**Naval**

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# The Beginning of Infinity, Part 1

66:09 Get podcast

*A collection of all the episodes on The Beginning of Infinity.*

## Science Is the Engine That Pulls Humanity Forward

*"Believe in science" is an oxymoron*

**Naval:** Welcome, Brett, to the eponymous Naval podcast. The topic that we started out on was the timeless principles of wealth creation. And then we touched a little bit on internal happiness and peace and well-being.

I'm first and foremost a student of science. I'm a failed physicist, in the sense that I loved physics, I wanted to pursue it, but I never felt I was going to be great at it. I was more pulled into technology, which is applied science.

Nevertheless, I remain a student of science. I remain fascinated by it. All of my real heroes are scientists, because I believe science is the engine that pulls humanity forward.

We're lucky to live in an age when scientific and technological progress seem not likely, but inevitable. We've gotten used to this idea that life always gets better.

Despite all the complaining about how productivity growth is stagnant, the reality is, anyone who owns a smartphone or drives a car or even lives in a house has seen technology improve their quality of life over and over again. We take this progress for granted, and it's thanks to science.

To me, science is also the study of truth. What do we know to be true? How do we know something to be true? As I get older, I find myself incapable of having an attention span for anything that isn't steeped in the truth.

The background on this particular podcast series is that I thought I knew a lot about science. And there was a lot about science that I took for granted, such as what a scientific theory is and how scientific theories are formed.

Most of us have a vague idea of it. Some people think science is what scientists do, which has a definitional problem. What is a scientist? Other people think science is making falsifiable or testable predictions, and maybe that's closer to it. Sometimes people say, "It's the scientific method." And what is the scientific method? And then they start describing their junior high school chemistry experiment and lose the trail after that.

Especially these days, when we're told to "believe in science"—which is an oxymoron—people respect science, but they don't understand what science is.

The idea of what science is gets hijacked, sometimes by well-meaning people who want to convince you of the science and sometimes by not so well-meaning people who want to influence the way that you think and feel and act.

## The Beginning of Infinity

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*David Deutsch's book expanded my repertoire of reasoning*

**Naval:** I was pleasantly surprised a couple of years back when I opened an old book that I'd read a decade ago called *The Beginning of Infinity* by David Deutsch.

Sometimes you read a book and it makes a difference right away. Sometimes you read a book and you don't understand it; then you read it at the right time and it makes a difference.

This time I went through it much more meticulously than I had in the past. Rather than reading it to say I was done reading it, I read it to understand the concepts and stopped at every point where something was new. It started re-forming my worldview. It changed the way that I think.

I credit this book as being the only book in the last decade—except maybe a few of Nassim Taleb's works and maybe one or two other scattered books—that made me smarter. They literally expanded the way that I think. They expanded not just the repertoire of my knowledge but the repertoire of my reasoning.

People throw around the phrase "mental models" a lot. Most mental models aren't worth reading or thinking about or listening to because they're trivial. But the concepts that came out of *The Beginning of Infinity* are transformational because they very convincingly change the way that you look at what is true and what is not.

Karl Popper laid out the theory of what is scientific and what is not; what is a good explanation and what is not.

Deutsch dramatically expands on that in *The Beginning of Infinity*. The wide-ranging nature that he covers is incredible. He covers epistemology—which is the theory of knowledge—quantum mechanics, multiverse theory, infinity, mathematics, the reach of what is knowable and what is not knowable, universal explanations, the theory of computation, what is beauty, what systems of politics work better, how to raise your children, and more.

These are all-encompassing, long-range philosophical ideas.

## Nullius in Verba

*Take no one's word for it*

**Naval:** *The Beginning of Infinity* is not an easy book to read. Deutsch wrote it for other physicists and philosophers. He has a certain peer group that he respects, and that respects him, and he has to meet them at their level.

I wanted to understand the principles in the book so I could confirm or refute them for myself. I love the old motto from the Royal Society, "*Nullius in Verba*," which means, "Take no one's word for it." In other words, figure it out yourself. That's the only way to know anything.

To do that, I was reading the book and started reading blog posts on it. Eventually I came across Brett Hall and started listening to his podcast, ToKCast, which stands for the "Theory of Knowledge-Cast." I've brought him on this podcast to discuss the ideas in *The Beginning of Infinity*.

Brett, listening to your podcast helped me clarify a lot of these principles. I would love to explore the depth, clarity, reach, and importance of these ideas. Then hopefully someone out there can become smarter by it.

**Brett Hall:** Hello Naval, it's great to be here. You've raised so many interesting aspects of *The Beginning of Infinity*, which has become a real passion of mine. Like a lot of people who enter science, when I was at school I thought, "Well, I want to be an astronomer, so I'll go to a university and do a physics degree, then do an astronomy degree, and then become a professional astronomer."

One day I picked up David Deutsch's *The Fabric of Reality* in a bookstore and started reading it. The first chapter described what I was trying to achieve in my life. It was putting into words what I felt my university studies and my general outlook on life was about.

Deutsch says that the ancient philosophers thought they could get an understanding of the entire world. As time passed, though, modern science made it seem as though this was an impossible project. There's no way you could understand everything about reality. There's too much to know.

How could you possibly know everything?

## Explanations That Reach the Entire Universe

*We can understand anything that can be understood*

**Brett:** At the beginning of *The Fabric of Reality*, David Deutsch presents this idea that you don't need to know every single fact to fundamentally understand everything that can be understood.

He presents this vision that there are four fundamental theories from science and outside science: quantum theory, the theory of computation, evolution by natural selection, and epistemology—which is the theory of knowledge. Together they form the worldview, or lens, through which you can understand anything that can be understood.

**Naval:** I saw a beautiful video with him on YouTube where he was making the same points. He said, "You don't have to memorize and know every fact. You don't have to know where every particle moved. If you understand the deep underlying theories behind everything, then you know at a high level how everything works." And this can all be understood by a single person, a single brain, a single human being. It's accessible to anybody.

That is a jaw-droppingly powerful idea. We can have explanations that can reach the entire universe. It's interesting that the theory of relativity is not in the list of four theories.

**Brett:** Deutsch regards quantum theory as being deeper than the theory of relativity. It's not to say that we're dismissing relativity, but his guess is that quantum theory will be more foundational than the theory of relativity. There'll be a space-time of the multiverse, and the multiverse is David's explanation of quantum theory. That's why relativity doesn't appear among them.

At some point most physicists expect that we're going to have a unification of quantum theory and the theory of relativity.

## Read the Best 100 Books Over and Over Again

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*Many claim to read, but very few understand*

**Naval:** *The Beginning of Infinity* reminds me the most of *Gödel, Escher, Bach* in that it is very wide-ranging and stitches together ideas from many different disciplines. It's very difficult to understand and follow completely. Everyone claims to have read it, but, as far as I can tell, very few people understand it.

I had this experience in college when I first found Hofstadter's work. I remember that I put it on my bookshelf and I started reading it, and I started reading it, and I started reading it. About a year later, I was probably halfway through it. Then I just ran out of time. I had other things going on.

I remember that I would approach my other friends in college and would say, "This is a great book, you should read it." And a week later they'd roll back and say, "Yeah, I read *Gödel, Escher, Bach.* It was great." And I felt like the stupidest person in college.

It was only years later that I realized nobody had read it. When you get older, you get more confident in those confessionals, where you either say, "I didn't read it" or "I read it at a constant pace and when I encountered something I didn't understand, I kept going."

I confess, to this day I have not read all of *Gödel, Escher, Bach.* But at least at this point, I've gone through and found the parts that were most interesting to me—which were the Gödel parts—and did read those and try to understand them. I skipped the parts that were not as interesting to me—which were the Bach parts.

*The Beginning of Infinity* is similar. Everybody in my social circle has it on their bookshelf. Many claim to have read it, but very few have gotten it.

I go back to this point that was first eloquently stated on Twitter by a character named @illacertus, who essentially wrote,"I don't want to read all the books; I just want to read the best 100 over and over again."

I'm currently stuck in a loop where, at least in science, I'm only going to read *The Beginning of Infinity* and *The Fabric of Reality* over and over again until I understand them fully. If I had read them 20 years ago, I would know a lot more, because then I would have chosen the right books and the right authors to read subsequently.

It's a hard book to follow. You should buy the hardcover and electronic versions, so you have it all.

**Brett:** And the audio version.

**Naval:** Get it every way possible. If you can get through it in the first sitting and understand all the points at a deep level, then congratulations. But if not, we're hoping to break it down for you.

## We're at the Beginning of an Infinity of Knowledge

*Progress is inevitable as long as we have good explanations*

**Brett:** The difference with *The Beginning of Infinity* is you're getting a worldview. You're not getting the standard take from physicists about how to understand quantum theory. You're not getting the standard take of how to understand knowledge from philosophers. And you're certainly not getting the standard take of how to understand mathematics from mathematicians.

Deutsch is an expert in all these areas.

**Naval:** What's at the core of the worldview?

**Brett:** Deutsch's worldview is that reality is comprehensible. Problems are solvable, or "soluble," as he writes. It's a deeply rationally optimistic worldview that believes in good scientific explanations and progress.

Progress is inevitable as long as we have these good explanations. Good explanations have tremendous reach. They are acts of creativity.

Humans are problem solvers and can solve all problems. All sins and evil are due to a lack of knowledge. One can be optimistic about constant progress. That's what the title refers to: We're at the beginning of an infinite series of progress.

It's a very optimistic take. It states that we are at home in the universe and the universe is ours as a resource to learn about and exploit; that material wealth is a set of physical transformations that we can affect; that everything that is not forbidden by the laws of physics is eventually possible through knowledge and knowledge creation.

He also writes about how humans are universal explainers, that anything that can be known and understood can be known and understood by human beings in the computation power of a human system.

Everything is knowable by humans. We're at the beginning of an infinity of knowledge.

We understand things using good explanations and constantly replace old theories with better ones. There's no endpoint in sight. There's no perfection. Every theory can be falsified eventually and improved.

We are on our way to being able to do everything that is not forbidden by the laws of physics.

## People Are a Force of Nature

*We create knowledge that transforms the universe*

**Brett:** Knowledge is what transforms the world. We can take some raw material that has no particular use and within that raw material, we can find uranium nuclei, which then can be used to create bombs or energy in a nuclear reactor. We can find within something that for almost the entire geological existence of the earth sat there inert and would have done nothing, absent people. People are the entities within the universe that create explanations. They're able to explain what raw materials might be transformed into.

Now, what are they transforming these raw materials into? Civilization. People creating knowledge end up becoming literally a force of nature.

If we seek to explain something like the shape of a galaxy or the shape of a star, any astrophysicist will give you a story based upon the laws of physics about how gravity will pull things into spheres, how the laws of thermodynamics will cause certain kinds of gas to heat up and expand. All of the known laws of physics are sufficient to explain what we see out there in the cosmos.

But the laws of physics alone will not be able to explain the appearance of Manhattan. You have to invoke things other than merely the fundamental laws of physics. You need to invoke the existence of people and their capacity to explain the world scientifically, philosophically and politically. It's all of those things that will come together to explain why we have certain structures like skyscrapers in Manhattan.

This is a profound idea. It's an idea that seems to have been overlooked by scientists, many of whom have a reductionist idea about how to explain what we see in our environment. They seek to explain only the natural phenomena that are in an environment.

Of course, everyone wants to know how the laws of nature work. But if we want to understand how the universe is going to evolve over time, whether it's locally on our own planet or, eventually, the galaxy, we're going to have to talk about the knowledge that people create and the choices that they're going to make into the future.

This is a different vision of the place of people in the universe.

## It's Impossible to Predict the Growth of Knowledge

*The laws of physics can't predict the future*

**Brett:** Stephen Hawking famously said, "The human race is just a chemical scum on a moderate-sized planet, orbiting around a very average star in the outer suburb of one among a hundred billion galaxies. We are so insignificant that I can't believe the whole universe exists for our benefit." This vision of what people are, and of what the planet Earth is, is true in a trivial sense, but it misses the point that people are a kind of hub. We are, so far as we know, the sole place in the universe that is creating knowledge, an open-ended stream of knowledge that could transform the rest of reality.

In the same way that gravity is able to pull a galaxy into a particular shape, knowledge in the future will be able to shape the course of the planet, the solar system and, eventually, the galaxy. We will have a profound impact on everything that we can see around us. There's nothing the laws of physics, the laws of chemistry, or even the laws of biology can do to predict what is going to happen in the future.

It's impossible to predict the future growth of knowledge. That's the nature of knowledge, because knowledge creation is genuinely an act of creation. It is bringing something into existence that wasn't there prior.

**Naval:** If you could predict it, you would have invented it already. A lot of our deeply pessimistic world views come from a straight-line linear extrapolation of negative trends while ignoring positive trends. Positive trends mostly come through creativity and knowledge creation, and it's inherently unpredictable.

Every generation has its doomsayers, Cassandras, and modern Malthusians who say, "On this trajectory, we're all going to die." They're very popular for the same reason that zombie movies and vampire movies are popular. But the reality is that they cannot predict what we're going to do in the future that is going to improve our quality of life and save us from inevitable ruin.

## Humans Are Unique in Our Ability to Understand Things

*Knowledge is in the observer, not the observed*

**Naval:**The value is in the knowledge, and the knowledge is inside the observer and the creator, in other words, a human. It's not inside the thing itself. For example, oil is useless unless you know how to refine it, burn it, and use it for combustion. Information is useless unless there's a brain there to receive it.

There could be a signal broadcasting English into outer space, but if there isn't a creature capable of understanding what that language is, how it works, and who's conveying it, then it's just modulated electromagnetic frequencies that don't mean anything. So a lot of the information—a lot of the value—is within a particular knowledge-bearing entity.

As the reach of science grows, we have gotten to a very reductive science where we break things down to smaller and smaller pieces. Then we try and explain things on the basis of that. There is a counter-trend in science, complexity theory, where we talk about emergent properties and higher-level systems. They're looking at systems as they operate chaotically and unpredictably at a micro-level; but at a macro-level we can make certain statements about them that do have explanatory power.

Humans are unique in our capability to understand things.

## Good Explanations Are Acts of Creativity

*They're not derived from looking at the past*

**Naval:** There's a phrase you'll hear Brett and I use over and over again: "good explanations." Good explanations are Deutsch's improvement upon the scientific method.

At the same time, it's beyond science. It's not just true in science but in all of life. We navigate our way through life, and we do it successfully by creating good explanations. If you take away nothing else, try and understand what a good explanation is.

A good explanation, first and foremost, is testable or falsifiable. You can run an experiment in the real world to see if it's true or not. Even stepping back from that, it's a creative explanation. It looks at something that's going on in the real world and says, "This is why it's happening." It is a creative leap that says, "This is the underlying explanation for how the thing works."

For example, when I'm watching a sunset with my young kids, I ask them: "Is the sun going somewhere? Is it moving? Or is it that maybe we're moving, and we're moving in such a way that it looks like the sun is setting?" Which is the proper explanation?

Looking at it naively, you would think the sun is hurtling across the sky and going around the Earth. But that's not the only explanation. There's a completely creative explanation that seems to fly in the face of the obvious observation of the sun's movement but could also fit the facts—but it requires some creativity. That explanation is that the Earth is rotating.

Good explanations don't have to be obvious. They're not derived from just looking at what happened in the past. Rather, they are testable. There are experiments we can run to figure out if it's the sun that is going around the earth or if it's the Earth turning.

## Good Explanations Are Hard to Vary

*They should make risky and narrow predictions*

**Naval:** Brett, would you say that a scientific theory is a subset of a good explanation?

**Brett:** Yes. They're the testable kinds of good explanations. Falsifiable theories are actually a dime a dozen. This doesn't tell you anything about the quality of the explanation you're being given.

The example that's used in *The Fabric of Reality* is the grass cure for the common cold. If someone says, "If you eat 1 kg of grass, it will cure your common cold," then they have a testable theory. The problem is that no one should test it. Why? Because they haven't explained the mechanism that would enable grass to cure the common cold. And if you do eat 1 kg of grass and it doesn't cure your cold, they can turn around and say, "1.1 kg might do it."

**Naval:** Right. Or you need a different kind of grass.

**Brett:** It's always testable, but you're not making any progress.

**Naval:** The second piece of a good explanation is that it's hard to vary. It has to be very precise, and there has to be a good reason for the precision.

The famous example used in *The Beginning of Infinity* is the explanation for why we have seasons. There's the old Greek explanation that it's driven by Persephone, the goddess of spring, and when she can leave Hades. There was this whole theory involving gods and goddesses. Not only was that not easily testable, it was very easy to vary. Persephone could have been Nike, and Hades could have been Jupiter or Zeus. It's very easy to vary that explanation without the predictions changing.

Whereas, if you look at the axis tilt theory—which says Earth is angled at 23 degrees relative to the sun and therefore we'd expect the sun to rise here in the winter and over there in the summer—the facts of that are very hard to vary. It makes risky and narrow predictions. The axis tilt theory can predict the exact length of summer and winter at different latitudes, and you can test that precisely.

Beyond it being a creative theory that is testable and falsifiable, it should be hard to vary the pieces of that theory without essentially destroying the theory. And you certainly don't want to vary it after the fact—like in your grass example, "Oh, it was 1 kg? No, now it's 1.1, now it's 1.2."

Finally, the predictions that it makes should be narrow and precise, and they should be risky. For example, I believe in relativity it was Eddington who did the experiment and showed that starlight gets bent around an eclipse. And that was a prediction that Einstein had made in relativity, which turned out to be true. That was a risky prediction that took a long time to confirm.

## There Is No End of Science

*We can keep on making progress*

**Brett:** Eddington's experiment is an excellent example of what's called a crucial test, which is sort of the pinnacle of what science is all about.

If we do a test and it doesn't agree with a particular theory that we have, that's problematic. But that doesn't mean that it refutes the theory. If you were to refute the only theory that you have, where do you jump to? You don't have any alternative.

If we were to do a scientific test tomorrow and it was inconsistent with the theory of general relativity, then what? There is no alternative to general relativity. In fact, there have been experiments over the years that seem to have been inconsistent with general relativity. Guess what? They've all turned out to be faulty. If you had to choose between whether or not general relativity has been refuted by your test or your test is flawed, go with the fact that your test is flawed.

In the case of Eddington's experiment, we had two viable theories for gravity. We had Newton's theory of universal gravitation on the one hand and we had Einstein's general theory of relativity on the other.

The experiment you described of how much the light bends during a solar eclipse is the correct way of describing what happened. It is not that we showed that general relativity was correct in some final sense; rather, we refuted Newton's theory of gravitation. Newton's theory was ruled out because it was inconsistent with the test, while general relativity was consistent with the test.

This doesn't mean that general relativity is the final word in science. It means that it's the best theory we have for now, and there's a whole bunch of reasons that we might think general relativity ultimately has to be false in the final analysis. This is another aspect of the world view that we never have the final word—and that's a good thing. That's optimistic because it means we can keep improving, we can keep making progress, and we can keep discovering new things. There is no end of science.

People have feared that one day progress will come to a halt, that science will end. In fact, we are at the beginning of infinity, and we will always be at the beginning of infinity precisely because we can improve our ideas.

We're fallible human beings. None of our theories is perfect, because we aren't perfect. The process by which we create knowledge isn't perfect, either. It's error-prone.

## There Is No Settled Mathematics

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*Proofs are not certainties*

**Naval:** There are two other scientific thinkers who I like who come to similar conclusions as Deutsch.

One is Nassim Taleb, who popularized the idea of the black swan, which is that no number of white swans disproves the existence of a black swan. You can never conclusively say all swans are white. You can never establish a final truth. All you can do is work with the best explanation you have today, which is still far better than ignorance. At any time a black swan can show up and disprove your theory, and then you have to go find a better one.

The other one I find fascinating is Gregory Chaitin. He is a mathematician very much in the vein of Kurt Gödel because he explores the limits and boundaries of what is possible in mathematics. One of the points that he makes is that Gödel's incompleteness theorem doesn't say that mathematics is junk; the theorem isn't a cause for despair. Gödel's incompleteness theorem says that no formal system—including mathematics—can be both complete and correct. Either there are statements that are true that cannot be proven true in the system, or there will be a contradiction somewhere inside the system.

This could be a cause of despair for mathematicians who view mathematics as this abstract, perfect, fully self-contained thing. But Chaitin makes the argument that, actually, it opens up for creativity in mathematics. It means that even in mathematics you are always one step away from falsifying something and then finding a better explanation for it. It puts humans and their creativity and their bid to find good explanations back at the core of it.

At some deep level, mathematics is still an art. Of course, very useful things come out of mathematics. You're still building an edifice of knowledge, but there is no such thing as a conclusive, settled truth. There is no settled science, there is no settled mathematics. There are good explanations that will be replaced over time with more good explanations that explain more of the world.

**Brett:** This is something that we inherit from our schooling more than anything else. It's part of our academic culture, and it bleeds into the wider culture as well. People have this idea that mathematics is this pristine area of knowledge where what is proved to be true is certainly true.

Then you have science, which doesn't give you certain truth but you can be highly confident in what you discover. You can use experiments to confirm that what you're saying appears to be correct, but you might be wrong. And then, of course, there's philosophy, which is a mere matter of opinion.

This is the hierarchy that some people inherit from school: Mathematics is certain, science is almost certain, and the rest of it is more or less a matter of opinion. This is what Deutsch calls the mathematician's misconception. Mathematicians have this intuitive way of realizing that their proof—the theorem they have reached by this method of proof—is absolutely, certainly true.

In fact, it's a confusion between the subject matter and their knowledge of the subject matter.

## The Methods of Mathematics Are Fallible

*Even if the subject matter is not*

**Brett:** If I compare math to physics: We have this domain called particle physics, and the deepest theory we have in particle physics is called the standard model. This describes all of the fundamental particles that exist and the interactions between them, the forces that exist between them, and the gauge bosons, which mediate the force between particles like electrons, protons and neutrons.

Now, what is matter made of? We would say matter is made of these particles described by the standard model of physics. But does that rule out the fact that these fundamental particles might themselves consist of even smaller particles? We have a possibly deeper theory called string theory. So our *knowledge* of what the most fundamental particles are and what, *in reality*, the most fundamental particles are, is different.

So, too in mathematics. Deutsch explains that mathematics is a field where what we're trying to uncover is *necessary truth*. The subject matter of mathematics is necessary truth, in the same way that the subject matter of particle physics is the fundamental particles.

But since the subject matter of fundamental particle physics is the fundamental particles, that doesn't mean you actually find the fundamental particles. All it means is that you have found the smallest particles that your biggest particle accelerators are able to resolve.

But if you had an even bigger particle accelerator, you might find particles within those particles.

This has been the history of particle physics. We used to think that atoms were fundamental. Then, of course, we found they contained nuclei and electrons. In the nuclei, we found out that there were protons and neutrons. Inside the protons and neutrons, we found out they were made up of quarks. And that's where we're at right now. We're at the point where we say that quarks are fundamental and electrons and fundamental.

But that doesn't mean that we're going to end particle physics right now. What we need are further theories about what might be inside of those really small particles.

Comparing that to mathematics, if necessary truth is the subject matter of mathematics, mathematicians are engaged in creating knowledge about necessary truth. Because a mathematician has a brain—which is a physical object—and all physical objects are subject to making errors of degradation via the second law of thermodynamics—or simply the usual mental mistakes and errors that any human being makes—a mathematician is just as fallible as anyone else. So what they end up proving could be in error.

**Naval:** If I understand this point, even mathematics is capable of error because mathematics is a creative act. We're never quite done. There could have been a mistake in your axiom somewhere.

## All Knowledge Is Conjectural

*Be skeptical of absolute certainty*

**Brett:** All knowledge is conjectural. It's always being guessed. It's our best understanding at any given time.

You're right to say that the axioms might be incorrect. How do we know that an axiom is incorrect? Traditionally the answer has been, "Because it's clearly and obviously the case." How can you prove that x plus zero must equal x?  You just have to accept that it's true.

But consider something like Euclid's Elements. Anyone might want to try this experiment for themselves: Take a piece of paper, take a pen, draw two dots on the piece of paper. Now, how many unique straight lines can you draw through those two dots? It should be fairly obvious to you that only one line can be drawn. However, we know that's false.

Reflect on the fact that as you're staring at the piece of paper, through which only one straight line is being drawn, you have the feeling of certainty. You are absolutely sure that you're not wrong. This feeling is something we should always be skeptical of. When people have been absolutely certain, even in a domain as apparently full of certainty as mathematics, they've been shown to be wrong.

So how can we show it's wrong? You might think that I'm cheating, but, then again, you have to reflect on whether you understood what I was saying when I first told you to draw a unique straight line through two points. Bend the piece of paper. Think in three dimensions. Wrap the piece of paper around a basketball if you have one. Now consider the ways in which you could draw a straight line through those two points.

You could punch a hole through one of those dots with your pen and push it out through the other side through the other hole—and now you have a different straight line. You have the straight line that is drawn with your pen, and you have a straight line that is literally your pen pushed through these two dots.

Your initial feeling of absolute certainty that only a unique line could be drawn through these two dots is false. You might be thinking, "That's unfair, that's cheating." You were thinking in two dimensions. I wasn't. I was thinking in more dimensions than that.

Karl Popper has this wonderful saying, "It is impossible to speak in such a way that you cannot be misunderstood." This is always the case.

Even in mathematics, where we try to be as precise as possible, it's possible for people to make errors, to think false premises about what argument they're trying to make.

This particular example of Euclidean geometry—because geometry was traditionally done in two dimensions on a piece of paper—was resolved by various people and led to geometry in curved space, which led to Einstein coming up with the general theory of relativity.

So it is questioning these deepest assumptions we have—where we think there's no possible way we could be mistaken—that leads to true progress and to a genuine, fundamental change in the sciences and everywhere else.

## Is the Universe Discrete or Continuous?

*Quantum theory and relativity disagree*

**Naval:** You said that we went from atoms in the time of Democrates, down to nuclei, and from there to protons and neutrons, and then to quarks. It's particles all the way down, to paraphrase Feynman. We can keep going forever. But it's not quite forever, right? At some point you run into the Planck length.

**Brett:** There's the Planck time, there's the Planck length, there's even the Planck mass, which is actually quite a large mass. These things don't have any physical significance. It's not like the Planck time is the shortest possible time, and it's not like the Planck length is the shortest possible length. The reason for that is because these Planck things are part of quantum theory. But length is not described by quantum theory. It's described by the general theory of relativity. And in that theory, space is infinitely divisible. There is no smallest possible length or time.

This illuminates an ancient tension between the discrete and the continuous. Quantum theory seems to suggest that things are discrete. For example, there's the smallest possible particle of gold, the gold atom. There's the smallest possible particle of electricity, the electron. There's the smallest possible particle of light, the photon. In quantum theory, we have this idea of discreteness, that there is the smallest possible thing from which everything else is built.

But in general relativity, the idea is the opposite. It says things can continuously vary, and the mathematics requires that things be continuously variable so they can be differentiated and so on. The idea is that you can keep on dividing up space and you can keep on dividing up time.

Physicists understand that there is this contradiction at the deepest level of our most foundational explanations in physics. It's one of the reasons why there are these attempts to try and unify quantum theory and general relativity. What is the fundamental nature of reality? Is it that things can be infinitely divisible, or is that we must stop somewhere or other? If it's infinitely divisible, then quantum theory might have to be subservient to general relativity. We just don't know.

## Every Theory Is Held Inside a Physical Substrate

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*You're always bound by the laws of physics*

**Naval:** There goes my solution for Zeno's paradox, which says before you can get all the way somewhere, you have to get halfway there. And before you can get halfway there, you have to get a quarter of the way there, and therefore, you'll never get there.

One way to get past that is to say even a series of infinite things can have a finite sum. You run the infinite series and sum it, and we learn pretty early on that it converges. Another thought I had was that you have to cover a minimum distance, the Planck length, and therefore you will get there. It's a finite series of steps. But you're saying we just don't know.

**Brett:** If the laws of physics say that we can cover one meter in a certain time period, then that's exactly what we'll do. And our current understanding of the laws of physics says precisely that. So Zeno's paradox is resolved simply by saying that we can cover this space in this amount of time. It's silent on whether or not space is infinitely divisible.

When someone asks, "Is space infinitely divisible?" Then I would say, "Yes, it is." They might turn around and say, "How do you know?" And I would say, "General relativity." How do I know that's true? Well, I don't know that it's true. However, it is the best explanation that we presently have of space-time. And then they might get into a discussion about, "Well, if it's infinitely divisible, then you're presented with Zeno's paradox all over again." And I would say, "No, you refute that by a simple experiment."

So we don't know how it is, but we can travel through all of these infinite points if, in fact, there are infinite points. Zeno's paradox is about the domain of pure mathematics. But we don't live in a world of pure mathematics; we live in a world of physics. And if physics says that we can transverse an infinite number of points in a finite amount of time, then that's what we'll do regardless of the mathematics.

**Naval:** Every mathematical theory is held inside a physical substrate of a brain or a computer. You're always bound by the laws of physics, and these pure, abstract domains may have no mappings to reality.

## We Can't Prove Most Theorems with Known Physics

*Unprovable theorems vastly outnumber the provable ones*

**Brett:** The overwhelming majority of theorems in mathematics are theorems that we cannot possibly prove. This is Gödel's theorem, and it also comes out of Turing's proof of what is and is not computable.

The things that are not computable vastly outnumber the things that are computable, and what is computable depends entirely upon what computers we can make in this physical universe. The computers that we can make must obey our laws of physics.

If the laws of physics were different, then we'd be able to prove different sorts of mathematics. This is another part of the mathematician's misconception: They think they can get outside of the laws of physics. However, their brain is just a physical computer. Their brain must obey the laws of physics.

If they existed in a universe with different laws of physics, then they could prove different theorems. But we exist in the universe that we're in, so we're bound by a whole bunch of things, not least of which is the finite speed of light. There could be certain things out there in abstract space that we would be able to come to a fuller understanding of if we could get outside of the restrictions of the laws of physics.

Happily, none of those theorems that we cannot prove at the moment are inherently interesting. Some things can be inherently boring—namely, all of these theorems which we cannot possibly prove as true or false.

Those theorems can't have any bearing in our physical universe. They have nothing to do with our physical universe, and this is why we say they're inherently uninteresting. And there's a lot of inherently uninteresting things.

## Probability Is Subjective

*All physically possible things occur*

**Naval:** Does probability actually exist in the physical universe, or is it a function of our ignorance? If I'm rolling a die, I don't know which way it's going to land; so therefore I put in a probability. But does that mean there's an actual probabilistic unknowable thing in the universe? Is the universe rolling a die somewhere, or is it always deterministic?

**Brett:** All probability is actually subjective. Uncertainty and randomness are subjective. You don't know what the outcome's going to be, so you roll a die. That's because you individually do not know; it's not because there is uncertainty there deeply in the universe. What we know about quantum theory is that all physically possible things occur.

This leads to the concept of the multiverse. Rather than refute all of the failed ways of trying to understand quantum theory, we're going to take seriously what the equations of quantum theory say. What we're compelled to think about quantum theory, given the experiments, is that every single possible thing that can happen does happen. This means that there is no inherent uncertainty in the universe because everything that can happen actually will happen. It's not like some things will happen and some things won't happen. Everything happens.

You occupy a single universe, and in that universe, when you roll the die, it comes up a two. Somewhere else in physical reality, it comes up a one, somewhere else a three, a four, a five, and a six.

**Naval:** If I'm rolling two dice, then the universes in which they sum up to two is less than the number of universes in which we roll a seven, because that can be a three and a four, a five and a two, and so on. So the number of universes still does correspond to what we calculate as the probability.

**Brett:** Yes. This leads to what Deutsch calls their decision-theoretic way of understanding probability within quantum theory. Decision-theoretic means you assume there's proportionality between the universes' way of splitting things up. So if you're rolling two different dice, then the universes proportion themselves into measures. A measure is a way of talking about infinities.

## Is Light a Particle or a Wave?

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*God does not play dice with the universe*

**Naval:** There's a YouTube video in which Deutsch explains the famous quantum double-slit experiment, which is about particle-wave duality. Is light a particle or a wave? You pass it through a slit and, depending on whether there's an observer and interference or not, it ends up in a wave pattern or as individual photons.

This is a famous experiment that has baffled people for a long time and caused them to revise their world view. It led Einstein to say, **"**God does not play dice with the universe.**"**

**Brett:** Einstein was a realist at the time when the founders of quantum theory were trying to develop a good explanation of what precisely was going on with these experiments in quantum theory. Einstein rejected all of them on the basis that they weren't realistic, and he was right to do so because none of them made any sense.

To this day, none of the other alternatives make any sense.

Now, Einstein didn't know about the multiverse. We had to wait until Hugh Everett in the 1950s was able to devise a simple, realistic way of understanding quantum theory. But if I go back to this idea of the double-slit experiment, it is often claimed that particles have a duality to them: Sometimes they're particles, and sometimes they're waves.

For example, the electron, given certain experiments, will behave like a particle. And in other experiments, it behaves like a wave. People who hear this think, **"**Well, okay, that kind of explains what's going on.**"**

In the photoelectric effect, you shine a light at electrons, which literally means you're firing a photon—a particle of light—at an electron, and you can knock the electron out of the atom. This is supposed to be proof positive that light, in the form of photons, and electricity, in the form of electrons, are both particles, because they're bouncing off one another.

That's what particles do; waves don't do that. Watch water waves at the beach, and you'll see they pass through each other. They don't bounce off one another. Waves will bounce off particles, but they won't bounce off each other.

Prior to Young's twin slit experiment, we relied on Newton's ideas of light. Newton's idea was that light was corpuscular, as he said, which means made of particles.

Then Young came along and shined a line through two slits, cut into a piece of paper, and what you find when you project that light onto another sheet of paper is not just two beams of light. You find what's called an interference pattern, where the light has interfered with itself.

It's similar to when waves pass through small apertures, or natural geological gaps. The waves will interfere with one other. They produce crests in some places and troughs in others. They can cancel each other out. This was supposed to be proof to some of the early physicists that light, in fact, was a wave.

Now we get to quantum theory and find that things we thought were certainly particles—like electrons—interfere with each other when we do the same experiment with them. It appears as though we've got particles acting like waves and waves acting like particles.

The resolution to this is not to admit nonsense. What often is explained in quantum theory lectures at the undergraduate level is that you have to accept that something like a photon is born as a particle, lives as a wave, and then dies again as a particle—which is nonsense.

The reason it's nonsense is because the photon doesn't know that it's alive or dead. It doesn't know what experiment it's participating in.

## The Multiverse

*Experiments force us to acknowledge other universes*

**Brett:** We have to come to a deeper understanding of what is going on in this double-slit experiment. If we fire either a photon or an electron at that double-slit apparatus and put a detector at either of those slits, then we will detect a particle.

We can detect that we've fired a particle; we can detect that a particle is going through those slits; and we can detect a particle at the projection screen as well.

When you do this experiment in the laboratory using electrons, you can see the dots where the electrons strike, hitting the screen. But you don't get a simple pattern that you would expect.

If you're firing cannonballs at a wall through the same two holes, you would expect all the cannonballs to land in one of two positions behind the wall.

But with particles at the quantum level, that's not what happens.

The only explanation is that when we fire a photon, there's the photon that we can see in our universe and also there are photons we can't see in other universes that pass through the apparatus. These photons are able to interact with the photon that we can detect.

This is where the concept of interference comes in. Interference is an old concept in physics. It goes back to waves. Waves certainly interfere, but we need to understand the way in which particles can interfere with one another. This includes particles that we can observe and particles that we can only assume to observe given these experiments.

This is why we are forced to acknowledge the existence of these other particles—and not only these other particles but other universes in which these particles exist.

## We Explain the Seen in Terms of the Unseen

*No one has ever seen the core of the sun*

**Brett:** At this point people might object, "How dare you invoke in science things that can't be seen or observed? This is completely antagonistic towards the scientific method, surely."

And I would say that almost everything of interest that you know about science is about the unobserved.

Let's consider dinosaurs. Dinosaurs are unobserved. You say, "Ah, hold on, I've been to the museum, I've seen a dinosaur." No, you have seen a fossil, and a fossil isn't even a bone. It's an ossified bone that has been metamorphosed into rock. So no one has ever seen a dinosaur.

We have seen things that look like dinosaurs and interpreted them to be huge reptilian bird-like creatures. When we assemble their skeletons, we make up a story about what this thing was that walked the earth tens or hundreds of millions of years ago.

In the same way, no one has ever seen the core of the sun and no one will ever observe the core of the sun. But we know about stellar fusion. We know that hydrogen nuclei are being crashed together there to form helium and in the process producing heat.

We don't see the big bang. We don't see the movement of continents. Almost everything of interest in science we do not observe.

**Naval:** Even many of the things that we say we have seen, we've actually just seen instruments detect those things. We're watching the effects through instruments and then theorizing that there are other universes out there where the photons are interacting with the photons that we can see.

## Science Expands Our Vision of Reality

*The multiverse is another step in this direction*

**Brett:** Many scientists and philosophers have talked about the concept of a multiverse. But we're talking about a very strict, very sober understanding of what a multiverse is.

All of these universes in this multiverse obey the same laws of physics. We're not talking about universes where there are other laws of physics.

We used to think that everything in our universe—other planets, stars, the sun, the moon—orbited around us. We existed on this tiny planet.

Then our vision of reality got expanded a little bit. We realized that, in fact, we were not the center of the universe—the sun was the center. We also realized the sun and some of the other planets—Jupiter, Saturn and the other gas giants—were bigger than our planet. So our universe became larger.

Then we realized that we were just one star system among many in a huge galaxy of hundreds of billions of stars. Later we realized that this galaxy is one of hundreds of billions of galaxies.

The history of ideas and science is a history of us broadening our vision of exactly how large physical reality is.

The multiverse is another step in that general trend, and we should expect it to continue. It shouldn't be that hard for people to accept that this is the way to understand things.

Do we know everything about quantum theory and how this multiverse works? No. We haven't united the multiverse with general relativity. We still need a space-time or a geometry of the multiverse.

## Science Is an Error-Correcting Mechanism

*It does not presume to predict the future from the past*

**Naval:** Where do good explanations come from?

There's currently an obsession with induction, the idea that you can predict the future from the past. You can say, "I saw one, then two, then three, then four, then five, so therefore next must be six, seven, eight, nine."

There's a belief that this is how new knowledge is created, that this is how scientific theories are formed and this is how we can make good explanations about the universe.

What's wrong with induction, and where does new knowledge actually come from?

**Brett:** You mentioned the black swan earlier, and I'd like to go back to that. The black swan is an example people have used over the years to illustrate this idea that repeatedly observing the same phenomena over and over again should not make you confident that it will continue in the future.

In Europe we have white swans, so any biologist who's interested in birds would observe white swan after white swan and apparently conclude that, therefore, all swans are white. Then someone travels to Western Australia and notices swans there look otherwise identical to the ones in Europe—but they're black.

Let's consider another example of induction.

Ever since the beginning of your life, you have observed that the sun has risen. Does this mean that scientifically you should conclude that the sun will rise tomorrow and rise every day after that? This is not what science is about.

Science is not about cataloging a history of events that have occurred in the past and presuming they're going to occur again in the future.

Science is an explanatory framework. It's an error-correcting mechanism. It's not ever of the form, "The sun always rose in the past, therefore it will rise in the future."

There are all sorts of ways in which we can imagine the sun won't rise tomorrow. All you need to do is to take a trip to Antarctica, where the sun doesn't rise at all for some months of the year.

If you go to the International Space Station, you won't see the sun rise and set once per day. It will rise and set repeatedly over the course of your very fast journey around the Earth.

## Theories Are Explanations, Not Predictions

*The prediction comes after the explanation*

**Brett:** There's another example like this. You can do this with a saucepan at home. Put a beaker of water on a heat source, then put a thermometer into that water and turn on your heat source. As time passes, record the temperature of the water.

You'll notice the temperature of water increase. So long as the heat source is relatively constant, the temperature rise will be relatively constant as well. After one minute, the temperature might go from 20°C to 30°C. Imagine every minute it climbs by another 10°C.

**Naval:** But at some point, it's going to stall when it hits the boiling point.

**Brett:** Precisely. Now, if you're an inductivist—or even a Bayesian reasoner—and you don't know anything about the boiling temperature and what phenomena happen at that temperature, you can join all of those lovely lines into a perfectly diagonal straight line and extrapolate off into infinity.

According to your Bayesian reasoning and your induction, after two hours we should assume that the temperature of that water will be 1,000°C. But, of course, this is completely false. Once the water starts boiling, it stays at its boiling temperature. We get a plateau at about 100°C that remains there until all the water boils away.

There's no possible way of knowing this without first doing the experiment or having already guessed via some explanatory means what was going to happen. No method of recording all of these data points and extrapolating off into the future could ever have given you the correct answer. The correct answer can only come from creativity.

Notice that science is not about predicting where the trend starts and where the trend goes.

To explain what's going on with the water, we'd refer to the particles and how, as the temperature increases, the kinetic energy of the particles starts to increase. This means the velocity of the particles is increasing. Eventually, particles in the liquid state achieve escape velocity from the rest of the liquid. At this point, we have boiling.

That escape velocity—the technical term is latent heat—requires energy. For this reason, we can have heating of water without a temperature increase.

That's what science is, that whole complicated story about how the particles are moving faster. It's not about trends and predictions; it's about explanations.

Only once we have the explanation can we make the prediction.

## Make Bold Guesses and Weed Out the Failures

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*The best theories come from your imagination, not extrapolation*

**Naval:** Going even further, it's not just science.

When we look at innovation, technology and building—for example, everything that Thomas Edison and Nikola Tesla did—this came from trial and error, which is creative guesses and trying things out. If you look at how evolution works through variation and then natural selection, it tries a lot of random mutations and filters out the ones that didn't work.

This seems to be a general model through which all complex systems improve themselves over time: They make bold guesses and then they weed out the things that didn't work.

There's a beautiful symmetry to it across all knowledge creation. It's ultimately an act of creativity. We don't know where it comes from. It's not just a mechanical extrapolation of observations.

I'll close with the most famous example of this. We talked about black swans and boiling water, but the fun and easy one is the turkey.

You have a turkey that's being fed very well every single day and fattened up. The turkey thinks that it lives in a benevolent household—until Thanksgiving arrives. Then, it's in for a very rude awakening. That shows you the limits of induction.

**Brett:** Precisely. Now, the theories have to be guessed.

All of our great scientists have always made noises similar to this. It's only the philosophers and certain mathematicians who think that science is this inductive trend-seeking way of extrapolating from past observations into the future.

Einstein said that he wasn't necessarily brighter than most other people; it's that he was passionately interested in particular problems. And he had a curiosity and an imagination. Imagination was key for him. He needed to imagine what could possibly explain these things.

Einstein wasn't looking at past phenomena in order to come up with general relativity. He was seeking to explain certain problems that existed in physics. Induction wasn't a part of it.

**Naval:** Good explanations rely on creativity. They are testable and falsifiable, of course, and they're also hard to vary and to make risky and narrow predictions. That's a good guiding point for anybody who is trying to figure out how they can incorporate these concepts in their everyday life.

Your best theories are going to be creative guesses, not simple extrapolations.

## Science Advances One Funeral at a Time

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*Even the best get stuck*

**Naval:** There's some deep symmetry between multiverse theory and Feynman path integrals, right?

**Brett:** You're absolutely right. Feynman believed in multiple histories, but it's an open question whether he thought these were actually physically real things or merely mathematical objects. He was relatively silent on the matter.

Feynman was a realist and an absolute genius—probably the second greatest physicist of the 20th century after Einstein—but he made one of the worst quips. He said, "If you think you understand quantum theory, you don't understand quantum theory." Which is nonsense. David Deutsch understands quantum theory. That was one of the few occasions when Feynman fell into irrationality.

**Naval:** I think it was Planck who said, "Science advances one funeral at a time." Unfortunately, even the best get stuck behind.

I see this in my own field. Some of the greatest investors of our time—people like Warren Buffett and Charlie Munger—are absolute geniuses but cannot wrap their minds around cryptocurrencies.

The idea that there's extra-sovereign money that's native to the Internet and programmable is foreign to them because their money is always something that has been provided by the government and controlled by the government. They just cannot imagine it any other way.

It's just the nature of people.

## It's Rare to Have Competing, Viable, Scientific Theories

*General relativity vs. Newtonian mechanics is a recent example*

**Naval:** There's also Solomonoff's theory of induction. I don't know if you've looked at that at all?

**Brett:** I've heard of it, but I haven't investigated it.

**Naval:** I'm going to mangle the description. It says that if you want to find a new theory that explains why something is happening—in this case something that's encoded as a binary string—then the correct one is a probability-weighted theory that takes into account all possible theories and weighs them based on their complexity. The simpler theories are more likely to be true, and the more complex ones are less likely to be true. You sum them all together, and that's how you figure out the correct probability distribution function for your explanation.

**Brett:** That's similar to Bayesianism, isn't it? In both cases they're assuming you can enumerate all the possible theories. But it's very rare in science to have more than one viable theory. There was the Newtonian theory of gravity and the theory of general relativity. That's one of the rare occasions where you had two competing theories. It's almost unknown to have three competing theories to try and weigh.

**Naval:** What confuses people is that induction and Bayesianism work well for finite, constrained spaces that are already known. They're not good for new explanations.

Bayesianism says, "I got new information and used it to weigh the previous probability predictions that I had. Now I've changed my probability based on the new data, so I believe that something different is going to happen."

For example, there's the classic Monty Hall problem from the "Let's Make a Deal" TV show. Monty Hall calls you up, and there's three doors. One has a treasure behind it, and there's nothing behind the other two.

You pick a door—one, two or three. Then he opens one of the other two doors and shows you there's nothing behind it.

Hall asks, "Now, do you want to change your vote?"

Naive probability says you shouldn't change your vote. Why should it matter that one of the ones he showed you doesn't have something? The probability should not have changed.

But Bayesianism says you've got new information, so you should revise your guess and switch to the other door.

An easier way to understand this is to imagine there were 100 doors and you pick one at random. Then he opens 98 of the remaining 99 and shows you there's nothing behind them.

Now do you switch?

Of course you do. You had one in 100 odds of picking the right door the first time, and now your odds are 99 in 100.

So it becomes much more obvious when you change the thought exercise to being one of the two.

People discover this and say, “Of course, now I’m a smart Bayesian. I can update my priors based on new information. That’s what smart people do. Therefore, I’m a Bayesian.” But it in no way helps you discover new knowledge or new explanations.

**Brett:** That’s the uncontroversial use of Bayesianism, which is a very powerful tool.

It’s used in medicine to try and figure out which medicines might be more effective than others. There are whole areas of mathematics like Bayesianism that can be applied in science without controversy at all.

It becomes controversial when we say that Bayesianism is the way to generate new explanations or the way to judge one explanation against another.

In fact, the way we generate new explanations is through creativity. And the way we judge one explanation against another is either through experimental refutation or a straightforward criticism, when we realize that one explanation is bad.

## We’re All Equal in Our Infinite Ignorance

*The door is always open for new ideas*

**Brett:** Induction says that prediction is the main reason science exists, but it’s really explanation.

You want an explanation of what’s going on, even if you can’t necessarily predict with any certainty what’s going to happen next.

In fact, knowing what’s going to happen next with some degree of certainty can be deflating. The unknown can be far more fun than absolute certitude about what tomorrow will bring.

**Naval:** This brings us to the related point that science is never settled. We should always be free to have new creativity and new conjecture.

You never know where the best ideas are going to come from. You have to take every idea that’s made in good faith seriously.

This idea that “the science is settled” or “the science is closed” is nonsense. It implies that we can all agree on the process with which we come up with new theories.

But new theories come through creativity and conjecture. The door is always open for new people with new ideas to come in and do that.

**Brett:** As Popper said, “In our infinite ignorance we are all equal.”

Even if someone claims expertise—and they might have a valid claim—there's an infinite number of things they don't know that could affect the things they do know.

The student who's not expert in anything can still come up with an idea that can challenge the foundations of the greatest expert.

Like the child, the expert is ignorant about a whole bunch of things and could have errors. Someone who lacks that fine-tuned knowledge can still point out those errors and present a better idea.

## It's Easy to Extrapolate How Things Will Get Worse

*It's harder to guess how life might improve*

**Naval:** A lot of the theories as to why we're imminently going to create an AGI are based in a naïve extrapolation of computational power.

It's almost an induction of more and more computational power. They say, "AI has already gotten good at vision and beating humans at chess and at video games; therefore, it's going to start thinking soon."

Another offshoot is this idea that humans are eating up all the Earth's resources, so having more humans on Earth is a bad idea.

But if you believe that knowledge comes through creativity, then any child born tomorrow could be the next Einstein or Feynman. They could discover something that will change the world forever with creativity that has nonlinear outputs and effects.

**Brett:** At the moment we're very concerned about the pollution and the loss of certain species, and these are legitimate concerns for some people. But it should never be at the expense of the long-term vision that we can solve all of those problems—and far more—if we could progress at a faster rate by using the resources that we have available to us.

**Naval:** Why does the world always seem to be full of more pessimists than optimists, especially when we still live with mostly Enlightenment Era values and such tremendous innovation?

There are probably multiple reasons for that. It's easier to be a pessimist than an optimist. It's hard to guess how life is going to improve; it's easier to extrapolate how it's going to get worse.

You could also argue that the risk of ruin is so large—you can't come back from it—that we're hardwired to be pessimists.

If you're correct as an optimist, then you have a small gain. But if you're wrong when you're optimistic and you get eaten by a tiger, then it goes to zero.

## Pessimism Seems Like an Intellectually Serious Position

*We've innovated our way out of previous traps*

**Brett:** If you're an academic, being able to explain all of the problems that are out there and how dangerous these problems are and why you need funding to look at them in more depth appears to be the intellectually serious position; whereas, someone who claims that we can solve it sounds a little bit kumbaya.

In fact, collaboration, cooperation and resource exploitation are the things that will drive this knowledge economy forward so that we can solve these problems.

It always seems more intellectually serious if you can stand out there with a frown on your face in front of a TED Talk audience and say, "These are all the ways in which we're going to die, in which the Earth is going to fail, and in which we're going to come to ruin."

**Naval:** I'm guilty of having recorded one of these doomsayer podcasts about enders blowing up the Earth. That was the one podcast I regretted the most. We had a great conversation, but I don't fundamentally agree with conclusions that we should slow down because the world is going to end.

The only way out is through progress.

I haven't promoted that podcast as much as others. When I read Deutsch, I realized why: Pessimism is an easy trap to fall into, but it implies that humans are not creative. Pessimism doesn't acknowledge all the ways that we have innovated our way out of previous traps.

Entrepreneurs are inherently optimistic because they get rewarded for being optimistic. As you were saying, intellectuals get rewarded for being pessimistic. So there is incentive bias.

If you're a pessimist, you get your feedback from other people. It's a social act. You're convincing other people of your pessimism. But entrepreneurs get feedback from nature and free markets, which I believe are much more realistic feedback mechanisms.

So far, most of the pessimistic predictions have turned out to be false. If you look at the timelines on which the world was supposed to end or environmental catastrophes were supposed to happen, they've been quite wrong.

## Rational Optimism Is the Way Out

*Pessimism is self-fulfilling*

**Naval:** Professions in which you get your feedback from other members of that profession tend to get corrupted.

When you see a journalist writing articles to impress other journalists or a restaurant owner trying to impress other foodies and restaurant owners, it's usually not practical or high-quality.

The journalist or restaurant owner may receive accolades within certain elite circles, but that doesn't reflect reality.

A scientist or an experimentalist gets feedback from Mother Nature, and an entrepreneur gets feedback from a free market in which people vote with their money and time. Those are much better predictors.

People who get paid to operate in the real world tend to be optimistic. People who operate in ivory towers are incentivized to be pessimists.

**Brett:** To be an entrepreneur, you need to be optimistic about the fact that you're creating something that other people are going to find value in.

People who have a pessimistic philosophy tend to have a pessimistic psychology as well.

If you're constantly thinking about all the ways in which the world is going to wreck and ruin, then this has a day-to-day impact on your outlook on everything—the rest of society, your family, and your friends—because you think this world is condemned.

You're going to feel that weight on your shoulders, and that's going to come through in how you present yourself to the rest of the world.

We see a lot of this on social media. Entrepreneurs are typically too busy to spend a whole lot of time on social media, but you get scientists, academics and journalists who are depressed with life because they have a pessimistic view of reality. That impacts their subjective experience of the world.

On the other hand, people who are creating are trying to bring something new into existence.

**Naval:** Unfortunately, pessimism is self-fulfilling.

Here we take the stance that all evils are due to lack of knowledge. Rational optimism is the way out. The data supports it, and history supports it.

Through creativity, we can always come up with good explanations to improve our lives and everybody else's lives.

So stay optimistic.