FOREIGN POLICY ASSOCIATION

Einstein: His Life and Universe
With author Walter Isaacson

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[START TAPE 105054]

FEMALE VOICE: Please join me in welcoming Mr. Walter Isaacson.

[Applause]

MR. WALTER ISAACSON: Thank you. Thank you so very much.

FEMALE VOICE: You're welcome.

MR. ISAACSON: Thanks. And I really want to thank Dan and Joanna and the Foreign Policy Association. I've been to many of these lectures and it's a great association and a great lecture series and I'm very honored to be a part of it.

I have a speech here that I prepared because Joanna actually asked me if I would speak on the mathematical tensor calculus underlying general relativity. But having talked to some of you in the crowd, instead of doing that, if Joanna doesn't mind, I want to talk about imagination and creativity and why Einstein's great leaps were not great leaps of science or great leaps of math but also great leaps of the imagination.

Those of us who study diplomacy, those of who, you know, love Shakespeare or Picasso or go to Momo [phonetic] or go to symphonies, we love the notion of creativity but we don't think that math and science is as creative unless, of course, we're scientists.

One of the joys I had in writing about Albert Einstein was to just see how imagination and creativity are part of the scientific process, especially when it comes to Einstein. Now the good news for those of you who are intimated a little bit by the notion of Einstein is that Einstein was no Einstein when he was a kid.

He was very slow in learning how to talk. So slow that when he was growing up in Germany, his nickname in the family was der Depperte, the dopey one, in the family. They even consulted a doctor because his parents were worried about his slow verbal learning ability.

But I think that slow verbal learning ability was the first clue we have to the imagination and creativity of Einstein because he did not think in words. He did not think verbally. He thought in pictures. He thought visually. He

spent his time throughout his life doing what he called visual thought experiments. That's what you and I would call daydreaming, but if you're Einstein you get to call them visual thought experiments.

Secondly, he was very rebellious as a child. He was always defying authority, which was not exactly appreciated in the German school system of the late 19th Century. So much so that one headmaster actually kicked him out of school and another amuses us by saying this Einstein will never amount to much.

But that too, that rebelliousness, that willingness to defy authority and question the prevailing wisdom, that was part of his ability to think out of the box, be more creative and make the leaps of the imagination that I think distinguished his science.

When he was a kid at age five, his father gave him a compass, for example. And he said he sat up night after night watching that compass and seeing how the needle would twitch and point north and he said it sent chills down his spine as he tried to visualize unseen force fields in the universe and what type of unseen force could be making that need twitch and point north.

Now I don't know about you, but I can remember getting a compass when I was a kid, right, and you think wow, cool, look, the needle points north. You go outside and you think, oh look, wow, this is great. And then about a minute later you're on to something else, right? You say, hey look, a dead squirrel. And you think, oh wow, you know that's interesting and you forget about the compass. For the rest of his life until his deathbed his is visualizing force fields and wondering what makes that needle twitch and point north.

One of the myths about Einstein which unfortunately is a myth—you kind of want it to be true—is that he failed math as a kid when he was student in Germany. I say you want it to be true because if you Google Einstein failed math you get about 66,000 websites listed. And they say things like, as everybody knows, Einstein failed math as a kid, so maybe there's hope for me yet and stuff.

In fact, he was not very good in languages, he didn't do well in French, but he did very well in math in school because he

realized that he could visualize the equations, imagine them, picture them. He knew that a mathematical equation is just the good Lord's brush stroke for something that actually exists in physical reality.

I was helping my daughter who's 17 with her math homework about a week ago and she'd gotten some simple equation that she had multiplied wrong. And I said, Betsy, just look at it. It's got, you know, $2X^2 + Y$, it's got to slope upward like that. It's got to swoop up. And she said what do you mean? And I said, well if you just look at the equation you're supposed to visualize how it moves. And she said, no dad, that's not how they teach math these days.

I hate to say it, but Einstein was probably smarter than my daughter at age 17, at least in math. And when he was 17 he was trying to visualize and picture what are known as Maxwell's Equations. James Clerk Maxwell had just come up with these set of equations, four major equations and other equations and if you look at the equations of Maxwell combined and visualize them, well if you're Einstein and you look and you visualize them, something very interesting becomes apparent, which is they define a light wave or any electromagnet wave.

And if you look a the equations, the wave always has to travel at the same speed, whether you're traveling one way or another, you're moving towards the light, away from the light, you're riding alongside the light wave. No matter what happens, the equations fit together so the light wave always travels at a constant speed, about 186,000 miles per second.

So Einstein at age 17 is visualizing this and he's like trying to figure out what would happen if I rode alongside a light beam. He says, what if I rode alongside the wave and I went faster and faster and I tried to catch up with the light wave, wouldn't the wave seem stationary to me. You know, wouldn't I be able to catch up with it and it would be just be stationary next to me. But Maxwell's Equations don't allow for that.

And he said, it caused him such anxiety that he went around for weeks on end with his palms sweating as he worried about this paradox. Now this caused me to think of all the things that were causing my palms to sweat at age 17 when I was

growing up in New Orleans and none of them were Maxwell's Equations, but that's why he's Einstein and we're not.

Like my friend Benjamin Franklin, he is so frustrated by the rigid school systems he becomes a runaway at 17. Runs away from the school, sort of gets kicked out of the school but then leaves the German school system, goes to Italy and then to Switzerland where he thinks he can have a more imaginative and creative education. And he applies to the second best college in Zurich, the Zurich Polytechnic, and he gets rejected.

Now those of us who were 17-year-olds who by December 1st have to have their applications to college in and were sweating this out—I've always to meet the admissions director of the Zurich Polytechnic who had turned down Albert Einstein. But fortunately for his reputation and probably fortunately for Einstein, Einstein gets in his second go around, on his second attempt a year later. He's able to get into the Zurich Polytechnic and he does pretty well.

However, his ability or his propensity to question authority, to challenge every statement doesn't go over well with his professors. He's able to alienate all three of the professors and the Zurich Polytechnic that are his main professors there by defying their authority.

There's Heinrich Weber who is a physics professor. And at one point Einstein explains to Weber the dilemma Einstein sees with Maxwell's Equations, which is couldn't you catch up with that light wave? Wouldn't it look stationary to you? And Weber says, well I don't actually teach Maxwell's Equations. They're too new, they're just a theory. At which point Einstein quits calling him Herr Professor and starts calling him Herr Weber instead of Herr Professor and Weber considers that an insult and quits having anything to do with Einstein.

There's Pernet who's the laboratory instructor. Einstein was never a very good experimentalist, which is probably why he had to become a theorist. But at one point Pernet gives out the instructions for doing a laboratory experiment in this class and Einstein somewhat ostentatiously just throws them away and does the experiment in his own way and he ends up blowing up the equipment. So Pernet puts him on academic probation for his entire senior year.

And then there's Minkowski, the math instructor who teaches math by rote, doesn't sort of understand the notion of visualizing equations. So Einstein quits going to his lectures and has his friend Marcel Grossman take notes for him. And so we get a nice report from Professor Minkowski, one of his reports, which is "This Albert Einstein is a lazy dog" it says.

Thus it is that Einstein's the only graduate of the 1900 class at the Zurich Polytechnic in physics and math who can't get a doctoral fellowship, a teaching fellowship, an assistant professorship, a lectureship, can't get any job.

He applies for 17 jobs around Switzerland including at high schools to teach math and physics but he can't get good recommendations from any of his three main professors. Weber keeps writing really bad recommendations for him.

And Einstein wanders around for two years unemployed until finally Marcel Grossman, that kid who took notes for him in math class—Marcel Grossman had an uncle who knew somebody and was finally able to get Albert Einstein a job as a third class examiner in the Swiss Patent Office in Bern, Switzerland.

A third class examiner because Einstein twice had written a doctoral dissertation and twice the authorities in Zurich who couldn't quite understand what he was talking about had rejected it. So Einstein didn't have a doctorate so he couldn't be a second class examiner or a first class examiner.

So there he is sitting there on his stool six days a week examining patent applications. But lest we feel sorry for him, I think this was a godsend. I think it was the best thing to happen to him.

First of all, he would never have been a very good acolyte of the academy, kissing up to the professors, teaching the conventional wisdom, trying to teach the prevailing dogma.

Secondly, he had a boss who had him do what he knew best how to do. The boss, Friedrich Haller said to him, whenever you get a patent application question every premise, challenge every assumption and try to visualize as you read it how it would work in physical reality, something Einstein is great at.

And most of the patent applications he got dealt with synchronizing clocks because Switzerland had just gone on standard time zones and the Swiss, if any of you know Swiss people, they tend to be rather Swiss. They get kind of obsessive about synchronizing their clocks. And so when it strikes 7 in Bern, they want it to strike 7 that exact same instant in Zurich.

And the patent applications for synchronizing clocks all had one thing in common. You have to send a signal between two distant clocks to synchronize them and that signal travels at the speed of light, whether it's a light signal, a radio signal, an electric signal and there you got this third class patent clerk, Albert Einstein, still trying to figure out what would happen if you rode alongside a light beam.

Now by this point the entire physics establishment is caught up with this problem that Einstein figured out at age 17 which is why is the speed of light constant. You have Michelson and Morley doing experiments about when the earth's going toward the sun, away from the sun, why is it the speed of light is always constant. You have Lorenz up in Holland coming up with Lorenz Contractions, Tanqueray [phonetic] in France has come up with theories.

Nobody can quite figure out how it works and one day in May of 1905, now that the papers are available we know exactly how it happened. He's taking a walk with Michele Besso, his best friend who works in the patent office, another ne'er do well engineer and Einstein says, I've got it. I've figured it out. And Besso said, what is it? You know he knew the problem that he'd been working on.

And he said, Einstein said, it depends on what you mean by being simultaneous. Now I know that sounds a bit like Bill Clinton, you know, it depends what your definition of simultaneous. You and I know what simultaneous means. It means it happens at the same time.

But if you're a patent examiner or you're Einstein, you say well how do I visualize that? How do I observe it? How do I know it happens at the same time? And he says, one way is if two very distant events happens and somebody is standing halfway in between and that person sees the light from both of those events at the exact same moment, the light from those two events hits him at the same moment, that person

will say those events were simultaneous.

So Einstein says to Besso, imagine a very long, very fast moving train. And here's the point of what I'm trying to say is this isn't looking at Michelson and Morley's data, this is not heavy science, this is a leap of creative imagination done as a thought experiment while sitting on a stool and walking with a friend from the patent office.

He says imagine a very long fast moving train, lightening strikes both ends. There's a person on the platform halfway in between. He sees the light from both strikes at the same moment and he says well the strikes are simultaneous.

And then Einstein says yes, but imagine there's a woman on the train and she's exactly halfway on the train, but the train's moving forward real fast. And in the tiny fraction of a second it takes the light to travel she's a little bit further ahead by the time the light gets there and she says no, the one in front happened first. She sees the one in front first.

Now we intuitively say she's wrong and he's right because he's standing still, but neither one of them is right, neither one of them is wrong because there's no absolute rest at the universe. There's no person who can say I'm totally still, she's moving, all motion is relative, even Galileo knew that.

And so, you know, you may think okay, you're sitting still right now and you're not moving. No, you're moving 36,000 miles per hour as the earth goes around the sun and the sun's going around the galaxy an the galaxy is doing God knows what. Everybody's in motion in the universe, all motion is relative. And if all motion is relative then simultaneity is relative.

What's simultaneous is different depending on your state of motion and nobody's right and nobody's wrong, there's just different ways to define what's simultaneous, depending on your state of motion. And from that it's a very small leap to say time is relative depending on your state of motion. And what it means to the kid chasing up with the light wave he figures out is that you can move faster and faster but the light wave will always move compared to you at the same speed but time for you slows down.

Now this ain't intuitive. And you're shaking your heads and you don't get it. And he publishes this paper along with four other miracle year papers in 1905 and don't feel bad because the rest of the physics community didn't get it either.

In 1906 the next year, he's still applying for jobs teaching high school and still getting rejected. 1907, he's still a third class patent clerk in the Swiss Patent Office in Bern. 1908, he just—nobody quite realizes that he has changed the entire notion of time and said that time is relative depending your state of motion and that this changes all of physics.

There was one person who got it, one of—well among the people who really got it, the very interesting woman, a woman named Mileva Maric. Mileva Maric was a young woman who wanted to study physics and math, a brooding Serbian from Zagreb. And her father who was an army officer got the all males Zagreb Academy to take his daughter to study physics and math.

This was a long time ago when women weren't supposed to study physics and math. And she graduates from the Zagreb Academy and she becomes the only woman in Einstein's class at the Zurich Polytechnic.

And as you might suspect from this very long windup and introduction to her, she and Einstein fall madly in love. The parents are against it, she's Serbian Orthodox Christian, he's German secular Jewish. His mother starts throwing crying fits say that, you know, his life will be ruined if they get married.

So they don't get married but they go hiking around Lake Como together. He gets her pregnant. They have an illegitimate daughter. They want to get married but they can't get married after they graduate because he doesn't have a job. The very week he gets a job in the Swiss Patent Office he and Mileva Maric get married. His parents aren't there. Her parents aren't there. Marcel Grossman, Michele Besso, all the friends are there.

They get married, they have two sons, but proving some fact about the universe, his mother was right. The marriage doesn't work. And it becomes a very contentious, bitter breakup of a marriage after she helped checking the math, doing many other things.

In fact the letters that have been kept under seal until last year that were mentioned earlier are all about his science while he's having this horrible breakup of a marriage. If you want to stay married to me here's what you have to do. You have to bring my food to my room. You have to expect no intimacies from me except for when I want them. It's just a horrible contract. She doesn't sign it, fortunately.

And finally they decide they want a divorce, but of course, they've got two kids and he can't afford a divorce. So he says to her, here's the deal, one of these days one of those papers will win the Nobel Prize. If you give me the divorce, I'll give you the money. Now that's pretty awesome and there's a lot of money. Al did not offer this to Tipper, I'm sure.

Anyway, but Mileva Maric is a very good scientist. She takes an entire week and she calculates the odds. She consults with other scientists up and down Europe, including Fritz Haber, and she finally decides to take the bet. It's not until 1922 that he gets his Nobel Prize. But when it happens she gets all the money and she buys three apartment buildings in Zurich. So don't try this at home, it doesn't always work.

In the meantime Einstein has finally gotten some recognition. He's been made a lecturer in Zurich and then a professor, a junior professor in Prague and finally Max Planck who up until then had been the greatest scientist in all of Europe figures out that this Albert Einstein, this patent clerk is on to something and recruits Einstein to be at the center of physics, the University of Berlin and a member of the Prussian Academy.

And he goes up there by 1914 just as Mileva stays back in Zurich, the marriage has totally fallen apart. They're having huge battles over the custody of the kids. And just as he moves up there World War I is breaking out. Ninety-three members of the Prussian Academy sign a very famous manifesto to the civilized world explaining German militarism and why Germany is in the right as it launches World War I. Only one person in the Prussian Academy refuses to sign it, the youngest and newest member, Albert Einstein.

In fact, instead of signing the manifesto he becomes a pacifist and becomes the head of the War Resistors League.

Now if you want to define nonconformity, imagine being the head of the War Resistors League at the end of 1914 in Berlin. The wife gone, he's unable to get much food because of the rationing, he's shunned by many of his colleagues, living in a garret apartment in Berlin.

And all that while, throughout 1915, he's trying to create and creating the most beautiful theory in the history of science, which is the general theory of relativity. Now the general theory, very simply, is called the general theory because the one I explained to you earlier about lightening striking the train and time slowing down applies only to a special case, the special case of constant velocity motion. It doesn't quite work if you're accelerating or slamming on the brakes or turning or rotating.

And Einstein doesn't like it when things apply only to a special case. That was one of his marks as a great scientist. He wanted general principles, rules that applied to everything, unified theories. He wants to apply his theory to accelerated motion. Secondly, he's been able to toss out all of the assumption with which Isaac Newton had founded modern physics.

Isaac Newton in book one of the Principia begins by saying, "Time marches along second by second irrespective of how we observe it." And Einstein the patent clerk has said, how do we know that. That's not true. That's an assumption that's not true. Newton had said that space is absolute, existing whether or not we observe it or not. Einstein says, how do we know that. There's no reason to believe that's true.

But there's one theory of Newton that Einstein has not yet overturned and that's Newton's grand theory, Newton's theory of gravity. Newton's theory of gravity simply says that gravity is the attraction between two objects. Two objects at a distance instantly attract each other. The sun instantly attracts the earth at a distance. The earth attracts the moon magically over a distance.

Einstein says that makes no sense. Nothing could happen instantly at a distance. Nothing can travel faster than the speed of light. So what Einstein tries to do is come up with a theory that will include accelerated motion and a whole new theory of gravity. And he does it, and this is the point once again, not with all sorts of very complicated science

although the math is pretty complicated when he wanted to finally put the math to it. But it really depends on a simple visual thought experiment, another creative leap of the imagination.

He says imagine being in an enclosed chamber, an enclosed elevator car with no windows. He says and imagine that elevator car is sitting still on the surface of the earth, in the gravitational field of the earth. What do you feel? Well you feel what I feel right now, you feel your feet being pressed to the floor. If I take something out of my pocket and I drop it, it falls to the floor at an accelerated rate, Galileo knew that from the leaning tower.

Einstein says now imagine being in that enclosed elevator car and you're deep in outer space where there's no gravity, but the car is accelerating upward real fast. There's a rocket and it's accelerating upward real fast. What do you feel? Well think about it. You feel your feet being pressed to the floor. You take something out of your pocket and you drop it, it falls to the floor at an accelerated rate.

What Einstein says just doing it in his head is that it's equivalent. All the effects of gravity are equivalent to the effects of acceleration, in fact there's no windows in that car, you can't tell it apart. You can't tell apart the effects of gravity from the effects of acceleration. And from that he comes up with a whole new theory of gravity that's not some little revision of Newton, but an entire overturning of out concept of the universe in which he says simply that gravity is simply when an object curves space.

You go, huh? Don't worry, he does it pictorially as a thought experiment for you. He says imagine a two-dimensional fabric like a trampoline in your back yard. You picture that? You take a bowling ball and you roll it on the two-dimensional fabric. What does it do? It curves the fabric.

Now imagine you roll some billiard balls behind it. What happens? They start rolling and then they start curving towards the bowling ball. Why? Not because, as Isaac Newton would tell us, the bowling ball's got some mysterious attraction, but because the bowling ball has curved the fabric. And so the billiard balls kind of roll down to it. We can all picture that.

If you're Einstein, you can picture the fact that an object curves the three dimensions of space, all three dimensions of the fabric of space. And if you're really Einstein you can picture the fact that it curves four dimensions because Einstein said time was a fourth dimension and that gravity is simply the curving of the four dimensions of space time by an object.

Now some of you I know were with me when we were doing the trampoline. And most of you are now shaking your heads, thinking curving the fabric of space. Don't feel bad. As I said before, it's not until 1922 that this guy wins the Nobel Prize. It was 1915. So the rest of the physics establishment is still not quite caught up with him.

In fact, they start labeling this—they start reacting to relativity, especially in Germany. Germany by then is losing World War I and they blame it on the internationalists. They blame it on the pacifists and they blame it on the Jews. And Einstein's three for three.

So they start labeling relativity Jewish science. Adolf Hitler, a young politician in Munich writing in [unintelligible] says that Einstein is polluting the minds of the good German youth with Jewish science instead of Deutsche physics, physics rooted in real reality.

Einstein who hasn't really made too much of his Jewish heritage up until then—as I say, he's a nonconformist. The best way to make him assert himself more as being Jewish is to try to criticize him for being Jewish. He's not an assimilationist. He becomes much more connected to his Jewish heritage.

Secondly, he comes up with a very simple experiment, a pretty simple experiment to show whether he's right or not. He says if my theories are right, if $E=MC^2$, if energy has mass and if gravity is the curving of space then gravity will curve a light beam. And he gets very specific.

He takes his field equations and he says, a light beam traveling right next to the sun, right next to the gravitational field of the sun will be bent by 1.7 arc seconds. If you look at the stars right as they get behind the sun, the starlight as it gets right by the rim of the sun will be bent by 1.7 arc seconds. There's a problem with that experiment that even you and I can figure out, which is you

can't see the stars right behind the sun because the sun gets in your eyes.

So they have to wait until the May 1919 total eclipse of the sun to see if they can photograph the stars during that four minutes when the sun is covered during the eclipse. And a British Quaker pacifist named Sir Arthur Eddington as World War I is ending decides to see if he can prove the theory of a German Jewish pacifist to show that science triumphs over politics and religion.

So he sends an expedition to South America and he himself goes on an expedition to Principe an island right off the coast of Africa near the equator where the 1919 eclipse of the sun will be most visible for those four minutes and they're going to photograph the stars during that four minutes of total eclipse.

It takes a long time for them to get all the plates back to London and compare the plates to see if the stars seem shifted from where they're supposed to be. But when they get the plates back Sir Arthur Eddington calls a meeting of the Royal Society in that Grand Hall in Piccadilly and it's only one item on the agenda, was Einstein right.

People from all over England come down. Bertrand Russell famously a student at Cambridge comes down and takes notes, has a wonderful description of the meeting. And Sir Arthur Eddington begins the meeting by being there at the podium and pointing to the portrait of the founder of the Royal Society, the first president. And he begins by saying, forgive us, Sir Isaac Newton, your universe has been overturned.

Now Einstein is back in Berlin. It was still too soon after the war for him to be able to travel. He gets a telegram. He shows it to Elsa Rosenthal one of his graduate students and she says, you must be thrilled. And he said, no I was confident. She says, yes, but what would you have felt if the experiment had turned out the other way and he says, I would have felt sorry for the good Lord because the theory is correct.

Something interesting happens though. Now that he becomes world famous, it was back in the days—you have to picture this as a though experiment—when The New York Times actually knew how to write good headlines and they have a golfing correspondent, and Henry Crouch is in London, he's the only

correspondent they had there at the time and he gets Arthur Eddington to explain this twice after the meeting. His files his story.

And The New York Times headline, which I reprint totally in the book because those were people like myself who are recovering journalists and we just love this headline. It's The New York Times front page, it says, "Lights All Askew in the Heavens." The next deck says, "Men of Science More or Less Agog Over Eclipse Observations." Then it says, "Einstein Theory Triumphs." Then it says, "Stars Not Where They Were Calculated or Supposed to Be." And then the final deck says, "But Nobody Need Worry."

Anyway, Einstein becomes a total superstar and Germany re-embraces him, of course, and he's supposed to represent Germany at the Solvay and other science conferences but Einstein gets a call, a telegram and then a visit from Chaim Weizmann, the head of the World Zionist Organization.

He had never met Weizmann before, never been that interested in the movement. But Chaim Weizmann says you see what's happening to Jews in Germany now. You see the persecution that can happen anywhere. You need to come with me to America to raise money for displaced Jewish scholars for Hebrew University and you know, to help refugees and scholars.

And Einstein surprises everybody by saying yes. And it's a huge deal. They sail over. It takes five days for them to get over. The news reels are doing everything. They're 15,000 people there to meet Weizmann and Einstein at the Battery when they arrive in Lower Manhattan.

Weizmann gets off the boat first and they ask Weizmann what they ask anybody who's been with Einstein, which is, do you understand the theory of relativity. And Weizmann says on the way over Professor Einstein explained it to me many, many times every evening and by the time we got here I was convinced that he understood it.

They take him all over Princeton where he gives four great lectures. One of the students is quoted in the Princetonia as saying, I sat in the top balcony but he spoke over my head nonetheless. He goes to Harvard, you'll be amused to know Harvard did not offer to have him give lectures. He does fundraising a few times—partly because Frankfurter and

Brandise [phonetic] were sort of the big Jewish leaders out of Harvard then and we not as much in favor of the Zionist cause as it was coming through of Weizmann and Einstein.

Only those of us who live in Washington can fathom this. When they get to Washington, the Senate of the United States decides to debate whether relativity theory is true or not. Senator John Rankin of Mississippi led the opposition. And Senator Boise Penrose of Pennsylvania was in favor.

They bring in the him to see President Harding. They ask Harding what they ask anybody who's been with Einstein which is, do you understand relativity. As I said, this was a long time ago, back when politicians gave honest answers, so Harding said no. And Einstein said well that doesn't matter because he, Einstein, did not understand the theory of normalcy which was Harding's political platform.

Anyway, something unusual happens though at this point. He becomes famous. He says when you become famous your fame is draped around your calcified shell but your mind begins to become more stubborn. And here was a guy who had been such a rebel as a kid and all of the sudden he becomes less of a rebel as he turns age 50. Some of you in this room I can see, I identify with. We know what it's like to turn 50 and know what it's like to be no longer quite as rebellious as you were as a kid.

His quantum theory one of his other 1905 papers that light can be both wave and particle has been turned into quantum mechanics by people like Niels Bohr who say as a result of it, it means that things at the subatomic level happen by chance. They happen randomly. They're not governed by laws. Heisenberg has turned it into the uncertainty principal that we can't know precisely the momentum and position of a particle.

Einstein just doesn't like that. He says well we can't depend on our observations. Well he said, well that's what you said back when you did special relativity. He said, yes, but that was a great one-trick pony. It shouldn't be ridden much too often.

And they said yes, but you know you always told us to defy conventional thinking and to show a contempt for conventional wisdom. And he said, yes, and to punish me for my contempt of authority, the good Lord made me an authority myself.

Over and over again he would argue, I cannot believe that God would play dice with the universe, meaning he couldn't believe that things would happen by chance at the subatomic level the way quantum mechanics has it. At one point Niels Bohr at one of the conferences finally says to him, Einstein please quite telling God what to do.

People though that he was just invoking God as a figure of speech but also as he turns 50 he becomes much more religious. He becomes much more aware of his faith. He starts writing articles for The New York Times and many other places on science and God, on religion and science. It surprises a lot of people.

He's at a dinner party in 1929 in Berlin, very secular society there, just as he turns 50 and the hostess can't believe that he believes in God and he said yes. He explained. He says we're like a small child entering a library and we know that the books have been created and we know they're ordered by certain laws, but it's a topic far too vast for our limited imagination. So we should be awed and humbled and reverential about it.

Another time he was asked about it he said, well there's a spirit manifest in the laws of the universe, a spirit in the face of which we must be humbled and awed, that's my sense of religion. He did not believe in a personal God you could pray to and have the God intervene or intercede or change the laws of physics for you. You couldn't sort of pray hard enough and get the Washington Redskins to win or something.

And he said for some people miracles are evidence of God's existence but for me it's the absence of miracles, the harmonies in the laws of the universe that are evidence of the great creator.

Now this did not—when he wrote this for The New York Times did not satisfy a Cardinal. Cardinal William O'Connell up in Boston who gives a sermon saying it still smacks of atheism because it's not an intercessional God.

So Rabbi Goldstein here, Herbert Goldstein who was the head of the Reform Jewish Movement sends Einstein a great telegram. It says, Einstein, do you or do you not believe in God. Answer, 50 words or less. Einstein doesn't use up his 50 words. He simply says I believe in Spinoza's God, a god who's spirit is manifest in the harmonies of the universe.

Now that doesn't satisfy the Cardinal, I don't think, or the Rabbi—I feel like I'm in some joke, a Cardinal, a Rabbi and Einstein, but you know, it would satisfy Benjamin Franklin or Thomas Jefferson or a lot of people who as they wrestle with the concept of a creator come to a dais concept of something that's larger than we can imagine and not necessarily a personal, an intercessional god, but a god that you can believe in and have reverence for nonetheless.

Einstein also changes his political views quite a bit. After Hitler takes power he comes to the United States in 1933 and when Hitler takes power Einstein is no longer a pacifist. He says that if he were a young man now he would go in the army, sometimes it's necessary to fight evil.

And he writes of course the most famous letter ever written by a scientist to a politician. He writes a letter to Franklin Roosevelt in 1939 explaining, based on $E=MC^2$ that it could be possible to create, as he put it, a controlled atomic chain reaction and that could lead to the construction of bombs.

And Franklin Roosevelt reads the letter, Alexander Sachs brings it to him, actually reads it to the president to make sure the president listens. And he says, the president says this demands action and he creates the Manhattan Project to launch the atomic bomb.

In one of history's ironies because Einstein had been such a pacifist, J. Edgar Hoover would not give him a security clearance, the head of the FBI, so he couldn't work on the Manhattan Project. Nonetheless, we still picture Einstein. He's on the cover of Time magazine when the bomb goes off. The next week there's a picture of Einstein with a mushroom cloud and $E=MC^2$ written on it.

And once again, it affects his politics and his world view. The quote that you mentioned earlier, another translation of it from the German is when he hears the bomb has been dropped, he says, everything in the world has changed except for our way of thinking.

So he becomes somebody who's in favor or arms control and he's always opposed nationalism. He says in a world of rival nationalities if everyone can get the bomb it's a recipe for our destruction. They ask him at one point how do you think World War III will be fought. And he says he doesn't know.

He says, but I do know how World War IV will be fought, with sticks and rocks.

So he becomes the head of the movement for the control of nuclear weapons. He signs the Bertrand Russell Albert Einstein manifesto for world peace, dedicates himself to that. He also dedicates himself to a 25 year failed but maybe a someday will succeed effort to find the unified field theory.

A unified field theory that would take that twitching needle of the kid when he was five years old and magnetism and electricity and gravity and put it into a unified field that would explain all the forces of nature and remove the uncertainties from quantum mechanics. All alone, because people think he's on some odd quest he keeps searching for that unified field theory.

He's also asked when Chaim Weizmann dies, Ben-Gurion, Prime Minister Ben-Gurion asked Einstein to be president of the state of Israel. As I hope I've established, Einstein's a really smart guy so he says no thank you. I did find in the archives a wonderful letter that Ben-Gurion wrote to Aba Eban who I know most of you have met when he was here as an ambassador from Israel to the United Nations and then to Washington.

And Ben-Gurion writes to Aba Eban and he says I offered the presidency to Einstein because I had to but tell me, what do we do if he accepts. So I think it was more of a pro forma offer. But Einstein does agree to give worldwide radio address at the request of Ben-Gurion. A worldwide radio address for the anniversary of the state of Israel. But he tells Ben-Gurion that he wants to give the speech but not about Israel but about world peace in the atomic age.

But before he can give the speech he's had an aneurism that he's been afflicted with for 10 years and it bursts and he's brought to Princeton Hospital and he's hemorrhaging and he decides not to have an operation. He decides that it's futile, that his time has come. And so he knows it's really his last day as he's hemorrhaging in Princeton Hospital, his family gathered around him.

But at one point during the day he reaches to his bedside table to start writing the speech that he knows he's never going to be able to deliver. He just writes the first

sentence because he wants it to be clear that he's writing a speech about something larger, about the need for peace in a nuclear age. And he writes the first sentence which is I speak to you today not only as a Jew and not only as a new American citizen but as a human being. Then the pain becomes too great and he puts it aside.

But later that evening after everybody had gone, he revives again for just a little while. He reaches to his bedside table and instead of picking up the speech he picks up 12 pages of calculations he had brought with him from his office. The latest 12 pages he had been working on on the unified field theory, 25 years of work, still doing the calculations. And he sits up that night and starts writing line after line of tightly written equations.

I went over to Hebrew University because even though I had seen, you know, the replications of these last pages I actually wanted to touch the final pages myself. And you can just look at that final page, very carefully written, very tightly written equations making a couple of math mistakes as he goes along and then crossing them out and correcting them.

But as he gets nearer the end of the page it starts to get a little wavery until finally right before he goes to sleep for the very last time, you see one last line dribbling off, one last line of equations that he thought would get him and the rest of us one step closer to that spirit manifest in the laws of the universe.

And so that's how a very rebellious and impertinent but unbelievably imaginative and creative third class patent clerk became the mind reader of the creator of the cosmos and the locksmith of the mysteries of the atom and the universe. Thank you all very much.

[Applause]

[END TRANSCRIPT]