

Program Information:

Title: Neil deGrasse Tyson: Death By Black Hole
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Moderator:

Good afternoon everyone and welcome again to the Commonwealth Club located in San Francisco. It's my pleasure today to be your moderator for today's event featuring Dr. Neil deGrasse Tyson, a name well known to anyone who enjoys reading about our universe and thinking about " questions about from when it's came and where is it going? Dr. Tyson's education actually relates to a physics degree from Harvard and a PhD in astrophysics from Columbia. His professional research in cosmology and astrophysics including " very broad subjects including star formation, exploring stars, dwarf galaxies and the structure of the Milky Way. In 2001 Dr. Tyson was appointed to a 12 member commission to study the future of the US aerospace industry in which he published a final report in 2002.

Again in 2004 Dr. Tyson was again appointed to serve on a 9 member commission on the implementation of the United States Space Exploration policy. Following upon that Dr. Tyson was appointed by NASA to help them deal with the very difficult question of how the ambitious programs of NASA can be reconciled with a very restricted budget for their goal and mission.

We are, of course, blessed not only with his technical expertise as it informs the scientific community but he is a very important member of that community of scientists who help inform the public to a greater understanding of scientific issues, a topic which is more and more important as we as a public are decided to have opinions about and vote for people to represent us who might have a lay understanding and hopefully even an enlightened understanding of the critical scientific issues facing us today. In this regard Dr. Tyson has published 7 books, that are directed towards people like us and is the host of course of the Nova ScienceNow program with which you may be very familiar with him. I would like to, at this moment, introduce Dr. Tyson and please give him a rousing welcome.

Dr. Neil deGrasse Tyson:

Thank you for that warm welcome. It's good to back in this visit to San Francisco. I am told the Sun was out a couple of days ago, is that right? The rain is " plants need rain more than we do. Thanks for coming out for this. I am just here to just kind of talk about the universe, but through the lens " I am restricted to the universe in my subject matter " in Death by Black Hole, at first I couldn't resist that title. There is a chapter in here with that title and that chapter bares that title because it's a complete discussion of how you die when you fall into a black hole. And when I think of black holes I think of sort of the adult counterpart to what as a kid would be T-rex, because every kid loves T-rex but why do they love T-rex, it's because T-rex can eat the kid.

All right, and you tend to have a deep respect for things that can eat you. So black holes, when you come too close to them weird things happen to your body. And I will get back to that in just a few minutes. I am not going to read from the book because you can just get the book and read the book yourself. So presumably you came to hear me say something differently enlightening or even relatedly enlightening to what's in the book. And so what I am going to do is and look the book is organized into sections with multiple chapters within. I am going to like pick one of the chapters within each section that happen to be one of my favorites. And then I will just kind of give you some summary points of those chapters.

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□□□□□□□□□□ Okay and then “ so this will be a sampling of the science that titillates me, but also this collection is the science that has been most requested by the public. Even if I didn't think it was interesting the public thought it was interesting. I thought well let me find out why and part of it was this black hole thing. Everybody wants to know about black holes. If I am on the plane and someone sees I am reading some astrophysics literature “ so what do you do? I do astrophysics. First question, tell me about black holes? Then may be search for life and Big Bang and I am trying to think well, suppose I said I was like “ you know, nuclear chemist or particle physicists. That would just end the conversation right there but they find I “ I have studied the universe and it becomes this very engaged conversation.

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□□□□□□□□□□ So, this is appetite for cosmic content that, for which I see myself as a servant of public interest, and so the material that's in here is the blending of aspects of Universe that I want to bring you to. And aspects of the Universe for which I know the public has a deep curiosity to learn more about and so that's how that goes. And let me lead off by the “ with the following datum. There is about 6500 astrophysicists in the world. It's not very many actually, just you know, a few thousands and there is about six and a half billion people in the world.

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□□□□□□□□□□ So if you divide those 2 numbers you get one in a million. So “ no, no what I mean, the point of that exercise “ the point of that exercise is if you ever find yourself in the company of an astrophysicist that's your chance to ask the question, because you never know when that's going to happen again. That's “ that's just advice. Okay and I think that's why “ like I said I am on the airplane that the people just bust out with questions. Like they have got some question center within them and its building up and then they are ready to explode and the whole of the rest - so, it's just so “ you know.

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□□□□□□□□□□ Okay, here we go. What I try to do here is connect the reader to the Universe in a way that allows you to become a participant in the machinery of the cosmos. So I would like to think of this book as your way to go around the back door and lift the hatch and see the gears turning and the oil box and the pulleys and the levers and all the things that allow you to understand not simply what's in the universe but how the Universe works. And in that way you are empowered to have fresh thoughts about what's going on rather than just repeat the factual information you would otherwise get. That's the goal of this book.

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□□□□□□□□□□ Okay and I invite to sharing that goal if, in fact, you value that level of intellectual diversions in what is otherwise your work day. So I have got a chapter called Coming To Our Senses and I am told I have like half an hour or something, right? Is that about half hour? Happy to do that. All I want, okay. I will give you a late pass when you go back to work, okay if you need “ Coming To Our Senses there is a whole chapter called Coming To Our Senses and what that is, you know we have got five senses, right? The touch, taste, smell “ touch, taste, sight, hearing. Thank you. Thank you. That's it five senses. Then occasionally you get the person who comes up to you and says I have a sixth sense, okay.

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□□□□□□□□□□ These are people who claim to know stuff that they wouldn't other wise know, typically. It turns out if you take those people and put them in the laboratory the sixth sense just simply goes away, under controlled circumstances. So either the sixth sense is the shy thing that doesn't lend itself to “ to investigation or it just doesn't exist at all and we have duped ourselves into believing you had this power.

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□□□□□□□□□□ But what I want to share with you is the fact that modern science, beginning “ beginning 20th century began to invent apparatus that would measure things “ that are completely outside of your five senses. No capacity to measure it whatsoever. So that in fact modern science has multiple senses, dozens of senses. So you want to ask what

“ you have a sixth sense. Here is some things that you can't measure, for example, the magnetic field in this room. The human body has no capacity to measure the strength of the magnetic field. The human body has no strength to measure whether we are being bombarded by ionizing radiation. You would eventually figure that out as your limbs fell off, you know as you “ you come to learn that this was the case but while it was happening you would have no idea. We don't have radiation, high energy radiation detectors built into our system. We have got detectors that can do it, so if there is something that is admitting ionizing radiation anywhere around, we would be able to find it. I call that a sense, another kind of sense.

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□□□□□□□□ Now not only can we go outside of our five senses, we can vastly improve the five senses we have. And so what science is about of course, is advancing our capacity to intersect with the cosmos. That's what science is. So that's what a microscope does. You see smaller things that you never know. The telescope sees farther away. Particle accelerator, all of this are simply ways to enhance and extend and invent beyond our five senses. The simplest ones among these are you know, this visible light, ROYGBIV right. You know, ROYGBIV remember him, red, orange, yellow, green, blue, indigo, violet.

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□□□□□□□□ There is really only six colors there but Isaac Newton who first labeled these, he had a fascination with the number seven and he came up with six colors, I got to put in a seventh one, so he slipped in Indigo there, didn't belong there at all. But he slipped it in, if you are going to put in Indigo you might have like, put in seven other colors, have 14 colors in the spectrum. If you are going to be that specific, Indigo is a narrow segment between the blue and the violet. It doesn't - that scheme deserve it's own color name. Unless you are going to have way more than seven to label. But that's neither here, nor there. So - so those are the colors.

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□□□□□□□□ We define that as visible light, but light goes far beyond each side of that spectrum. You go beyond violet you get ultra violet, you go the other side of red you get infra red and you keep going in each direction so, violet - ultraviolet, x-rays - gamma rays, red - infrared, micro waves - radio waves. All this is light, it all travels at the speed of light and we had no telescopes capable of observing outside of the visible spectrum until 1920 and that was a very crude telescope itself and we didn't start really getting data on this until the 1950s and 60s.

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□□□□□□□□ So we were practically blind to the universe. Before 50 years ago, thinking that our eyes were somehow the true measure of what's out there. So all of our detectors and telescopes were extensions of our eyes and not probes into whole other branches of what we call the electromagnetic spectrum. And so your senses are really these, you know, they are good for you know, getting around the house but they are not good for decoding the Universe. And here is how they get in the way.

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□□□□□□□□ There is something called common sense, right what is common sense. Common sense, is if I let go of this gavel it will drop. So let's try that. Okay, it dropped, now so, so important is that fact to our senses that when you tell me to drop it, that's an instruction for me to let go of it. What you really should be telling me to do is let go, that's your instructions to me, then it drops. Okay.

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□□□□□□□□ Suppose we lived in a world where 30 percent of the time I let go this would float up to ceiling. Then you wouldn't say just drop it, you just say let go and 30 percent of the time it would go up. Now this would - it would sound like you are making this up to be funny but no, there are parts of the universe for which the laws of physics, as we experience them, no longer apply. One of them for example, is the branch of physics called quantum mechanics where matter behaves in ways that defy common sense. Particles exist here, disappear out of existence and pop into existence over here without any visible means of getting from here to there.

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□□□□□□□□□□ A particle sits there minds it's own business and then transforms into another particle of a whole, completely different identity, a split second later. This is matter behaving, not badly, matter behaving normally under those conditions. So if I am here and " I and this cup of water disappears and shows up over here, we would say that doesn't make sense. But if that's all you had known as a particle you say, hey, that makes sense. So, what you think makes sense has nothing to do with reality, it just has to do with your life experience. And your life experience may only be a small smidgeon of reality. Possibly even a distorted account of reality at that.

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□□□□□□□□□□ So, what this means is beginning in the 20th century as our means of decoding nature became more and more and more powerful we started realizing, our common sense is no longer a tool to pass judgment on whether or not a scientific theory is correct. And thus was born quantum mechanics, relativity, curved space, expanding Universe. So when I tell you that the entire Universe, it's been around and expanding for 14 billion years. You go back 14 billion years ago the entire universe fit on the head of a pin, you are going to say that doesn't make sense. And I am going to say I don't care that it doesn't makes sense, the Universe doesn't care that it makes sense to you.

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□□□□□□□□□□ That's not its " that's not its goal in life, to make sense to you. It issues forth from a whole other investigation of the behavior of matter of the large. Einstein's general theory of relativity, and then its the shot gun wedding of the general theory of relativity, the theory of the large, with quantum mechanics. This is the physics of the small. The early Universe the large was small and there is general relativity and quantum mechanics intersected in a shot gun marriage. They are not otherwise compatible descriptions of the universe. This works there and this works there, now they got to work together.

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□□□□□□□□□□ We have no understanding of how they work together " we got top people working on it. They call string theorists, okay and they are still not there yet. They are still not there " they are working on it. Every time I ask they would say, oh we are couple of years away. They have been saying that for 20 years, I have been asking them since the early 80s but this is the only game in town and they are very inexpensive to support. You give them a pencil, you say, here you go and some paper and we will throw in a computer, then they are done, okay.

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□□□□□□□□□□ So, I am okay with that. They are not going to bankrupt the science budget. And so in the exposition of Coming To Your Senses, its basically a celebration of what it is to have five senses but then the reality check on the fact that our senses are not only feeble, they are inadequate to properly decode all that's going on in the natural universe. And so " a prevailing theme here is an attempt to " give a reality check to the urge that we have, the urge " understandable but inexcusable urge that we have to think more highly of ourselves than we actually deserve.

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□□□□□□□□□□ This is a theme that's repeated through the history of human assessment of our place in the universe. And in a little bit, in a little ways it continues that way today. But I " some of " some are sort of " have enough foresight and hindsight to say I am not going to make that mistake again. But here we are in earth and earth is special because its earth and rest of that's just the sky and then we find we are one of the planets and then, oh ours truly, our Sun is special. No that's one of a 100 billion other suns in our galaxy. Well, the Milky Way, yeah that's the universe " that's " no " Milky Way is one among the 100 billion galaxies in the universe.

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□□□□□□□□□□ Well " for in the galaxy " we have to be in the center of the galaxy. No " we are out somewhere in nowhere. Okay, leading completely undistinguished existence in an undistinguished quadrant of an undistinguished galaxy. Get over it, okay. Find some other ways to measure your importance in life, don't reference the Universe. Why not help someone? That'll measure your importance. Okay " that's how to be important, help

somebody else. Lead a better life. And so that's a running theme by the way. I just you know I say that, yeah but every one of these chapter has some reference to it.

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□□□□□□□□□□ And so let me move on and pluck another one from the how much time have I made up all the time just talking about that. Yeah, I got a chapter called the planet, Vagabonds of the Solar System. That ones fun. I am not going to dwell on that, too much because in there we are talk about Pluto. Pluto, you know has been on hard times, Pluto. And I am and its interesting because my I had a little something to do with that. In the year 2000 our exhibits at the American Museum of Natural History, I and two colleagues of mine were co-writers of all the exhibits.

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□□□□□□□□□□ We decided, upon noticing, that Pluto there are other objects orbiting the sun about where Pluto orbits. About the same size of Pluto, made of the same stuff as Pluto, same cockamamy orbits like Pluto has and so we said well, lets organize exhibits of Pluto with the rest of these other newly discovered brethren in the Solar system. And then the giant the gas giant planets, that put those together, they have more in common with each other than anyone has with any other object. The rocky smaller planets, I mean Mercury, Venus, Earth and Mars they had more in common with each other than any one of them has with anything else. So we presented the Solar system as a collection of families.

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□□□□□□□□□□ Well, page one story of the New York Times, Pluto not a planet, only in New York. My phone was ringing off the hook, I was getting hate mails from 3rd graders and I said Man people feel strongly about Pluto and most of the Pluto lovers out there are there any among you in the audience? Pluto lovers, raise your hands if you are a Pluto we got Pluto lovers in the front row. Now I will bet you 10 to 1 that this will play out exactly as I know, okay. Pluto lovers please raise your hand once again, did you know that there are 6 moons in the Solar system bigger than Pluto. Moons, he didn't know that Earth Moon among them, didn't know that. That's because the Pluto lovers have elevated Pluto to a greater significance that it actually is. It has grown in your mind and in your soul, but not in the Universe.

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□□□□□□□□□□ Okay, so Pluto, did you know, not meaning to be dissing you in the front row here but I had to get this, did you know, Sir, did you know that Pluto is more than half ice by volume. Which means if you brought Pluto in, if you put no you don't have to bring it too close, just bring it to like where earth is, the heat from the Sun would evaporate the ice, turn it into gas and it would make this long plume of a tail. Now now what kind of behavior is that for a planet? We have words for things with tails. We call them Comets. Comets cross the orbits of other planets, so does Pluto. Pluto crosses Neptune's orbit.

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□□□□□□□□□□ We just added all up. There is there is no way out of this you just just let and I think the reason why Americans liked it so much is because we have this other association with Pluto, Pluto the Dog. Europeans don't care. I spoke to Europeans, they said, Oh we don't care whether its planet or not. Who cares! Because they don't have this dog legacy. This this baggage. You know who Pluto is, the creature. Anyone doesn't know that Pluto is Mickey's dog.

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□□□□□□□□□□ Now I don't know about you but that's disturbed me for a long time. Some thing's not right in the mammalian kingdom. If Pluto is Mickey's dog and Mickey is not Pluto's mouse, there is some wrong there. A mouse owning a dog, dogs eat mice, okay. So I want to understand how is it that a mouse can own a dog? Then I learnt that actually I called up Disney and apparently, this is important stuff you got to know. So apparently if you don't wear clothes you can be owned by another creature who does. That's how you can have animals owning animals, okay.

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So Pluto runs around butt naked and Mickey Mouse wears that bow-tie and so that's how you get the social order of the characters. Well, meanwhile it turns out that Pluto, the dog, was first sketched the same year that Pluto the object was discovered. So it had " both had the same tenure in the hearts and minds of the American public. And Pluto, the object, was discovered by an American. So this " this sort of importance of stuff Americans do, getting into the thought equation about how you evaluate who and what Pluto is or should be.

So, anyhow, there is a little bit of that in the vagabonds of this. Right now, it was much, we file this wide, that " this month I am depositing a manuscript to my publisher called the Pluto Files. This is an exposition of all the hate mail and all the correspondence that I have had with people who are just pissed off about what we did with their favorite planet. I had to get that off my chest so I got that " how am I doing on time? I mean I got so much I want to do. The Universe is a big " it's like here " you got 30 minutes, give them the whole Universe. It's like how am I going to do that.

So I told them about the Asteroid that's coming. No, no, I know, if there is enough time we will tell them about the Asteroid that's going to hit. Okay, good. If I forget, remind me then about the killer Asteroid. That's due to come on Friday the 13th in April of 2029. But, this only if I forget. Just remind me about that. It's headed for the Pacific Ocean by the way. But look - I will fill in if we can, - that's just the test, I am going to wait till the very end and see how badly you have to get back to work, all right. It will be, it will be " there is a chapter, excuse me, I am recovering from a chest cold.

There is a chapter here called Goldilocks and the Three Planets. And this is simple, the idea is simple but the consequences are profound. If you want to look for life in the universe, beyond earth, how do you go about it? We have to kind of define life, but you only have an example of one. Biologists celebrate the diversity of life, but behind closed doors they lament the fact that they only have a sample of one, because all life on earth has common DNA lineage. And so in fact there is no bio-diversity on earth compared with what the biology would be to a completely alien creature. Then you are talking diversity. Okay. So " so that's just " it's that.

So, now one of the things that we are pretty sure life, as we know it, requires is liquid water, carries nutrients around, its very common ingredient in the Universe, hydrogen and oxygen. So where would you have to put a planet so that it could sustain liquid water and its orbiting around a star. You don't want to be too close because the water would evaporate. You don't want to be too far away, the water freezes. So it's got to be just right. So that's why it's like the Goldilocks thing. Okay, you remember Goldilocks. That story disturbed me too.

If I were the bear I would just eat Goldilocks you know. Sleeping in your bed, eating your food, you just maul her, all right, but " but that's not the story that they wrote. But surely that's what would have happened in that under those conditions. So any way, so " so there is Goldilocks. We have a zone around every star for which these conditions hold. We call it the habitable zone. Too many syllables I know, forgive us for it, but we couldn't figure out what else to call it. Some call it the green zone, but, you know, they are habitable zone.

For our Solar system Earth is in the habitable zone, its right there. Of course, its there, we have to liquid water on our surface. But how about if you go a little to the left, go a little closer to the sun, you get what's generally referred to as our sister planet. It's about the same size, about the same density, same mass, it's the planet Venus, little closer to the Sun. What's the temperature on Venus? What's its atmosphere made of? It's got a carbon dioxide atmosphere 100 times the density of Earth's atmosphere and it has a roaring green house effect, a runaway, it is so hot on Venus " it is 900F. I did the calculation, you could take 16 inch Pizza, put it out on the window sill, it will cook

in 9 seconds. Now of course you would have vaporized along with it, so its " its not an " it's a thought experiment. Its not " we are not inviting you to try that.

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□□□□□□□□□□Something bad happened on Venus, something bad happened there to its climate. Some knob got turned. Lets " let's look a little to the right. The next planet out from the Solar System from us. That would be Mars, Mars has evidence of once having running water on its surface, there are river beds that meander, all the visual cues that you see when you fly across country on the airplane and you looked down you see the Mississippi Delta, you see if there is flood, you see the " the plane, all of these features are there. Yet there is not a single drop of water left. Something bad happened on Mars too, something changed there.

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□□□□□□□□□□I want to know what that was, because today we are turning knobs on Earth, big knobs, Carbon dioxide knobs, environmental knobs. It is all Earth will be fine - I don't know that. I got a neighbor to the left, a neighbor to the right. Mars is bone dry, 200 degrees below zero. Venus is 900 degrees. I want to understand what can go wrong in the cosmos. So that we can avoid that for Earth. And so Goldilocks and the three planets is an assessment of where conditions would give you liquid water and what would then drive your capacity to search for life and that for me is one of the most fascinating of the modern frontiers of cosmic discovery.

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□□□□□□□□□□And so Jupiter is pumping heat into Europa. Europa's way and Jupiter is way outside the habitable zone because you calculate the habitable zone based on Sunlight. But out there you got a heat source from Jupiter getting pumped into it. It is icy on the surface and liquid ocean beneath it. It has been liquid for billion years. I want to go to Europa to go ice fishing, cut through the ice, lower submersible, look around see what's there. See what swims up to the (indiscernible) and licks it, that would be kind of cool. Liquid water for billion years, imagine.

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□□□□□□□□□□Life on earth didn't require that much time to form. Life of earth is something you might have not have known, it's a recent thing. We all took biology at school, I think, presumably, okay. You took Biology and what did you learn? Well, when did " when did the Earth form? The Earth formed four and a half billion years ago. What's the earliest sign of fossil life? Back then when we took biology it might have been three billion years ago, maybe 3.2. So then you say life, well, life had one and a half billion years to form on earth, okay. From the primitive chemistries of the early days to the complex chemistry of life and that's pretty good because then we want another three billion years after that. But as time went on, we found earlier fossil evidence, not 3.5, 3.7 billion years.

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□□□□□□□□□□As time went on what we found is that the early solar system was a shooting gallery of left over debris slamming into earth surface. If you are going to do that, it's not fair to start the life clock because complex chemistry could not have begun if you are liquid molten surface. So that's not fair to start the life clock then. Let that period of heavy bombardment which is officially called the period of heavy bombardment - it is true. I have said this before we tell it like it is in Astrophysics, okay.

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□□□□□□□□□□Spots on the Sun what are they called, sunspots, thank you. Dark areas of space you fall in, you never

come out again. Black Hole see, we are into one syllable “ one syllable lexicon. The origin of the entire universe space time and anything, Big Bang, okay. As a biologist what's the most important molecule deoxyribonucleic acid. 12 syllables or 10 syllables later you get the molecule. So where was I, before I interrupted myself? Well, thank you, somebody was paying attention over here on the left aisle, the period of heavy bombardment.

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□□□□□□□□□□Once we could do the computer calculations of how long it would take to vacuum up the remaining debris of the solar system to become the planets, we realized that took upwards of 600 million years. Earth didn't cool down until 600 million years after it formed. So you go from four and a half billion years ago to 3.9, 3.9. Now you start the life clock and when is the first sign of fossil evidence, 3.7, 200 million years to form life on Earth, that's nothing in the time of the earth and its least than nothing in the time of the universe. So you have complex chemistry enabled by the ingredients of life itself. Hydrogen, oxygen, carbon, nitrogen, other the famous element, other. Those are the top five ingredients in life on earth.

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□□□□□□□□□□What's the top ingredients in the Universe? Hydrogen, and we have seen that on Earth. Our next one is helium, the helium is not chemically interesting. You can inhale it and you know it sound like Mickey Mouse, but its “ it doesn't bind with anything, so it's not useful to us chemically. Next in universe is Oxygen, that's what it was in the human body. Next is Carbon, that's what it was it. Next is Nitrogen, that's what it was with us. Next is other, just like it was with us. So if we “ if we were made of like some isotope of Bismuth, then you would have an argument to say that we are something rare in the cosmos. But we were made of the most common ingredients with a chemistry based on Carbon which is the most of fertile of all elements on the periodic table. You can make more molecules out of carbon then you can with all other elements combined.

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□□□□□□□□□□So you got the right ingredients and you have the fertility of the carbon atom. You are there and give Earth 200 million years you are there, you are there. And so when you want to think about the search for life elsewhere these are factors that come in. Just because you hadn't figure out how to do it yet in the lab, it doesn't mean nature had a hard time doing it, that's the hubris again. Okay. Just because you can or can't do something therefore it is impossible that way in the whole universe. We got to be a little more humble about our ignorance and get top people working on it. And so I had a point out of all of that, I forgot what the point was going to be.

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□□□□□□□□□□Speaker 2:

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□□□□□□□□□□Dr. Neil deGrasse Tyson:

□□□□□□□□□□Europa. Thank you. So here with it, so here we got, lets say we find - you could see, people on the left side of the room are actually paying attention. You guys over here I don't know what you are doing, okay. Left side of the room, yes. So, Europa, let's say you find life. Here is in unresolved question, okay. We have got top people working on this without a solution yet. If you find life on Jupiter's moon, Europa, do you call it European? You see we don't have an answer to that yet. We don't know what to do about that, okay, I don't know, just okay.

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□□□□□□□□□□By the way these are not just idle thoughts. For example, because you want to like get the answer before it happens, so you are not caught having to make something up on the fly. If you are from Mars, you are a Martian, right. You are from Earth, you are earthling. You know, we have heard it. If you are from Venus, you are Venutian. But it turns out, the astronomers got there too late. We got to Venus too late. And we were “ we have regretted it ever since.

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□□□□□□□□□□ Okay, Mars is the God of War, remember from Roman mythology. Venus is the Goddess of Love and Beauty. They called that planet Venus before they knew that you would instantly vaporize on Venus's surface. Okay, because it is beautiful in the sky even though it's seething gases of carbon dioxide and sulfuric acid, beautiful Venus, anyhow. So we got there too late. We were beaten - we got beat. Why? Because the medical community started looking around, they got the microscope. They look and say hey, there is this particular disease that only, class of disease that only shows up as a product of love making. We must name that disease after one who is accountable for this. That would be Venus, won't it. Let us name these diseases venereal diseases. To be a Venus is to be venereal. And then damn we could - so at that point we can't now call life forms from Venus, venereals, right.

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□□□□□□□□□□ Imagine the space traveler, hi, we are venereals. It's like oops, excuse me. If somebody else had shake that hand, you know, so we had to then invent a new thing that is not derivable from the latin and so we just invented Venutian. But it really they should be venereals, okay. So this is stuff that - I have 30 seconds left here before we go to Q&A. Where - but I am not done yet. I said only after I am done.

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□□□□□□□□□□ I notice against the left side of the room asking about the asteroid. They don't even care when they die, alright. They don't know over here on the right. I should first describe to you how you die falling into a black hole, you're ready? Its quick, I get this done like that. You're ready? I got a whole chapter on it but I wouldn't tell you because it's kind of " because, you should know this. All right, you are standing up on Earth. Your feet are close to the center of the earth than your head is. You can calculate that the force of gravity at your feet is stronger than the force of gravity at your head because the closer you are to the center of the gravity of an object the stronger its gravity is. It's that simple. Not more complicated than that. But don't blame your light headed on this fact because that difference is very small, because your height is small compared with the size of the Earth.

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□□□□□□□□□□ But imagine you are falling towards an object where your height becomes significant compared to the size of the object. Under those conditions the difference in gravity becomes ever so great, like as you descent to the center of a black hole. So you take a feet first dive, you begin to stretch. It will kind of feel good at first, right? We all stretch, wake up in the morning the first thing you do, stretch. And then you realize its not stopping, okay and you begin to stretch more and more and more and you can calculate when the force " the difference in the force of gravity becomes greater than the molecular bonding forces of human flesh. At that moment your body will snap into two pieces, most likely at the base of your spine.

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□□□□□□□□□□ Now you will be able to watch this, okay because " not because all your vital organs are above your waist. You have important organs below your waist but they are not vital. Okay " so your " so you just watch that, you watch your legs toward a descent, then the upper part will feel the same effect as you get closer, so will lower part. So they will then snap into 2 pieces. Now you are 4 and then 8 and then 16 and then you bifurcate your way down to the abyss. Now, it gets worse! Not only did you become the stream of particles you are getting funneled through the fabric of space, because Einstein's general relativity tells us that gravity curve space. And in the vicinity of a black hole you are funneled down to a point.

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□□□□□□□□□□ So you are not only stretched, you are extruded through this structure. Like tooth paste through a tube. And we have a word for this, it's called spaghettification. It's a real word, I am telling you and we are good at inventing words about how to kill people. When electricity was discovered and used in the late 1800s " 1900s they said, hey you can would kill somebody with electricity. Let's invent a word for that, Electrocute! Okay so we are good at inventing death words. Spaghettify. You become Spaghettified and the Death by Black Hole chapter talks about not only how you will die but how Black Holes dine upon stars and gas clouds that wander too close, as they get flayed of their outer

surfaces.

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□□□□□□□□□□ And I will leave you with, I guess, you want to know about the Asteroid. Okay â€œ I would take two minutes and we go Q&A beginning quarter two, how about that Sir? You are cool with that. He is cool, okay. He is the coolest guy around, he just chilling here. And I got to give this side of the room a chance to redeem themselves, okay. So December 2004 an Asteroid was discovered. By the way Asteroids are discovered all the time. This is not a new thing. Hundreds of asteroids are discovered each year and some years thousands get logged, brand new asteroids, new to our awareness.

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□□□□□□□□□□ This one was discovered, they calculated its orbit and we found out that the orbit would come dangerously close to earth. And the uncertainty in the orbit was such that it's next time around it might even hit earth. And if it hit earth at the center point of the uncertain orbits, so in other words you run the computer model and there is a range of orbits it could have based on your data. When you get better data then that range get narrower and narrower and narrower. But based on the data available at the time there is a range of orbits within there, there was a tinier range of orbits, where if it threaded that key hole, it would hit us 7 years after that. Why didn't you read about it when that happened? By the way it would hit â€œ if it went through the center of the key hole it would hit the Pacific Ocean 500 kilometers west of Santa Monica. I will describe the tidal wave it would make in just a moment, the tsunami that would be.

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□□□□□□□□□□ Why didn't you hear about it? Because the week it was discovered was the week of the Indonesian Tsunami. And so the odd thing though is that, right, do you know it is not a - it's not to duly grab the headlines, but if this asteroid hits it would create a tsunami beyond measure. No, we can actually measure it, but beyond anything you would ever seen that would make the Indonesian Tsunami look like a â€œ the tides just rolling in. And so we keep monitoring the orbit trying to get attuned and so here are the facts. On Friday the 13th of April in the year 2029, this asteroid named Apophis, That's the Egyptian God of Death and Darkness. We didn't name that one Bambi, okay.

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□□□□□□□□□□ It obviously got named after we saw where it was headed. So and I am not ignoring you guys over there, I am just trying to bring them into the conversation over here, the right side of the room. So Apophis is the size of the Rose Bowl. Imagine the Rose Bowl were like an egg cup and then you get an egg to fit in it, that's the size of this asteroid. On April 13th the year 2029 it will come close enough to Earth to dip below our orbiting communication satellites. It will be the biggest closest thing ever to come to Earth in our recorded history. Recorded meaning, when we took records of events and things. Now the uncertainty in that orbit includes what, I am saying, is called the keyhole, a narrow region within these uncertainties.

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□□□□□□□□□□ If it threads that keyhole it will hit us seven years later once again on April 13th, although this time not a Friday. It would be a Thursday at that time, I am pretty sure I looked it up. Thursday the 13th you know that would create a whole new legend of movies, you know, Thursday the 13th you know. So what you want to do is make sure it doesn't go through the keyhole. Now you got some people out there just blow the sucker out of the sky, you know. These are the men who wield nukes, because they, you know, they can justify your nuclear arsenal. But that's â€œ that's not a good idea, because you blow the thing to smithereens, now all the smithereens are headed towards you. And what would have hit it one spot now takes out half the world. So plus you don't know where it's going to go.

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□□□□□□□□□□ Bombs are uncontrolled releases of energy, that's why they are bombs, okay. So you want to be able to control what this thing does and one of the â€œ one of the things to do is to deflect it from harms way. So we have got top people working on deflection scenarios. When you deflect it, you have got to be careful, because it is still there and

you got to look over your back next time its around, you got to keep looking at it, okay. You have got the power to deflect, you now have the power do not greet the same fate that the dinosaurs did 65 million years ago when an asteroid came and took them out leaving them extinct, because I don't want to be the laughing stock of the galaxy when they find out that a species that had a space program and the intelligence to stop an asteroid impact just simply went extinct.

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□□□□□□□□□□ That'd just be embarrassing. I don't want, you know, its okay for the dinosaurs. They had that pea brain and they didn't have opposable thumbs, they were not going to build a spaceship. So it's called Apophis. I would think of it as a coming attraction in a continent near you.

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□□□□□□□□□□ Let me just end quickly, it plunges into the Pacific, it will go by three miles down before it then explodes. Cavitating the Pacific in a three-mile wide hole. So you now have a hole three miles wide and three miles deep. Water does not like having holes in it. So the act of having made the hole sent the pulse of water to the shores all around. Then the water fills in the hole with such ferocity that the water rises back up high into the atmosphere, falls back down, cavitates another hole. There goes another pulse and this will continue for dozens of times. It will go to the shoreline, the wave will go to the whole entire North, North American Coastline and the wave will go in maybe about a quarter of a mile. Then it will get pulled back out to get ready for the next wave. It's not one of this one way marching tsunamis like the one in Indonesia. This one goes in and comes out. Now if you had a home here, the home comes out, gets taken out, but now the wave comes back in, in comes your home again, but it doesn't have the shape that it had before. It's now debris and so the debris becomes this mulching machine, this sand blasting machine. This thing that ablates the entire coastline wiping it clean of all traces of civilization. So have a nice day. Thank you for your -