EPISODE 35
THE UNIVERSE

Hi there. Welcome to the end of the world. My name is Michael Folz. And this is Episode number 35 of my podcast Dial It Back Or Die. Today we're finally going to be getting into the nuts and bolts of Science. Specifically, to start everything off I'll be making a brief survey both of the Universe that we live in and of our place within it. Some of which you may already know. Even if that's the case, though, the Big Picture, as it were, might still be somewhat different from what you've been led to believe.

Whatever the situation, however, it occurs to me that a lot of facts and figures are going to be coming your way. So I thought that I would take this chance to remind you that, if for whatever reason you would like to go back over any of this at a slower pace, there is a PDF for each episode at the relevant 'chapter post' on the podcast website, dialitbackordie.com. Which you can read, even print out, at your leisure.

Anyhow, with that taken care of, let's get started.

To begin with, the Universe is very big.

But you probably already knew that.

What you might not be aware of, though, is that the odds against said Universe existing—or at least existing in a way that we ourselves could exist—are as large or ever larger. In fact, the odds against the Universe existing in a coherent form are so ridiculously large as to be about as mind boggling as it can get.

Before we can get into that, though, I'm going to have go through just a tiny bit of math with you. Because it's plausible that some of you at least may not be all that familiar with scientific notation.

The concept of which is not really all that difficult. Because scientific notation exists for the practical reason that science has to deal with some very large and some very small numbers. For instance, it is presently estimated that there are about 300,000,000,000 stars in our galaxy. On the other hand the diameter of an atom is approximately .00000000001 inches across. And all those zeros can easily get confusing, especially if you are trying to, say, compare the diameter of an atom with all of the stars in the galaxy.

So what scientific notation does is to standardize the way that those numbers are presented. For instance, instead of writing '1000' the scientist writes 10^3, which you can understand as either 10x10x10 or as a 1 followed by 3 zeros. Similarly a million (1,000,000) is 10^6 and a billion (1,000,000,000) is 10^9. ('6,000', by the way, would be written as $6x10^3$.) And for numbers smaller than 1, scientists put a minus sign in front of the superscript. Thus 1/1000, or .001, becomes 10^{-3}. (Note that, however, just to mess your mind up, there are only two zeros in the decimal representation.) Which means that those 300 billion stars in our galaxy now become $3x10^{11}$ stars. That teeny tiny atom is now $1x10^{-12}$ inches across.

And now that we've established all that, let's start having some fun with numbers, scientific notation style.

Specifically, let's compute how much visible material stuff there is in our really big Universe.

Now, as I've already mentioned, atoms are really small. Indeed, 12 grams (that's less than half an ounce) of Carbon (which could come from coal or diamonds or the graphite in a lead pencil) contains about $6x10^{23}$ of them. (By the way, if you remember this from Chemistry class, that's known as Avogadro's number.)

Of course the Earth is stupendously larger than a half an ounce of Carbon. In fact, it weighs 6 sextillion (that's $6x10^{21}$) tons. And the Sun is stupendously larger than the Earth. In fact, it's about a million times bigger. So—especially if you are a little rusty on your math—it might surprise you to find out that it has been calculated that the Sun has 'only' about 10^{57} atoms in it. Because at first glance this number might appear to be only a little more than twice as large as the number of atoms in that little half ounce piece of coal.

But this brings us to an important point about superscripts. Because recall that 1,000 is 10^3, or 1 followed by 3 zeros. And 1,000,000 is 10^6, or 1 followed by 6 zeros. Obviously 1,000,000 is not twice as much as 1,000, even though the superscript ^{6} is 'twice' the superscript ^{3}. What's going on here is that when we multiply numbers in scientific notation we *add* the superscripts. Thus 10^6 is 1,000 times bigger than 10^3. And 10^9 is therefore 1,000,000 times bigger than 10^3.

Okay, I am aware that some of us have more of an inclination for math than do others. So if you'd just as soon not have to learn any new math at this point in your life, just keep in mind that as we get up into the double digits on the superscripts, the numbers that we're dealing with are really, really, really big.

Getting back to the math, though, I mentioned at the beginning that there are currently thought to be about 300 billion ($3x10^{11}$) stars in our galaxy. Clearly, no one has been able to count them all, so this is merely a best guesstimate. Here on Earth, on a clear night out in the desert, you might be able to see 4,000 of them. And the awesomeness of such an experience usually really sticks with you, so I highly recommend it. But on such a night you are still only seeing about one-fiftieth-million (1 in $5x10^7$) of our home galaxy.

And of course our Milky Way, although it is a rather large galaxy, is not by any means the only one. For it is estimated that there are about 100 billion separate galaxies out there in the rest of the Universe. Truly incomprehensible.

So let's take those 100 billion galaxies, multiply that number (on average) by a 100 billion stars, and then multiply that number (10^{22}) by the number of atoms (10^{57}) in our one star (the Sun). By adding these exponents you now get the number 10^{79} as the approximate number of atoms in the Universe.

That's10,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000 000,000,000,000,000,000,000,000,000,000 if you haven't gotten the hang of this scientific notation yet.

These are all impressive numbers any way you look at them. But I'm not just trying to bowl you over with the immensity of this space-time continuum that we're inhabiting. Because, as I said, it turns out that by all rights this immense space-time continuum shouldn't even be existing.

Let's start with the Big Bang. As you probably know, about fourteen billion ($1.4x10^9$) years ago the Universe literally exploded out of nowhere ('nowhere' being an infinitely dense point). Which is bizarre enough in itself. But, according to the laws of physics, for every particle of matter which is created a particle of anti-matter is also created. And those same laws of physics dictate that when matter and anti-matter meet they annihilate one another. So either there should be an equal amount of anti-matter somewhere in our Universe, or the Universe should have ended right when it began. But neither is the case.

Exactly *why* matter should exist now is therefore one of the major unanswered questions in physics. Various theories do exist. But in virtually all of them it is assumed that by far the largest part of the original Universal Stuff did indeed cancel itself out. And that what now remains is just a teensy smidgen of that Big Bang explosion.

And while you're contemplating that, let me introduce you to the Cosmological Constant. Because without it the Universe would have expanded so rapidly that gravity would have never taken hold, and all those stars and galaxies would have never happened. Further, said Constant has been computed to be at the scale of 10^{-122} (Or, if you like fractions, 1 divided by 10^{122}.) Which totally dwarfs that number for the quantity of atoms in the Universe. But on the other hand if the Cosmological Constant had turned out to be any larger than this, the Universe would have immediately collapsed upon itself.

In other words, the Universe turns out to have been remarkably, even freakishly, fine-tuned.

And this fine tuning shows up almost everywhere you look. For instance, besides the fundamental force of gravity, there is also the so-called strong force, which holds the nuclei of atoms together. This force has been calculated to be .007. If it had been .006 then only Hydrogen, which is the simplest element, could exist, and then that's all that the Universe would consist of. On the other hand, if it had been .008 then all the Hydrogen would have immediately clumped together into Helium, and *that* would have been all that there was in the Universe. Either way, no stars, no starlight, no planets.

Or take electromagnetism, the force that binds electrons to atoms. If its strength was 4% different in either direction then both Carbon and Oxygen, not to mention all the other heavier elements, could not exist. Period.

And one can go on and on with this. In fact, it has been recently estimated that there at least 200 various parameters, all of which have to be *simultaneously* fine-tuned in order for the Universe to exist in a such a way so that we can exist. And the odds of all this happening by chance have been estimated at anything from 1 in 10^{50} to 1 in 10^{100} to even way smaller than that.

Remember once again all those zeros on the atoms in the Universe calculation?

It's all kind of mind blowing, isn't it?

Now you'll recall from the History section how I pointed out that prior to the mid 18th Century the vast majority of deep thinkers had concluded that the reality of there being universal and elegant physical and mathematical laws was the most stunning evidence and proof possible of the existence of God. And that even scientists who we presently think of as rebels and free thinkers, such as Copernicus and Galileo, had this attitude.

So you might expect, especially given your new appreciation for Occam's Razor and Bayesian Inference, that this fine tuning phenomenon might well turn present day physicists into humble theologians when contemplating the absurdly small probability of our existence.

But you would be wrong.

Instead the reality of these delicately balanced parameters is referred to as the fine tuning *problem*. And not, as any otherwise reasonable person might conclude, the fine tuning *miracle*. Because it is deeply disturbing to people brought up to be Materialists to try to deal with such a state of affairs. Because since their ideology adamantly refuses to accept the possibility of there being design or reason or meaning to the Universe their minds desperately try to come up with some other way to explain what is going on.

Thus were born a couple of concepts that a surprisingly large number of present day physicists believe in. And the first of these is called the Anthropic Principle.

What this does is to state, basically, that we humans could only contemplate a Universe in which we could exist. Which may or may not sound deep to you. But in essence said Anthropic Principle isn't saying anything that is more profound than, It is what it is. In other words, the Anthropic Principle is all a big 'Duh'.

But those who believe in the Anthropic Principle then often also believe in something called the Multiverse.

And you might well have heard of this idea. That in reality there are an infinite number of Universes. And thus there are an infinite number of variations on how the various elemental forces and other parameters interact. And thus the fact that we are in one that works for us is due to the simple fact that, in all that infinite number of Universes, we just so happen to be in the one that works for us.

QED. Problem solved.

Except that, as with the 'matter that thinks' hypothesis of three hundred years ago, this is nothing more than just hyperactive mental noodling. There is absolutely no 'science' that is involved with such speculation.

And here's why. As I just went over in the last chapter, actual science requires coming up with a hypothesis that is somehow provable. (Or falsifiable, which essentially amounts to the same thing.) But *by definition* we can never see anything which is outside of our Universe. Moreover, a hypothesis is supposed to be developed because of the existence of some evidence or phenomenon which is not explained by current scientific theory. But here the evidence of a fine tuned Universe is most definitely not denying any established science per se. Rather it is denying a belief in a Materialist ideology that was inherited from the 18th Century.

Think about it for a minute. A scientist would sneeringly laugh at anyone who posited the existence of ghosts or angels or woodland sprites. But at least there are people who claim to have seen or otherwise experienced such beings. In the case of a Multiverse no one is even beginning to claim that. And yet any number of physicists fervently believe in its existence, write learned papers about it, argue about its true nature, etc., etc.

Pretty strange, eh?

But wouldn't a much better answer be that this fine tuning problem is an excellent first example of Bayesian Inference? After all, remember that just because someone gave you a million dollars for that piece of paper you found on the ground doesn't mean that you had found a lottery ticket or that you had won the lottery. Your mind had just jumped to that conclusion because it knew of no other framework where something like this could happen. Similarly, the fact that the existence of the Universe is beating 1 in 10^{100} or 1 in 10^{150} or whatever odds means that it is overwhelmingly probable that we totally lack the intellectual means to properly address the question.

Now in earlier times when this happened we subsumed all of these unanswerable questions into something we called God. Today, of course, 'God' is an emotionally freighted word. So you might prefer to call it 'X the Unknown'. But please be aware that X the Unknown is real and X the Unknown is huge. And just as the relatively recent discovery of both Dark Matter and Dark Energy means that the visible Universe that we thought we knew so much about only comprises about 5% of what's actually out there, and, further, that we don't have the slightest clue as to what Dark Matter and Dark Energy really are, so, too does the fine tuning problem show that all of our vaunted scientific progress of the past couple of centuries—which really has been quite amazing—is almost definitely not even the tip of the iceberg.

And we'll get back to this in a little while.

For right now though: Even stranger than the fantasy about Multiverses is the present day proclivity to believe that there are many, many worlds where life, even intelligent life, exists. Since there are those 300 billion stars in our galaxy alone, so the thinking goes, and since recent advances in astronomy have shown that at least 20% of those stars seem to have planetary systems, a current oft repeated claim is that there are some 50 billion Earth sized planets out there. Surely life must be endemic!

Well, not so fast.

Now partially this misapprehension is due to what I've stated before, namely that most astronomers have only the foggiest understanding of biology. But specialization in science starts out so early that it's also true that most astrophysicists have only a foggy understanding of, say, planetary astronomy, let alone the myriad astronomical and geophysical parameters which must all be met before life can exist.

And it also has to do with, once again, ideological preconceptions. Which we'll get to in a bit. But for right now let's start with a far from complete list of everything that has to go right before life could even conceivably exist on a planet. And, remember, each and every one of these conditions has to *simultaneously* exist. So that, if life only required three conditions, and the chances of Condition A, Condition B, and Condition C are each one in ten, then the chances that all three conditions are met is one in ten times one in ten times one in ten. Which is one in a thousand.

And in the end we're talking about at the bare minimum twenty or thirty conditions. Because in the end no one really knows how many, because we have exactly one example of life existing, and that's us. We have no idea what differences in mass and gravity, rotational spin, atmospheric makeup, UV level, and the like might actually have on the development of life. And those are just some of the 'unknowns' that are known. It is entirely plausible that there are even more stringent parameters that we're not even aware of.

Just to give you an idea about how constrained it all is, though, let's get started on a short list.

First, there are many good reasons to believe that photosynthesis, which is ultimately the basis of over 99% of our life on Earth, is only possible in yellow light. And yellow stars, of which our Sun is one, make up only 3% of our galaxy. Moreover, yellow stars are some of the only ones which both put out enough heat and also last long enough and with enough of a constant energy flow to support an evolutionary time span.

Then there's the fact that most stars are in binary systems or larger, and it is difficult to see how the gravitational and energy dynamics would be stable enough in many or most of those. Further many stars are in massive clusters of a million or more, which look beautiful through a telescope but which would be hellishly intense environments for the purposes of life developing.

Speaking of which, our Sun is about halfway out on one of the arms of our massive spiral Milky Way. But most of our galaxy's stars—billions upon billions of them—are for all intents and purposes a super massive cluster in its center (along with a giant black hole). And the gamma and other high intensity rays which saturate such a high density area would kill any attempts at life.

And further out from us along those arms? As you may know, nearly all of the heavier elements which exist—basically almost anything much more complex than Hydrogen and Helium—have been created by supernovas, which are extremely rare explosions of stars. Extremely extremely rare. Which is why the Universe had to exist for nine billion years before our solar system could be created. But as we get further from the center of the galaxy the stars tend to get older and dimmer, and the space in between them is lacking in Carbon and Oxygen, let alone Iron and Lead, etc., so it is impossible that any rocky planets like ours could form in such circumstances.

But what about all those exoplanets which have been recently discovered? Well, like all the stars which we can individually see, even those that are 1000 light years away are still in the relatively tiny neighborhood surrounding us, which does have those heavier elements. But for all the excitement of discovering these planets (and the truly incredible leaps in technology that have allowed us to do that), what we have found is not at all how we had imagined other planetary systems would be.

Now the theory had been that, should these systems exist, they would exhibit the same characteristics as ours: As a result of an original spinning disc of matter, there would be a stately procession of planets on a single 'ecliptic' plane, with smaller, terrestrial type bodies on the inside and larger, Jupiter-like gas giants further out. Such a calm and ordered state of affairs is needed for several reasons. First and foremost, since evolution seems to take several billion years, a planet would seem to need a remarkable stability in orbit, amount of heat absorbed every year, etc., in order to be eligible for life. And it would also need to have the rest of outer space around it cleared of almost all debris, which in our instance has been nicely accomplished by the relatively giant gravitational fields of Jupiter and Saturn. (And we absolutely need that clear space around us. Remember that the dinosaurs were wiped out by an asteroid that was almost trivially small, about ten miles in diameter.)

But virtually all of the exoplanets which have been discovered seem to be in systems bizarrely different from our own. For instance, a common example would be a Jupiter sized object a thousand times larger than the Earth that whizzes around its home star every four days. (For comparison, Jupiter takes twelve years.) Moreover, many of these planets circle small, cold, red dwarf stars (which make up at least 70% of the galaxy), and/or are in multiple star systems (which make up at least 55%), both of which as I just noted are highly unlikely to support life. And we have absolutely zero idea as to the amount of 'space junk' which might be constantly bombarding them.

It should be admitted that it is far easier to find large exoplanets with small orbits than it is to find small ones with longer orbits. But even though by now several 'Earth-like' planets in orbits far enough away from their star to be in a habitable zone where water can exist (which we shall shortly see is absolutely essential for life) have in fact been found, there is no reason why, outside of wishful thinking, one might suppose that life might exist there.

And to see why this is the case we need to look no further than our closest planetary neighbor, Venus.

Almost the exact same size as Earth, and well within what had always been assumed to be a habitable zone, Venus is in fact utterly inhospitable to life. This is primarily because its atmosphere is almost a hundred times larger than ours, and is composed almost entirely of carbon dioxide, with a strong dollop of sulfuric acid. The runaway greenhouse effect that has resulted from this means that the surface temperature there is around 850º Fahrenheit. Not to mention that the atmospheric pressure is fifty times that of what it is on Earth. (By the way, if it weren't for the much smaller natural greenhouse effect of *our* atmosphere, the average temperature here would be 15º, well below the freezing point of water. So that then life would be impossible here, also.)

The point is that, just as there has to be an incredible amount of fine tuning for the Universe to exist, so too do the parameters have to be almost as tight for there to be even the possibility of life getting a start. And it doesn't stop with just having the composition of the atmosphere perfectly right. For instance, the main reason that Mars no longer has an atmosphere is that it doesn't have a protective magnetic field, which means that something called the solar wind has slowly stripped it away. Venus doesn't have a magnetic field either (although its atmosphere started out as so massive that it still exists nonetheless). Earth does have a magnetic field, however. And this, along with our super thin ozone layer, also serves to niftily protect our DNA from being zapped and mutated by cosmic rays.

And why do we have a magnetic field while our next door neighbors don’t? We don’t really know. Which means that we have absolutely no idea of how common magnetic fields would be on other small exoplanets.

And then on the other hand, if we had a magnetic field as large as Jupiter's, then *that* would destroy any chance of life developing.

Finally, there is our Moon, which is the only one orbiting one of our solar system's eight planets which is even remotely similar in size to its host. Interestingly, even though its diameter is one quarter that of the Earth, because volume is a cube of diameter, and since the Moon is made of lighter material, its mass is only about one-eightieth of ours. That is still large enough, though, to keep our rotational spin constant and to keep us from slowing down so that, unlike Venus and Mercury, one side is not overly warmed up for months at a time. The moon's gravitation also serves to keep our tilt at 23° so that, again, we maintain a stable position and do not gyrate wildly like a top. And for these and other reasons many astronomers now argue that life on Earth could not have evolved if the Moon hadn't been there.

And yet the reason that the Moon is there is because, right at the beginning of the solar system, the Earth was hit by an object about the size of Mars. Now granted that there were many more giant rocks flying around back then. But when you consider the immensity of space the odds are still minuscule that such a collision would have occurred between such relatively massive objects. Moreover, if you vary the size of that original ‘Moon rock’, its speed, angle of collision, etc., if you vary any of these, then such a collision could have just as easily resulted in the Earth splintering into bits.

Finally, the particular angle and speed which did occur might well have been what it is that set in motion both the existence of continents and the mechanism of plate tectonics, otherwise known as continental drift. And as we shall shortly see those plate tectonics were almost definitely necessary for the origin of life. What's more, without continents there would have never been dry land for life to evolve on to and for us to walk around on.

Speaking of which, if there had been slightly more oxygen on the primordial Earth, then it would have reacted with all the primordial hydrogen and, plate tectonics or not, everything would have all been under water. And if there had been somewhat less oxygen, then the oceans might not be there. (Although, to be fair, no one is still quite sure how all that water did come about.)

And I could go on and on. And if you don’t trust me on this, there is a book called ‘Rare Earth’, which was written by two esteemed astronomers, which goes over much the same material. But I do hope that by now you can see how truly rare and precious the astronomical conditions are which are necessary in order for life to even have a fighting chance.

So why, knowing all this, would any scientist think that life must be a common occurrence throughout the Universe? It's easy to see how the popular imagination would be so inclined, especially given that science fiction and its attendant alien life forms are so dominant in our entertainment these days. But real scientists are well aware that other science fiction ideas, such as time travel or moving faster than the speed of light, aren't remotely possible, even theoretically. What stops such people from recognizing the same *scientific* limitations on extraterrestrial life?

Partially this is because when scientists are talking about the possibility of 'life' they are usually referring to super-simplistic forms of life, such as viruses, or tiny microbes at best. And, as we shall shortly see, there are orders of magnitude of difference in complexity between, say, a virus and a bacterium, between a bacterium and a complex cell, and between a complex cell and a multicellular critter. More importantly, as I keep pointing out, science is so hyper-specialized that many of these enthusiastic alien life promoters are simply unaware of all the critical parameters which are involved.

I suggest, however, that what underlies a belief in the easy proliferation of life, as with so much else, are those simplistic ideological presuppositions of the 18th Century. And to illustrate the point, think about how you were around the age of eighteen. If you were like most of us, back then even though you were intellectually aware that you would die at some point, for all practical purposes you thought that you were invincible. And you probably undertook certain actions that, now that you are older and wiser and have internalized how easily life can end, you would never think of doing today.

What's more, if someone back then had nagged you about how rare and precious life is, you probably wouldn't have wanted to listen to them.

Now think about the point I keep making about how one could look at 18th Century ideology as analogous to adolescence, with self absorbed teenage humanity angrily rebelling against all of the rules of those mean parents called Church and State, and foolishly thinking that all of its desires could be fulfilled forever. If what is going on now is a resurgence of that psychological immaturity, then the last thing that anyone wants to hear about or contemplate is that, no, this conscious life here on Earth is not just supposed to be about fun and games. How much more superficially comforting to think that, hey, life goes on everywhere, so that we don't have to worry if we lose ourselves to utter foolishness and screw our human consciousness up.

So... if you ever do have the chance to go out to the desert to see all those stars, please take that opportunity, look up at it all for a very long moment, and try to contemplate just how awfully alone we almost certainly are in this very big Universe. And how carefully and conservatively we should therefore be treading.

Again, not that I'm suggesting that during that moment you should be deciding whether or not God exists. In fact, as I pointed out some minutes ago, using such a term as 'God' at this point is probably counter-productive, since it contains so much psychological baggage. Far better to say 'X the Unkown' or 'Who Knows?' or 'What the…?'

But I would hope that this episode has been sufficient to help you to recognize that the more we learn about the Universe the more obvious it is that so far we really don't have a clue as to what is actually going on. What's more I am hoping that you take away from this that an attachment to simplistic Materialistic and atheistic views from the 18th Century is confining our imaginations as much or more than any strict, fundamentalist belief in the Book of Genesis might have done.

Indeed, while you are out there in the desert, try to also contemplate this point again: Maybe the Universe is way too complicated for the brains of mere mortals to ever understand. As we shall see, considering the absurdly short length of time that 'thinking' man has been around, not to mention all of the inherent flaws in our thinking apparatus, it is almost inconceivable that this is as smart or as conscious as a being can get. After all, a fish is pretty damn complicated. But it can't understand calculus. Nor will it, under any circumstances, ever be able to. Why should we think that since a few of us can understand what we consider to be higher math that therefore this means that all of us are at the end of the intelligence or consciousness line? Why, at this stage of our knowledge and evolution, should we even assume that there is an end to the line?

Humility.

So missing in that 18th Century. And also now in our 21st.

Because, however your mind answers these and other cosmic questions, at the least I am hoping that you accept that something very, very exquisitely strange and weird is going on. And that it has been going on for billions and billions of years to get us to this point. And that we would be extremely immature at best to think that somehow we've come to the end of figuring out what it all means.

After all, it is not a certainty that climate change is going to have horrible results. There’s just a very high probability. And in the same sense I can’t prove that complex life, let alone conscious life, is so achingly rare in the Universe that for all intents and purposes we are totally alone. But I do know that there’s a very high probability that this is the case.

And just as environmentalists have every right to be freaked out over their highly probable, but not certain, fears, so, too, should you and I be freaking out over our culture's flagrant disregard for the nurturing and continuation of a consciousness which, so far as we know, has only been around for a few thousand years out of the last 14 billion.

But wait a minute, you may be thinking. Because even if there's only a billion to one chance that all the astronomical and geophysical conditions are met, what with 300 billion stars in our galaxy and 100 billion galaxies, that means that there would still be other special instances just like the Earth.

Well, first, how are you going to find that one in a billion needle in haystack? And, further, I haven't even started in on the tight parameters required for life itself.

Which I will be doing in the very next episode.

Of course, that means that you will have to wait until the next episode. Because this one is now officially over. In the meantime, though, once again I would like to thank you so much for so far having listened.