Physicist Carroll: Atoms and Eve incompatible

DAN BARKER, FFRF CO-PRESIDENT:

Last night we gave an Emperor Has No Clothes Award to Donald C. Johanson. The very first Emperor recipient, in 1999, was physicist Steven Weinberg. Today's recipient is also a physicist. Sean Carroll is a theoretical physicist at Caltech in Pasadena. He got his Ph.D. in 1993 from Harvard and was on the faculty at the Enrico Fermi Institute at the University of Chicago. He does research on cosmology, field theory, gravitation, and quantum mechanics. He's especially interested in how quantum mechanics intersects with cosmology. He's worked on dark matter, dark energy, modified gravity (maybe he can explain what modified gravity is — it only falls part way, or what?), topological defects, extra dimensions and violations of fundamental symmetries.

He lives in Los Angeles with his wife, the writer Jennifer Ouellette. His most "popular"-level book, published in 2013, is called The Particle at the End of the Universe: How the Hunt for the Higgs Boson Leads us to the Edge of a New World.

I think it's safe to say you won't hear Sean Carroll call the Higgs boson "the God particle."

By Sean Carroll

Thank you very much, Dan, and thanks to everyone here. It's a tremendous honor for me to receive the Emperor Has No Clothes Award. I looked on Google and couldn't find any major awards that have been won both by Ursula K. Le Guin and Jesse Ventura other than this one.I have to admit, it's also a little awkward because I looked through the list of previous winners and saw so many people who've done fantastic work for the world, out there fighting for secularism in the public sphere. I'm a theoretical physicist. I like to think about things. I don't really like to do things.

So I thought about what could I possibly say for the award speech. Then I remembered the holiday season is upon us. Next week is Halloween, which is paradoxically one of the favorite holidays among the naturalist and atheist communities. With that in mind, I was inspired to take death as the theme of my talk.

You might point out that I am not an expert on death either, much less secularism. It's an intimidating and forbidding topic. I thought I would soften it a little bit and bring it more into my wheelhouse by also talking about physics, which everybody has warm fuzzy feelings about.

A couple of months ago, I found myself in New York City participating in a debate. Steven Novella and I were arguing against the resolution, "Death is not final." For the resolution were Eben Alexander and Raymond Moody. Eben Alexander is a neurosurgeon and New York Times best-selling author [of Proof of Heaven] who contracted meningitis and went into a coma and visited heaven. You know that because he says he did and he's very sincere.Steven and I did our best to present the more scientific case. The good news is that we won the debate. These "Intelligence Squared" debates are high-quality events, and they were a little nervous to have this one because they are usually about politics. They take a poll before and after, asking how many audience members agree or disagree with the resolution. Happily, we actually changed people's minds a little bit – a good number of the undecided people came over to our side. You can in fact change people's minds by talking and having a reasonable discussion about controversial issues.

But there were still a substantial number of people who think that death is not final. It's a very compelling vision. It's easy to say that wishful thinking has something to do with it. But whatever the motivations might be, there are even many atheists and naturalists who think that we just can't say whether there is life after death. They would say that there is no evidence one way or another.

I want to tell you that we can say that there is no life after death. Sorry.

Why is that true? The argument is basically the following: The mind is the brain. That's what the mind is, there is nothing else other than the brain that is going on. And the brain is made of atoms. Here is the controversial part — even some of my friends get annoyed when I say this. But it's the truth so I will lay it on you. We know how atoms work. They are not a mystery to us. And they work in such a way that when you die there is no way for the information that is "you" to persist after death. There is no way for that stuff, that knowledge, that set of beliefs and feelings that made up you, to leave your body. Because it is stuck there with the atoms that are decaying in your tomb or being cremated or whatever your favorite way to be after death is.

We don't know all of the laws of physics by any stretch of the imagination. But we know something about them, and we know enough to make a very powerful claim: there is no room for new laws of physics that would affect how the atoms in your brain actually work.

That's a very subtle statement. I think that Dan mentioned I have three hours to give this talk, so . . . I would get tired if that happened, but I would give the whole explanation for the laws of physics, how they came to be, why we are confident in them.

Instead I will just intimidate you into submission by showing you an equation. In this one

equation are summarized all of the laws of physics necessary to understand the atoms in your brain at the energy mass and length scales relevant to your everyday lives. We have quantum mechanics, we have spacetime, we have gravity, we have the other forces, electromagnetism and the nuclear forces. We have matter, the electrons and the quarks you're made of, and we have of course the Higgs boson.

There are plenty of things physicists don't understand, but we know enough to say that if there are any other forces, particles, fields, phenomena, they can't affect the atoms in your brain. If there are new particles and fields that we haven't yet seen (which there probably are), either they're so weak or short-lived that they would not have any affect on what the atoms are doing, or we would have found them in experiments. Those are the only two options.

No one ever understands me when I say this, so I'm going to say the same thing over again. I'm not saying we understand all of physics. I'm not even saying we know how the fundamental laws come together to make complicated things like frogs and ecosystems and spiral galaxies. There are enormous amounts of work to be done in understanding how science works, including physics.

But we have a basic underlying framework, which we call quantum field theory. This framework is either true or false. All the evidence says that it's true, and if it's true then there is no room for new physics that can in any way affect what goes on in the atoms in your brain. We understand what they do. There is therefore no room for the information that you persist after you die.

Schrödinger's egg

And yet, Eben Alexander sells a lot more books than Steve Novella or I do. He's No. 1 on The New York Times best-seller list. What are we to do with people who say that they have evidence that there is life after death? I like to put it in terms of two options.

Option one is that some ill-defined metaphysical substance, not subject to the known laws of physics, interacts with the atoms of our brains in ways that have eluded every controlled experiment ever performed in the history of science. Option two is that people hallucinate when they're nearly dead. I leave it to the court to decide.

We're not going to simply trust the claims of people who have actually visited heaven and come back to sell books about it. We can be scientific about this. We can ask: Okay, given that we're made of atoms and we understand what the atoms are doing, what is life? What is this complex nonfundamental phenomenon that arises out of the motions and

interactions of the fundamental particles of which we are made?

Famed Austrian physicist Erwin Schrödinger was one of many physicists who fled Austria just before World War II. Even though he had already won the Nobel Prize, he had difficulty finding a position, because his family included both his wife and his mistress. Finally, the government of Ireland invited him to help found a new Institute for Advanced Studies in Dublin. He moved to Ireland and wrote a little book called What Is Life? It became quite famous because it prefigures a lot of what we soon thereafter discovered about DNA and the genetic code, just on the basis of thinking like a physicist.

He also tried to address the question in the title of his book. When is a piece of matter said to be alive? It's a wonderful thought-provoking answer. He basically says something is alive when it keeps moving long after it should have stopped.

You have a little baby chick, it grows up to be a chicken. As long as you feed it, it's going flap around and raise its wings and so forth. When it dies, it will stop moving. It will decompose and return to the ground. Schrödinger wants to know what's going on, what is it that keeps alive things moving and walking around and making noise and raising a fuss.

Answering creationists

The answer, as he quite correctly puts it, relies on my favorite law of physics, the second law of thermodynamics. This law says that the entropy of the universe or of any closed isolated bit of the universe increases as time goes on.

Entropy is simply a measure of the disorderliness, the messiness, the chaotic nature of stuff. If you start with an unbroken egg, it is easy to break the egg. That makes it more disorderly and disorganized. It's easy to turn that broken egg into scrambled eggs. Again, more disorganized. It's very difficult and would never happen by itself to take the scrambled egg and make it back into the pristine form of an unbroken egg, Humpty Dumpty notwithstanding. This law is very profound and captures people's imaginations.

At a scientific level, it also captures the imagination of creationists. They say, look, there is a fundamental law of physics. You're telling us, one of the famous laws of 19th century science says that things run down, that things become less and less organized over time, that ultimately the universe will reach "heat death." Yet you expect me to believe that all of the marvelous complexity of life and the biosphere and this evolution that you guys talk about all just happened starting from some disorderly primordial goo. How is that possible?There is a simple and perfectly correct answer, which focuses on the phrase "isolated systems." The Earth is not an isolated system. There's a little story you can find

on the Internet. I'm not sure if it's true or not. It's a creationist saying, "You know, the physicists always say that the Earth is not an isolated system, but that can't be right because if it were, there would be a giant glowing ball of energy in the sky."

That's probably not true. That's just too good to be true, if anyone ever said that.

But there's another question, somewhat more subtle. It doesn't seem to violate the letter of the second law of thermodynamics for life to arise on Earth. But does it violate the spirit of the law? Why is it that complicated elaborate complex organisms arose just through the impersonal working out of the fundamental law of physics? If there is no guidance there, if anything, the tendency seems to be towards messy disorder.

So visualize life here on Earth, a lively landscape on a sunny day. The sun is a hot spot in a cold sky. If the whole sky were the same temperature as the sun, Earth would get a lot more energy. Energy is good. But the Earth would soon come to be the temperature of the sun, and we would all die. On the other hand, if the whole sky were the temperature of the night sky, the Earth would come to be the temperature of the night sky — and we would all die.

Why life arose

The reason why we are here and life arose on Earth is because the sun is a hot spot in a cold sky. What matters is not that we get energy from the sun, but that we get low-entropy energy. Orderly energy, which is able to do useful work. We chew our cuds and we photosynthesize and we have conventions, all of which degrades that energy. We raise its entropy and then we send it back to the universe.

For every one photon of light we get from the sun, we radiate 20 photons back into the universe, with 20 times the entropy. We give exactly as much energy back to the universe as we get: On average, each photon we radiate out into the sky has one-twentieth the energy of the ones we receive. What matters is not that the sun is a source of energy but that it's a source of energy in a low-entropy form.

This is not just here in our biosphere. This is something that is characteristic of the universe as a whole. Let me remind you of the history of the universe. If you took a picture of the universe one second after the Big Bang, it would simply be a featureless bright glow in all directions. Sometimes you'll see the Big Bang, which happened 13.8 billion years ago, portrayed as like a bright dot on a black background. That is completely wrong. That makes you think that the Big Bang was an event with a location at a place in a preexisting space/time, which is not right. The Big Bang is the whole universe beginning.

One second after the Big Bang, the universe was hot, it was dense, it was smooth, and it was the same everywhere. It was shining with a brightness of, I don't know, some really bright thing.

We can take a snapshot of the universe 380,000 years after the Big Bang. This is the moment when the universe became transparent. The radiation from that moment, the cosmic microwave background, has been imaged by astronomers. And what we see is the gradual formation of structure. The universe is growing increasingly lumpy and inhomogeneous. Some spots are a little bit emptier, other spots are a little bit heavier, a little denser. And if you go on, gravity increases the contrast of the universe, until we get the wonderful collection of galaxies and stars and superclusters we see in the current universe.

We now live roughly 10 billion years after the Big Bang. (Really it's about 13.8 billion years, but only the order of magnitude concerns us for now.) We live in a world with hundreds of billions of galaxies, and who knows how many conventions are going on with extraterrestrials fighting to keep church and state separate in their local environment. The universe will continue to evolve, even after we're not here.

Above us only space

Now picture the universe 1 quadrillion years (1 followed by 15 zeros) after the Big Bang. Ultimately the stars will burn out. After about a quadrillion years, the last star will stop shining. We'll have nothing in the universe but cold rocks and black holes. But even that will not be the end. Because all those rocks, those planets, those dead stars, those comets, will fall into the black holes.

Stephen Hawking in the 1970s taught us that black holes do not last forever. They give off radiation, they will evaporate and will eventually disappear. That will take one googol (1 followed by 100 zeros) years. The last black hole will have evaporated and there will be nothing left but empty space. Our best current model is that empty space lasts forever, infinity years into the future.

That's the history of the universe. I want you to notice something about this story. Entropy increases as the universe expands, so soon after the Big Bang, the fact that the universe was very smooth was actually in that physical circumstance a reflection of the fact that it's very orderly. It was so dense and the gravity was so strong that keeping everything smooth is a very rare and finely tuned state of affairs. Entropy grows as the universe expands, structure forms, stars shine, people live and die, and eventually you reach empty space. Which turns out, if you go to the math, to be a very high-entropy state.

But complexity, the organization of the stuff that is going on, is a completely different thing from entropy. In the beginning, the universe was a very simple place, just hot and dense and smooth. And the end, a googol years from now, the universe will be a simple place once again. It will be empty space. It is between when the entropy is increasing from low to high that the universe became complex, forming planets and stars and galaxies and living organisms.

That behavior is not an accident. That is a universal way that complexity behaves. Entropy just goes up, but complexity first goes up and then fades away once you approach the final state, which we call thermal equilibrium. So the right answer to the creationists is that not only is it allowed by the second law of thermodynamics — that complex structures like living beings arose here on Earth — but the reason why is because of the second of thermodynamics. We are parasitic upon the increase of entropy of the universe.

We are little surfers riding a wave of entropy until we eventually scuttle up on shore, and it'll just be empty space forever. And again, the universe is not special, you can see this in a cup of coffee. You take a cup of coffee with the cream separate, that's low entropy. Highly organized but also very simple. If you mix them together, it is high entropy, everything mixed together but also very simple.

It's the "in between" when you see the tendrils of the cream reaching into the coffee and swirling in little complex patterns. That's when you get the complexity of the universe. These little swirls, these little ethereal bits of complexity that are caught between the simple beginning and the simple end. That's us. That's what we are, temporary eruptions of structure and organization as the universe goes from simplicity to simplicity.

A couple of years ago, I was lucky enough to be sitting on a plane next to Michael Russell, who is a geochemist at the Jet Propulsion Laboratory in Pasadena, Calif. He saw some paper I was reading, and says, "Oh, the meaning of life. I know that one, that's easy. It's to hydrogenate carbon dioxide."

As a geochemist, Michael knows that the early Earth's atmosphere was dominated by carbon dioxide. And from a chemist's point of view, that is a very low-entropy thing to be. There is a much higher-entropy thing to be, a place the Earth's atmosphere wants to go to, which is methane. But it can't get there. There is no simple chemical reaction that takes you from carbon dioxide to methane. What you need is a complicated system, a pathway of many complex chemical reactions that will take you there.

So as the early atmosphere and the early oceans sloshed about, occasionally there would fluctuate into existence just the right thing to do all the chemical reactions in the right

place. Increasing the entropy of the atmosphere that caught on and became the first living being. That's what life is. That insight is crucial, not only to the scientific definition of life but to our actual lives.

This is the thing that the audience didn't understand when Steven Avella and I were debating Eben Alexander and Raymond Moody. The thing they didn't get the most was, "But when you die, where do you go? Isn't energy conserved, don't you have energy, doesn't it go somewhere?" The answer is that life is not an energy, a force, a spirit, a substance. It is a process. It is a chemical reaction.

The end of a life is putting out a candle. When you put out a candle, the energy doesn't go anywhere. The reaction stops. When you die, you don't go anywhere. Your atoms are still there, with all of their energy, but you stop happening. That's what it means to die. It will happen to you. If you wait long enough, we will all reach equilibrium.

It's very possible, by the way, that medical science will extend our lives by an enormous amount. It's not at all in violation of the laws of physics for human beings to live thousands or tens of thousands of years. But we are not there yet.

We, like other mammals on Earth, get roughly 1.5 billion heartbeats per life span. Then that will be it and you will go away. This is why the afterlife is a false consolation. This is why this wishful thinking, this hope that life is eternal and will go on forever, is not the right hope to have. This is why I like to say that heaven is a bad idea.

Just like [previous speaker] Anthony Pinn pointed out, this wisdom can be found in poets and songwriters. Heaven is a bad idea because you reach thermal equilibrium and nothing happens. It's boring! David Byrne knows this: "Heaven is a place where nothing ever happens." Leonard Cohen knows this: "The place was dead as heaven on a Saturday night."I'd much rather be spending my Saturday night with the infidels talking about things than in heaven with the angels.

There is a fantastic novel written by Julian Barnes called A History of the World in 10½ Chapters. In the last chapter, he puts forth his idea of heaven, in fictional form. And there's always a catch if you're in a novel version of heaven, right? His hero, who is sort of a working-class, blue-collar British duffer, dies and goes to heaven. He has a guide who explains, basically, here's how it works: It's heaven, you can have whatever you want. The catch is that you have to figure out what you want. It is up to your imagination and capabilities to ask for things. We're not going to make suggestions.

This guy knew what he wanted. He wanted to play golf, he wanted to have sex, and he

wanted to have breakfast for three meals a day. So that's exactly what he got. For hundreds of years he became very good at it. He had sex with all sorts of women in various different combinations. He became so good at golf that he got a hole-in-one on every single shot on every single course in heaven.

Then he got bored and told his guide about it. The guide said, "Well, everyone has the option here of dying, of truly ending their lives."

"How many people ask for that option?" The guide responded, "Everybody asks for that option, eventually."

Because it's a mistake to think that there is some perfect way to be. This is the lesson of our ephemeral, entropy-driven life. So it's not just heaven is a bad idea. Happiness is a bad idea.

Don't get me wrong. I like happiness. I'm personally quite happy. What I'm against is fetishizing happiness. If you go to The New York Times best-seller list, if it's not "proof of the existence of heaven" books, it's happiness books. Not a lot of cosmology books on there yet.

Hedonic treadmill

We make a mistake because we think that there is some way, some situation we can put ourselves in, where we can reach perfect happiness, and then we can stay there forever. And that will be like heaven. But the nature of life itself is movement and change and evolution. There can't be a perfect state of being. There is science behind this. Psychologists talk about the "hedonic treadmill." They study people to measure their level of happiness before and after some life-changing event. If you win the lottery you become happy, but a few years after you're at the same level of happiness you had before winning the lottery. If you get in a terrible accident and become paraplegic, you become unhappy, but a few years later you're the same level of happiness you had before the accident. You can talk about the chemistry of it. The dopamine is flooding your brain, and you get used to that and want more dopamine but can't get it. But it's all based on a fundamental flaw. There is no way to achieve this perfect, everlasting happiness because that situation would be never changing. That's not that interesting and it won't make you happy. It's a fundamental contradiction.

So what do we have instead? Again, I refer to the wisdom of the poets. Muriel Rukeyser is a poet who has one of my favorite quotes: "The universe is made of stories, not of atoms." She's not one of these anti-science poets. She wrote a wonderful biography of Willard

Gibbs, who is America's greatest 19th-century scientist.

Her point is: If you meet someone for the first time, and you're on a date or you're in Starbucks or whatever and they say, "Tell me about yourself," you don't give them a list of all your atoms. I'm a faculty member at Caltech, so maybe there it would happen. At Caltech it would be considered kind of sexy to list all of your atoms.

But most of us choose to take a step back. We tell a story about who we are and how we got there. That story gives meaning and success to our lives. It's not the attainment of any one state of being. It's a story with a beginning and a middle and an inevitable, according to the laws of physics, end. How well that story is received once you're done telling it is a measure of the success of your life.

Death is serious but . . .

I don't want to belittle the very real sorrow that accompanies death. We all have friends, family members, loved ones who have died, and it makes you very sad and that is not a mistake. It is sad when we lose someone that we care about. Knowing that it's inevitable doesn't make the sorrow go away, but maybe it affects how you deal with that sorrow.If I may put forward an inappropriate joke by comedian Robert Schimmel. He's quoted in a wonderful new book that recently came out by my friend Eric Kaplan called Does Santa Exist? It's a philosophical, ontological, epistemological look at the difficult question of Santa Claus. He relates Schimmel's joke, and Schimmel says, "You know, my son got cancer. And it was just the most horrible thing. I really thought there could be nothing worse than hearing that your son has cancer. Then I got cancer."

That was the joke, right there. He got cancer. I'm a physicist, not a comedian.

If you are ever in Paris, you can visit what are called the catacombs of Paris. There are many kilometers of tunnels underneath the streets where they have interred literally millions of human skeletons. In the 18th and 19th centuries, they weren't really good at building graveyards. When it would rain a lot, the skeletons would sort of float down the streets, so they dug up all the graveyards and put the bones in the catacombs.

It's a very serious and somber place in some ways. But the attitude is very different in Paris than you would get here in the United States. There is a somber air, inevitably, but there is also some fun, some whimsy there. Whoever was arranging the skulls and so forth would make little hearts. They have playful mottos and quotations on the walls. Here is one, roughly translated: "Thus ends everything on Earth, spirit, grace, beauty, talent. Ephemeral like a flower, blown away by the slightest wind."

The attitude is basically, "Haha, you're laughing now but you'll be here before long." The point is that death is serious. It's OK to treat it seriously, but the reason it's serious is because life matters. The life we have right now is not a dress rehearsal. It's the only performance we get to give.

The universe can be kind of overwhelming. We're a very tiny part of it, but we are a remarkable part. We are just collections of atoms, but we are collections of atoms that have attained the ability to think about ourselves, to reflect about the world that we live in and to write our own stories.

Our lives will not last forever. And that is what makes them matter so much. Thank you.Heaven is a bad idea because you reach thermal equilibrium and nothing happens.