who discovered the expanding universe, he started his career as a lawyer; his father was a lawyer, he was a lawyer, but he read Jules Verne as a child, and always had this romance with the stars. And so he gave up a very lucrative career as a lawyer, went to the University of Chicago, got a Ph.D., and then went on to discover the expanding universe and to become the greatest astronomer of the 20^{th} century. Or look at Carl Sagan, the great astronomer; Carl Sagan, when he was a kid, he read the, "John Carter of Mars" series, and he dreamed about chasing the beautiful Deja Thoris over the sands of Mars. So science fiction helped to inspire Carl Sagan to become a scientist and so there are many relationships between science and science fiction.

Not to mention the fact that usually, people like Gene Roddenberry steal ideas from physics like antimatter and warping of space and time, but once in a while, we physicists steal something from science fiction. For example, the precise way in which the Enterprise warped space to go faster than the speed of light, there was a theoretical physicist, who watched the Star Trek series and said, “Well, is there an exact solution of Einstein’s equation which can replicate the motion of the Enterprise?” So he sat down with a sheet of paper and worked it out. The Enterprise basically squeezes space in front of you, expands space behind you, and that’s how it goes faster than the speed of light – and he found a solution. Believe it or not, we now have a solution of Einstein’s equations, which was motivated by the motion of the Starship Enterprise on the Star Trek program.

Marc Pelletier
That definitely brings us to a point where art is absolutely important into developing our understanding of life I suppose, because then without art, we wouldn’t have the creative ideas to really re-examine – I suppose science and art both require tremendous amount of creativity, especially if we move science forward in giant leaps.

Dr. Michio Kaku
Yeah, well you know, art forces you to dream – and if you think about it, imagination is more important than knowledge – now of course you have to have knowledge, but to be on the cutting edge, knowledge is not enough; you need to have imagination – and that’s where art comes in, because art frees the mind from too much knowledge and allows you to make connections that are at first impossible, but later, become obvious. And that’s why I hope to capture that sense of wonderment in my book, “Physics of the Impossible” to re-create that feeling of being a kid watching Star Wars and ET for the first time, and then wondering, are any of these technologies consistent with the laws of physics? That’s what the book is all about.

Marc Pelletier
Let me ask you one last question. Where do you get your source of inspiration physically? Like, how do you set yourself into the zone, I suppose, like what I call it, the Thought Zone where you can be creative; do you… I get my best ideas in the shower. What do you – how are you going to solve that, the most important question or identify that one inch equation?

Dr. Michio Kaku
Well, everyone has a hobby…

Marc Pelletier
It’s kind of personal…

Dr. Michio Kaku
Everyone has a way to relax, like Einstein used to play the violin, and the joke is that when you bring four mathematicians together, you get a string quartet. Physicists also have a way of relaxing; believe it or not, most theoretical physicists relax by mountain climbing. We have and institute at Aspen, where physicists mountain-climb and talk about String Theory. However, three of my friends have died in hiking accidents, two of them tragically, and I prefer not to climb mountains because you can fall off, as has happened to two friends of mine. So, I would rather do something different; I’d rather communicate with people; I’d rather talk to people, because you know, we’re all born scientists; every one of us is born a scientist; we wonder about where life came from, where the Earth came from, where we came from, what are the stars all – what are they all about? All of us are born scientists until we hit high school; then it’s crushed out of us, and then we forget the romance of science that we had as a child. I wanted to re-create that romance, re-create that wonderment for kids, and also for grownups who never grew up, who still share that thrill of discovery, wondering what’s out there, where do we come from, what does it all mean? And these are the cosmic questions that unfortunately are addressed in science fiction,

but very rarely are addressed in our school system, which as I said before, is one of the worst known to science.

Marc Pelletier
I'm going to thank you for being on this show. Is there – so, you have a website, and I think it's a great portal into your work, especially in radio and books.

Dr. Michio Kaku
Yeah, it's www.mkaku.org. That's the website.

Marc Pelletier
Great. I'll put a link to that as well in the notes so that people can get to it. It provides links to the radio shows?

Dr. Michio Kaku
That's right. Yeah, I'm on 130 radio stations around the country. I have two weekly science programs that go out to about 130 cities.

Marc Pelletier
Well, it's easy to understand why. You simply type your name into YouTube, and there's hundreds of videos which describe – that really help us get that sense of wonderment as well about the world and the universe, and I appreciate you sharing it with us.

Dr. Michio Kaku
Okay, thank you. Real pleasure!

Marc Pelletier
I'd like to thank Dr. Michio Kaku for his fantastic insights today. I'd also like to thank Leo Laporte for co-producing the show and Dane Golden at twit.tv for helping us get it up onto the interwebs.

I'd also like to thank the listener. Thank you for your donations. You really help get this show up on the air. I'd like to have a quick shout-out to Dr. Ginger Campbell who is the host of a podcast called the Brain Science Podcast, she's put together an aggregator of sorts for science podcasts. It's called sciencepodcasters.org.

I'd also like to mention that the transcripts to the shows are available thanks to Pods in Print. And you can access those transcripts for free on futuresinbiotech.com.

For Futures in Biotech I'm Marc Pelletier.