2015 10 29 Thursday Neil deGrasse Tyson The Cosmos

NEIL deGRASSE TYSON

AB: "From the high desert and the Great American Southwest I bid you Good Evening, Good Morning, Good Afternoon, wherever you may be on the planet's twenty-five (25) time zones, each and every one covered like a nice warm blanket by this program, *Midnight In The Desert*. I'm Art Bell.

Rules for the show are simple: No bad language and only one (1) call per show. Easy, easy, easy rules."

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AB: "We've got Neil deGrasse Tyson here tonight, probably the world's premiere astrophysicist. The world's … actually."

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AB: "All right, stay right where you are. Coming up in a moment, Neil deGrasse Tyson will honor the show with his presence. I'm Art Bell. From the middle of the desert, just adjacent to Area 51 – hear that, Neil? – this is *Midnight In The Desert*."

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AB: "Coming up now: Dr. Neil deGrasse Tyson was born and raised in New York City where he was educated in the public school system clear through graduation from Bronx High School of Science. Tyson went on to earn his B.A. in Physics from Harvard and his Ph.D. in Astrophysics from Columbia.

Neil's professional research interests are very broad, but include star formation, exploding stars, dwarf galaxies, and the structure of the Milky Way. Neil is currently kicking off the second season of National Geographic channel's Emmy-nominated *Star Talk* … Don't miss it!

He also hosted *Nova ScienceNow* and *Cosmos: A Spacetime Odyssey*. Neil is the fifth head of the world-renown Hayden Planetarium in New York City and the first occupant of its, uh, Frederick B. Rose directorship.

He is also a research associate of the Department of Astrophysics at the American Museum of Natural History and the man who was at the very least an accessory to the pre-meditated murder of the once glorious planet Pluto.

Welcome to the show!"

NdT: (laughing). "Okay."

AB: "How you doin'?"

NdT: "Guess I know where you are on the Pluto debate."

AB: (laughs). "Nowhere really. (NdT laughs). I just read that and I thought it was cute. Um …"

NdT: "Boy, you antagonize well." (laughing).

AB: "Yes, well it is said … since we have it as a subject … actually I'm nowhere on the Pluto debate. I just thought it was cute.

The question is: Why did you think that Pluto should be demoted as it was?"

NdT: "Well, just to be clear, ah, I got implicated going back now fifteen (15), sixteen (16) years. Uh, we were redesigning the Hayden Planetarium and the facility – the building that contained it."

AB: "Yes."

NdT: "And in that redesign, we're creating an entire new modern astronomy museum."

AB: "Ah!"

NdT: "And in that museum, it's like how … we're cutting metal, and we want … if we're going to cut metal, we want, you know, content of high shelf-life. And so we looked at Pluto and said: 'You know, Pluto, uh, looks more like these new things that have just been discovered – these Kuiper Belt icy bodies in the Outer Solar System. They look more like each other than either one of them looks like any of the other planets in the Solar System.

So all we did was group it with this new swath of newly-discovered real estate called the Kuiper Belt. We didn't demote it …."

AB: "Hmm-hmm."

NdT: "… That all came from other people. This got noticed and people say: 'How come you didn't group it with the rest of the planets? You must be anti-Pluto!'

And that's when all the hate mail started coming in, from primarily, third (3rd) graders." (laughs)."

AB: "Really … third graders. Um … yes indeed!

Well, uh, it's all over …"

NdT: "And a few years later an official vote would be taken by the International Astronimical Union formally sort of demoting it from its planet status to a dwarf planet with new definitions of what that even means."

AB: "Well, it's all over the internet that you were part of that."

NdT: "Yeah, I … I … okay, I'll admit to like driving the getaway car. (AB laughs). But you have to have been the one who discovered these other objects in the Outer Solar System, which forced the conversation.

I was just … I was an accessory for sure, but not more than that."

AB: "Okay. All right. Well, let me now ask that we've had a good look at Pluto, and the *amazing* geography on Pluto, and the fact that it's a little bigger than we thought it was – have you reversed your position?"

NdT: "Oh? No! In fact, it's not a … it's not like I … I … it remains true no matter what that …, and these other objects are more alike than any of them are like the rest of the eight (8) [planets]. So … so … and it was a little bit bigger, like by a few inches, you know, this is not like 'Oh, it's twice as big!' (AB laughs). It's like a little bit bigger."

AB: "Right."

NdT: "And … we were all delightfully surprised by how much surface, ah, features … by how many surface features manifest in these high resolution photos, that …"

AB: "Yes."

NdT: "… have no real explanation, ahh, beyond something happening from within. Many people expected it to be sort of … its surface to be a victim of collision, so it would be cratered perhaps, or you know, ice freezing and refreezing, but its got like mountain ridges and valleys."

AB: "Yes."

NdT: "So fascinating features that deserve much more attention than Pluto has gotten in the past."

AB: "Since we thought it was pretty much basically a billiard ball – and we've now found out what it really is – does that say to you one (1) of two (2)

things: Either Pluto came and got captured from elsewhere – where it really was active – or … or it really has a lot going on internally?"

NdT: "Okay, so I'm not the best expert on Pluto compared with my colleagues, who study it professionally, but I can tell you that Pluto has a large moon of its own – a moon called Charon, larger relative to it."

AB: "Right."

NdT: "And in fact it has the largest moon relative to it as a host planet than any other planet in the Solar System. Next comes Earth. Earth and its Moon … we have a pretty big Moon compared to us.

Um, so and then on top of that, its got like other moons in orbit. And it's hard to capture a rogue … ball with all of its moons intact. It doesn't really work out that way dynamically."

AB: "Good point."

NdT: "So … so … unless there's some result I have yet to see, um, I don't know anyone who is thinking that this was just sort of a captured object. It … it … it works well just as having formed with everybody else.

It orbits in the same direction around the Sun as the rest of the, you know, the rest of the objects [planets] …"

AB: "Um-hmm."

NdT: "… in the plain of the Solar System, and so … even though it's tipped pretty far out. Typically thirty (30) degrees out of the plain of the Solar System. One of the oddball features of Pluto that left people suspicious of its planetary allegiance going back forty (40) years, by the way.

But so … so, um, generally if you're captured, it's ,,, you have an orbit that's ... that's more weird than either [even] Pluto's orbit."

AB: "Sure, sure. So that … that means internal heat, volcanic stuff, uh, radiation … something?"

NdT: "Yeah, I mean if you're going to make mountains, something's moving around on the surface of your object. And so … no, it remains a frontier. And, uh, the data are coming back slowly, 'cause to get the spacecraft to Pluto as quickly as we managed … I mean, my colleague's managed to get it there.

Because the Number One rule in all of Science is that you want your experiment finished before you die. So … (NdT laughs) … and Pluto is really far away. So the way to accomplish this is you … you make the lightest possible space probe and you put it on your most powerful engines. And this gives you very high acceleration away from Earth.

In fact, I … I … it passed the orbit of the Moon in like nine (9) hours."

AB: "Wow!"

NdT: "Or something of that order. Whereas it took the astronauts three (3) days to get to the Moon. That's how this thing ... that's how fast this thing was moving."

AB: "Oooh ... it was screamin.'"

NdT; "But yeah, so the reason why I'm dragging you through those details is that the ... they could have given it, uh, multiple means of transmission and data-taking and high bandwidth, but that would have cost weight. And then it would have taken much longer to arrive at its destination.

So as it is, the ... the ... the, um, transmission back to us and the data-taking of Pluto itself happen through sort of the same channels within the electronics. And so it's a very slow going in the obtaining of the data from Pluto. And they'll be ... they'll continue to feed us for many, many months to come."

AB: "What's the baud rate coming back? Do you know? Probably about ...?"

NdT: "I don't know the exact rate. ..."

AB: "Low."

NdT: "I don't know the ... it's high enough, you know, so you're not there forever. But the point is, it could not give us data simultaneously while it was flying by Pluto. So all of our knowledge of what it was doing was on sort of models of its trajectory and what we expected it should have been doing while we were not communicating with it, 'cause it needed every bit of its electronics to obtain the data during that fly-by.

And there it is traveling for nine (9) years [!] and then it's like a few hours in a fly-by of Pluto before it ... before it emerges on the other side headed for other destinations in the Kuiper Belt."

AB: "All right.

Well, now I want to ask you about the really, really, really big story … ah, I sort of broke this early on. Ah, not the first I'm sure, but probably the first big one … was in the Washington Post.

I'm talking about the star that has … and the headline was: 'Serious Scientists Talking About an Alien Megastructure.' I call it 'KIC8462852' I believe, um, KIC seems like an easier name."

NdT: "Kepler telescope, right?"

AB: "Yeah, that's right. Kepler of course is now conveniently *disabled* for the moment, so we can't continue to look with Kepler, but what they did find, uh, caused the one scientist to really to, you know, open her eyes quickly, pass it on to, uh … uh, scientist Jason Wright at Penn State, and he said the word: *'Aliens.'* I would think that, uh, before any scientist, uh, any astrophysicists would utter that word, they would think their career, their family, their life – everything ahead of them … (AB chuckles) … before they would even suggest that word.

Um, it is though a fascinating story, and I'd like your take on it."

NdT: "Well, sure. So … no, no we all love the aliens – don't', don't get … don't get us wrong here. The … the … the issue is … (NdT smirks) … if you … if you come upon something that you do not understand and you're a scientist …"

AB: "Um-hmm."

NdT: "… history of the exercise in coming upon things that you don't understand, tell us that, um, to echo a comment I first heard made by Carl Sagan: 'The most extraordinary explanation is not likely to be the most likely explanation.'"

AB: "Hmpf."

NdT: "This is just simple … this is just … this is a simple, um, recounting of the things scientists have come upon that they did not understand in the past. And so for them in a press release to say: 'We don't know what it is … could be aliens (!)' is 'We don't know what it is … it could be a new kind of star system …"

AB: "Um-hmm."

NdT: "… that we haven't studied yet. It could be a new kind of, uh, orbital dynamics that we haven't learned yet.'

I would go through a list of maybe a hundred and fifty (150) things personally before I would land on 'aliens' as a possible explanation for it."

AB: "All right. I don't know if their list was that long, but they did ... they virtually went through everything they could think of before they got anywhere near that word.

I … I guess the one (1) standing item it could still be would be a … a comet swarm they're suggesting, but the odds of that are very, very low."

NdT: "Yet, ah, what even those odds are, it is surely higher than it being an intelligent alien civilization. That's all I'm saying.

And so, you would invest- … just the history of this exercise, that's all I'm saying!

Um, you … you could spend your life as a scientist, um, exploring the least statistically ,,, when I say 'statistically,' again I'm basing it on the things that were mysteries in the past that got solved, okay? And we learned that they were not solved by 'aliens' or … or … or new forces of Nature, or God or Spirits. They were solved by known laws of Physics in a new way that we had yet to explore. [Yes, but what about the still unsolved? – JS].

Given … given that track record, I'm simply saying that … that I would not lead with that explanation. I would … and comets … I would make sure … make sure I could rule out comets. And then, by the way, I would still say, you know, I just don't know what this is."

AB: "Hmpf."

NdT: "And I would need better data before I would start commenting that it might be intelligent aliens.

By the way, it's a … it's a, um, I'm not faulting people for arriving at conclusions to interpret things you don't understand. **We have an urge to need to have an answer to things.** This is one of the greatest drivers of sort of religious texts. Because you go to your religious texts, they'll have *answers* to things you don't know anything about.

'Like what happens after you die? And how did it all get here?'

And then you have an answer! And then there's comfort in having an answer. Whether or not you choose to investigate the answer to see if it's in fact held up by data doesn't matter – you have an answer.

Successful scientists are not the ones who invoke answers that have no support of evidence …"

AB: "Hmm-hmm-hmm …"

NdT: "… in the face of ignorance. They just say: 'I will pose more experiments until I have enough information to judge what it is I'm looking at or what it is I've tested."

AB: "Okay."

NdT: "And that's what distinguishes successful scientists from not."

AB: "Well, I'll show you this: It got everybody excited enough so that virtually every radio telescope on Earth as of right now is pointed at that and listening really closely."

NdT: "Exactly! Because we don't know what it is. Not because we think it's aliens.

There's an important distinction there. We are perfectly content standing on the precipice of what is known, but peering into the unknown and saying: 'I have no idea what's out there.'

Let me … and … and I have a hint: Here's something in particular that I don't know what it is. Let me design more experiments to find out. And then when I have something reliable, I'll report on it to you. You'll be the first to know! … Or the second to know …"

AB: "Okay. These are what? What … fifteen hundred (1500) light years away … something like that?"

NdT: "I forgot how far away it is, but …"

AB: "Pretty close, um, way out there, so … every radio telescope now pointed in that direction, and … but I don't think we're going to get a discrete signal, you know, nothing in Morse Code, nothing like that, but …"

NdT: "Keep in mind that the signal that was obtained … what Kepler Telescope does in case people, um, hadn't … hadn't read up on it … It was a telescope … it's run it's useful life now, by the way. Um, it's , ah … it was … it was conceived and designed for one purpose: To discover Earth-like planets …"

AB: "Right."

NdT: "… around Sun-like stars."

AB: "Right."

NdT: "And so it had a target list and it focused in one (1) direction in the sky. And because planets are so dim relative to their host stars, the way this was going to measure it was to look for what we call 'transits' of the planet across the surface of the Sun. And … which would require of course that the star system you're observing is 'edge-on' to you, 'cause if it were 'face-on' then the planets wouldn't go in front of the star, and then you would see nothing."

AB: "Right."

NdT: "Nothing to notice."

AB: "Sure."

NdT: "So if it passes in front of the star, and you're monitoring the intensity of the light carefully, you'll see the lightship ever so slightly, because the planet is blocking out some of that light.

And then the dip comes back up …"

AB: "Right."

NdT: "… as the planet moves off the sun's surface from the … from transiting across. And then if you see this repeat, then you have things like the size of the planet …"

AB: "Um-hmm."

NdT; "You have the orbital time …"

AB: "Sure."

NdT: "… you can deduce a lot of information, and the Kepler Telescope produced a catalog of … released a catalog of eighteen hundred (1800) planet candidates. And, by the way, there's more data in the pipeline still to come.

But those are the ones that are like secure enough to actually put out the press release on. And in there is this one (1) object that has this peculiar eclipsing pattern … this peculiar darkening of the star relative to all the other planets that have been discovered. And my expectation we would have for what's going on around it.

And we discover new stuff all the time in the Universe, and for that reason I think astronomers are some of the more humble among the professions that are out there, because we are dumbfounded all the time. We discover Black Holes – who ordered that? We expand the Universe – who ordered that? …"

AB: "Right."

NdT: "You know, dark matter, dark energy …"

AB: "We'll get to all of those, but you've got to admit twenty-two percent (22%), uhh, occlusion is just incredible. I mean ten percent (10%), twelve percent (12%), twenty-two percent (22%) we can …"

NdT: "Yes, we just don't … it's a mystery."

AB: "It's a good one."

NdT: "There's plenty of mysteries!"

AB: "I mean, Venus would only dim it by what … one percent (1%)?"

NdT: "Yeah, yeah, ahh … yeah, it's one one-hundredths (1/100ths) … less than that. It would dim it by, um, yeah, dim it by less than one percent (1%). That's correct."

AB: "So somethin' big is goin' on!"

NdT: "Yeah, but like one-tenth (1/10th) of one percent (1%) … Venus would dim our Sun by if somebody else were lookin' at it from afar.

So it's some huge thing – we don't know what it is. So … it's cool! And by the way, anytime there's something that we don't know what it is – like you just noted – people bring *all* the armament to bear on it. Every possible telescope. Even if you had a different observing plan set up for it, you will turn the telescope in that direction …"

AB: "Hmm …"

NdT: "And … because we have more powerful telescopes on Earth than what Kepler was. Kepler is basically a discovery telescope, right? And so, um, it's turned for this one specific purpose.

You take the big hammers down here on Earth and focus on that star. Now you have a pre-selected star where you know something interesting is already happening."

AB: "All right. Doctor, if they … if they come up … if the radio telescopes come up with nothing more than a rise in noise floor as they're aimed at this, uh, star system, um, would that raise … would that raise your curiosity level another notch?

I mean, I don't imagine a single signal, but I do imagine the possibility of an industrial alien society having, um, using a lot of electromagnetic stuff."

NdT: "So let's go there. So that's … so that's a good hypothesis. So, ah, let's back up to the Kepler Telescope however and let me just affirm for you that it's only using visible light. And that's how it noticed that the light of the host star dimmed."

AB: "Got 'cha."

NdT: "So now … if it is an alien, if it is something that we don't understand but could be … have some intelligence … If it has some intelligence, um, it would also have to have technology, ah, because presumably we counted ourselves as intelligent as a species long before we had technology. Technology communicating with itself, with others … then there'd be radio signals. So you take our largest radio telescopes, aim it at this …"

AB: "Right."

NdT: "… and look to see if your radio signal goes up."

AB: "Right."

NdT: "Whether or not you can interpret it …"

AB: "That's right."

NdT: "You said it could be the floor … the noise level goes up, that means some … even though you don't know what it is and can't decode it.

Some extra stuff is happening there. And you compare the noise level to the noise level you'd expect just for the native emissions of the star, 'cause you don't … you don't wanta, you know, read something that is natural to what you already know it would be emitting. So it would have to be above all of that. Then that would be interesting!

And by the way, that could be just some new radio phenomenon, and that alone would not presume that it has intelligent aliens with technology."

AB: "No, I said: 'Raise the interest …"

NdT: "Even though it is some kind of radio source."

AB: "… Raise the interest level by a notch,' is what I said."

NdT: "It would … Definitely! That's the right way to say it. It would further raise the interest level.

Now if you turn … if you take the radio telescopes and point it … and there's no increase or blip going on – by the way, you'd have to do this at many frequencies … all right? It's not like well they just listen …"

AB: "Oh, they're going to! Many, many."

NdT: "Yeah, of course. You just spread it out. And if nothing's there, than we bring optical telescopes back to bear on it to see if we can try to get an image of it."

AB: "All right."

NdT: "It's interferometry …"

AB: "Doctor …"

NdT: "… and all the other secondary means."

AB: "Hold on a sec … we're at a break point. Ah, it's the long one. Enjoy it. We'll be back. Dr. Neil deGrasse Tyson is my guest."

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AB: "We're honored this night with the presence of Dr. Neil deGrasse Tyson. And, uh, … guess my pre-show notes, uh, just can't be right, um, judging from what I've heard. It says here that he was prepared to come on tonight and completely reverse his position on the frequent transit in our atmosphere of UFOs.

So … guess I was wrong about that. Doctor?"

NdT: "Heyyy …"

AB: "Hey!"

NdT: "So you're … you're putting words in my mouth? Is that what you're doing?"

AB: (laughs). "No! … (laughs more) … I'm kidding. (NdT laughs). I know that you're not a real UFO kind of guy, so …"

NdT: "Well, I … I don't know that I have a position on anything. I just, you know, if … uh, I'm just thinking if they were to visit us, we wouldn't require somebody's eyewitness testimony. You'd have way better evidence than that.

And so … wanta keep lookin' for 'em, go ahead. I'm not going to stop you. (AB laughs).

But I have judged what people seem to be so low the likelihood of them being real as to not trigger any interest in me at all."

AB: "Um-hmm."

NdT: "But I'm glad some people are, 'cause one day you'll find one and then you won't need … no one will have to believe what you say because you'll be walking down the street towing a flying saucer (AB snickers) for everyone to investigate. And then we're done – and then … you were right all along. But now you have actual material evidence for it."

AB: "Yeah, if I get to actually tow a UFO, then probably …"

NdT: (laughs heartily). "It'd be a little one! Okay?"

AB: " … I'm gonna come up with better technology. Hah, hah."

NdT: "Maybe with somebody's truck. We got trucks towing all kinds of stuff. I bet we could find one.

My favorite scene in, uh, in the movie *Independence Day* was when the alien sort of crashes in the desert and Will Smith pops the hatch (AB laughs), punches the alien in the face with a 'Welcome to Earth!' (AB laughs more) … drags him across …." (NdT laughs).

AB: "You know, actually, uh, I think that's about what would happen in real life. Let's say …"

NdT: "I'm thinkin' so too!"

AB: "… if something landed, the door opens, the ramp comes down, the little green guy starts down the ramp … He would be so full of lead before he got to the bottom of that ramp. (NdT laughs). Then he'd be rollin'."

NdT: "It'd be that quick – a hundred million (100,000,000) *guns* in the United States would greet him first. Then we'll hand him over to the military." (AB and NdT both laugh).

AB: "Yeah, that's right I'm afraid. Um …"

NdT: "Yep."

AB: "… all right, uh, let's move on to other things. So much … well, while we're still … while we … what … we have not left alien life … the Big Question: Ah, is it your view that somewhere out there, almost unquestionably, there is life?"

NdT: "Well, I … the way you have to approach that is not saying 'yes' or 'no,' you just have to … have to sort of assess likelihoods. And … so …"

AB: "How about probability?"

NdT: "… it wouldn't have occurred. Yeah, yeah, I would say likely …"

AB: "Likely?"

NdT: "… that there's life … that there's life elsewhere in our galaxy."

AB: "Good."

NdT: "Certainly the Universe. But I'm not basing that on … on … on wishful thinking, all right?

You base it on an analysis of what I would think is a sensible analysis of how long the Universe has been around; how many stars there are; now the likely and better determined number of planets that would exist around those stars; and how long did it take life to start on Earth? Actually it started pretty quickly."

AB: "Um-hmm. Um-hmm."

NdT: "Within a couple hundred million years of when it could've possibly have started."

AB: "Right."

NdT: "By the way, it's not that life took eight hundred million (800,000,000) years from like 4.6 billion to 3.8 billion, all right? Or 3.7 billion … No! … no, no, no.

Because the first half a billion years on Earth, we were still being heavily bombarded by the accretion of the leftover things in the Solar System that were basically still making the planets."

AB: "Um-hmm."

NdT: "So it's not fair to begin the stopwatch then. Wait until that cools off. Now you can make complex molecules, and … because under high temperatures, complex molecules don't form. So … start when you can.

Now you start the stopwatch and then two hundred million (200,000,000) years later we have simple life, but self-replicating life. And then, yes, it would take another three hundred million (300,000,000) years before you had complex life, but life itself happened pretty quickly. And the ingredients on Earth are the same as the ingredients practically everywhere in the Solar System. Carbon, nitrogen, oxygen, hydrogen … these are some of the most common ingredients of the Universe.

If we were made of something *rare*, you might have an argument. Like – I joke about this – an isotope of bismuth! (AB laughs). If life on Earth were based on *that*, then you could say: 'Heyyy … hey we got somethin' good goin' here on Earth. Nobody else has got this!

Well, they can't possibly have it in large numbers. And … but we're made of the most common ingredients – like it or not.

And so, given these factors it is easy to think that Life – even at possibly as we know it – could have formed in countless places across the galaxy and the Universe. And now you want to ask about intelligence – that's like another level, and of course, who are we to even say that we are intelligent? Because we invented the test to decide who is intelligent and who isn't. (NdT and AB both laugh). And humans win that list and no other creature does.

So the hubris of that for me is laughable, but given even accepting that, um, it's not clear that intelligence is inevitable. Because if the asteroid never took out the dinosaurs, our mammal ancestors would still be there having not evolved into something more ambitious than themselves."

AB: "Um-hmm."

NdT: "And … because the dinosaurs were around on Earth for longer before the [asteroid] hit than the time that has elapsed since then.

Now this is a profound fact because it argues strongly that were it not for the … the asteroid, the dinosaurs would just simply still be here and we'd be running for cover under their feet the way rats and mice run for cover under our feet. And so that would be an Earth without intelligence, but teeming with life."

AB: "You don't think that other ecological changes would have taken them out eventually?"

NdT: "They … they were going for hundreds of millions of years. What's another sixty-five million (65,000,000)?"

AB: "Hmm …"

NdT: "Which is the time that has elapsed since they have been extinct."

AB: "True."

NdT: "Sixty-five million (65,000,000) is *small* compared to how long … so they don't … now by the way, we use the word "dinosaur" but that refers to many, many species – some of which came and others went … okay? Not all the dinosaurs you see in the cartoons – or in any authoritative source … (AB smirks) … were all alive at the same time, right?"

So … I say "dinosaur" as just this dominant lizard, ah, reptilian thing on Earth. But T-Rex surely would have had his run and maybe gone extinct, but other dinosaurs would have risen up as had happened over the hundreds of millions of years that preceded it.

There's no indication that these big-brained mammals – derived from tree rodents of the day – uh, would have evolved to anything more ambitious than what they were at the time."

AB: "Dinosaurs originally I guess were … or birds of today are descendants of them, right? Some birds?"

NdT: "Yeah, they're … they're a branch of what we would think of as dinosaurs … and I learned all this … I work at the American Museum of Natural History, which has an entire department of vertebrate paleontology. That's how … that's how … how much the study of life goes on in the museum that they can separate lifeforms that have vertebrates from lifeforms that don't, and in two (2) different departments …"

AB: "Right."

NdT: "… in the museum.

So vertebrate paleontologists – these are the dinosaur hunters. And … I learned from them. I didn't know before I … uh, I mean I've been at the job for twenty (20) years, but ah, being near them sensitizes me to all these … these things that they know and that they study. Including the fact that birds are direct descendants of dinosaurs.

And … but …but colloquially when we say "dinosaur," no one is thinking "bird." We're thinking the dinosaur formerly known as Brontosaurus … you know, the classical dinosaurs that you see …"

AB: "Sure."

NdT: "… in the movies."

AB: "Okay. Let's change to the large … Oh, before we do that, I … um, I actually heard you on another podcast – Joe Rogan …"

NdT: "Oh yeah, yeah … !"

AB: "… and I really, really get a kick out of the, uh, the talk you had about, you know, people who think that the world is gonna end.

September was a very interesting month, because I talked to a lot of these people. And there were at least three (3) separate … when the first day came – I can't remember what it was now – and the world didn't end, they were kind of upset and set a ... a second date. That passed. They set a third date. That too passed. I haven't heard from them since … they're probably warming up for something new. But the world should have ended in September according to all these folks. My God, I got a lot of email about that!"

NdT: "Well so … what … what … what I find fascinating – and somebody should study it, if not psychologists or social … cultural anthropologists, somebody should study the fact that there are communities of people, who are predicting the end of the world and then are *upset* when the world does not end!" (NdT breaks into laughter).

AB: "What is that about?"

NdT: "It can't be that they were wrong …"

AB: "Yeah, what is that about? Why would they be upset?"

NdT: "I … I … I don't know. This is what I'm saying. Somebody's got to study it and figure out what's going on in the human mind, in the human brain, where there are people who are only happy when they're sad." (NdT laughs).

AB: (laughing). "Apparently so, yes!

Well, um, you're right about that. They kind of slunk away … you know?"

NdT: "And there's a great website for – you can Google it – for 'Ends of the World. And there's … it is a … an endless list of predictions made for the end of the world. They go back thousands of years. And it gives … and not all of them give a date: 'Oh, sometime in the next ten (10) years.' Ten (10) years goes by and it makes a note that the world has not ended yet.

But what's interesting to me about the End of World scenarios is whoever is telling it to you, it is very likely – I would say a certainty – that they're telling you the world will end in our lifetime. And this … and if you … if you become a believer of that, then you end up joining the movement. And then they become the head of the movement.

Whereas, if they tell: 'The world is definitely going to end in a hundred and fifty (150) years …'"

AB: "Aah!"

NdT: "… nobody's interested – nobody cares." (NdT laughs).

AB: "That's right."

NdT: "It's a less potent argument to give to grow the cult of whatever it is you're creating for yourself."

AB: "But there are people not in cults who follow this. I mean, millions of them, literally! It's amazing to me …

I … I … so I thought that was a good discussion.

Anyway, on to the Large Hadron Collider – that's news right now. They're powering it up to, um, apparently a power they've never reached before with two (2) things in mind: 1) Possibly it's said or it's rumored to create a mini-Black Hole, and/or 2) To connect with another dimension.

What can you say about this?"

NdT: "Yeah, so … so … I mean, my specialty is astrophysics not particle physics, but I can tell you what I do know from my … I have a lot of friends who are particle physicists.

So, first of all, just keep as background information that when modern physics make discoveries, typically …"

AB: "Yes?"

NdT: "… it's because an experiment has been designed that enters a regime of energy or force or pressure, or some measurable quantity that had never been reached before."

AB: "Um-hmm."

NdT: "And that's not fundamentally different as a goal from the astrophysicist saying: 'I want to now have the biggest telescope there ever was, because that will enable me to see dimmer things than ever before …"

AB: "Right."

NdT: "… farther than ever before.' And anytime you push such a frontier, you are bound to make some kind of a discovery. Because you are entering what we call a parameter space never before explored.

So with the Large Hadron Collider with this new … this new round if you will, um, they'll reach higher energies with that as you'd expect every next time they do this once you refined the operations of it … plus they got the Higgs-Boson out of the way, so now that, you know ,,, now they keep going, so … the mini-Black Holes – these are fascinating things, because they're not particularly stable and they evaporate essentially instantly."

AB: "Hmmm …"

NdT: "From … by Hawking radiation … these are … evaporate."

AB: "Higgs-Boson evaporated pretty much right way too, right?"

NdT: "What was that? Say again."

AB: Higgs-Boson pretty much evaporated …"

NdT: "Oh, oh so … so … so … so, um, we wouldn't say in that case … we wouldn't say 'evaporated' – it *decayed* into another particle."

AB: "Okay."

NdT: "Or another kind … But a black hole, I mean, we literally … there were particles that were inside the Event Horizon that now emerge from outside the Event Horizon in the space around the black hole. And the black hole loses mass … and this continues until the black hole loses mass entirely, and then it disappears forever."

AB: "Um-hmm."

NdT: "So if it makes black holes, they'll be tiny black holes and they'll be of no real … They might be fun to study, but they have no danger or consequence."

AB: "So there's no danger they'll create a black hole and it'll just not disappear … see that would be problematic."

NdT: "Ahh … you mean if it just decided to eat everything?" (NdT laughs).

AB: "Yeah, starting with the collider, I'm sure." (AB chuckles).

NdT: (laughs). "Is that when they first clicked on the switch of the collider? There was a … there was a … there was a YouTube, uh, clip of … of like the security camera of the parking lot outside of the … the CERN facility, and they had a countdown clock near it. (NdT and AB both snicker). And they have seconds to turn on. So he turns it on and then this hole opens up in the parking lot and all the cars fall in." (Both laugh).

AB: "Really!"

NdT: "You know people create a videographers, you know, uh, especially when inspired by science catastrophe. Um, it makes for some entertaining viewing.

Um, so, ah, there … there is no risk of that. By the way, your concern is healthy, but unfounded. What I … what I mean by healthy is, one should always ask, uh, what is the risk – could this happen? Could this possibly be?

And if you look at the history of these kinds of experiments …"

AB: "Yes …"

NdT: "… everybody's worst nightmare was never realized. And … because the worst nightmare that people came up with were not based on the reality of the calculations that were actually done.

And so, uh, yeah, we'll just look for more discoveries of things. And I … I don't even know what next particle they're looking for. Um, maybe next time we talk I can come in with a … with a portfolio of what remains to be discovered."

AB: "Some … some … it's smaller than Higgs – I know that. Smaller than Higgs."

NdT: "Exactly! Well … well consider that they're … they're … they're three (3) kinds of discovery: I think something will be there and I'll look for it, and lo and behold, I'll find it. And that … that gives credence to my … my hypotheses that I put forth to begin the experiment.

But another one is: It should be there and I look, and it's not there. That's almost as interesting – maybe more interesting – than finding what you're looking for … in not finding what you're looking for.

And a third one is: You find stuff that you never even dreamt should be there."

AB: "Hmmpf."

NdT: "And these are three (3) fascinating outcomes …"

AB: "All right. How 'bout this one? Something … something happens that you weren't prepared for."

NdT: "Yes, that can happen at any time. … Yes."

AB: (AB laughs). "Yes, well that's the one everybody worries about … uh, and I'm not saying what's going to happen, but if you were to ask a scientist at CERN: 'What is the risk of something catastrophic occurring? Um, how would they answer, do you think?"

NdT: "You know, I … I … I don't know, but that's a great … Lemme … lemme think of a … of a way to pose that question slightly differently:

So it would be: 'Are you prepared for something to happen that you're not not prepared to happen?' (NdT and AB both laugh) … is kind of what you're asking."

AB: "It is."

NdT: "And … and I guess by definition, the answer is no, by definition.

However, you can … you can quantify, um, some of these risks. For example, at a baseball game, there's a ball thrown ninety miles an hour (90 mph) …"

AB: "Right."

NdT: " … the bat's swung at ninety miles an hour (90 mph), and if any of these gets loose, it can fly into the stands and hurt you.

So you say: 'Watch out for the possibility of these flying into the stands and hurting you."

AB: "Hmpf."

NdT: "And you can ask: 'What would a rotating bat going ninety miles an hour (90 mph) do to the human body?'"

AB: "Wow!"

NdT: "You could calculate this …"

AB: "Sure …"

NdT: "… and figure this out."

AB: "… sure."

NdT: "And so … so even if it never happens – course it has happened – but even if it never happened, you can judge what kinds of things can go wrong, uh, based on what things you know you do on the baseball field.

Or based on what you know you do in a particle accelerator. There's a limit to how much energy can possibly leak out, because you know how much energy you're putting in."

AB: "Hmm …"

NdT: "You don't get energy from nothing."

AB: "… yeah. Yeah."

NdT; "You can … you can … you can *contain* your concerns in some way, but I have … I have to concede: At some limit, if you've never can anticipate it – something could happen that you've never anticipated."

AB: "Well, in a major league ballpark you can put up a fence. And so you probably limit the, you know, your liability when somebody gets whacked … 'cause they're not going to get whacked."

NdT: "Exactly. Yes, but … yes. So maybe my example wasn't as good as it could have been."

AB: "So I'm not sure putting a fence up around CERN is going to cut it."

NdT: "Well, the Mets are in the World Series, so I have to mention a baseball …" (NdT laughs).

AB: "Nah, that's fine."

NdT: (continues laughing). "But yeah, a fence – that would be interesting. It would … (AB laughs) … it would keep the baseballs out of CERN, but that's about it."

AB: "Keep the nutcases out! Maybe … um, so this is about to happen I guess within the next few days, or it's happening now …? I … I … I don't know."

NdT: "I don't remember when the next phase is, but it's soon."

AB: "It's very close.

Um, black holes are very interesting …"

NdT: "(interrupting) By the way … by the way … I gotta tell you. We would have had something three (3) or four (4) times more powerful than this had the budget not been cut to zero by Congress in 1993. We were building the superconducting supercollider …"

AB: "Oh, yes …"

NdT: "… in Texas."

AB: "… I know."

NdT: "Not many states are large enough to have contained the size of this circle. Of this particle …"

AB: "They actually started digging!"

NdT: "They even had a hole dug!"

AB: "That's right."

NdT: "That's correct."

AB: "That's right."

NdT: "And … and you can read the reports, and they say: 'Oh! Budget overruns! And we have to conserve' … and all this. And I have a different interpretation of what happened. It's very simple: In 1989 peace broke out. Any previous budgets that funded particle accelerators got funded!"

AB: "Uh-huh."

NdT: "Because people know in the Twentieth (20th) Century that physics mattered. A physicist is an expert in matter, motion, and energy.

And what is war if not the simple transfer of energy here to energy there."

AB: "And money from here to …"

NdT: " … we're really good at."

AB: "Yeah!"

NdT: "And when … when you're at war – cold war, of course, that was – money is flowing like rivers. …"

AB: "Dr. Tyson, we're at a break …"

NdT: " … anytime you can justify it."

AB: "You're absolutely … this is what I want to talk about when you … we get back. Not only as it relates to … to Hadron Collider or the collider that could have been in Texas, but I want to talk about the space program. I'm so sad about our space program. We'll be right back. This is *Midnight In The Desert*."

* * *

AB: "It is our honor to have with us tonight Dr. Neil deGrasse Tyson, uh, probably the nation's, um, absolute premier astrophysicist, probably so in the world. And, uh, you're not going to want to miss his *Star Talk* on Sunday, October 25th at 11 p.m. Eastern time. That's going to be quite a show.

Now, um, I wanta jump because I wanta talk a little bit about … Look, when I was thirteen (13) years old I got my 'ham' liscense and I went into

radio. I was deeply into electronics. I loved and still love electronics. I'll be a 'ham' till the day I die … more ways than one.

And, um, it was a wonderful, wonderful time to grow up. I grew up watching the space program. I grew up watching Man stand on the Moon. I grew up seeing all of that and it's all … I don't want to say it's all gone, but … I don't know … The spirit that America had, what we were, looking to the future they way we did – it's just not the same.

Uh, Dr. Tyson, would you care to comment on that?"

NdT: "Ah … sure. What distinguished the 1960s from all times that followed it, and … and of course the 1960s ended in like 1972-'73, okay? I guess with the end of the Vietnam War and when we stopped going to the Moon."

AB: "Yes."

NdT: "and of course the Sixties began when the Beatles, you know, appeared on Ed Sullivan. So … that's the operational definition of the 1960s. (Both NdT and AB chuckle).

And so in the Sixties, every single space mission was more ambitious than the previous one …"

AB: "Aww, yes!"

NdT: "… because there was a goal set that had not yet been reached.

And so, Gemini had two (2) astronauts and not one (1). And each Gemini was testing spacewalking and docking – maneuvers that you would need to execute in order to go to the Moon.

When the last Gemini spacecraft was retired, there was the Apollo spacecraft waiting in the adjacent launchpad, ready to start its round of tests. And culminating, of course, in the landing on the Moon with the Apollo Eleven (11) in July, 1969.

When you look at modern times, where people are getting excited about the space shuttle or the space station, um, you're advancing a technological frontier to build a space station the size of a football field orbiting the Earth."

AB: "Um-hmm."

NdT: "No doubt about it.

But you're … as far as [unintelligible], for my money, you're not actually advancing a space frontier. What you're doing is you're boldly going where hundreds have gone before …"

AB: "Hmm-hmm."

NdT: " … into low Earth orbit. Ah, and so that's why people are accusing … people are asserting that: 'Oh well, space is just not interesting.'"

AB: "Ahh!"

NdT: "Well, it's not interesting because there's … there's not an advancing frontier to garner the headlines such as what happened in the 1960s. Sooo …"

AB: "Nor do they seem willing to admit how many things came out of the space program that we take for granted now."

NdT: "Yeah, there's … there … I can't even begin to … That's a whole 'nother conversation."

AB: "It is."

NdT: "Perhaps … perhaps the most under-heralded aspect of the space program was the need to miniaturize electronics …"

AB: "Um-hmm."

NdT: "… to save on the weight of the launch vehicles. And so every functioning piece of electronics, from the computers to the communication device … Everything! A lot of engineering brainwork went into make them small. And the act of doing so, then led Earth people to say: 'Hey, this … this radio that used to be a piece of furniture in like grandparent's living room …"

AB: "Hmm-hmm."

NdT: "… uh, maybe I can fit that on my hip.

Clearly no one in the 1920s was looking at the radio, saying: 'I want to carry that around with me …"

AB: "Right."

NdT: "… and one day I will.' No one is even … know how to have that thought! Because that's not – what's … that's not the … the … the mindset at the time. So … so … so much of what we count as … as modern access to computing and electronics as being portable, are traceable to the trend that was initiated by NASA simply to go into space.

And that's … and that's not simply a patent. It's not a spin-off in any literal sense. It is a trend in what you needed to do to get the job done!"

AB: "Right."

NdT: "And what impact that had on the innovation of everybody else here on Earth."

AB: "So … what's happened to us? In other words, why can't this case be successfully made to those who hold the purse strings for whatever we wanta do?"

NdT: "Well so, I wrote a whole book on this, like … It was called *Space Chronicles: Facing the Ultimate Frontier*. And by the way, that book was my … the title I submitted it with to the publisher was not that title. The title I submitted it with was *'Failure to Launch: The Dreams and Delusions of Space Enthusiasts.'* (AB laughs).

And the sales people said: 'Oh, we can't sell a book that has the word *Failure* in it.' And I had a whole argument with them that I lost, okay?

So … so here's the thing: Many of us who remember the space program, however, we will recount it as being the deeds of … of, you know, the deeds of explorers. It's in our DNA. Perhaps not only as a species, but as Americans. Look what we did!"

AB: "Yes."

NdT: "And … and there's a lot of that going around. But consider, we were at war! We were at war with a sworn enemy."

AB: "Um-hmm."

NdT: "And in fact, almost every single metric of success in space, *we did not win – the Soviets won*. They had the first satellite. They had the first non-human animal. They had the first human. They had the first woman. They had the first black person. They had the first space station. They invented the rocket equation that tells us how to actually design rockets to have them launch to go to our destinations.

What we did – and they didn't do – we landed on the Moon. So we did this one (1) thing and then we said: 'We win.'" (NdT laughs). [Query: What about the space shuttle missions and Voyager 1 and 2? – JS].

AB: "Yes, and they now virtually hold the keys to the space station. They're the only ones who can get us up there."

NdT: "They're the only one. And I used to say that 'we hitch a ride with them,' but you know, we're paying tens of millions of dollars per seat just to get … to get to the space station.

So … so … so, that leads you to wonder: 'Do we need to be at war in order to stimulate a moving frontier in space?' Because that's … there is no question that's what stimulated it the first time.

And I joke about this … I imagine visiting China, and go visit the head of China and whispering in his ear (AB softly laughs), and saying: 'I just want you to leak a memo – and then it'd be true – just leak a memo that says you want to put military bases on Mars and then we would … we would design, fund, build a spacecraft and launch. We'd be on Mars in ten (10) months …"

AB: "Wonderful!"

NdT: "… for sure. And so …" (NdT laughing).

AB: (AB laughing). "No, that's good. I'd rather not have to go to war to achieve it, but you know what? Right now, if you look at what's going on in the world right now with Russia in Syria and the proxy wars and all the rest of this baloney. China with their islands, us with sailing by 'em … we're getting' closer to the old Cold War by the minute."

NdT: "Yeah, that's a scary prospect because things are not becoming less tense, they're becoming – it appears – more tense. And … with us putting our warships near the Chinese islands that they're building, in that same article that I read of this was that the Chinese had put one (1) of their warships off the coast of Alaska when President Obama was visiting Alaska.

So it's like tit-for-tat kind of war games going on … so I don't know what the long-term future of that is, but maybe the only thing that will keep us safe is that everybody, you know, everybody's in debt to everybody else." (NdT laughs).

AB: "Well, there is that. I guess if we got into a tiff with China, uh, we would suddenly just say: 'All right, we're keepin' our money.'"

NdT: "Right, right. And they don't want that. And so maybe it's the economies that are preventing it.

But, I have … I have another plan: Listen, I don't wanta call it a plan – an *idea*, I'd rather say."

AB: "Okay."

NdT: "And that is the … the … for a nation to grow economically and to maintain a sense of security and, uh, health, and wealth, it will require innovations – we know this! Innovations in the STEM fields – the Science, Technology, Engineering, and Math fields. These are the engines of tomorrow's economies. We've know this since the Industrial Revolution and before.

So … so … with this, we can … we can pose the question: 'What is the greatest driver of innovations?' And what we have today are people saying: 'I know what we have to do. Let's create programs that get kids interested in STEM fields. That'll fix everything!'"

AB: "Hmpf."

NdT: "No, it's not! You know why? Because adults outnumber kids five (5) to one (1). And adults vote. And adults wield sources and funding. And adults … adults are in charge.

You have scientifically illiterate adults. I'm not waiting around thirty (30) years for the eighth (8th) graders to become President and then solve these problems! This is an adult problem. An adult science illiteracy problem that is in the way!

So when I … here … so what I would suggest is if the government says: 'We're going to go into space in a big way,' then it becomes highly visible as going to the Moon was highly visible. The government said: 'We're going to put people on Mars,' and you know who those astronauts will be? They're in middle school today.

Let's *select* the Mars astronauts today (!) and it will be fifty (50) notable school students from across the country."

AB: "Uh-huh."

NdT: "And *Teen Beat* will follow them! (AB laughs) And we're all gonna want to know: Are they eating their, you know their three (3) squares meals?"

AB: "Yes …"

NdT: "Are they getting good grades?

And we would grow up with them. And they would be the first pioneers to Mars. And to do that, you're going to have to innovate in countless ways to get people to Mars safely and have them return. Plus you're going to have to use materials on Mars, if we're going to spend any time there unless you send cargo ships in advance.

But all of this has never been done before, which means you're gonna have to innovate. And that will turn a sleepy nation … it … it … it … a sleepy country into an 'Innovation Nation.'

And when you're an innovation nation, you know that there's something *cool* about innovating. You have the same attitude toward innovation that Elon Musk has."

AB: "Ah, yes!"

NdT: "He wouldn't sit there isolated as a lone genius trying to solve all of our problems, because we'd all be part of that same solution path.

So I see space as a … as a *force* operating on our urges to be … to be, uh, innovative – whether or not you are actively engaged in aerospace fields. And that would be transformative of our nation."

AB: "Um … okay. Um, if you were in charge … if you were in charge of NASA and you had lots of money, and you could set the agenda for our next big goal, what would it be?"

NdT: "So … that's a great question. So I … I … I'm going to … (clears throat) … ah, (laughs) … I'm going to give you an unorthodox answer first …"

AB: "Sure."

NdT: "… and then the longer, real answer.

My unorthodox answer is: I don't want to be head of NASA …"

AB: "Huh?"

NdT: "… because the head of NASA reports to the President."

AB: "Um-hmpf."

NdT: "But we as citizens … the President reports to us.

And so the real power is not in who is head of an agency – the real power is in the electorate. So … if the electorate understands the value of this, then they would only elect into office the people who resonate with that valuation.

And then you don't have to run to Washington … NASA wouldn't have to run to Washington every two (2) years with hat in hand saying: 'Please prop up my budget!' Those folks would already be in place."

AB: "Well I've been watching these silly debates and not once have I heard a question about space."

NdT: "Precisely. Or science even. Forget … but science and technology, you know, this is some optional thing that maybe we'll get to if we have time, when there is no health, wealth, or security without it.

So I am astonished that it has not only has not been addressed directly by the candidates, the journal lists are not going there either! Maybe they think that science is not going to sell in debate ratings? I don't know! But it's a *travesty* if we're going to have debates where science is not the these … at least one (1) of the topics of the debate!"

AB: "That's it!"

NdT: "Because somebody's got to recognize that there is no modern society, as we have come to build it, without the contributions of science and technology to it. That's all there [is] … pure and simple. Now …"

AB: "Yeah, well here's another mystery you can try and explain … um, while there's not much interest among the public or … or maybe that's wrong, there is … While there's not much money getting poured into it – if any at all – look at **Hollywood!** That's all they're doing!

Did you see *The Martian*? Great movie actually!"

NdT: "I … I think that Hollywood is a litmus test for what the appetite that … that exists for people to want to think about space … to go into space … to dream of tomorrow."

AB: "Yes!"

NdT: "And the great thing about *The Martian* was science and technology were themselves characters …"

AB: "Yes!"

NdT: "… in that film!

You were … you … you … My favorite compliment[ary] thing to say about *The Martian* was they had the … the … the cliched scene that any astronaut movie's gonna have: Where one of the astronauts is looking at a video screen of their spouse and their child …"

AB: "That's right …"

NdT: "… Say, when you coming home? And they touched the screen. … When they did that in this film I'm thinking: 'Can you hurry that up, please? I wanta see if the experiment's gonna work! (AB laughs heartily).

And that's normally the most touching scene in any of these other films. And this one … it kinda got in the way!"

AB: "Yeah."

NdT: "Cause the science and technology was the … was where all the suspense was."

AB: "It was great!"

NdT: "And the action, and the … So … so … now to answer your question: What I think we should do, ah – and I would offer this to people and they can decide for themselves – I don't start movements. I'm not hittin' people over the head. I want people to vote freely according to what their own thoughts are … provided they're informed thoughts. I'm going to give you some information.

My sense is that if you set the next goal as a destination – such as Mars – you might get stuck with the Moon problem. What was that? It's: 'We're going to the Moon,' and we got to the Moon and then NASA was not designed to do anything else! Because so much money got pumped in to make that one result happen. That the rest of the Solar System laid untouched! Because it all got focused in a singular goal.

What I would suggest is don't even make Mars a singular goal. You say: 'Let us create a suite of launch vehicles that have the capacity – depending on combinations of sort of strap-on boosters – you can go to any destination you want … !"

AB: "Oooh, I like that!"

NdT: "When we built the interstate [highway] system for the United States, they didn't say: 'Let's just connect LA and New York.' No … let's build the roads everywhere!

I don't know in advance how creative people wanta be in this part of the country versus another, so let us enable all transportation.

So … if so … if you can do this, then sure they'll be scientists that want to go to Mars and look for life. There could be miners who want to extract, uh, mineral resources from asteroids …"

AB: "Um-hmm."

NdT: "And maybe robots will do that first, or … or people. We might wanta put a telescope at one of the Lagrangian points on the other side of the Moon …"

AB: "Yes!"

NdT: "… tourist jaunts to the far side of the Moon … and then *ALL of the Solar System becomes our backyard!* You're going to have to innovate to make all that happen.

And then once those frontiers are touched and the routines are established that you seed that to private industry, which then makes a buck off of it.

And then the Solar System becomes our intellectual and … and vacation playground."

AB: "Well, listen, um. Hollywood's still all aglow with it, and as an example *The Martian* drew in hundreds of millions of dollars … it did very well! That indicates the American public is still very, very interested.

So … it's just like the lack of a goal. We don't have a goal, and that interstate system you talked about … we got *potholes* in it! Potholes!"

NdT: "What? (!) … Yeah, I mean it's … it's … it's, uh … the infrastructure, that's a whole other conversation of course. And …"

AB: "Sort of."

NdT: "I … I don't know what country this is sometimes when I look around. Ah, I'm old enough, maybe as are you, to remember in elementary school they would show these film loops of other countries. You know, and it would be like, you know, United Nations week or something."

AB: "Right."

NdT: "And you'd see these … these like Third World countries – as they were known back then – where, you know, oxen drawing plows driven by people …"

AB: "That's right."

NdT: "… flies were on their faces, roads were washed out … and we had a certain smugness about it: 'We're Americans – they need our help.'

And then here in the 21st Century, the economy tanks, uh, New Orleans floods, ah, you know, ah, bridges collapse …"

AB: "Yes."

NdT: "… planes collide. And I look at this and: 'What country is this?' We don't have the tallest buildings anymore … Who would have thought that our planes would be flying slower today than at any time throughout the 1960s?

Um, you know, I was expecting that we would have the longest tunnels and the longest bridges, and for a while as a kid I thought: 'Well, this is just like a peeing contest … (AB laughs) … Well, what good is that? And then I realized that if you build the tallest building, you have to innovate to do that, because you're doing what no one has done before!"

AB: "Exactly."

NdT: "Patents will be awarded. And so, the very act … the very audacity of wanting to extend a technological feat … Yes, there's pride and some … and some ego involved, but at the end of the day some new discoveries are made that in essentially every case applied to the rest of society in ways that move our culture and our nation forward."

AB: "Okay. Well, I don't think that the decaying infrastructure and our apparent … *apparent* non-interest in space, uh, are different. I think it's all wrapped up together. Something …"

NdT: "… in a malaise."

AB: "… in a malaise, yes! Indeed, a malaise. And we're not fixing things. We're not building things bigger as you point out. Something has happened to us and, um, perhaps you oughta be in the business of

starting a Movement of some kind. I don't know what that would be, but …"

NdT: "No, but then … no, as an educator I'd rather, ah, educate people and occasionally enlighten them so that what the country does not is what the electorate wants to do.

I don't wanta drag people. I don't wanta … uh … uh, you'll not see me hitting politicians over the head no matter what they say …"

AB: "Hmpf!"

NdT: "… 'cause they're representing an electorate. So if they say something and it's … it's … it's … even if it's like scientifically illiterate – and they're gaining votes – that means they're being supported by people who resonate with that science illiteracy. And so, as an educator it's my duty I think to alert people of things they might not have known but should know before they make judgments. Before they formulate opinions. Before they vote!

And then after I tell them what I think they need to know, and they still want to vote for the person – Fine! It's … it's … it's a 'free democracy.' That's how it's supposed to work.

But I fear that many people are simply unaware of perhaps what they need to know to make informed decisions about this – the 21st Century."

AB: "I wouldn't even … if somebody said: 'Well, okay, who do I vote for so I get exploration, I get money to NASA, you know, we begin moving ahead – there ain't no such candidate …"

NdT: (laughs).

AB: "See that's …"

NdT: "Who came closest to that candidate was Newt Gingrich back in what was it? '08 [2008]."

AB: "Oh, the Moon stuff."

NdT: "Yeah, he was talkin' and people made fun of him, and I'm thinking … I'm thinking … and I'm not … you know, I know him. We've met a few times. Um, but I wouldn't count myself among his great supporters or anything. So … nonetheless he says let's have Moon bases, people mock him for that, and I can tell you that given the state of technology – for him to

suggest Moon bases, it's not as crazy as President Kennedy saying: 'Let's walk on the Moon' at a time when we had no spaceship at all!

Think about … so … think about what … how big [of] a step that was for Kennedy to say: 'Let's put a man on the Moon before the decade is out.' [It's] not a big [of a] step [now] as saying: 'Let's put Moon bases on the Moon,' now that we already have a space program."

AB: "All right. Question for you: Are Moon bases actually sustainable? Could we do it? Is it just a matter of money?"

NdT: "Um, no … so Moon bases you'd have to … it's an outpost so you'd have to …"

AB: "Yes!"

NdT: "… you need a supply chain. You're not going to grow anything on the Moon."

AB: "That's what I meant."

NdT: "… create. So to have … you'd have hab[itat] modules, right?"

AB: "Yep."

NdT: "You'd have to do what … what … what Matt Damon did on Mars.

But you're not really living on the Moon – you're living on Earth on the Moon."

AB: "Sure."

NdT: "You're creating a seventy-two (72) degree habitat with a farm inside. And … and I would question why you might do that? It seems to me much more fun to just have a quick vacation there and then come back. Not try to just live there. I mean, I don't see the point of making that your permanent residence since it is supremely hostile to human physiology to step outside." (Both NdT and AB laugh).

AB: "Yes, immediately so … yes.

Ah, um, but so … it would be doable but the question is why?"

NdT: "Yeah, I would say … definitely have an outpost, like we have outposts on Anarctica. Like there are no permanent residents of Anarctica, for example.

And by the way, Anarctica is balmier and wetter than Mars. And I don't see people lined up, you know, to live in condominiums in Anarctica. So … the same challenge would apply to Mars.

You really … you would have to terraform Mars to make it someplace you want to go hang out. And … I don't have a problem with that. We're just nowhere near … you know, we can't predict next week's weather, much less terraform an entire planet … and turn it into Earth. So … we've long … I don't know how long … a hundred … a century away, perhaps? Don't know, but, um …"

AB: "We better find somewhere to live. The way things are going right now, we may need it."

NdT: "Well, so that's a common argument that in fact, Stephen Hawking – you're in good company – (AB laughs). Stephen Hawking made a similar argument, as did Elon Musk. And we want to be a multi-planet species in case there's some catastrophe: An asteroid or a virus or … or nanobots take over.

And … and on the surface that sounds good and it makes good newspaper copy … click bait on the internet … However, if you have the resources, if you have the geo-engineering power to terraform Mars – turning it into Earth – then it seems to me that you have the power to reflect an asteroid from hitting Earth in the first place.

People say: 'We're trashing Earth. We need another planet.' If you have enough resources to transform another planet into Earth, you can terraform Earth back into Earth!"

AB: (laughs). "That's true!"

NdT: "So … so … so I don't see … I don't agree with the practicality of making humans a double-planet species. Because whatever that effort is, it's gotta be less to permanently inoculate ourselves from any bad virus – whatever effort that takes! That's gotta be easier than shipping a billion people to Mars. (NdT laughs). That's all I'm saying!"

AB: "Um, do you worry at all about the possible ramifications of nanotechnology? I … I've thought a lot about that."

NdT: "So … so … a couple of things. Um, the … just to … you have a way for your brain to enter that conversation.

Your ability to build things or to manipulate things, or to invent things – that is, to create objects …"

AB: "Um-hmm."

NdT: "… are intimately linked to the size of the tool you're using. So … so … if you are constructing an office building, you're not using tweezers and a microscope."

AB: "That's right."

NdT: "You're using bulldozers and … and … So the size of the tools are commensurate with the size of the project. So now you have a surgeon operating on your eye. So now the tools have to be small … or on your brain, they have to be even smaller.

So now, when you think of nanotechnology possibly making robots or machines the size of let's say human cells, that's … you need tools as small as human cells to make these things!"

AB: "That's right."

NdT: "Or you exploit biological, um, molecular, uh, activity so that it makes a sort of … or you … you … you … you … you deputize molecules (AB laughs) in the service of your machines in some way that has not yet been achieved. They'll be the merging of biology and technology.

But … but, um, my point is if you want to go there, you have to have tools that size. And if you have tools that size: 'Oh My Gosh!' You could … you could manipulate viruses!"

AB: "Oh yes!"

NdT: "You could, uh, I mean that … that's an extraordinary frontier! And of course there's a dangerous side!"

AB: "Oh yes!"

NdT: "There's a dangerous side when we invented knives. Right? You can kill people or you can kill your food.

So … so … I'm not saying there aren't hazards. And I'm not saying that we should not have a growth of moral turpitude … (Is that the right word ... turpitude?) … (AB smirks) … um, fortitude to accompany such discoveries.

But when I pause and reflect on the power we would have over our genome …"

AB: "Right."

NdT: "Over our … over our medicines and how much that could help the human species, I'm not even thinking about what bad it can do.

You … you put … you set up laws and say: 'Thou Shalt Not Do These Bad Things With This Technology.'"

AB: "Um-hmm."

NdT: "Of course, they'll be bad people who will! You find them and arrest them, and put them in jail. Just as there are bad people who will stab you with a knife or shoot you with a gun – you take them and put them in jail. All right, so we'll need laws to grow up alongside it. But there is no doubt that so many of the same things that we fall victim to is simply because we don't have the tools and the knowledge of how to use such tools even if we don't have them commensurate with the size of the actual phenomenon going on that we would want to manipulate."

AB: "There's just been one big change in the world, Doctor, since what you're talking about now, and that is: Back then we could depend on Mutual Assured Destruction (MAD). You know, somebody pushed the wrong button. Now, we have people in the world whose … the very centre of their ideology is to bring upon us Armaggedon. To start the War of Wars that will essentially end everything.

So, uh, if something gets in their hand that would accomplishment that, they don't mind dyin'! They're ready to give up their life to end it all …"

NdT: "You're right. That was a gamechanger and for us stateside that all changed of course on September 11th where …"

AB: "That's right."

NdT: "… at any minute before September 11th we would have said to ourselves: 'Yes, negotiate with the terrorists. Maybe we will survive."

AB: "Yeah."

NdT: "As long as nobody's surviving … all bets are off!"

AB: "All right, good. Hold it right there. Good long break – seven (7) minutes – then we'll be back.

My guest I am honored to have with me, Dr. Neil deGrasse Tyson. You're listening to *Midnight In The Desert.*

* * *

AB: "We are graced with Dr. Neil deGrasse Tyson this night. I'm Art Bell. He's a fascinating guy! There's no question about it. Ah, he does *Star Talk* and I should add that *began* Sunday, October 25th, [2015] at 11 o'clock. And it's in that slot and, uh, just to finish up on my thought: In the old days, we were worried about the Russians, they were worried about us – we all know what would happen if some idiot pushed the button.

Today I somehow imagine I guess some guy named Muhammad, dressed probably in classy black ISIS attire with a little test tube full of something called 'grey-goo.' And you know, there wouldn't even be a discussion about whether it's a good idea to let it loose or not … they'd just let it loose … be that quick.

So that's what I was talking about, Dr. Tyson. It's a … it is verifiably a different world."

NdT: "Yeah … I mean, I think, ah, one of the things we need to think of as modern civilization is that if we are going to, ah, respect … if we are going to respect people's belief systems [It can't just be 'beliefs' – it has to be a 'system.' – JS], that's, ah, and that's what you would defend in a free society, of course."

AB: "Of course."

NdT: "One of the things that distinguished the United States from so many other countries that came before it or have come since … so … the difference however is that belief systems are not founded in objective truths, they're founded in personal truths. So it is your personal truth if Jesus is your Savior. Or if Muhammad is … that's your person, who is responsible for your … for your, um … uh, spiritual fulfillment."

AB: "Sure."

NdT: "And … and you go around the World and people have their personal truths.

But when it is time to do established governance in a pluralistic society, you cannot create laws based on personal truths, if you plan on those laws to govern everyone.

So … so you need to take a step back and say: 'What are the objective truths that we know about in this world? We have methods and tools to establish objective truths … it's called Science.

And I've been quoted as saying as I said I think once on *Bill Maher*: 'That the good thing about Science is it's true whether or not you believe it (!)'"

AB: "Hmpf."

NdT: "So it's something that applies to everyone."

AB: "Right."

NdT: "You base your laws and your notions and your … and your … and your legislation on that, and that they can protect the freedom you have to have whatever belief system you want. If you have an entire community of people who … who do not care if they remain alive …"

AB: "Right."

NdT: "… because they want you to have their belief system. That is a destabilizing force not only in a nation, but in civilization itself."

AB: "Sure is. … Sure is, and, uh, they wouldn't hesitate for a moment if they had something like that. They wouldn't even have a discussion about whether it was ethical or not, or a good idea, or suicide. They are ready to become martyrs to bring upon the end of the world. And so they would do it. Hopefully nobody …"

NdT: "Yeah, what I wonder is …"

AB: "Go ahead."

NdT: "You know, what I wonder is if … this is more hopeful thinking here … if that kind of attitude and that kind of state-of-mind is actually incompatible with wielding weapons of the power to actually effect that kind of outcome. Because you have to … you have to know what … how the laws of physics work. You have to …"

AB: "Yeah …"

NdT: "… if you want to blow up the world.

You have to … and … to … to … to study to learn how to do that. At some point maybe you'll question the role of your personal beliefs in

inflicting it upon other people no matter what your personal beliefs are. Or … or … or taking it or trying … ['Beliefs' now, not 'belief systems' – ☺].

And one thing to convince people 'cause they, you know, you … you preach to them. It's another thing to … to bring them on by force. And by the way many of the … the … the successful religions over the years accomplish their success by just such activities …"

AB: "Um-hmm."

NdT: "… right? Ah, we can see … we can speak of peaceful Christmas today, but they're whole episodes where that was not the case …"

AB: "Ohh …"

NdT: "… as you well know. (AB laughs).

And so, there was, um, so … so we're talking about modern society and post-Dark Ages modern society. And for that to function as we would hope as civilized people, then some- … something's got to give. At some point …"

AB: "Yeah, something will give, all right."

NdT: "… so that can move forward."

AB: "Well, as Lenin said: 'If you could make it so, would there be no religion?' I know that's a … that's a got 'cha question."

NdT: "Look, I'm a … I'm a … I'm a fan of a free society. You can think whatever you want. Just don't require that other people think it as well. Then you've made a dictatorship. It's no longer a free society that our founding fathers had imagined for us.

So … I'm not … I don't run around chasing people and their religion. Um, it's not what I do. And it's … that would be a violation of the freedoms guaranteed to all of us in the Constitution.

Is the freedom to … your freedom of speech, and what goes with that is your freedom of thoughts."

AB: "Um-hmm."

NdT: "You have that. Whatever you want.

But, for example, if say you … you have a cult that is afraid of the number thirteen (13) …"

AB: "Uh-huh."

NdT: "Okay, what is it? Triskaidekaphobia … fine … Fine! Okay? Go ahead! But don't be tasked with designing elevator banks (NdT laughs, then AB laughs) leaving out the thirteenth (13th) floor of buildings." (NdT laughs more).

AB: "They do."

NdT: "That shouldn't be your job if that is what you're afraid of."

AB: "Yes, indeed."

* * *

AB: "All right, so, um, here's something that I'm sure you can warm up to. You … you … um, you are combining pop culture and science in this new TV, ah, show *Star Talk*, right?"

Ah, I would guess this is what you were talking about earlier … an effort to get people involved. And if it takes pop culture to ease them into science, so be it."

NdT: "Yeah, I think it … Yes! (AB laughs). I think of it in a slightly nuanced, different way."

AB: "Okay."

NdT: "And that is, um, I realized over the years that I was doing something that I didn't even know I was doing. Until I looked back on it and said: 'Wow, so that's what I was doing!' And now I can say like I've known it all along, but really I hadn't even discovered this in myself.

What I realized is if you take science and imbed it in pop culture, then it is a ready-made vessel for people to embrace the science."

AB: "Right."

NdT: "Because people already know pop culture. That's the definition of pop culture.

For example, two (2) … three (3) weekends ago … two (2) weekends ago, I … I finished watching a movie and I had a half-hour (30 min.) before my

next TV show I was watching, and I just started channel-surfing, as any red-blooded, couch-American does. (AB laughs).

I'm channel-surfing and I stumble upon the Cincinnati Bengals going into overtime with the Seattle Seahawks. And I said: 'Perfect! I got thirty (30) minutes … a fifteen (15) minute overtime … let's just … something good … something good is gonna happen!"

AB: "Sure!"

NdT: "Something interesting, uh, suspenseful is going to happen.

So after the … the first round of exchanged possessions, the Cincinnati Bengals comes into position of a winning field goal kick.

So there it is … it's heighth … the ball goes forty-two (42) yards as it tumbled through the air in this *long* arching trajectory. And it hit the left upright …"

AB: "Uh-huh."

NdT: "… and then deflects into the goal posts …"

AB: "Oh!"

NdT: "… for the winning kick!"

AB: "Uh-huh."

NdT: "The Cincinnati Bengals win by three (3).

And I looked at that and I said: 'Oooh! I gotta tweet this!' So I get on the Twitter … on Twitter and I say: 'Okay, the winning field goal overtime kick by the Cincinnati Bengals was likely enabled by a third of an inch drift due to the rotation of the Earth.' (AB laughs!).

And people like …"

AB: "Ahh …"

NdT: "… it blew people's minds! People said: 'Oh my gosh!'

Now here's the thing: I didn't have to explain what football was. I didn't have to explain a field goal kick or overtime, or who the Cincinnati Bengals were. (AB laughs). Not everyone is football fluent, but enough people are for that tweet to matter to them.

And it got picked up by the … the sports networks, and everyone was talking about it! (AB laughs). And it was no effort for me! I just happen to know what these deflections are. I did the calculation some time ago and I just carried it forward into this moment.

So in *Star Talk*, the more I can find ways to imbed science into pop culture, I think the more accessible it is to people without dumbing it down. I'm not dumbing anything down!"

AB: "Right."

NdT: "I'm telling it like it is …"

AB: "Sure you are."

NdT: "… right?

Yeah! … and so that's the subtle difference. It's not that I'm trying to use it to … to … to … to soften it. I'm using pop culture as this … as this moving vessel that's already comin' through your living room. And then the science is for the taking.

And that's what it has been. And *Star Talk* is the television embodiment of that. And of course it's based on a radio show of the same name that … that posts fifty (50) times a year, but National Geographic channel has … has sort of plucked their ten (10) favorite guests each season, and that they get lifted up and jump species onto television."

AB: "That's amazing!"

Well maybe, you know, that's just you walkin' your walk! The one you talk about, and, uh, I hope it works! I hope it succeeds … what's the response like?"

NdT: "It's been very warm. In fact the first season this past spring, uh … got an Emmy nomination, and I was very flattered by that. It meant … we didn't win, but it got noticed.

And … you know, you win an Emmy because people in the television professional community vote for it, right? It's a … it's a peer award in a sense."

AB: "Right."

NdT: "It's not a committee. It's not some-, um, someone up on high.

So the fact that it got noticed told me that maybe, when you combine the fact of how well *Cosmos* did appearing on Fox …"

AB: "Sure."

NdT: "… not on, you know, not in the science ghetto channels of the upper dial. (AB laughs). But Fox … on Sunday night where everybody's home already.

Ah, when you look at the success of *Cosmos*, and the fact that I have … I mean, every morning when I look … Do I have how many Twitter followers? 4.6 million Twitter followers …"

AB: "That's a lot!"

NdT: "Should I remind these people that I'm an astrophysicist that they can still pull out if they need to? (AB laughs).

And look at the success of – it's not just me – look at the success of *The Big Bang Theory* television show … The number one (1) show on television in any genre. It's pullin' down $330,000 per thirty (30) second commercial. This is …"

AB: "Incredible!"

NdT: "And this is … though they be caricatures, their banter is legitimate science unfolding right before our eyes. And look at … as we said earlier in the broadcast, look at the success of *The Martian* and *Interstellar* and *Gravity*. And you have a biopic on an astrophysicist called Stephen Hawking where the lead actor wins the Academy Award! (AB laughs). A biopic on … on … on Alan Turing with marquee actors ... Benedict ... 'Cabbage Patch' ... what's the guy's name?"

AB: "My point is all of this should somehow translate, you know, into the American people demanding, ah, that their ... people who represent them start looking again at Science. At Space. At things that we ..."

NdT: "Completely rational thought. And I'm thinking ... maybe, ah, delusionally that the demographic who knows that are people who are thirty-five (35) and under.

These are the people who grew up with the iPhone and smart phones, and they know what value technology is to them. And they don't want to live without it.

And these are the people who ... who didn't necessarily become scientists, but they took science in high school and maybe even in college ... *and they liked it!* And they want more of it. And they ... and they want to consume it in one way or another.

And they, so ... so ... so ... that is the community, in fact, who grew up with Bill Nye, the Science Guy ..."

AB: "Um-hmm."

NdT: "... in their classroom."

AB: "Right."

NdT: "And so it's a different approach to science than what an older generation had seen or experienced. And this demographic, however, is not yet old enough to run the country, right? They're just coming into the age of ... of ... you know, none of them are on Boards yet. But some of them are actually self-made, entrepreneur billionaires, right? And they see that. They're one of them, right?

How old is Elon Musk, you know? How old could he possibly be? Or the founder of Twitter? Or of Facebook, or of any of these other sort of moguls, really? They all come from that demographic. And they know it's technologically driven. So however delusional I am, I'm thinking that as they move up in the ranks ... Oh, by the way they also lead the country in support for social causes in the sense that if you ask who is a fan ... who is a fan, um ... ah ... do you object to same-sex marriage, okay?"

AB: "Um-hmm."

NdT: "The objection refraction is like ten percent (10%) or fifteen percent (15%) for the thirty-five (35) and under and it's like eighty percent (80%) for sixty-five and over."

AB: "Right."

NdT: "So there ... there's a definite social trend as well as a scientific, technological trend.

And look at how many people go to Comic-Con. Have you been ... maybe you've been ... surely you've been to San Diego during Comic-Con? You can't even believe it! Hundreds of ..."

AB: "Oh!"

NdT: "... thousands of people show up there."

AB: "Yep."

NdT: "And it surely began as just a small illustrator's conference, you know, decades ago. Now look at what it is.

It ... by the way (NdT laughs) I've said this before – I have this fear that we have actually been visited by aliens, but they happened to land in San Diego during Comic-Con and nobody noticed." (NdT and AB both laugh).

AB: "That's a puzzle!

All right, so when I asked about the ... the reaction to *Star Talk*, it wasn't so much about the awards though I'm very, very pleased that you came close to getting it. What I meant is: 'Are you getting a lot of emails I hope from young people inspired by it?'"

NdT: "Yes. Yes, they're people … and of course, um … ah, good news for you as well as others – the fact that people spend time in cars and in … and in, ah … um … ah, and in fitness centers and in other places, the audio medium has … previously I think was … was given up for dead a few years back … has … has vision. The growth of podcasts."

AB: "Wow!"

NdT: "The ways that people obtain information today, uh, may be primarily through just the audio medium.

And so, ah, there are many people, so I listen to you on my drive and I listen to you on my … on the treadmill, because each of those shows that go to National Geographic channel also airs as an audio podcast. And … and on SiriusXM radio as well."

AB: "It's roaring back, Doctor! Remember the old days when you'd see a kid goin' down the street with a transistor radio …"

NdT: "Yeah!"

AB: "… plastered to his ear? Okay, today they're plastered to hips and pocketbooks – they're called I-phones and Androids."

NdT: "Yes, exactly! Exactly! With a Bluetooth headphone connection …"

AB: "That's it!"

NdT: "… so we don't even see the device anymore."

AB: "That's right."

NdT: "So … so … um, so yeah, there's no end of communication on this. And by the way, just in case people haven't seen or heard an episode, just if … if I can spend fifteen (15) seconds describing the structure … ?"

AB: "Go for it!"

NdT: "I'm the host. And I'm a scientist. And my guests are hardly ever scientists. They are hewn from pop culture. And my conversation with them orbits – if I may use the word – …"

AB: "Hmm …"

NdT: "… all the ways that science has influenced their lives or their livelihood. And that way their fan base gets to see them in just such a conversation.

So I'd like to think that *Star Talk* not only attracts people who know they like science, it also attracts people who don't know that they like science. (AB laughs). Or better yet, people who know that they don't like science.

And these people … how would you ever get science to them if they didn't simply follow their … their … their people wherever they went as a fan of who happens to be my guest?

And then, the way I make this work is I have a comedian, who is my … a professional stand-up comedian as my co-host …"

AB: "A-ha!"

NdT: "… and they provide levity when necessary. And then I bring in, if necessary, an academic expert, 'cause not all the topics I talk about are astrophysics.

It could be, um … uh, neuroscience. Or it could be, uh, philosophy … whatever … I bring in an academic expert and they provide a sort of uh … uh, gravity valve … (AB laughs). A levity valve and a gravity valve, and I … and I as host … I … I … I adjust those valves so that I can hit a consistent delivery of … of … of humor, of pop culture, of science. And what I like to think of as a tapestry that gets woven during the show ... so that at the end of the show, you now have a cozy blanket to cuddle with."

AB: "Heh, heh! Well, it's apparently working! And that's why I asked you about the emails. Um … ah, hopefully you're firing people up! We need it!

If we don't start pretty soon, I don't know, there could be a sort of a … a break point where if we don't begin educating people … If people don't dive into math, if they don't be- … become entranced in science … with science, rather … um, it may become too late and we may not have enough to lead any longer – if we're even leading now? Not so sure about that."

NdT: "Yeah, yeah, yeah … you put your … the nail on the head there because ... because having led is not a guarantee that you will continue to lead. And … you know, I think we got kind of lazy. We got complacent and lazy, because we basically led the world in every metric – scientific and technological advance – in, um, in the second half of the Twentieth (20th) Century.

Yes, we were behind the Russians in these checkpoints, but by and large, you look at the strengths of our economy …"

AB: "Sure."

NdT: "… and other factors … Ah, it was … it was America's century. And it … the way we're goin' is so not going to be our century going forward. And … and if we don't embrace this in just the recitation you gave, in the way that you described it, then someone … some other country will! And … you know, Science and Technology does not have nationality branded on it. It exists to be discovered in nature. And … uh, if we don't do it, somebody else will. And if that's the case, we will dance to the tune that they play."

AB: "You bet!"

* * *

AB: "Well okay, this is a very unusual opportunity for you. Neil … Dr. Neil deGrasse Tyson is our guest and if you want to ask any sort of question at all, um, I guess nothing is really too silly, so … you're welcome!

* * *

"And I do have one (1) other question before we go to the phones and that is this: Ah, we covered what with the … the collider was doing with respect to the possibility of a miniature black hole … there's also people that are talking about the possibility, ah, Doctor, of communication with or discovery of another *dimension*. What do you think?"

* * *

"I hope we've still got him. Doctor, are you there?

Oh, man! What happened?

He should be there. Doctor Tyson? Hmmm. Can you guys hear that? (sound of static). Kind of weird … Hello, Doctor? I actually heard breathing for a moment.

Doctor, are you there?

I wonder if he thinks we've got a very long break. That could well be. Do you hear that? (sound of static again). Pump it up a little here. (sound of static continues).

So it would do me no good at all the way I see it to hang up and redial. If I did that I'd get a busy signal, right? [sound of static persists].

Very unusual situation.

I am very curious about that. In other words, the collider can create a black hole, one would think that it can also perhaps connect with it, or at least prove another dimension … which would be very, very, very interesting.

So many questions, and I have no idea at all what's going on here … ? (sound of static continues).

Um, so what I think I'm going to do is answer a few calls … I swear I can hear him in the background. That is Dr. Tyson, right?

It's, ah … let me explain a little bit about broadcasts. When we connect with somebody, ah, we actually lock that line and I have locked – at the beginning of the program, the way I locked Dr. Tyson's line.

Are you there, Doctor?

Are you okay, Doctor? I'm starting to worry now! Dr. Tyson? Dr. Neil deGrasse Tyson … (sound of static continues) … Is there … ?

I guess … I can see … I can hear movement, so … you hear that? (sound of clicking on the line).

As though he's, ah, just sort of marking time …

I was going to begin to worry about whether he was actually perhaps ill or something? Or even fall asleep … he is back East …"

NdT: "Are we talking about me here?"

AB: "Oh, hi! Dr. Tyson!"

NdT: "Hello. I just ahh …"

AB: "Hah! " (AB exclaims with relief).

NdT: "I went dark for like seven (7), six (6), five (5) minutes, and then …"

AB: "I could hear you."

NdT: "… about [unintelligible] seconds ago, I heard your voice."

AB: "I could hear … suddenly you heard my voice …"

NdT: "Yes."

AB: "Wow! Incredible! Absolutely incredible!

Okay, I've got …"

NdT: "It was odd, because you just kind of blanked away."

AB: "Ah! Ha-ha-ha! Honestly, I was here. I could here you moving in the room …"

NdT: "Oh, yeah … yeah …"

AB: "That was really strange."

NdT: "… okay … um-hmm."

AB: "Okay. All right, so one last question, then we'll … I've got a million people who want to talk to you.

Uh, with respect to the large collider, I did ask you about the possibility of a miniature black hole, ah, as well as one that could eat us all. Ah, but I did not ask you about the possibility of, uh, either opening or discovering or communicating with another dimension."

NdT: "Yes, you did ask and we got distracted by the black holes."

AB: "Right."

NdT: "So … so … there is … there are suggestions that the manifestation of … of particles in higher dimensions has certain … certain, um, testable, measurable implications in our own dimension. And so … so this is how

you can actually propose a scientific test for something you know is not within your reach, because maybe the thing that is not within your reach has indirect consequences for things that are in your reach.

(AB clears his throat).

And so, yeah, there's some hypotheses that the higher dimensionality which we think we live in … um … you know, ten (10) – eleven (11) dimensional space, which you've surely heard about …"

AB: "Sure."

NdT: "… um, from others on this … on this show. That … you know, we only experience our three (3) spatial dimensions and one (1) time dimension. But in the realm of a particle accelerator, you're … you're … you're extending beyond what your life experiences are."

AB: "Um-hmm."

NdT: "And … so to the extent that higher dimensions exist and manifest in our own, there could be some experiments to test for that. And, um … um, that should be a fascinating space moving forward."

AB: "Um-hmm. Do you think that other dimensions are likely?"

NdT: "Um … I don't see why not. I mean why … why should the Universe stop at the number of dimensions that we sense?

And why are our senses the measure of anything other than just our ability to survive on the … on the plains of Africa and not get eaten by a lion, right?"

AB: "Um-hmm."

NdT: "I mean, that's really what our senses are attuned for. They're not tuned to decode the … the operations of the Universe outside of those regimes. And this is where the methods and tools of science get involved to do so.

And that's why the Universe has no obligation to make sense to us."

AB: "Heh."

NdT: "Because the definition of making sense is that it happens in our life experience. Outside of that it just is what the measurements show it to be. And then you have to … so … so for some people it's uncomfortable. They want … they want to stand in denial of it."

AB: "Um-hmm."

NdT: "When I say: 'The whole Universe was once the size of an atom.' They say: 'No, that can't be so. It doesn't make sense.' – Precisely!" (NdT laughs).

AB: "All right, well …"

NdT: "It doesn't matter!"

AB: "Yes, like with the miniature black hole, uh, it would be an amazing discovery of course, but is it … should we do that and connect with another dimension in any way at all? Possible danger?"

NdT: "You know, I … I … I … I've been reading about higher dimensions ever since I was a kid, and it's some of the most fascinating, mind-expanding thoughts you can have …"

AB: "Oh, yes … !"

NdT: "… is imagining a cube in four (4) dimensions … five (5) dimensions, you know: How many sides would it have? What would the sides look like?

Just as a square has four (4) sides that are lines, a cube has six (6) sides that are squares. And a hypercube has eight (8) sides that are cubes.

And now this is when your mind starts blowing …"

AB: "Heh, heh, heh, heh."

NdT: "… because what does that even mean? But I'm just following a mathematical sequence here.

And so, it is possible to formulate what the behavior of things would be in higher dimensions, because you can see the tramline going into them from one (1), two (2), and three (3) dimensions that we're familiar with."

AB: "Right."

NdT: "But that doesn't mean they'll be easy to understand, and they might even be impossible to understand. That's why the mathematics matters.

And so, ah, to … to access another dimension, if we could, that would just be kinda cool I would think. I mean, I … I see all this as amazing frontiers, not as something to fear."

AB: "Hmm … perhaps another dimension … Do you think it might be detectable by gravity?"

NdT: "Well so … ah, gravity is a fascinating force because in fact, it can … I don't want to call it the power, but is has the properties of where it can emanate from our … from our manifold, from … from our universe and be felt by adjacent universes to us. So if there's a Multiverse, the different Universes can in principle feel each other's gravity."

AB: "Um-hmm!"

NdT: "It's significantly weaker …"

AB: "Right."

NdT: … but they can, and this would … would be a *way* to know the presence of a parallel universe would … without actually venturing there, which could possibly be quite dangerous for you if the laws of physics are slightly different.

Your body will … will collapse into a pile of goo (AB smirks) because they're … the intermolecular forces are different and they can't maintain the molecules that make … make up you.

So … yeah I … I will not be the first one to voyage into such a universe, but given the fact that gravity, as we know and understand it, can penetrate those membranes whereas other forces cannot, that's a fascinating, um … uh … uh ... *fact*, that I think deserves much further exploration."

AB: "Boy, it sure is! Um, you know, given a choice – if a scientist has put in, I don't know, a decade's work on some project and he's got an 'On' button and an 'Off' button. And the 'On' button is going to initiate the experiment – whatever it would be – ah, he might sit there for a few moments thinking about the possible implications, side effects of pushing the 'On' button, but in the end, he's going to push it, right?"

NdT: "Yes. For sure.

Now, consider that rarely is that experiment so … out there that it would completely transform all of life and civilization as we know it."

AB: "A-ha."

NdT: "What is more typical is that there's some other experiment that someone had done, and this person says I think I can make that a little better or a little faster, or a little cheaper or a little stronger …"

AB: "Uh-huh … yes."

NdT: "… and so then they build an increment on that. And then they push the button.

And so, generally this button pushing is going on as this person … one person steps on the shoulders of someone who came before them. They rarely if ever have a brand new thing out of the box that no one knows anything about and they push the button, and the world ends."

AB: "Okay, well I'm going to be watching the parking lot at CERN. (NdT laughs).

All right here, we're going …"

NdT: "I'm sure it's still on YouTube. You'll find it's really cute."

AB: "Okay."

* * *

Aud: "It's an honor to be talking to Dr. Tyson."

NdT: "Oh, thank you! No, don't even … I'm just here to share knowledge. (NdT and AB laugh).

Aud: "So, ah, I have two (2) questions – the first is just a 'yes or no' question. Is there going to be a second season of *Cosmos*?"

NdT: "Oh, thanks for asking. So I … Seth MacFarlane, as you may know, was the Co-Executive Producer of *Cosmos*, which is part of how it landed on Fox, 'cause he's in a sense a Fox property with his *Family Guy* and his other projects. So he and Ann Druyan, who is the co-writer of … of *Cosmos*, not only this one but the original one with Carl Sagan.

They're both working to get this thing in motion and greenlit. And I don't have the latest from them, but they're working hard to make that happen. So … um … and at different dinners that we've had over the past months … but different parts of the band have gotten back together (NdT laughs), so we'll see. But, ah, it's likely to happen, but I don't wanta pre- … ah, I don't want to jinx anything. (AB laughs). Let me just say: People are working hard to make it happen. But thanks for your question."

Aud: "Second question: What's your best guess as to what happened before the Big Bang?"

AB: "Oh! Oh!"

NdT: "Oh? Yeah, I … I … my best guess based on cogent ideas that are emerging from, you know, Cosmologists, is that, you know, we're one bubble in a Multiverse. And the Multiverse is … would be the entity that we're not … we're not familiar with in thinking about and interpreting.

But if you have a Multiverse that is birthing Universes, ah, and … that come in and out of existence – we're just one (1) of them. And … so our whole world … our whole sense of the world begins when our bubble started expanding. But if you go back to before the bubble, there's this Multiverse there.

Now here's something that may force you to lose some sleep. Is … our experience tells us that the Universe hardly ever makes anything in ones (1)s. All right, we thought maybe Earth is special – no, it's one (1) of eight (8) … or more planets.

Um, how about the Sun? Hey! No, it's one (1) of like, you know, four hundred billion (400,000,000,000) stars in our galaxy.

Well, the galaxy … No, there's fifty billion (50,000,000,000) galaxies in the Universe.

The Universe? Well, maybe there's a Multiverse …

Well, how about the Multiverse?" (NdT answers by laughing).

AB: "Hmpf. Professor, I've got a question for ya."

NdT: "What's that?"

AB: "Who blew the bubble?" (AB laughs).

NdT: "Who? You mean … who … how does the bubble begin?"

AB: "Yes."

Ndt: "We're still trying to understand the Multiverse. And … to finish the point of that – maybe there's some other kind of entity that is comprised of multiple multiverses."

AB: "Hmm."

NdT: "That is an interesting … I mean …"

AB: "It is."

NdT: "… it [tunnels] all the way down as an interesting …"

AB: "Yes."

NdT: "… question here.

And so … so … we don't … it is a frontier to pose and answer the question: 'What was around before the Big Bang?' Or how did it begin? That's a … we have top people working on that. And so, we just don't know."

AB: "We're close, aren't we?"

NdT: "Who blew the bubble? We don't know. (AB laughs).

And who implied that it is a 'who'?"

AB: "Well … I … that was a cute way …"

NdT: "Of course, of course. You have to be careful how you word a question, because it could bias an answer into a place where you're hopelessly looking for an answer. Like asking: 'What kind of cheese is the Moon made out of?' (AB laughs).

Well, if that's your question, then you're answers and the experiments they devise will *fail*, because it's not made of any kind of cheese.

So … yeah. I knew you would be havin' fun with it, but it has a serious response."

AB: "Okay."

* * *

Aud: "How long do you think it will take Man to actually land on Mars?"

AB: "Ha."

NdT: "Yeah, no … well … (NdT laughs). You know, that is such an … such a good question that has possibly no real answer to it.

You know, I can tell you this: That if we find oil on Mars, we'll be there really soon. (NdT and AB both laugh).

Um, so it's … I don't think and this is my … my candid read of human behavior – I don't think it is enough motivation for any of our species …"

AB: "Right."

NdT: "… to spend the money to get to Mars to just say: 'It is our destiny,' or 'It is the next frontier.' That kind of talk hardly ever comes along with the money necessary to make it happen.

The money that gets spent is almost always driven by the desire to make more money, the desire to protect your security, or that's it, kind of. In the old days you would do it for Kings and Queens, and Gods. Nowadays those are diminished forces and making things happen …"

AB: "So in other words, we need an economic reason or … a war?"

NdT: "Ah, my read of history tells me that, and I wish it were not so, but that's … and … and … and nobody wants a war, I presume, and so it means an economic reason. Now does it mean finding … hmm, oil on Mars? No, there are other ways you can construct an economic reason, as I hinted to you earlier. Where you just do it and then the whole country – the world – sees: 'Wow, this is a cool thing to do. I want to discover as well. I want to explore. I want to innovate.' And it … everybody becomes an innovator no matter what they do. And that would transform an economy, it will transform a culture, and you'll turn the world into the World we all thought we'd be living in …"

AB: "All right."

NdT: "… the Tomorrow that never came. That's what we'd be living in."

AB: "Indeed."

* * *

Aud: "This is legendary, okay? I remember watching an episode of *Cosmos* that you did – you had talked about Venus, how it's very similar to Earth. And how like if all the volcanoes went off and everything, if we used all our resources, Earth would be a lot like Venus.

And it really kind of shifted my paradigm a bit, and I … you know, I'm hearing all this talk about Mars, you know, and uh, how there's life on Mars, and um, I guess my question is: Is … could maybe Mars not, um, have had like old life on it, but maybe Venus did?"

AB: "Well, I haven't heard about life on Mars, really. Um …"

NdT: "Yeah, so but these are good questions.

So Venus, you know, is kind of a hopeless cause today. It's … it's nine hundred (900) degrees Fahrenheit. And I did the calculation where you can cook a sixteen (16) inch pizza on the windowsill in nine (9) seconds. And then someone geekier than I was said: 'No, you did the calculation wrong. You left out the variant effects of the hemisphere, and in fact, I will cook in two (2) seconds. (NdT laughs). So … I got … I got schooled on that one, so it's a two (2) second pizza instead of a nine (9) second pizza.

So … so … an interesting question is: on Venus before if had this runaway greenhouse effect …"

AB: "Um-hmm."

NdT: "… or on Mars back when we know it once had running water , could there be evidence of civilizations that have come and gone. And that's an unknown question … I mean, it's a … it's a perfectly legitimate question and has no known answer at this point. And will require … look at what we're discovering even on Earth, but it requires major excavations.

We didn't know about *Pompeii*, until what was it? Eighteen whatever (18??). Pompeii is a modern discovery yet that thing was around two thousand (2000) years ago. And that's on our own Earth!

So … it's intriguing to imagine that these are dead planets of lost civilizations, but it will take much more of a space program than we currently have in order to investigate that."

* * *

AB: "Um, since you mentioned greenhouse stuff, I guess it's worth asking, ah, runaway greenhouse – is that possible here on Earth in your opinion?

NdT: "So … when I first looked at this problem, it turns out I overestimated, um, the … I was thinking that if we were not careful we could become Venus …"

AB: "Right."

NdT: "… because we're flanked by two (2) planets that have gone … something's gone wrong – something's gone bad. Venus with the runaway greenhouse effect, Mars once having water – now it doesn't, and

we're sitting exactly in between them … Which way are we going to head?"

AB: "Right."

NdT: "So … but when I … I spoke with some colleagues of mine and then I came to realize that if you burned all the coal and all the gas and the sequestered carbon for fuel that is there ready …we were already pulling out of the ground, we will *not* have a runaway greenhouse effect like Venus."

AB: "Yes."

NdT: "What we'll have is an Earth with no ice caps and a very different coastline, and all the greatest cities of the world would become completely flooded.

But we will not have a runaway greenhouse because you … you just have to go back to a time when there was no buried carbon. And we did have high carbon dioxide levels in the atmosphere, and its called the carboniferous period on Earth, where, um, there was heavy growth of plants and the plants … and trees. And the trees didn't have anything to have them decompose, because bacteria had not gotten savvy enough yet to figure out how to digest the … the … was it the lignim or one of the molecules in the tree that made it strong? So the trees grow and they die. They … they … they fall over and they do not decompose. And so the world is accumulating this layer of vegetation …"

AB: "Hmpf."

NdT: "… that's not decomposing, and that would ultimately become the oil reserves.

So … so … there was a time when the dinosaurs were around, there was no ice anywhere in the world. And they had much less land because of that fact."

AB: "Well, what about our submerged … yeah, what about our submerged cities, Doctor, and the fact that any good growing would move from the central part of the U.S. way up north into Canada somewhere?"

NdT: "Yeah, exactly. I think, uh, you could probably move farms fast enough to keep up with this change …"

AB: "Okay."

NdT: " … to where it was previously not arable – now it is. And maybe it was and now it's not.

You … you could do that, 'cause what are you moving? You're just, you know, planting your seeds in a different place.

The hard part would be the cities and all the people whose entire lives … You know, when you flood the coastlines, rich people lose their second home and poor people lose their only home."

AB: "Right.

NdT: "Look at how many poor people live in poor countries on the coast, because that's where transportation or … or commerce, or whatever else is conducted. So … so … we're … we're now making that happen at a rate faster than we could possibly respond given the locations of the major cities in the world, which historically have always been on the river's edge …"

AB: "Yes."

NdT: "… or on the ocean's edge."

AB: "Right."

* * *

Aud: "Hello. I'd like to know what the nature of the edge of the Universe is, if there is an edge?"

NdT: "Yeah, that's a great question. So there's a … there's a little bit of confusion about that. Let me just straighten that out right now.

We have what we *speak of* as the 'edge of the Universe,' but it's not an actual edge any more than your horizon at sea is an edge. It's just … it's the … it's the … it's horizon! It's a visible horizon beyond which we cannot see. All right?

And that's this, you know, ah, when you look out that's where their [sic] cosmic microwave background emanates from. And we have no reason to think that the Universe doesn't continue well beyond that horizon for the same reasons that the ocean continues beyond your horizon when you're in the … on the ship at sea. And the … this analogy is very potent for this case.

So … so … um … so the question is how much bigger than our horizon must the Universe be?"

AB: "Hmpf."

NdT: "And there are people who have estimated this based upon some plausible arguments – and forgive me, but I forgot the number – but so … I … maybe ten (10) … factors of tens (10) larger, or possibly infinite, but we know it's bigger than our horizon.

And … so … um … in that sense there's no edge when you get to the edge and fall off … (AB smirks) … especially if the Universe, the actual Universe is infinite.

But our visible edge, that's just there like any … any horizon at sea that you'd have if you voiced it from … from a ship's mast … masthead."

Aud: "Cool! Thanks."

AB: "All right."

* * *

Aud: "I just wanted to ask Dr. Tyson where exactly the expansion of the Universe takes place? Ah, I understand we see it through Doppler shift and distant galaxies and whatnot, but I just wanted to know if, ah, where exactly it takes place?"

NdT: "So … so … we … we're stuck in a paradigm of mind where when an event happens, you can go point: 'Oh, it happened right there.' All right?

But we are less … we're … in our minds we don't think of events happening at a time in a coordinate, all right? So … so … the Big Bang happened *everywhere*. 13.7 … 13.8 *billion years ago.* So you have … so I can point to it, but I'm pointing backwards on the timeline to show you *when it happened*.

And the *when* is no less legitimate than the *where* in localizing things in space and time for you."

AB: "Um-hmm."

NdT: "So … so … everything you see participated in that expansion and continues to do so. And if we drop one of the dimensions of this analogy to get … to perhaps shine a little better light on it – and you probably heard this example before – you think of an expanding balloon. Um, so now all of space is now the surface of a balloon. The surface is expanding …"

AB: "Right …"

NdT: "… if you inflate the balloon."

AB: " … right."

NdT: "And you say: 'Well, where is the centre of this expansion? Where is it coming from?'

It's not on the surface of the balloon … anymore! It is back through Time. So you have to look in the time dimension back when the balloon was smaller. And then you can point to that exact moment in Space and Time when the Universe began."

AB: "Okay."

* * *

Aud: "I just actually wanted to ask, um, if time travel would be possible, um, should we … say, ah, watch the, I guess, energy output problem?"

NdT: "Ah, so … yes, yes, it turns out that if we had the power over the fabric of space and time enough to build wormholes, then there are trajectories around and through where you can come out in a different time from when you left – like in your past.

And … this is kind of scary because – let's say you did that and then you prevented yourself from building the wormhole … (AB laughs) … to travel back in time to see your past."

AB: "Paradox."

NdT: "But then you wouldn't have … you'd have a time paradox.

And so there's some people – I think Stephen Hawking included – who are thinking that though we have not discovered it yet, that eventually we will find a fundamental law of physics that prevents backward time travel … just so we don't suffer from that paradox."

AB: "All right."

NdT: "And … but we're not there yet."

AB: "All right Doctor, hold on. We have one last segment. Sit tight …"

NdT: "All right!"

AB: "… it's a long break, and try to be there if you can, when we get back. Ah-ha-ha-ha-hah! That was so strange! I could hear him …! Somewhere-In-Time, right? Ha-ha.

I'm Art Bell. This is *Midnight In The Desert*."

* * *

Ancr: 'What's in the Dark, Stays in the Dark. Call *Midnight In The Desert* at 1-952-CALL-ART …"

* * *

AB: "We are so honored to have Dr. Neil deGrasse Tyson with us this night. A zillion phone lines going off here, so I know that I really, really, really got to get to you and I promise I will.

Just one (1) quick question, Dr. Tyson … ?"

NdT: "Yes?"

AB: "Okay, it concerns a wormhole. Now I watched Jodie Foster in *Wormhole* [sic] [AB means *Contact* – JS] … [It's late!]. (NDT laughs heartily, AB also laughs).

NdT: "You got evidence maybe …"

AB: "If we were … No, no, that's not the question.

If we were actually able to transit in a wormhole, ah, do you have any imagination that tells you what it might be like?"

NdT: "No, I don't. And you know, I … I … I just go with how wormholes are traditionally portrayed as this sort of … this sort of vortex through the fabric of Space and Time.

I think if … if the folks back in the year 1968 when they made the film *2001*, that if they had a sort of deeper sense of the vorticity of a wormhole that they might have shown those psychedelic scenes a little differently, 'cause as they were, you looked like you were moving through parallel sheets."

AB: "Hmpf."

NdT: "And they might have made it sort of more circular, more cylindrical.

But, ah no, I have no idea whatsoever.

I'm wondering if you wouldn't feel the journey through the wormhole, you just sort of step through this portal and come out the other side. And bada bing, you're there!"

AB: "Right."

NdT: "And … because that's what it's doing.

You know what it's like? It's like the doors in *Monsters, Inc.*"

AB: "Ah-ha-ha! Yes!"

NdT: "Those are wormholes, right?"

AB: "Um-hmm."

NdT: How come a door manufactured in the factory and they open the door … the Monster … and they show up in the child's closet ready to terrorize them."

AB: "Yes."

NdT: "There's no journey that they take …"

AB: "That's true."

NdT: "… because the door is the same door!"

AB: "Right."

NdT: "And so that … maybe that's really what it's like? It would be less cinematic though if they portrayed it."

* * *

AB: "Doctor, are you the one who coined the phrase: 'Death by Black Hole'?"

NdT: "Well, that's the title of my … one (1) of my books …"

AB: "Oh, oh!"

NdT: "The best-selling of my books is *Death by Black Hole*. It's still out there. Ah, I'm flattered because there's a lot of energy that I put into its contents and it's how I communicate. And it's … it's called *Death by Black Hole: And Other Cosmic Questions*. So yeah, that's the title of one (1) of my books."

AB: "Okay. All right."

NdT: "That's how I want to die! That's how I want to die – send me into a black hole."

AB: "Be quicker anyway."

NdT: "That's way preferable to getting hit by a bus."

AB: "Heh."

* * *

Aud: "Um, I do have a question that I've wanted to ask you for many years actually. Have you ever seen a UFO … a ship and knew that it wasn't from the Air Force or anyone?"

NdT: "So … so I've seen, um, as is true with most astronomers, particularly those who began as amateur astronomers as I did."

AB: "Yes."

NdT: "An amateur used in that context is actually a badge of honor, because Amateur astronomers know the night sky better than any other people on Earth. And so the … you would never go to an amateur neurosurgeon, right? (NdT laughs). But if you went to an amateur astronomer, you can guarantee that they'll give you a tour of the night sky.

In that capacity where I'm looking up every night – and I know the sky like the back of my hand enough to tell Jim Cameron that his sky was wrong just on a glance above the sinking Titanic. So … that's … that's … that's not special talent. That's a talent that any astronomer would have who is an amateur astronomer."

AB: "Okay, spill it – what did you see?"

NdT: "So not only that, so now I also know weather phenomenon …"

AB: "Nnnnn …"

NdT: "… and I'm trying to get the weather out of the way, so I can see the stars."

AB: "Swamp gas."

NdT: "So I have seen things that would have stumped me if I didn't have the body of knowledge that I do about what is possible to be seen in the night sky."

AB: "Um-hmm."

NdT: "And so … I … I have never seen anything that I did not fully understand in the context of either weather phenomenon or astronomical phenomenon."

AB: "'kay … well, okay that's your answer …"

NdT: "Yes, yes … uh-huh."

Aud: "Thank you very much. You are very interesting. And I love the way Art can sit back and listen, and we can all listen and join in and enjoy a guest for a change. Thank you."

AB: "That's what it's all about. Thank you. Ah …"

NdT: "Excellent, thanks."

* * *

AB: "Okay, um, I had the experience of seeing something that … um, Doctor … I guess I can't help myself.

On the way home from Vegas one night in a car with my wife, ah, after working a show in Vegas, and uh, my wife said: 'What the hell's that?'

I said: 'What do you mean?'

'Somethin' behind us!'

'All right.' We get out of the car – real quick story – we look up. Here comes behind us, this – at about a hundred and fifty (150) feet – this giant triangular craft. Looked very metallic. Very quiet here in the desert. You could hear crickets a quarter (1/4) of a mile away. This thing passed directly over our heads, continued out toward, by the way, Area 51 – which is just adjacent to us here – uh, and was defying gravity. It was not flying, not aerodynamic flight.

So it was either lighter than air or defying gravity – one (1) of the two (2). And it was gigantic. The moon, the stars went away … the classic stuff. I saw that!

If you were to see something like that, how would your mind – being a scientist – digest it?"

NdT: "Okay, uh, I'm guessing this was at night?"

AB: "It was."

NdT: "And … and … and most of these kinds of sightings happen at night where there's … you've lost all sense of relative scale …"

AB: "Yes, sir."

NdT: "So now it's just there in … in the darkness of …"

AB: "Not … not all sense of scale, I mean we had the moon and we had the stars to go by …"

NdT: "No, no … no, no, my point is if … if this object that you've never seen before …"

AB: "Right."

NdT: "… and there is nothing else adjacent to it that is familiar to you …"

AB: "Right."

NdT: "Then to assess its size becomes essentially impossible. … You saw surely yesterday the images of the military blimp, ok?"

AB: "Yes!"

NdT: "So if you just see the blimp in the sky, in those images you have *no idea* how big that is."

AB: "True."

NdT: "Is it half a mile across? Is it a toy blimp? Until you came near the trees, until it's … there's something … there's something behind it …"

AB: "Okay …"

NdT: "So it makes … it makes judging the size very difficult. So … at night there … there are things you can't see, and that's why so many such sightings are reported at night."

AB: "Hmm …"

NdT: "Rather than in the daytime."

AB: "Okay."

NdT: "So I generally have binoculars with me at all times. I pull out my binoculars and try to find out what it is. And if I don't know … if I can't figure out what it is, I say: 'Oh, it's a mystery.'"

AB: "Okay."

NdT: "Well, they're doin' something cool over Area 51. Uh … so …"

AB: "Well, that's my guess. This thing was about a hundred and fifty (150) feet above me. I'm tellin' you, Professor, it was close. Ah, and … and get this as a follow-up, um, about a week later the local newspaper made an inquiry of the local Air Force Base, Nellis."

NdT: "Um-hmm."

AB: "Nellis reported back … reported back in the newspaper: 'Oh, yes (!), there … there was a secret mission at about that time that flew over …"

NdT: "Um-hmm."

AB: "… the Pahrump Valley."

NdT: "Okay."

AB: "It was … it was a C-130 aircraft. (AB laughs).

Um, I was in the Air Force, ah, Professor, and I flew in C-130s …"

NdT: "It was a large craft."

AB: "… and I guarantee you it would have rattled my teeth at that altitude."

NdT: "Yeah, yeah, you can't mistake a C-130, but it could've been a drone for example. You know, ah, drones are pretty silent and … and they would move exactly as you're describing. You're saying 'defying gravity,' therefore it must have been lighter than air. No, it could have had propellers. You know, silent plastic propellers …"

AB: "Could have."

NdT: "… like a drone."

AB: "Could've."

NdT: "So … so … um, yeah, binoculars help. Because they not only help you see things close up, they also detect much more light than your human eye does."

AB: "Yeah."

NdT: "So you can see other textures and things that would otherwise go unnoticed, um, by your unaided eye. So carry binoculars with you, so the next time that happens …"

AB: "Oh, it would have been nice – binoculars, camera … whatever."

NdT: "Or … take a big net … Take a big net and capture it." (NdT laughs).

AB: "All right."

* * *

Aud: "Ah, the Multiverse … as a comic book fan, I'm already familiar with it. I was wondering if I would ever be able to, ah, meet my doppelganger out there?"

NdT: "Oh, um … yes, so … what you're implying there is given the Multiverse, there would be countless other Universes in every possible combination of atoms and events, and probabilities. And so there is surely one with one person just like you out there, or maybe exactly you.

And … and it's, ah, it's an intriguing thought. I have my skepticism of how large these infinities are. They're in it turns out they're hierarchic of infinities … some infinities are larger than others, and I plan to do some calculations on this to … to confirm for myself how big that infinity is, because if it's not a big enough infinity, we're not going to get you. We'll just get sort of other universes. And, uh, the variations in all those universes will not be enough to find a universe that will make someone just like you.

It's much more likely that you'll find someone else who looks like you on Earth. So once you start there, (NdT laughs), be happy with that …"

AB: "Yeah."

NdT: "… because 'multi' on you is a long time coming!"

* * *

Aud: “So, ah, you guys know the ‘parallel planetary’ theory?”

AB: “No.”

NdT: “I don’t think so. I don’t think so.”

AB: “Parallel planetary …”

Aud: “I mean, theoretically if you met yourself in another Universe or whatever … if you could take a spaceship and then you flipped a coin like, you know, I’m sorry … um …”

AB: “Are you talking about parallel Universes, caller, not parallel planets, right?”

Aud: “Yeah, parallel universe theory …”

NdT: “Ohh, oh okay … so go on, yes? Uh-huh, so?”

Aud: “If you flipped a coin if you met yourself, you know, if you could fly to another parallel Universe and you flipped a coin … what would it land as?”

(AB laughs)

NdT: “Well, uh, you have to be careful about other Universes because the … the same concepts that lead to the prediction of other Universes also prescribe that they have slightly different laws of physics operating within them. So ... ah, you can bring a coin but does the coin remain a coin in that other Universe?

Does the ... you just don’t ... does the structure of matter ... is metal matter in that Universe? You don’t know!

So, what I would do with that coin is flick it from my Universe into that Universe and see what happens to it ... ! (NdT and AB both laugh). And then if it survives that trip, then maybe I’ll dip my toe in ... and then go meet myself.”

AB: “Well maybe you just flipped that coin into an anti-matter Universe.”

NdT: “Oh! That as well! (AB laughs). If ... if an alien lands, don’t shake its hand until you toss it a coin. (AB laughs). If the alien spontaneously ... (both AB and NdT laugh) annihilates, then you say: ‘Nope, that was an anti-matter alien.’ It probably would have annihilated by coming in contact with Earth’s atmospheric molecules to begin with.

But this is what led to the idea that the Tunguska explosion might have been an anti-matter, uh ... uh, chunk that exploded in mid-air. But you don't need anti-matter to make that explosion. An ordinary asteroid or comet will do.

So ... um ... so yeah, make sure they're not anti-matter. That would be a bad situation."

AB: "It certainly would.

Have to apologize ... of course, there's be nobody left to apologize to."

NdT: "And by the way, there's ... there's ... there's an idea a few years ago that all the anti-matter that should have been in our Universe, funneled out to make its own Universe. And so you have creatures and planets and stars that are all made of anti-matter, and its regular matter that's exotic to them.

And ... and ..."

AB: "Wow!"

NdT: "... yeah. So ..."

AB: "That's something to think about."

NdT: "[unintelligible – That's?] an out-there idea."

AB: "Ya, it is."

* * *

Aud: "I have a couple of questions."

AB: "Go!"

Aud: "One is ... I'm wondering if your guest knows what these, ah, small lights that everyone sees in the night sky ... They look kinda like stars, but they're moving way too high for a plane. Sometimes changing direction. A lot of people I know have seen these."

AB: "Well, until you've got changing directions, I would have said satellites, but ... changing direction is a problem."

Aud: "But don't satellites just like orbit with the Earth, when they just move along with ..."

AB: “Steadily along.”

NdT: “They don’t change directions. No, Art is right. A satellite is ... is a ballistic trajectory in orbit around the Earth. Under no ... satellites have no rocket control or anything. They just orbit ... An orbit is a ... is a stable thing that requires no fuel to maintain, unless you’re very low and your atmosphere is ... is eating up your energy, and you have to boost yourself back up.”

AB: “Right.”

NdT: “But otherwise, no. If it’s changing direction, it’s definitely not a satellite. It’s something else, and ... and ... and ... who knows what it is? And by the way, I’m perfectly content looking up and saying: ‘Gee, I don’t know what that is.’ And then, you know, try to figure out a way to figure it out. And that’s ... and that’s a healthy posture.”

It’s very different to say: ‘I don’t know what that is – therefore it’s intelligent aliens visiting us from another planet. Uh, you know, if you don’t know what it is, there is no ‘therefore ...’ that follows that sentence.”

AB: “Well, Doctor ...”

NdT: “At least I don’t know what it is.”

AB: “Right.”

* * *

Aud: “Could the human body act as a capacitor absorbing electricity and then discharging it just like the Dark Lord in Star Wars?”

(AB chuckles / NdT laughs).

NdT: “No, so here’s the problem: We are not good at holding electricity the way a capacitor is designed to do. We are very good at transmitting electricity, so that’s why when you rub your feet on the wool carpet ...”

AB: “Um-hmm.”

NdT: “... Budda-bing! It comes right out to the ... to the doorknob. Um, well maybe you could ... you would need ... would have to ... need an insulating layer that you could release, and then the electricity comes out of you so then you can aim it at whatever is your target. Ah, but you would have ... you would need assist with insulators that can de-insulate you on command. Then you could walk around with stored electricity ...”

AB: ”There you go.”

NdT: "... for sure.

Um, but one other thing about the lights: What you should do as I said earlier in this ... in this, ah, a few minutes ago, carry binoculars with you. You know, do further experiments on them and see if it happens in the daytime.

We have a better view of it. This is ... this is the investigation that any good scientist will do when they confront something they've never seen before or don't understand."

AB: "Professor, if you saw something that, uh, was so indisputably, impossibly from Earth, would you go home and think about it before you made a public statement?"

NdT: "No, I would try to get data on it! I would ... I would get video cameras. I would get sound recorders. I would try to observe it in different wavelengths of light."

AB: "Yeah ..."

NdT: "I would get as much data as I possibly could.

Then I would say: 'Here's something I saw last night, and here's the data on it.' And I would publish that. For sure!"

AB: "Well, that would be great if you had all those things handy ... (!) But you know a lot of times when you see these things, a) you're in shock and b) nothing's handy."

NdT: "No, no ... I will so not be in shock. I'm like ... this is ... I'm trained to study that which I do not understand. That's what I do. I live my whole life doing that. And so ... I would get as much data as I could.

If I could get no data on it, it would be an interesting cocktail party discussion. But there's nothing to go public on because I have no way to ... I have no way to ... to confirm for people what I saw other than eyewitness testimony. And in the 'Court of Science,' that is the lowest form of evidence there is. Which is odd, because in the 'Court of Law,' it's one of the highest forms of evidence there is."

AB: "And it's also why we have a lot of innocent people on death row."

NdT: "Precisely because of ..."

AB: "Yes."

NdT: "... the failure of eyewitness testimony."

AB: "There you have it."

NdT: "And we know this. Psychologists know it. We've known it in science forever. And so, even for lesser things than visiting aliens, do we not use each other's eyewitness testimony?"

AB: "You know what? We're done! I ... the show's over! There's nothing I can do about it. We could go on and on.

Uh, you're way back on the East Coast, right?"

NdT: "I am, yeah. Three in the morning (3:00 a.m.) here, but that's fine."

AB: "Thank you so much! It's been an honor having you on the show! *Star Talk* ..."

NdT: "Well, all right ... the questions were great! And ... and thanks for fixing that *Star Talk* <u>*began*</u> October 25th ... (AB laughs) ... when it goes every week for ten (10) weeks. Yeah! Yeah!"

AB: "Okay, yeah. All right."

NdT: "People will think you went back in Time. You see, you gotta watch out for that! (NdT laughs). You're Time Traveling ...."

AB: "I'm constantly watching out for that. Thank you, Doctor."

NdT: "Yeah, okay, great ... Great evening!"

AB: "Good night, my friend. Bye-bye."

* * *

AB: "Wow! That was something! Really something!

Truly an honor ... very, very, very bright man."

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