David Jay Brown
Interviews

Kary Mullis

Kary Mullis won the 1993 Nobel Prize in Chemistry for his invention of the polymerase chain reaction (PCR), which revolutionized the study of genetics. The journal* Science *listed Dr. Mullis' invention of PCR as one of the most important scientific breakthroughs in human history.

PCR is a technique that allows chemists to easily, and inexpensively, replicate as much precise DNA as they need. This solved a core problem in genetics. Before PCR, the existing methods for making copies of those particular strands of DNA that one was interested in were slow, expensive and imprecise. The brilliance behind this invention, as well as it utter simplicity, lies in PCR's ability to turn the job over to the very biomolecules that nature uses for copying DNA. PCR multiplies a single, microscopic strand of genetic material billions of times within hours. The process has many applications in medicine, genetics, biotechnology and forensics.

When the Royal Swedish Academy of Sciences awarded Dr. Mullis the Nobel Prize, they said it had "hastened the rapid development of genetic engineering" and "greatly stimulated biochemical research and opened the way for new applications in medicine and biology." Just flipping through any current issue of the journals* Science *or* Nature *one will encounter advertisements for PCR systems every few pages. In addition to revolutionizing the study of genetics, it's also influenced popular culture and science fiction. Because PCR has the ability to extract DNA from fossils, it was the theoretical basis for the motion picture Jurassic Park. In reality, PCR is the basis of an entirely new scientific discipline, paleobiology.

Dr. Mullis earned his Ph.D. degree in biochemistry from the University of California at Berkeley in 1972, and lectured there until 1973. That year he became a postdoctoral fellow in pediatric cardiology at the University of Kansas Medical School. In 1977 he began two years of postdoctoral work in pharmaceutical chemistry at the University of California, San Francisco. He joined the Cetus Corporation in Emeryville, California, as a DNA chemist in 1979, and it was during his seven years there that he invented PCR. Dr. Mullis has authored several major patents, and he has received numerous, highly prestigious awards--including the Japan Prize in 1993, the Thomas A. Edison Award (1993), and the California Scientist of the Year Award (1992). He was inducted into the National Inventors Hall of Fame in 1998.

His many publications include "The Cosmological Significance of Time Reversal" (*Nature*), "The Unusual Origin of the Polymerase Chain Reaction" (*Scientific American*), "Primer-directed Enzymatic Amplification

*of DNA with a Thermostable DNA Polymerase" (*Science*), and "Specific Synthesis of DNA In Vitro via a Polymerase Catalyzed Chain Reaction" (*Methods in Enzymology*). Dr. Mullis is also the author of the book* Dancing Naked In the Mind Field *(Pantheon Books, 1998). This autobiographical account of his fascinating, and sometimes mind-bending adventures, simply overflows with a bounty of novel and thought-provoking ideas. Dr. Mullis makes a compelling case for the existence of greater mystery in the world around us, and he seems more interested in seeking truth than he is avoiding controversy.*

Dr. Mullis is currently a Distinguished Researcher at Children's Hospital Oakland Research Institute. He also serves on the board of scientific advisors of several companies, provides expert advice in legal matters involving DNA, and is a frequent lecturer at college campuses, corporations and academic meetings around the world. He is the inventor and founder of Altermune LLC. To find out more about Dr. Mullis' work, visit his Web site: www.karymullis.com

Dr. Mullis lives with his wife, Nancy Cosgrove Mullis, in Newport Beach, California and in Anderson Valley, California. I met Kary and Nancy in 1999, when we did a radio show together with the late Elizabeth Gips on KKUP in Cupertino, California. I spoke with Kary again on September 22, 2003 for this book. During the interview, I noticed playful, childlike qualities in Kary when he was discussing sophisticated scientific ideas. There was a simplicity, and a clarity, in the way that he approached complex ideas, and his mind seemed to exist in many dimensions at once. Kary put a lot of thought into each of his answers, and although his mind seemed to be moving very quickly, he also appeared to be a very relaxed. Kary has an uncanny ability to combine extremely far-out perspectives with very practical, nuts-and-bolts thinking.

We spoke about the direction of science, the relevance of nonrandom mutations in evolution, psychic phenomena and other unexplainable experiences, the nature of time, the "thickness" of the moment, and the possibility of an asteroid colliding with the Earth--which he thinks is the most urgent threat to life on this planet. We also discussed his current research, which offers tremendous hope as a medical treatment for dealing with virtually any type of pathogen by engaging the immune system in a novel way.

David: Where do you think humanity should be focusing its scientific efforts right now?

Kary: I think that if we, as a society, want to survive for a long time, then we've got to put up an umbrella over our heads to protect us from the things that are obviously going to fall on our planet.

I often wonder, given that the universe is so vast, with so many stars that must have planets like ours, why there aren't aliens down here trying to trade us beads and trinkets for Manhattan? (*laughter*) We must have something that they'd think was cool, and yet, it just doesn't seem to be the case. If it is, they're not making themselves known.

Maybe it's because cultures tend to get wiped out by asteroids. We have gotten to the point where we can look into the near vicinity of space and see the things that are a serious danger to us. The asteroid belt is full of things that don't have stable orbits. Maybe by the time a culture can recognize that, it's too late, because they have gone off on some ridiculous tangents. I think we've done that, in terms of our science.

We're not pragmatists anymore. For at least a couple of hundred years Americans have always been thought of as pragmatic philosophers--if it doesn't matter, we're not going to worry about it too much. We've spent billions and billions trying to understand something called 'The Grand Unified Theory of Everything'--and all you have to do is take LSD one time to realize that that is not going to happen. (*laughter*) You're just not going to find 'The Grand Unified Field of Everything'.

You can pretend to find it by spending vast sums of money and building huge machines. We're building this great big thing called BABAR, which looks like an elephant. It's an attachment that detects B-mesons, and will sit on top of the Stanford Linear Accelerator. They're making something that's going to produce a lot of what's called B-mesons, and, from its particular properties, physicists hope to understand enough to provide the final structure of the universe--'The Grand Unified Theory of Everything'.

But human beings, who are paying for this whole endeavor, will never understand this. I've been studying it since I was a little boy, and it's not really clear to me that this particular theory of everything is anything more than just a myth. You can find evidence for anything if you look hard enough.

David: What do you think is the biggest threat to the human species?

Kary: We need to know where the asteroids are, and which ones could be on a course for Earth sometime in the next five hundred years, or even right now. If something two miles wide crashed on this planet going 17,000 miles per hour-- which it probably would be by the time it got here-- it would destroy everything. It's done it before. We know for sure it happened 65 million years ago. That seems like a long time, but it's not an infinitely long time. It's just a long time.

You have to have a sense of a long distant future for man to be concerned

about something like that. There are many asteroids, and every now and then, because of interactions among themselves, one of them will flip itself out of the band between Mars and Jupiter. It will generally head sunward-- that means that it comes toward us. It only takes one, and in two minutes the whole planet will be uninhabitable. Maybe a few of us will survive. Perhaps a couple of people up in Denver will be able to hang on.

The last time it happened something five miles wide landed north off of present-day Yucatan. It left a hundred mile wide hole, and kicked up a tidal wave that, when it passed where Kansas City is today, was five hundred feet high. Denver would have escaped the tidal wave, but the world was totally changed in a matter of minutes.

We can prevent this from happening if we put enough attention towards it, and take our physicists off of things like quarks, which most of us are not too concerned about. We were worried that the Russians would get there first, and make a super bomb that we wouldn't be able to make. Now that's over, so let's put an umbrella of protection over our culture-- so that we have a million years or so to ponder what our options are. Who are we? That sort of thing.

David: Do you think it's possible to blow up an asteroid that's headed towards us before it strikes the Earth?

Kary: I think so. The next time one of them is about to land here, whether we've prepared for it or not, we'll probably try to do that. There have been a couple of movies where people make an emergency attempt to, and there have been technical papers written about it; but we shouldn't wait until one is almost here. We need to be watching them. There are now about seventy-five catalogued Earth-orbit-crossing asteroids. Astronomers are watching their orbits, but every now and then a new one appears, or someone suddenly discovers a new comet. Comets and asteroids both have that very unpredictable aspect. Some amateur astronomer in Arizona will suddenly see something, and say, Jesus, that's heading right towards us. It's going to be here in a month.

I think the problem is that when our physicists think of something fundamental, they assume that it is either the tiniest little thing, or the hugest. It's either the whole universe, or it's a vibrating string 10-45 meters wide or something like a quark that has absolutely no volume. It's more romantic, I guess, to talk about and study those sorts of things. I love it, but it's not as practical as studying and understanding the solar system. There are dangers to us right here.

If you look at the surface of the moon, where weather has not been destroying the evidence of impacts, what do you see? The whole place is full

of holes. Mars is the same way. There are all kinds of craters around, because things have been smashing into them. We watched eight or nine almost earth-size objects crash into Jupiter in 1994. They left huge holes, bigger than the earth. Any one of those impacts would have destroyed us.

We need to have space stations. We need to get away from here, and have people up there ready to defend us. This is not a fanciful idea. There's more evidence for this than for anything else that's dangerous to us. That's the way our civilization is going to end, when something big smashes into this planet. We're going to get to watch it on CNN, and we're going to be helpless

David: Do you think that the human species is going to survive the next hundred years, and if so, how do you envision humanity's future evolution?

Kary: I think the probability is good that we're going to exist for a whole longer than that, but exactly what the conditions will be, I have absolutely no idea. I see a lot of science fiction movies that I think are probable, and they're all different. I'm kind of an optimist. I don't think it's going to get terribly worse.

David: It's just that the human species has reached a point in its evolution where it has the potential to drive itself into extinction.

Kary: I am optimistic that we won't do it. That optimism does not arise from evidence, it's just my feeling that we won't. We've had the ability to wipe ourselves out for quite a while now.

David: Do you see any teleology in nature, or think that there is any direction in evolution? Or do you think it's purely a random process?

Kary: My feeling about evolution is that it seems to have a teleology, but it doesn't really. It's just the operation of selection on random changes, as far as I can tell. I accept that theory as being the way evolution works.

I think there is so much more in existence besides matter, energy and time. Nineteenth Century physics had those in an orderly arrangement, but it is too weird to be just that. There are other things going on, so evolution might not actually be without some kind of presupposed or predestined direction. But I think it's possible that it all happens through random changes.

There's a book by Richard Dawkins called *Climbing Mount Improbable* that I like. I think that the evolutionary mechanism makes it possible for very bizarre things to evolve in very slow steps. In his book Dawkins talks about the fact that you don't go straight up the face of Mount Improbable. (Mount Improbable being the end, or the present state of being, of some particular species.) You always go in little steps, back and forth, crisscrossing, finding

the trails.

If you look at any one of the little steps leading to something as improbable as the human eye, it doesn't seem like such a magical thing. In fact, if random steps aren't the mechanism whereby very complex things like those form, then the next possible choice is somebody did it. Then you have to figure out, well, where did that somebody come from? The beauty of evolution is it says it can happen anywhere and it will get really freaky. (*laughter*)

You don't have to know who or why. The laws of evolution say that if you have random chances of species undergoing changes, then the ones which are best fit to reproduce in the environment they find themselves in will survive and continually create weirder and weirder things. You'll end up with giraffes, elephants, crocodiles, and people.

David: I'm sure you're aware that there's evidence that E. Coli bacteria don't always mutate randomly--that there's actually a response to the environment with regard to how their genetic mutations occur, so as to be more adaptive. How do you account for that?

Kary: There's something like that in E. Coli and several other organisms. With the passage of a particular kind of retro-virus through several different species, there are certain DNA changes that happen that are actually not random. But if you look for the mechanism of those, you'd find that those mechanisms themselves are in place probably due to random things. In other words, the fact that you can change your DNA in a way that's not random, does not mean that most of evolution doesn't occur due to random changes.

I think it's not an unlikely hypothesis that we're here simply because we survived, and there were changes all along that were random. It doesn't take any more than that, because time is so long. Four billion years means a lot of generations, and little tiny changes at every stage of the way, selected by whatever was there, the environment at the time, could very likely produce things like this. Nobody's ever shown that experimentally. There is really no experimental evidence for Darwinian evolution ever creating a new species.

David: I guess it might take awhile to run the experiment. (*laughter*)

Kary: Yes, it takes time. But there are processes that help us to understand this. For instance, there are a lot of PCR-based permutation experiments, where you try to make a whole bunch of different kinds of the same molecule--millions and millions of variations of it. You select for the one that has a property that you like, and then you take that one and do the same thing to it. You can increase the ability of, say, some RNA species that

you're making, or some protein that you're finally making from it, to bind to some specific protein receptors, thousands of fold that way-- just doing it randomly.

You just reproduce the thing over and over in a way that will make little mistakes. Then you pick the best one, and do the same thing to it. Then pick the best one from that bunch and do it again. Eventually you end up with something that's almost qualitatively different, something that has a property that you've been selecting for which is so much greater than the thing you started with. You can almost say this is a different species of molecule.

That's sort of a test tube proof of the principle. The principle is almost like a tautology, in a sense, that, once you see it, you don't feel like you need proof for it. You say, well, of course that would happen. How else could it happen?

David: What about the possibility of a strange attractor, like we find in the dynamic systems of chaos mathematics? When I interviewed Terence McKenna he suggested that something at the end of time may be pulling us through evolution.

Kary: There may be something pulling us, and if so, that's going to be scary. (*laughter*) We're going to have to say, well, where the hell did that come from? (*laughter*) I like the idea that we have an independent existence that depends on nothing at all, except for the properties of matter and time. I like that because that's something we know about.

If there's some strange attractor driving us towards some particular evolution, then some people might feel more comfortable with that, but I wouldn't. I like that cold, clean feeling on the far side of the moon, where there's nothing but us-- just us and the chickens. (*laughter*)

David: Terence McKenna also told me that he thought that time was a type of wave, having a beginning point and an end point. What is your perspective on time?

Kary: It's clearly nature's way of keeping everything from happening at once. (*laughter*) It may be that it flows along in a straight line, or it may be that it has a lot of curlicue things in it. It might be that it's got a shape that we have no idea what that would even look like.

I enjoy fractal geometry as a sort of hobby. Fractal geometry does not have any straight lines in it. It doesn't have any edges, any background or foreground, and yet it's really pleasant to look at.

David: Just like nature.

Kary: Yes. I think nature is more like fractal geometry, than it is like Euclidian geometry. Euclidian geometry says there is such a thing as a line-- except a line is an infinitesimally thin thing. It's not a pencil line--that's a sort of an approximation to a line. But a real line doesn't have any thickness. A real point doesn't have any volume. A real square doesn't exist anywhere I've ever seen on the planet. No triangles either. Everything is an approximation to that, and the finer you look at it, the less of an approximation it is.

Let's say you ask, what is the perimeter of England? You could take a map of England, draw a circle around it, and say that is the perimeter. But if you get down really close, it becomes more difficult. How do you measure the perimeter of England? Let's say you take a rod and you see how many times it takes to walk around England with this rod end-over-end, and the rod is ten meters long. Then you say, well, it took me a million times, so it must be ten million meters around England.

But now if you get a smaller rod, perhaps five meters long, and do the same thing, it will turn out that you'll measure a larger perimeter of England, because that will work itself in and out better. The smaller the rod, the longer the perimeter of England gets. You finally have to conclude that it doesn't have a perimeter. (*laughter*)

David: Or that it has an infinite perimeter.

Kary: A perimeter is a practical word that we use to approximately measure something that we think about, like skin surface. But it's the same as with the perimeter of England. It goes in and out, and in and out. There's not really an edge of you. You really stick out into everything, and it sticks into you.

David: So, in other words, the boundaries that we perceive in the world are merely arbitrary creations of our own minds?

Kary: Yes. I think that the Buddhists have a name for that. It's the inter-penetrability of things--like when you close your fingers together like this. (*Kary intertwines his fingers together*) That's how you are with the universe. That's another thing, just like evolution, that you don't really need to prove to yourself. You just look at the principle and you say, yeah, that's got to be true.

David: From a psychological point of view, sometimes it seems as though time is composed of all these little discreet moments, like the stills of a movie, and we string them together somehow through our memories.

Kary: Yes, there do seem to be moments. I've experienced that, and I go

through the moment concept also. It's as if there are moments, and then there is space between them somehow. It's a subjective feeling that I get that probably relates to something, but I don't know how to set up a scientific experiment to measure a moment.

In the physicist's view, until the Twentieth Century, time was a continuous function. There weren't any punctate parts of it. It didn't stop and start--it was always there and it was running smoothly. Maybe the cogs and the gears of the clocks that we made were discreet--they made little movements, and you had seconds--but it was considered that those were due to our limitations, because we didn't have anything that would just totally and continuously measure time. We still don't.

But now, in our physics, it's not really clear that that is what is happening. The moment concept might be much more like what modern physics would say. Things do not run completely smoothly and even sometimes get ahead of themselves, in the sense that the cause of something happens after the effect of it.

David: That seems to run completely counter to the entire way that we perceive the flow of time. How do you think that happens?

Kary: I don't know. In quantum mechanics there's a fuzziness about precisely locating anything in time or space, so it is possible that the cause of some phenomenon occurs after the phenomenon has already happened. I mean "after" in tiny little increments like tiny fractions of picoseconds, or something like that.

The probability that the cause of something occurs after the effect decreases with the size and complexity of the thing that's happening, and with how much later you're talking about. But it's always there. It's always finite. It is not absolutely impossible for the cause to happen a long time after the effect. It's just a matter of some little mathematical function that drops off exponentially. So there's really no "now" ever, anywhere.

David: Of course the Buddhists would say that there's nothing else except "now".

Kary: It's almost the same thing when you get down to it. (laughter) When you say there is absolutely not a "now", then everything is "now" in a way.

There are parts of your brain that do not respond to time. In other parts, for example emotional areas, everything is happening now. There's no saying, well, that's over, so I don't feel sorry about it anymore. You keep it. One of my favorite quotes in my book was that there was a particular part of your brain that deals with the melancholy of things past, and, as you age, it grows

and prospers, until finally, against your better judgment, you listen to country music. (*laughter*)

David: When I interviewed parapsychologist Dean Radin he described experiments that he did showing people images on a video screen that were either pleasant or shocking, while a galvanic skin response system continuously monitored the people's reactions. A computer randomly chose the image five seconds before displaying it. The fascinating thing was that there was a significant change in the electrical conductivity of people's skin five seconds prior to their seeing a shocking image.

Kary: I sat wired up in front of Radin's machine myself one morning. I was intrigued. My skin conductivity could respond, not every time, but a statistically significant percentage of the time, to what sort of stimulus his absolutely random machine was going to present to me. I don't know what it means, but five seconds is almost an infinity compared to fractions of a picosecond, so I don't think that what Radin is investigating is the same thing as what Heisenberg is suggesting with the Uncertainty Principle and the fuzziness of time over ultra-short intervals. Both are weird from the standpoint of our normal sense of reality, but in a very different way. Picoseconds are not in our personal reality. Radin is addressing something to do with human minds on our time scale; whether our minds are really localized in space and time, like we normally think of them. He is not presenting a theory about things almost incomprehensibly small. He is demonstrating an empirical fact, a strange and unexpected property of things, on a scale of seconds, with which we are personally familiar, and he is doing it in a technically convincing way. I don't know what it means, that's why it's intriguing.

On a related but very different note, in one of the chapters of my book, I was talking about whether a computer could be ahead of you by looking at your brain activity. Before you would know you were going to do something, it would know. I feel like that's probably possible, but it doesn't suggest any radical new concept.

What Radin is getting at is something more curious. If you think about yourself as something going through time, how thick are you? You've got to have a certain finite 'thickness' in time, or you wouldn't exist. So you might be a fraction of a second, or a second wide, or five, sliding through time.

David: And your 'thickness' may change, depending on your neurochemistry at the time. (*laughter*)

Kary: Yes.

David: Perhaps our conscious experience of 'now' has a thinner 'thickness'

than other unconscious aspects of our brains? I've wondered if this possibility might be an explanation for what people have described as precognition. What do you think?

Kary: It might be that certain parts of you are weeks, months or years wide. Or maybe some part of you is "now" all the time--from your birth (or maybe even before birth) to your death. Some part of you is in the future at any moment, and some part of you is in the past, because you couldn't possibly be just in this infinitesimally thin thing we call "now"-- because there wouldn't be room for you in there. (*laughter*)

That's using a lot of concepts that come out of physics and maybe don't belong in that context, but I've always thought that a little bit of me has got to be in the future.

David: Or part of your brain can be processing information about an aspect of "now" that you're not quite conscious of.

Kary: Not yet conscious of, or maybe you won't ever be. Maybe it sticks out in lots of directions. (*laughter*) I mean, there's no need for this place to be just three-dimensional space and time. We have a subjective sense of physics that is consistent with three-dimensional Euclidian geometry. Euclid probably did too. But, a lot of modern physics says that this place has more dimensions than that. String theory says that it is all made of strings, vibrating in eleven dimensions. We are made out of things that are eleven dimensional.

David: At least.

Kary: This physics claims that eight of those dimensions have shrunk to such proportions that we can't perceive them in our normal life. They're just not wide enough to see. But we can infer them from the properties of tiny particles that we can see with enormous machines that we can build at great expense. And we can only understand the properties of all the particles we know about, from those machines, if the strings that compose them exist in eleven dimensions. That is to say, if these things which we are postulating to explain the things that we can see with machines are really things--meaning, they have a finite spot where they are sometimes, and they have a certain energy associated with them--then they have properties that can only exist in an eleven-dimensional space. This concept would be helpful if you could imagine an eleven dimensional space, which I can't. I'm still having trouble with five.

In my book I try to express this. I don't like to preach to people and tell them what I think they should be, but a lot of people need to be waked up to the fact that they follow like sheep. They think that the world has gotten too

complex and that they can't decide for themselves about complicated issues.

Let's look at global warming. If those guys with the satellite sensors and the banks of computers running global circulation simulation programs call a press conference to say, "If you don't stop burning fossil fuels the earth is going to get hotter and hotter until you're dead," most people will believe them. They don't think about the fact that with every scientific utterance that you hear or read, somebody's making a living.

Scientists get paid for making statements like that, and the more impact that their statements seem to make on our life, the more we're willing to support that sort of research. I make a case in my book for the fact that we're supporting a lot of research for very foolish things. We're still living on the frontier. We should be worrying about practical things.

David: Like the asteroids that may come crashing down on us.

Kary: Yes, like the asteroids. We're spending three million dollars a year on that. We've spent three billion dollars on trying to figure out some way to experimentally confirm the existence of something called the Higgs particle. Nobody on this whole block cares about it, and nobody's going to care about it, unless they happen to be in the group that discovers it.

We're putting money into things that often don't matter. If we believe there is a hole in the ozone, and the "experts" say we must replace the former refrigerants with new ones, patentable to a company like Monsanto, there is more profit to be made. The freon patents have run out. We will spend trillions on replacing it with something, equally likely to be bad for us in some way, and creating a black market for freon.

It's a ridiculous waste of the world's resources to be doing things like that, because there's no evidence for a hole in the ozone. Some labs were probably about to go out of business and needed a reason to exist and be funded.

If you really care about the planet, you don't have to always be torn by the latest fad, or the latest substitute for Catholicism--which I think environmentalism is in a way.

David: In other words, question authority and think for yourself.

Kary: And ignore alien orders. (*laughter*) Yes, absolutely question authority, because there isn't any real authority. It's a democratic place in a way. The whole concept of evolution says that we all have the same sort of beginnings. We don't come from something above, telling us what's right

and what's wrong. We have to figure it out for ourselves.

We're here, and we each have a spirit inside of us somehow that can make those decisions--if you keep informed. Don't read trash all the time. Every now and then read something that attempts to be factual, and try to make sense out it. But don't accept it as being factual. Just accept the fact that if you look at enough information, for a long enough time, you will start being one of the people in the world that can make decisions about what's really good for the planet.

David: What do you think happens to consciousness after death?

Kary: I think that consciousness decays to nothing after death. My approach is to ask myself what do I have evidence for? It seems like every living process does end at some point. It's a fuzzy thing, but as your body dies, I think your consciousness probably dies with it. Now, that's what I think--but what I would like to believe might be different from that. I'm not absolutely certain that that's a question that I have enough evidence to answer. In science you're supposed to have evidence.

It's all right to have a hypothesis, but you still have to have some evidence. You need to have something, like an indication, to make the hypothesis more than just a wish. Of course, being a scientist doesn't mean you don't have wishes. But, from a scientific point of view, I would say consciousness is definitely associated with the body as we know it. There's no reason to make up stories about things that we don't know anything about.

However, when I'm thinking about what's possible, then anything is possible. I think it would be pretty neat if we didn't dissolve after our death. It's not a question that there is an answer for. There's no reason to think that consciousness continues after death, besides just the fact that we would like it, and that we don't want to dissolve--but that's not really a reasonable kind of a scientific premise.

You couldn't get a National Science Foundation grant to study it properly, because we don't have any kind of indication that consciousness survives death. There are a lot of people that think that consciousness continues after we die, but I don't think that is reason for the scientist part of me to give it any truck at all. But there is a part of me, just like the rest of those people that feels immortal, and would like it to be that way. That question does not really have a rational answer.

David: It's a question that fascinates me because I think it really stimulates the imagination.

Kary: Yes it does. If you were to take a vote around the planet, it would

definitely come out that we are eternal and responsible somehow for ourselves and our actions forever. But that's not a rational point of view. There's nothing that we accept like that in science except for mathematical truths. The universe itself, we would say it changes, and it has a lifetime. And at some point, it will either return to a singularity, or it will just expand itself out of existence, or whatever. I mean, there's nothing around us that has that property of being immortal.

David: When I spoke with Rupert Sheldrake he told me that he questions the idea that there are these eternal, unchanging mathematical laws that govern the universe.

Kary: He questioned that too?

David: Yeah, he thinks of them more like habits than laws, and that they could be evolving, just like everything else in the universe is evolving.

Kary: Our idea about mathematics is that, once a theorem is proven, that it will always be true, because of the whole interwoven structure of mathematical logic. But a lot of things that we think are true in terms of physics, which is different from mathematics, have changed--like Newtonian gravitation, for instance. In the Seventeenth Century it seemed to be true, then, after three hundred years, with more thinking and better observations, it turned out not to be exactly true. Relativity came along and said no, you're dealing with elements like mass and length as though they were absolute and none of them are. Space is not absolute. Only the velocity of light is absolute. So everything had to be changed. But in mathematics, as long as we keep the definitions clear, it seems that a mathematical truth is eternal. The fly in the ointment, of course, is that mathematics does not say anything directly about reality. We make the associations intuitively and we also up the axioms for want of any other way to get them. But we wouldn't want it to be simple here, would we?

David: What Rupert questions is the idea that universal constants, like the speed of light, or gravitational constants, remain eternally unchanging.

Kary: There's no reason to think that those things can't change.

David: Yet that's the assumption that most scientists have.

Kary: The speed of light is something that actually is a measurement that we make, and special relativity says it will always be the same for everyone. But special relativity is just a theory in the same way that Newtonian mechanics was a theory. We could find out that in certain circumstances special relativity wasn't quite true. What we found out from Newtonian mechanics was that, in certain circumstances, Newton was wrong. The

mass of something does seem to increase if it is going, relative to us, at a speed near the speed of light. In fact, it doesn't even have to be going near the speed of light. If it's just moving at all, the mass increases. It's just that the increase is kind of small until it gets up to a very high velocity. Newton thought that mass would always stay the same.

David: Has your use of psychedelics influenced your scientific work, and how has it affected your perspective on life in general?

Kary: I would say that it was a mind-opening experience. It showed me that it might be a lot weirder here than I thought it was. So pay attention. Know what your assumptions are, and which of those are just arbitrary. Notice that things might be a little bit different than you think they are. I wouldn't say that it led to any particular developments in my thought, except that it just expanded it a little bit. I think almost anyone who's had those experiences would say that this place might be a little weirder than it appears. I'm not so certain anymore that the world is exactly the way I think it is. Most people get fairly stuck in ways of thinking that really are the current fashion, the current theory--like Newtonian mechanics seemed to be the way that things were for two hundred years.

David: What is your perspective on the concept of God?

Kary: It's a notion that really doesn't solve any philosophical questions; it just puts it off a little bit. On the other hand, it's a concept that occupies the minds of a heck of a lot of humans, so it's an important concept to keep in mind. But if you look at it in a philosophical way, it simply puts off any kinds of thoughts that you might have of your origins, or of your purpose. To just say, I'm here because of Allah, and I'm here to do his will, doesn't really tell you what to do, or why you're here. It just gives it a name, and there's nothing really specific about anything of it.

David: Do you think it's possible that there could be any type of intelligence or consciousness inherent in nature?

Kary: Well, what we know of the universe is so big, and so complex--on a large scale or on a small scale--that nothing really should be all that shocking to us. If it turns out to have properties that echo various religious beliefs, I don't think it would be terribly shocking.

But there's no evidence for such a thing. If you read and follow the thinking of those theories that are prominent today in terms of physics--like how physicists envision the whole of existence--and when they start talking about things like quantum mechanics, you realize that this place is so complicated, and so non-intuitive in a way, that anything is really possible, and nothing should surprise you.

But, on the other hand, there's no evidence that we are being lead by some divine purpose. There's no evidence for that, and there's no evidence against that. It's not a question that science really needs to address, because there's no evidence to support it. But we often ignore some of the weirdest things on the planet.

David: Like what?

Kary: Crop circles, for example. People might say that they don't exist, or they're all a hoax, but that's pretty silly. I don't think anyone could make some of the ones that I've seen. Either the pictures are faked, or the things are made by some kind of forces that we don't quite understand. They're not made by people going out in the middle of the night with sticks and ropes. There are a lot of things like that that we don't understand.

If you ask people the question, "Have you ever had any experience that you just could not explain at all, but you couldn't deny it?" most people will say, yes, that happened to me at least once. I consider that the experiences that I've had in my life are real in a sense. I don't make them up. Some things have happened to me that I can't explain, and I can't deny that they happened.

David: What are some of the things that have happened to you that you can't explain?

Kary: All kinds of things have happened to me that I can't explain. They happen all the time. Don't you ever have what you might call an intuition, but really it seems that you have seen into the future?

David: Sure.

Kary: I have that happen a lot. My wife has that happen. Just simple little things that are kind of contrary to any sort of scientific explanations that I can see. Actually, there's nothing in present day physics that says that you can't have precognitive experiences. Like I was saying earlier, part of you exists in the future. Present day physics says that the percentage of you that exists in the future drops off exponentially, and there's not much of it really, but how much does it take to see something in the future? I have all kinds of experiences that don't fit with the very simple and Newtonian picture of causality. Things seem to be connected by more dimensions than I can perceive with my vision, and modern physics says that's true.

David: Why do you think it is that so many conventional scientists are opposed to the idea that telepathy or precognition might have a basis in reality?

Kary: Maybe they think there's scientific reason to doubt that those things could possibly exist. I don't think there is scientific evidence for these phenomena. Science has been silent on those things because scientists don't know how to deal with them. They don't really present a side we can grasp.

David: Actually there has been quite a bit of serious research done trying to measure things like telepathy, and other forms of psychic phenomena.

Kary: Yes, but it's not been terribly successful. Some people claim to have telepathic powers, but they can't always do it on demand.

David: When I interviewed Dean Radin for this book, he told me that he did a meta-analysis of all the psi research that's been done over past hundred years. He said that, statistically, the odds of these hundreds of experiments--which tested for things like telepathy and psychokinesis--working out as positively as they did, were in the order of billions to one. The effects were small, but very statistically significant.

Kary: That may be so, but if I try to play the California Lottery, for the life of me, I can't get it right. (*Laughter*) I know that once in awhile somebody does, but never me. My wife Nancy had this dream that she won the Lottery. It was a powerful dream, and it woke her up. In the dream she won sixteen million dollars. It was Saturday, and the lottery was at thirteen million. She bought a ticket, but didn't get close. The following Wednesday, the lottery was sixteen million. She bought a ticket, got four numbers right, and made eighty-five dollars. She would have made a huge amount of money if she had gotten the Mega number correct. Amazingly, her incorrect numbers were only digits away from the correct numbers.

David: Do you have any kind of model that you use to explain experiences like that?

Kary: I just say that was something I don't understand. It was mystifying that she would get four out of six, because that's hard to do. After that happened, we tried doing it more often. I thought maybe she would be good at it. That's what a scientist would think. If you could get four of them one time, maybe the next time you can get all six of them. But it didn't work that way. On that particular day, the chances were high that she was going get it for some reason. Otherwise, it was just a complete coincidence that she had that dream.

David: It would be interesting to know how many other people got four out of six numbers right that day--and how many of those people had similar dreams.

Kary: Yeah, there are a whole lot of little questions like that. Do the people that win it just pick it by chance? Obviously, if enough people try, then somebody's going to win eventually, because that's the way it's set up.

David: I don't think that anybody ever wins it repeatedly. Or at least, I've never heard of anybody doing that.

Kary: I don't think people do. If somebody could, they probably would, wouldn't they?

David: You'd think. (*laughter*)

Kary: If people can really see into the future consistently, then they ain't telling me that. Nobody's ever told me they could see into the future anytime they wanted.

David: But then weird things do happen though.

Kary: Yes they do. Weird things like Nancy dreaming the lottery. She doesn't normally buy tickets. It has that element of somehow seeing into the future, but you can't really understand how it works. Anyone who doesn't think the world is much more mysterious than the simple picture that a physics laboratory would give you, has not really been watching closely. If you think that everything that goes on here follows a set of Newtonian rules of mechanics, or even Einsteinian kind of stuff, then you're not paying attention.

David: There are a lot of people like that.

Kary: Yes, they're not noticing it in their own life. They think it's just a coincidence. It's hard to say what the probability is that you will have a dream in which you've won the sixteen million dollar lottery, and in a few days, it is sixteen million, and you damn well almost win it. What is the probability of that? There's no way to compute what the probability of having a premonition dream is, and having it be close.

David: You could start keeping a log of your dreams.

Kary: If you do keep a log, and you're paying attention, then there will be more chances to notice things. There are more weird things going on in your life then you expect by pure chance. I've never had any luck moving things with my mind, like making a penny fall the right way. I know there are people who can guess them sometimes, but they can't do it all the time. So, I would say that this place is not as well behaved as our theories about it would have it be.

And exactly what we are--which goes back to your question about whether or not consciousness vanishes when we die--is something that we don't know. Most of the people in the world think that there is a nonphysical part of people. By nonphysical, I mean that you can't weigh it. But if it weren't physical in some way, if it never had any effects on what you think of as real, it wouldn't matter whether it was there or not, would it?

There are a lot of people who feel this weird thing about their soul. However they define the soul, they think it's there. They say that the soul has certain properties, and you can make it be either happy for you or sad, after you die, by doing certain things. I consider these people to not be deep thinkers.

David: Do you think their beliefs are some kind of psychological defense mechanism, or that their religious ideas come out of their fear of death?

Kary: I don't know where it comes from. Different cultures have all kinds of myths that are strongly adhered to by people. Christianity is one, and Islam is another. There are things in Buddhism that I would look at in the same way. They're just little myths that we don't really know much about, yet some people feel very strongly about them. So if you are studying humans, you certainly would not ignore religion, because it's probably one of the strongest forces that have affected us in the last three or four thousand years, and probably from long before that.

If you are studying what you think to be 'the entirety of existence'--like somebody who studies physics would think--and you can't put an experimental framework on it, then it's not really useful to entertain that sort of myth. In other words, if there's nothing you can do about it--you can't measure it, use it to predict something with, or do something with it that you can't do without it--then you have to ignore it. One of the principles in scientific investigations is that you keep it as simple as possible. You don't introduce an extraneous idea that doesn't have some sort of meaning in terms of an experimental proof that you can do.

So introducing this idea of a greater-than-human force--a god, with human characteristics (which is usually the way religions picture this thing, who has it all figured out--has no basis, as far as I'm concerned, in my experience, or in the experience of reliable observers that I have access to. I don't see any reason to use that as a hypothesis, and try to figure out an experiment to prove it or not.

David: A lot of people claim from their experience with psychedelics that they've had religious or mystical experiences, which caused them to suspect that there might be some kind of intelligence operating in nature.

Kary: Yeah, and after a six-pack of beer a lot of people think they're invincible, which they're not. I'm not discounting the fact that psychedelics might open you up to see things that are true, which you wouldn't have seen without them. But a couple of six-packs might also show you something. It doesn't prove anything. You don't assume that what you see while your mind is under the influence of some drug is truer than what your mind sees when it's not. When you go to Hawaii you might see some things that are quite different than what you would see on the West Coast of the United States--and that might make you think that there might be even stranger things. But you wouldn't say that Hawaii is truer than the West Coast of the United States.

David: What are you currently working on?

Kary: I'm in the process of starting a project which involves a way to redirect the immune system from one target to another, by using a chemical linker that will link an immune response that you have made for one thing to a new target, a target to which you would now like to be immune.

David: This sounds really exciting. How far along are you with this project?

Kary: We already know how to do it, and the experiments that we've tried to do it in with baby rats have worked. In the experiments we were able to take an immune response in baby rats that was made for this irrelevant organic chemical called phenylarsonic acid, and redirect that to this bacterium that would normally kill rats in a couple of days. By using this method we made it so that the bacterium wasn't able to grow in them at all. The bacterium that we injected in them, Haemophilus influenzae, would have killed them within two days. We gave them the organism first. Then, right after that, we gave them the thing that was going to protect them, and it worked in a really big way. The untreated rats that got the Haemophilus influenzae had something like a million microorganisms per milliliter of their blood in 24 hours. It grows really fast in a baby rat. The ones that got our treatment had none that were detectable which in our protocol is less than 20 per milliliter. So it was a big deal.

That experiment was a contrived experiment. We didn't start with a human that had been accidentally exposed to some pathogen. We started with some rats that had been intentionally exposed, and we knew exactly when and how much. We think that we can take that same system and adapt it, not only to humans, but to just about any human pathogen that we can define beforehand. For instance, people have defined the pathogen that causes anthrax. We can isolate and grow it in the lab. We can make something that will bind to it. In fact, there are lots of people who have already made things that combine with anthrax. What this invention does is take the thing that combines with anthrax, and uses it as one end of a linker, the other end of

which binds to the immune response that we already have. The invention is called Altermune, and it defines a class of drugs. In the case of the rats, we injected it in them. Hopefully, we're going to be able to produce Altermune type drugs that you could ingest, so you won't even have to have them injected. But if you've just been infected with smallpox, you won't mind an injection.

David: What are some of the other potential applications that you see for it?

Kary: Most of the possibilities that immediately come to mind have to do with infectious disease. The way we've dealt with modifying our immune system since 1794--when Jenner discovered vaccination--hasn't changed. We vaccinate ourselves for all kinds of things, and we do it in that way--by giving ourselves a damaged or dead copy of what we would like to be immune to. We inject it into your body, and you make an immune response to it over a period of a few weeks or months. Sometimes we have to give it to you on several occasions during that time. You make a whole bunch of antibodies, some of which will bind directly to that thing that we stuck in you or anything like it, and it permanently affects your immune system.

You can make someone immune to anthrax by vaccination, but if it has negative side-effects, they're permanent. The Altermune method takes an immune response that you already have, and, temporarily redirects it to some target to which you now want to be immune. For the method to work, you have to be prepared for it by having the pathogen in hand, in a fairly purified form. For most of the organisms that we're worried about in terms of bioterrorism, we do.

That's what causes the worry about them--people have been working on them, and they're around. Things like cholera or smallpox, all kinds of terrible things that people have been plagued by, and most of the people in the civilized world are no longer immune to them.

David: The implications sound staggering. What about diseases like cancer and AIDS?

Kary: Everybody asks, what about cancer? Cancer is not at all like an infectious disease, in the sense that every cancer cell is not like every other cancer cell, even in the same tumor. Cancer is a tough one. First I'm going to deal with diseases that we know the exact nature of, where an organism is responsible for it, and the absence of that organism will cure it. That's most infectious diseases.

AIDS doesn't fall into that category. Nor does it affect many people despite the press that it gets. Plus, the AIDS scientists say you can cure HIV if you want to, but you still don't cure AIDS, because the disease has already done

something to you. In terms of an infectious disease it's kind of an oddball thing. I don't think most of the research is reliable and I am not willing to spend a lot of effort on it. I'm one of the few outspoken people who say that there's no good scientific evidence that the diseases that are called AIDS are really caused by the retrovirus called HIV--in spite of its name. I've had a lot of trouble from people over that issue, because many are convinced that it does. But my assessment is that it is an unsupported and unsubstantiated belief.

There are all kinds of possibilities for the first Altermune targets, but we're going to concentrate on potential bioweapons. There's a list of about twenty different pathogens that people have associated with various biological warfare programs. Most of them came from the Soviet Union, but some of them were developed in the US before 1969, when we stopped making them.

There's fear that some of the pathogens have been produced intentionally and are still out there. How long is it going to be before somebody gives himself smallpox, flies to New York, and walks around for a couple of weeks until he dies? How many people would he infect? How many people would they infect? We have vaccines that may or may not be protective--nobody knows for sure. They might not work fast enough. They're slow in terms of producing their results. With Altermune drugs, you don't have to grow a new immune response; you use a full-strength immune response that you already have in place. You just divert it to the target that you now have in mind--and it's immediate. The chemistry is actually pretty complicated, but chemists are pretty clever these days. I'm glad to be one.