Hello everyone, welcome to another Q&A about the future of science and technology.
I see a number of questions saved up here.
Let's see… Anon is asking, will we ever invent a technology that changes how we think.
Not just what we can do.
Well, that's a… that's a… that's a complicated question. I think that, sort of, learning
Has been a thing that's changed how we think.
Over the course of history.
I think that the way we think about things is sort of critically dependent on both the knowledge that we have and the ways that we can formalize our thinking. I mean, the fact that one has logic or mathematics or now computation as sort of an underpinning, an infrastructure.
for having ways to think about things, that's been critical in changing the way that we think about things. I think if you were to go back a few thousand years and start
talking to people about many things that most of us can easily figure out, given the kind of thinking structure that, sort of, formalization and knowledge have provided, people from a few thousand years ago would be quite unable to figure those kinds of things out.
But now we can, because that's part of, sort of, the progress of civilization has been the accumulation of that knowledge. Now, as far as I'm concerned.
The, sort of a thing that you can think with these days is… is computation.
And I've spent a large part of my life developing our computational language, Wolfram language, that, that I, for example, I'm always thinking with, so to speak.
And these days, also, you can, to some extent, have a chat with your friendly LLM as a thing that you can think with, so to speak.
It's the… that's providing sort of an externalization of things where you, internally, are imagining what you want to think about, and then you're getting this kind of automation of thinking.
that, this leverage, this extra leverage from computational language, or from AI, or whatever else.
There's a quite… there's a different question, which is, well, what about the things that are going on, sort of, inside us humans.
to what extent is it… you know, to what extent can we imagine, sort of, modified hardware as well as modified software? I mean, in effect, the knowledge of our civilization is a modification to the software that we're running in our brains.
And…
That's, that's something that has been very powerful. Now you can ask the question, well, what if we modify the hardware of our brains? What if we have something that's, you know, directly sensing
Our, sort of, neural processes in our brains.
I think that's going to be more difficult than one imagines, and less obviously useful than one imagines. I mean, there are certainly cases where if your brain isn't hooked up the way you'd like, you know, your ability to speak doesn't work because the nerves that go to your vocal tract don't work anymore, or something like that, then being able to pick those things up in the brain
Is, rather than having to make use of your sort of standard human hardware is a huge win.
But then the question is, well, if we want to actually sort of augment the standard human hardware from even the way it was standardly built, and do something different, how is that going to work? I'm… I think I've talked about this before, I mean, I'm a little bit pessimistic.
about the ability to sort of go in and understand inner thoughts, because I think inner thoughts are sort of, by their nature, kind of incoherent.

I think thoughts crystallize when they get to the point of being spoken, or whatever else, or being remembered, but the sort of… the thought as it is being developed is something quite incoherent. I mean, it's the same kind of thing in computers. If you go and you probe the memory of a computer, and you watch all the bits going back and forth.
And, as a computer kind of tries to do something, it's not clear that it helps you
to sort of probe the computer down at the level of those individual bits flapping around. I mean, by the time the computer is displaying something on its screen, and it's a very coherent, you know, it's a window that's moving here, and it has this little button in it, or whatever else.
then that's something that is sort of human accessible that we can engage with. But when it's the stream of bits inside the computer that will eventually form into the picture of the window or whatever, it's less clear that that's useful to deal with. And you imagine the case of a computer. If you say, hey, computer, we can,
Well, in the case… let's take an LLM as an example.
and you say, let's, let's augment the LLM, let's augment that foundation model that, the… of language model, for example, let's augment that.
with a tool, I mean, I view our language, Waltham language, as kind of a foundation tool for LLMs, kind of providing this kind of broad access to computation and knowledge.
It's, can you augment the LLM with this foundation tool? Well, the answer is yes, and in fact, we're about to bring out some more technology to make that much more streamlined. But the way that tends to work is the LLM has had sort of its inner thoughts and all its neural net weights and activations and so on, but it's then produced a thing that
that is essentially linguistic, essentially a transport layer that can then be readily communicated to our foundation tool to then do a computation, go from there, go back to the LLM, and so on. You're interfacing with the LLM at the same kind of way that you would interface to a person when you're sort of talking to the person, so to speak. You're not interfacing to the LLM at the level of saying, let's take our foundation tool and let's poke those activations somewhere in the middle of this giant neural net to figure out what to do.
And I think… I think that's going to be the same story with brains, that just like with neural nets, the innards are doing this complicated, sort of irreducible computation, where it so happens that this lump of irreducible computation does something that's useful to the LLM, to us, whatever else, at the end, but you can't really expect to sort of monkey with it in the middle and have something useful happen.
So I'm a little bit pessimistic about the idea that we can kind of take brains and sort of augment the inner thoughts, when it's a question of, you know, oh, I'm imagining something… oh, I'm sorry, the,
I'm imagining something… That, just a second here, guys, I have…
I'm sorry. The, in any case, I'm,
We were talking about, kind of, the augmentation of,
To what extent one can expect, kind of.
to augment the inner thoughts and have that be useful. Now, if you say, well, let's replace all of the inner thoughts with something quite different, well, then you're not talking about… then there's much less human engagement in what's going on. I mean, it's kind of like you can have the computer just go off and compute things, as I often do.
Computation in the wild.
is, does lots of interesting things, but it's something which you have to kind of watch from the outside, just like we humans kind of watch the natural world from the outside. We're not kind

of… what we do in our brains is separate from what's happening in the natural world, except insofar as we're part of the natural world. We are sort of watchers of that and can analyze it with science and so on.
Let's see… There's a question here from Robot. What's the next iteration of humans equivalent to dinosaurs?
Well, I'm not sure what, quite how to take that.
the, well, you know, the dinosaurs roamed the Earth for, some number of tens of millions of years.
And, the, we humans haven't been around anything like that long, and the question of what, sort of, the future looks like
the distant future looks like in terms of our biological, existence and so on is, I think, still quite unclear. I think that, the, one of the features of,
the human condition is the thing that, sort of, we've centered on, and that we kind of, I think, generally like experiencing, and so on. And the question is then, how do you kind of bottle up the human experience
In a way that could be… you know, what happens if you can take the human experience and run it 100 times faster?
By uploading all the kind of human souls into some digital form or something like this. What does that… what does that mean for the human condition? Does one then still sort of preserve the essence of the human condition, or is there something yet different that becomes, sort of, the future? I think the thing that is
Kind of, the thing to realize is, sort of.
at any given time in history, the things one does at that time in history seem meaningful. If you go to a different time in history, the things that will be going on
will seem like they're very alien things that might or might not, seem kind of, seem to be worthwhile purposes. And I think it could very well be that the future of, the distant future looks Much more like, kind of, sort of arbitrary computational processes and so on, doesn't look like the human condition as it is today, and we might not even recognize the kinds of things that go on there.
And I think that's… it's a little… it means there's not a lot for us to talk about, so to speak, because the way we are today and the kinds of things we can talk about today just don't connect with the kinds of things that can be there in that form.
Let's see…
Well, as a… Question here…
Question here from Isaac. Which do you think will happen first, complete understanding of outer space or the deep ocean?
you know… There's a lot of technological reasons that,
I mean, space is useful for various technological reasons. Like, it's pretty clear that having a bunch of satellites in Earth orbit, doing remote sensing, providing telecommunications, maybe providing, computation server capabilities and so on.
That's useful. Putting, the… you know, we are supporting
the place where we're living, namely the Earth, and a good way to do that is to have things in Earth orbit. And there are even things we might want to do on the Moon, where we're delivering things more easily into Earth orbit. But those are all things that are… that, kind of… there's a reason to do those things.

when it's a question of sort of going and visiting some, you know, moon of Saturn or something, and checking out what's going on there, that becomes more, I think, of a pure science kind of thing, much less of a, hey, there's an obvious current purpose, current technological purpose.
to do that. Maybe a technological purpose will arise.
I'm not sure. I mean, when… it's interesting that in thinking about space, the ideas like communication satellites were very early ideas. I mean, this wasn't the kinds of things that one is now doing
certainly the details of how they're done, and whether you can, you know, be using, be, be, doing computer communications that way, and so on, those are… those details have changed, but I think that one knew pretty quickly
given the idea, the serious idea of launching artificial satellites, what the first round of uses for those will be, whether it's remote sensing and so on. I think maybe one exception to that is GPS. I don't think GPS was obvious when artificial satellites were first talked about. Now, it has to be remembered that, you know, Sputnik, for example, in 1957,
The excuse for Sputnik was it was a device to map the Earth's gravitational field.
Not… it's a thing that, sort of showed prowess in space type thing.
But, so the idea that there was sort of geo…
geodetic applications of space, that was an early idea, but I don't think the idea of using satellites as a way to do location information, I think that didn't arise immediately. I think it wasn't obvious that was possible, because it needs
electronics, fast, cheap electronics that can decode the signals, and it wasn't clear when that was going to arise. So, you know, when it comes to, let's go explore a moon of Saturn or something, maybe there are unknown, kind of, use cases,
But, to me, it seems like more of a basic science kind of, kind of, initiative.
And there's a question then of… there's always questions about why one does basic science. I think the thing that people have quite focused on is sort of the astrobiology angle of, well, what are the cool things we could do is find some form of life
on planet X or something, and that's kind of a motivation to do it. Otherwise, it's just, we're going to visit a rock, and, you know, why do we care about this rock? It's a little hard to justify. I will say, in terms of, sort of, alien life.
I would say that my view of how one thinks about that has evolved somewhat in the last few years as a result of working more on the foundations of biology. I do tend to think that there's sort of a feature of life
that's fairly special, that is this kind of bulk orchestration of molecular processes, and this kind of big hierarchy of sort of functionality in biological organisms. I mean, in a sense, any system does something
And to say, oh, biological organisms do these things that are purposeful is something that sort of gets philosophically confused, but I think, and this is the result of sort of recent science I've done, that there is a sense in which one can sort of distinguish
things that have been adaptively evolved to achieve a computationally simple process, that that has consequences for kind of the underlying structure of the system, and in particular leads to this kind of identifiable, small-scale mechanism, kind of bulk orchestration of processes kind of thing. And it's a really interesting question to me, how do you detect bulk orchestration? How do you
If somebody shows you, kind of, the analog of pond water from some alien world.

How can you tell whether the processes that are going on there are the result of sort of a big stack of adaptive evolution, biological-like evolution, or whether they're just something, or whether they don't have that kind of character to them? Now, you know, if one can identify sort of a way of
figuring out when bulk orchestration is occurring, that gives one a more abstract definition of life. Otherwise, we're stuck with saying life is like what we already can see on Earth, which has very detailed chemical features and so on, and that's probably not a general kind of thing. And so then the question is, well.
okay, can we identify life more generally? If we find life
general life somewhere that's different from… if we find sort of bulk-orchestrated processes on some random, you know, moon of Saturn or something, what does this mean?
it's an interesting thing, for sure. What, you know, what do we do with that information? I'm not so sure. I do think… I'm fairly convinced that life as it exists on Earth today is not the first form of bulk-orchestrated capability that existed on this planet.
And we are no doubt life, you know, 7.0 or something like this, with many previous iterations, maybe many more than that.
previous iterations that kind of provided the environment necessary for the detailed chemical processes and chemical mechanisms and ribosomes and all those kinds of things to arise. So one interesting question is, are there earlier forms of life that are still extant on the Earth?
And that we don't necessarily recognize. One of the things that's been surprising in biology is the discovery of quite different kingdoms of life, from the archaeobacteria to other kinds of things, that you might have thought, oh, we would have known all of the basic kingdoms of life a long time ago.
But actually, that doesn't seem to be the case, because it's hard to identify when a thing doesn't have properties that you are readily assaying for, and that you have other kinds of systems that interact with, it's hard to know it's there. It's just, well, it's a random collection of molecules, we don't really know what it does.
But that's why one needs, sort of, a general test for bulk orchestration. Coming back to the deep ocean.
I think one of the questions there is, do we know… do we know all the stuff that's going on in the deep ocean? Probably not. Could there be, for example, earlier forms of life in the deep ocean?
that don't exist now in standard terrestrial environments, or in the shallow ocean, and things like that. That's a possibility. It's kind of like a search for alien life in the deep ocean seems not implausible. I mean, we do know in hydrothermal vents, there are forms of life that are very sulfur-based, that are rather different from the typical forms of life that exist terrestrially. They're not so different
That they don't have ribosomes and things, but they do have a lot of different metabolic chemistry that doesn't rely on, for example, sunlight and so on to get powered.
So, there's sort of a question of, you know, one could imagine a sort of an interesting project of searching for alien life in the oceans, and that might be a thing. Now, what else do you use the oceans for? Well, there's mining. I mean, there's things that are presumably at the bottom of the deep ocean.
That might be interesting to have. I don't know.

I mean, that's also a thing that people talk about in outer space, the possibility of, you know, mining an asteroid or mining the moon for something really useful. I'm a bit skeptical about that. I think that
It's kind of like people say, oh, we'll mine them for rare earths. Well, actually, rare earths aren't really rare. What's rare about rare earths is the capability to refine them. That's what's difficult. It's not that, you know, tellurium or something is in short supply on the Earth.
there's more of it than we need. It's just a question of how do you separate it from the rocks that it's in, and that's a difficult thing, where there's sort of a tall technology stack. It's almost like in biology, where biology has built this kind of tall stack of capabilities that eventually leads to biological organisms of the kind we have today.
So, similarly, in technology, there are these sort of tall stacks of, essentially, supply chains. That, for things like rare earth minerals and so on.
Let's see…
There's a question here from Greg. Will human still mean the same thing in 200 years?
It's an interesting question. It's,
For example, if it turns out So… there's the…
As, for example, one pushes for sort of longer, effective lifespans, the sort of standardis, you human
Is not going to live that long without various kinds of fixing up, augmentation, enhancement, etc. And, you know, it is, I think, very unlikely that there is some kind of simple sort of elixir of eternal life
Where it just turned out that biological evolution set our clock to be, you know, live the four school years and 10 or a bit longer these days.
And that's it. That's not something where it's just a goof on the part of biological evolution. It may be that biological evolution tends to want the old to die off, that may be a good thing for the species as a whole.
But the way biological evolution and biology tend to work, even once you have that as a sort of primary driver, you're going to pile a whole bunch of,
Of capabilities onto that that are kind of like, well, since you're only going to live for this limited time, we can do all these kinds of things that make, sort of the life while it's going on better, and there are a lot of things that kind of have to get
unraveled to increase lifespan. So I'm kind of guessing that the longer-lived humans aren't quite the same humans as the humans of today. And I think the question of, you know, there are a lot of different issues. I mean, one is
to achieve, sort of, effective immortality within, kind of, a one human is immortal type… type setting. The other is, well, what happens when you can… when that sort of immortal version of the human
is more technological and engineered than our current biological humans, and at what point do we, for example, have readily copiable humans? I mean, the notion of individual identity kind of depends on the fact that we're all unique.
And, if… if we were readily copyable, I don't know what that means for the structure of society, or for our… even for our view of ourselves. I mean, I think it's an interesting question how one would feel if there were 10 of one, so to speak, that all have, sort of, the same memories, or forked at some point, and then go forwards. You know, I don't know whether… I'd like to think…
that I'd get on well with other versions of myself. I'm not sure if that's actually true.

I think it is a strange dynamic. Now, in some sense, in some sense, in human history, the notion of, sort of, the importance of individuals has waxed and waned in the course of human history. I mean, in much of current
human society, the individual is kind of an important… is an important thing. There are… there are other times and places in… in sort of,
in human society, where it really is all about the collective. It really is all about, you know, what do we achieve over the course of many generations? What does this whole collection of humans achieve? A much more ant-like view of the human condition, rather than the kind of, this person for themselves as an individual, which I think is a… is definitely a kind of a… particularly an American
historically, American
kind of, individualism kind of, push, and I think that's a… there's sort of a question of if there were… if everybody came with a… with an army of copies of themselves, how does that…
you know, how does that sort of play out with respect to the view of the individual, and so on? I don't know.
I think,
Yeah, I mean, it's hard to know. It's sort of interesting to realize that the base human condition has not changed, certainly in recorded human history, and probably not
for, you know, a solid maybe 100,000 years or something in the evolution of our species. And it's always sort of surprising how many things about what we do today are… have… sort of have echoes going back a very long way.
The main thing that's changed is the software of our civilization.
the knowledge that's accumulated, the kinds of things that we can do independent of the sort of hardware of our biological existence, which really hasn't changed in a very long time. I mean, I think people, you know, there have always been some people who lived a long time, and I think the knowledge to don't eat the poisonous berries type thing is kind of a large part of what has led to
And also the way that infrastructure can get built up and so on has led to much more uniform, long life.
Let's see…
Justine comments, which organs and body parts do you see humans losing or evolving, like how the appendix is basically useless? You know, this is the strange thing about biology, and I've really learnt this as I've tried to study sort of the foundations of biological evolution. You…
you get some whole structure, and it achieves some purpose. It does it in a fairly complicated way. You say, I don't think that particular feature of how it achieves this purpose is useful, but that's based on your understanding of what the point was supposed to be.
It's the… it does what it does, and it ends up being, sort of, a human or something, is… is…
it's not clear how much you can drill down and say, was there a purpose to this or not? In the case of the human appendix.
It's, you know, it was, oh, no, it's just a big nuisance because stuff gets stuck in it, and then it gets infected, and that's bad news.
But actually, it's clear that the microbiome, the bacteria that live in our gut and so on, have a whole civilization of their own, so to speak, and the appendix is a not completely useless sort of fertilizing garden or something for those bacteria. It's probably not necessary, but it's something which, in different circumstances, is probably convenient.

some aspects of the microbiome, the way the gut works and so on, probably is more suited to a world in which everybody has parasites, and the world is a much less clean place. And maybe some aspects of what's in the gut and so on are, are…
sort of unnecessary given the clean world. Now, that's a tricky business, because it's pretty clear that the increase of autoimmune diseases in younger generations is a consequence of the clean world.
that the immune system was kind of used to developing in a world where things were kind of dirty and messy, and people were getting infected with this or that, and they were, you know, there were… things were getting soil on them and things like this, which had all kinds of microbes in them, and so on. In today's much cleaner world, as the immune system develops in the first few years of life.
it's… it seems pretty likely that what's happening is it's just not getting used to having to fight these kind of, sort of the standard-issue antigens, so to speak. And so it's ending up, in its activity, it's ending up, fighting itself
and end up with autoimmunity and autoimmune diseases and so on. So the idea that… I mean, it is, in a sense, it's a little bit of a disappointing thing to discover that humans, the way we've evolved with biological evolution, we are suitable for a certain form of, you know, certain environment, certain form of life.
As we try and do something quite different.
will typically break things. And that's probably true in terms of things we can achieve in kind of the, in sort of the ways we live, and the way human society works and so on. There are things that are sort of a fairly good fit for the evolution that's been going on for millions of years and the biology of our species, and there are things where, yeah, you can do that.
But it's not going to fit with the way that we are biologically, and if we're going to change that.
that's a long process, or maybe we change it. I mean, this is another sort of issue of, you know, what if you can take that drug or make that, you know, surgical change or something
to, to change the way you are as a human, does that, you know, does it all fit together when you do that?
And the thing that's a little disappointing, because you might think, oh, we can figure stuff out, we can engineer stuff, we're going to make it better, and then you realize we're stuck with this thing that is sort of the biological evolution that we have grown up with that is, that's,
And as we try to sort of push out in some direction or another, it just doesn't work very well.
And, you know, it's also the case that the things, as I say, the things that we're most concerned about are sort of the current human condition.
And that's something that, you know, that's sort of the center of the world that we're talking about. We can imagine a quite different world in which
there are, you know, a quite different sort of human condition exists, where everything is just, you know, patterns of bits, and we're doing this and that. That's not necessarily a world that humans, as we are configured today, are going to care so much about.
I think,
you know, I would say in response to what Justine is commenting on, about things that humans lose and so on, I mean, things like the ability to digest, you know.
lactose and so on, and the various abilities to, do things with bright sunlight and things like that. That's been lost in some human populations, just because those things were, were kind of in the environment that those populations found themselves, those things weren't so relevant.
Let's see…

Double is asking, should we continue manned spaceflight programs, given that going forward, AI is more suited to explore space?
You know…
it's fun for people to, go do adventurous things in space, it's fun for people to hear about people doing adventurous things in space. I think the aspirational aspects of manned spaceflight are of quite high value in our civilization.
the pragmatic technological aspects, not so obvious. I think that one of the more extreme versions of this would be, you know, let's spread the humans around the galaxy.
And the problem with that is, it takes a really long time to get to, sort of, the next star system or whatever else. And unless you're freezing the humans, and, you know, they're sort of breaking off a fork of human civilization that will only come to life
sort of, in the very distant future of civilization on Earth, if you expect that they're going to be many generations of folks hanging out in the starship, you know, it's very clear that the things you get at the other end, by the time people have lived inside a metal box.
for, you know, 6 generations, 8 generations, more than that, I can't imagine
that the kind of the… what the human condition as we currently imagine it, will be preserved by that process. I mean, I… I have to believe that
that it's sort of an extreme version of what people think is important, and what people… how people lead their lives. A lot of that, in practice, depends on, you know, the coming and going of the seasons on the Earth, and the way that people explore and spread out, and so on. And if everybody is stuck in this metal box and knows that they're stuck in the metal box for many generations.
it's kind of going to be a different picture, and the things that we recognize as features of human society and the human condition today, I suspect, will be unrecognizable there.
So, you know, I think the thing that one imagines is in terms of the technological utilization of space, I mean, you know, it is the case that most of the satellites in Earth orbit
are purely autonomous. You know, you can think of them as AI kinds of things. You know, there aren't humans, there's no human telephone operator in space that's dealing with, you know, all of those,
All of those computer and eventually telephone communications and so on.
the things that the humans do on the space station and so on are different, and I would say less… they're things where one is trying to make use of either understanding more about the human physiology in space, so you need a human there to do that.
Or in…
some cases, sort of a diversity of action where it's better to have a human doing it, although it's just not clear how important that is. I mean, if you look at computer systems, for example, when you're dealing with data centers, for instance, the vast majority of what happens in a data center is just the computers doing their thing.
Occasionally, you'll get, you know, remote hands. You know, you can typically hire remote hands to go into a data center, open up your cage, and start, you know, doing things with your computers. Put out… pull out this, this rack and put in another… pull out this thing from the rack and
another… put in another blade in this place, and so on. I have no doubt
that that kind of maintenance, it will be, you know, somewhat convenient to have humans do that. I think if we get humanoid robotics really up to snuff.

My guess is that, actually, both for the data center application and for the space application, that it will be just fine to use humanoid robots rather than humans to do those things. So, I mean, I'm not sure. The aspirational aspect of humans in space, definitely a thing. The utility aspect of it. For technological purposes.
much less clear to me. And there are many things you don't have to solve if you're dealing with, with AIs in space that you do have to solve, you're dealing with humans. I mean, it's still not a great environment for typical, for typical AIs, because space is full of radiation.
From, from solar wind and so on, and cosmic rays.
And
it's… and that doesn't play nice with silicon chips and microprocessors and so on, but that's a solvable problem. I mean, you either have shielding, or you have different kinds of microprocessors that are more immune to radiation damage and so on. That's a very… that's a very easy problem to solve relative to the problem of human life support in space and so on.
Let's see…
Well, Simon is asking about
thoughts on the Department of Energy's big Genesis mission project. I'm not an expert. I did actually recently talk to somebody who is, involved in running that, and
I think, at this point, it's still a very small operation. Maybe it will become a very big operation, very big part of, sort of, the science landscape in the US. I think the question of, kind of, why do science, and why should governments support science.
you know, these are complicated questions. I think that the, you know, nations,
tend to, you know, nations are a thing which sort of try to defend themselves and so on, and nations have lots of value, and I think that the… one of the features of that project is the idea that it is, in some sense, a nationalistic project. One of the things that's complicated about science is that, first of all, the timescales for basic science are long.
Second of all, the kind of knowledge of basic science is sort of… when it comes to very basic science, it's kind of like it's just knowledge. It's not a question of the know-how of how you build this device. It's really… it's not sort of the details, the engineering details of how you build the device. It's more, well, it seems to be, more about sort of the general knowledge of how things work.
Now, it is an interesting point that when you look at areas of basic science, and you look at who's really making contributions to those areas of basic science.
They are surprisingly segregated.
In the sense that there are these sort of groups of people that learn about something, and then they teach other people, and it's a very human touch kind of process that some particular area of even basic conceptual science spreads. I mean, I think one of the things that I've realized is sort of a little unusual in my own life and times is that I have often entered areas of science where I didn't really have a human connection to that area
of Science previously. I just… Kind of learnt about it from books and started contributing to it. That's actually surprisingly unusual. I hadn't realized until recently how unusual that is. The vast majority of science gets done by people who are kind of socially connected to the people… to sort of earlier people in that area of science. But that being said, that sort of
leads to the same kind of thing that you get with engineering know-how. Oh, nobody knows how to build a very, sort of advanced semiconductor factory, because they just don't have the know-how. It's a thing that's been sort of passed human to human. Now, in that case, in addition to the know-how, there's also the supply chain of where do you get, you know, the ultraviolet,

illumination device from, and things like this. But… and I think, you know, there's a mixture. In most of these engineering… stacks of engineering capability, there's a mixture of know-how and actual access to stuff.
But I think this question of, to what extent is, you know, there's this sort of vision
That science is necessarily global.
Which is really not true. I mean, it's a… it's a thing where, the, sort of traditions have grown up in different countries, you know. In France, there's a certain tradition of pure mathematics, and it's very French, so to speak.
In some other place, there's a particular set of knowledge about making… doing something in nuclear physics, let's say, where the information is, you know, there's a sort of a sort of sequence of people who know about that kind of thing.
I mean, then there's sort of the question of, well, why do science? And usually the answer to that, historically, has been, well, A, because it's interesting.
That's one motivation. Honestly, I think science has sometimes, blown its, its sort of… because it's interesting story.
Because sometimes, the reason that people think it's interesting is because it somehow is connected to philosophy, maybe it's connected to theology, it's connected to kind of ways that people fundamentally think about themselves.
That's a thing which kind of gives a reason for it to be interesting, but insofar as science has said, we don't want to be involved with those kinds of things. That kind of cuts off
one of the motivating directions for doing science, because it's interesting, because it tells us something about ourselves, about the ways to… we should think about the world, things like this.
I mean, that's a reason to do science. I mean, there are reasons to do, sort of, things like medical science that are, again, very, sort of, personal, very, sort of, personal reasons
When it comes to other aspects of science, well, science helps the economy through technology. there's a reason to do that. Again, it comes back to individual people, and sort of the value that it has to people to have, sort of, a better economy and be able to get more stuff, and be able to produce more stuff, and so on.
And then, another reason that has historically been a big motivator for science is, is, is countries and, and, and wars and, defense and so on.
And I think if you actually look at the history of science, a rather shockingly large amount, I wouldn't put a number on it, maybe it's…
maybe it's a quarter, a third, maybe more than that, I don't know, of, sort of, big science that's been achieved has been achieved, sort of, in connection with military objectives.
And whether that's, you know, the development of radar, or the development of,
the things that… of lots of things that led to electronics, led to the electronics industry, and so on. You know, a surprising amount has been done
For those reasons. And it's, you know, this is, we are, as a species, we have a certain tendency to tribalism and so on, which I think is sort of a built-in feature, and we have a certain… there's also a certain sense in which…
It's a good thing that the world didn't just sort of turn into one country where there's sort of a single way everything should be done, because that's an incredibly fragile situation to be in, and we end up with these different ways that things get done in different places, in different countries, and so on, and inevitably, that's not something that's, that's always going to be totally harmonious, and that's a thing where… where there is, sort of a…

That's a motivator for science, is sort of maintain the status quo of your nation, your bubble in this whole picture, and so I think that's… I think that it is good to have definite directions for science. If you just say, hey, just do science, whatever science you feel like.
I don't think that works that well.
I think that if you say, do science that contributes to, you know, national security or something like this, the very definiteness of that, even if
the national security being pursued is not the security of your nation or whatever. The fact that there is a definite direction, I think, is very helpful in making things really happen in science. I think the just do science, any science is… is not such a promising thing.
And so I think that focus is worthwhile. I think it's great
when there are true, sort of, big aspirations for science. I mean, a lot of things related to space are kind of big aspirations in sort of science and technology. I have to say that in things I've been interested in, things like, let's find the fundamental theory of physics, seems like a worthwhile aspiration.
That one has not played in as coherent a way as some of these other kinds of aspirations. Perhaps it's more abstract, perhaps it's more like, what would we even mean by that, and so on, but I think, again, it's an example of sort of a big aspiration, which is a helpful thing for science.
Anyway, a few thoughts about that.
I think, yeah, I mean, you know, the dynamics to talk about, the particular dynamics of the world, you know.
One of the There's a question of narrative, there's a question of reality.
There are things like, you know, quantum computing, artificial general intelligence, you know.
Well, it's not quite… there's, you know, human immortality. There's, I don't know…
save the Earth from climate change, or whatever else. There are… there are these different kinds of, of things that are… that are a narrative.
And sometimes the narrative and the reality, you know, are quite far apart.
Is it…
you know, how does one feel about that? If you can drive the development of what will turn out to be very useful and valuable for the world from a narrative which actually isn't a particularly sensitive narrative.
You know, let's all go and invent warp drive or something, even if warp drive isn't possible, but the aspiration and the effort to invent warp drive might lead to tons of things that are very valuable, even though the final, you know, holy grail of warp drive is completely unreachable.
You know, that, that I think is, is,
I mean, I… I… it's… it's sort of, from an intellectual purity point of view.
it's… it's rather frustrating to see, oh, people saying, oh, we're gonna go chase this thing, where I'm like, that thing isn't a thing. That thing isn't going to be achieved. That thing doesn't make sense. But still, as a reality.
It's, it's, you know, it's a question of how do you get the world
to align behind and put resources into a particular kind of thing, and that tends to be more about narrative, often more about narrative, than it is about reality. I mean, there are some things where if you tell the world, gosh, if you invest in this, we'll all live twice as long, and we'll all be, you know, much happier than we were before.
Well…
That's a thing which, if, you know, in a sense, if you could really achieve and deliver on that, that's, you know, that's clearly worthwhile. I think it, I mean, it's sort of a…

it's… it's… one would like to think that everything that is being pursued, one could say it's really being pursued for a reason. We're really going to get there. The thing that we're aspiring to is really the place we can get to.
But I think as a reality, that's… that's not… that's not the thing. I mean, it's something you see a lot in the world of venture capital and startup companies and so on. It is…
For better or worse, the kind of… what the story is, is often a lot more important than, can the steps be taken and execute one after another, so to speak.
And, you know, by the time you put enough money into something, if you can manage it well, you can often backfill reality, even something that was quite crazy, in its first description.
And yet, if you don't have the resources, you may just never be able to get there.
So it's a… it's a complicated thing. It's sort of… it's disappointing for those people like me, who have a certain intellectual sort of purity, that, you know, one would like to be able to say, we're doing this because it really, really makes sense, rather than doing this because it's a good story that allows us to get the resources to do something that actually will make sense.
And, you know, I think in… if you look at the big investments that are being made in, and the aspirational investments in
in science, some of them are definitely things where it's kind of like, we've heard that somebody might make a quantum computer and break all the world's codes. So, you know, that's a thing we better put resources into, even if it makes no scientific sense.
And we've heard that AGI might arrive, and, you know, we might all become pets for robots type thing. And, you know, that, better not be the case. You know, if you're running a government.
And people say, wait a minute, you let us all become pets for robots? That was… that was shockingly irresponsible. You know, perhaps you should do so… have done something about that before.
Let's see…
Well,
RBS is commenting, last 50 years or so, our digital world has transformed completely, yet our physical world still seems stuck in the past.
with TVs and phones and transportation and so on, that operates the same way as it always did.
Look, I think the main issue is we humans have a certain form factor. You know, we are…
You know, we're the size and shape we've ever been, and if you want to get us from one place to another, you have to stick us in a vehicle that's gonna get a thing of our size and shape, and so on, from one place to another.
But of course.
some aspects of that have changed. You know, we have routine video conferencing, we have, you know, the ability to do that from a phone that's in one's pocket, and so on.
I think there are aspects of infrastructure, that, you know, we still use knives and forks. We still use, you know, we still, you know, typically will eat off plates and things like this.
it is that way, not because it kind of abstractly has to be that way, but because for us humans with, you know, hands and mouths and things like this, that's sort of the thing that fits the human form factor. Now, you know, we can push
different aspects of technology to relate. I mean, you know, it's like you have a phone, and it's the size that you can hold in your hand.
We could have a phone that was the size of one's fingernail, or the size of something smaller. It probably wouldn't be that useful to us, at least as an ordinary phone, not as just something you talk to, for example. Not that useful to us because

that isn't fit with, kind of, the human form factor. And so I think a lot of what hasn't changed is somehow connected to the human form factor. Some of it is also related to, kind of.
Investments in infrastructure that, well.
you know, things like roads, okay? There will come a time when, you know, the flying car really exists, and it's drones all the way, so to speak. And I'm sure that the roads that exist today will be, many of them will be as sort of overgrown and repurposed as the railroad tracks have been in many places. I mean, it's something where
That, for the infrastructure we have today, that makes sense, but, you know, when everybody's hopping around on their… on their drones and so on, it won't make sense anymore. And my guess is that,
sort of, it is interesting to look at, you know, when you look at old photographs, for example, of sort of cities of old, how similar do they look to cities of today? You know, there was a moment, 100 and something years ago, when there weren't any wires, and then there started to be wires, you know, electricity showed up, and then phone wires, and things like that.
And then, you know, there was a moment when there started to be trams in at least European cities, and and then there were cars. And, you know, the cityscape has changed a bit over time. And, you know, what will change in the future? Well, you know, presumably when things are flying around, that will be different. I mean, it's kind of ironic and sort of disappointing that if you look at the sort of pictures of the future from the 1940s, 1930s even, you know, they're full of flying cars, you know, it's flying cars between the skyscrapers type thing.
You know, another thing that will probably change in cityscapes is as the cost of construction, you know, when robotics really comes of age, the cost of construction will plummet, and it will be possible to build a lot more stuff.
And I don't know the sort of relationship of more built stuff
The value of, you know, when do you need to be, sort of, right there in a city?
can the exurbs develop as you can sort of hop to the exurb in your drone-type thing, or whatever? How will that be affected? And the ability to build stuff anywhere, and so on, and build it much more cheaply than it's built today, I don't know how that will affect, kind of, the general appearance of the built environment.
Possibly also, you know, a thing that has tended to be the case is that people at various times in history have said, the only buildings we can build cheaply are buildings that are very, sort of, very geometrical, very simple in structure, so to speak. I'm not sure how true that really is, but all of that very lovely ornamentation on older buildings is something you don't see as much on recent buildings, because it's like, well.
the machinery we have to build these things, and the, you know, it's machinery, not human labor. It would take too much labor to build all that ornamentation and so on.
If the economics of construction changes, that will change completely. And it will be routinely the case that you can have all sorts of elegant ornamentation and, you know, freezers and this, that, and the other, and elaborate gargoyles and who knows what on every building.
And so it may very well be the case that the view of the future from a hundred and something years ago, a very minimalist architecture and so on, because that's the way the machines will build it, that's the sort of way the science, scientific geometry kind of suggests, that that will give way, when the economics change, particularly, to very ornate kind of artistic, organic forms and so on. I'm not sure.
And that will change the, you know, the simplicity of the cityscape, so to speak, as it has been constructed by machines of today, may not

stay that way. And it may be that the, you know, the elaborate parks and so on that can be constructed but take a lot of labor to construct, that that will be something vastly more common and will sort of change the appearance of the built world.
RBS again is asking, what technology is needed to build a flying car?
I think it's mostly batteries that last a while. I mean, there are starting to be some test cases of flying cars. I think it's, it's,
it's like, do you trust yourself to a flying car? What happens when the, you know, what happens when there's a software glitch and all the rotors stop and the thing plummets? What, you know, is there…
Back in the day, elevators had this problem.
Back in the day, you know, the early elevators, you were kind of on a string, and if something went wrong, the elevator would, would, you know, would fall.
That… that stopped being the case when elevators started being connected to counterweights, and modern elevators for the last 100 years or so, more than 100 years.
have had this feature that it's like, it's the elevator, and it's connected to a counterweight that weighs more or less the same as the elevator, and you're just being sort of pullied up and down, so to speak, rather than, oh, whoops, the thing might… is sort of being pulled up on a string, and the string might… might unravel, and the elevator will fall, type thing. So, I don't think that mechanism… it's not clear what mechanism you could have
to have a thing that sort of stays in the sky, so to speak. Certainly, both for helicopters and, you know, you can… there's a certain amount of lift you still get, even if the rotor is sort of free-running, it doesn't just fall like a rock. It's still getting some lift.
And, you know, certainly there are some species of small planes, for instance, that have parachutes that can deploy, and, you know, one can imagine sort of having a situation where one feels pretty safe being, you know, a thousand feet up. Now, there are other things which, again, I don't know about.
You know, in… the atmosphere is pretty turbulent close to the surface, or can be pretty turbulent close to the surface. And, you know, it's going to be no fun for anybody if every time
you, you know, you get in that self-driving car to… that flying car to kind of hop home, so to speak, that you're, you know, thrown around all over the place, and will get totally air-sick, whatever happens. You know, how does one deal with that? Well, maybe that can be dealt with with control systems, where you can have sort of an inner part of the thing that's moving relative to the outer part.
And even though the air is buffeting the wings or the broters of the drone, that you are left suspended in the thing in the middle that isn't moving much. I'm reminded of a thing from the 1600s, Gottfried Leibniz, a well-known kind of philosopher-mathematician person of the late 1600s.
I happened to be looking at his archive and, discovered that he had a chair.
That he used to use, which he would suspend in the carriages of that time, so he could be, as the carriage was bumping along on a probably very bumpy road, he could be there in his chair that was sort of swinging back and forth.
using the fact that there was inertia to sort of the motion of the chair to be able to maintain sort of a smoother ride so he can continue to ride and so on. Maybe we'll be back to the same kind of thing for drones. I think that,
Yeah, I think a lot of it comes down to batteries.
And I think,

once that is solved, and I expect it will be solved, I mean, battery technology is a complicated material science and chemistry problem that's incrementally been getting better. Maybe there'll be some breakthrough that will be a different kind of material, or a different way of dealing with batteries, I'm not sure, but even on the incremental improvement.
I suspect one will get there to have something which is a viable flying car. I don't think that the control systems of flying cars are so complicated. I think it's an awful lot easier to fly in a sort of autopilot way that's been possible since the 1950s than it is to drive in an autopilot way that's only been possible very recently.
Dave.
Yeah, Memes was commenting, there are some flying cars. Yeah, there have been those things since the 1950s, and occasionally ones that sort of are the transformer that transforms from the car to the plane, and, you know, you drive it along the road, and it takes off, and so on.
somehow these transformer cars never seem to have caught on. I mean, they're also amphibious cars. I remember a friend of mine who had an amphibious car that, he thought it would be really cool to commute to work across a river
in… it was a practical disaster, I would say. Now, maybe if amphibious cars… again, nobody cares about amphibious cars at this point.
For, I mean, there are military applications, things like that, and applications where you have to go to very weird sort of places, but in the standard kind of built environment, nobody cares about that at this point.
I think, the, the thing that,
Yeah, so I… the transformer car that's a car, a car and then a plane doesn't seem to have caught on, and I mean, it's probably not helped by the fact that there are all kinds of, sort of, regulatory issues. It's like, there's regulations for cars, there's regulations for planes, they're different.
And, I mean, it's kind of like…
you know, you have to kind of plug in new technology into the infrastructure of old technology. Like, for example, when you're dealing with, kind of large drones and things like this, large unmanned, uncrewed aircraft.
it's still the case that they talk to air traffic control. It's just that the person who is the pilot is hanging out in some facility somewhere, not being actually on the plane. But it's sort of… that's necessary as a way to plug into the existing infrastructure.
This question here about Donut Labs battery from this year's CES. I did hear about that, I don't know enough about it.
Jamie is asking, could we ever have flying houses? Like, I didn't,
In Gulliver's travels, weren't there some flying houses there? I don't remember. But,
You know, the problem is, it… Well…
Back in the day, a technology that didn't make it was airships.
floating, you know, you could imagine a floating house that floats, you know, a giant helium balloon that has, you know, where your house floats in the sky. For some reason, that's never caught on. I think because, sort of, what's the point? And, it's hard to do. I have to say, I'm surprised that there isn't sort of a luxury hotel-type thing
that is, is themed as, you know, this, this airship. I think airships got a bad reputation with the Hindenburg. That, when was that? 1930s.
30s? Yeah. The, you know, there are two things that you can fill an airship with and have it, sort of.

well, two obvious things, hydrogen and helium. Helium's more difficult to get, but it's nice and inert.
Hydrogen is very… is much easier to get, but it has the problem that if it ever gets ignited by, then, you know, in the oxygen atmosphere that we have on the Earth.
you've got a great big explosion in chemical reaction and so on, and that's what happened to the Hindenburg, picked up, I guess, static electricity or something, and that caused a spark.
That caused the hydrogen to ignite, and that was really bad news.
So, but one could imagine, I mean, you know, you can have a floating house in the air, just as in principle, you could have a floating house on the ocean.
Again, you know, people hang out in their yachts for a long time, but there isn't really a static, you know, except very close to land, it's not something where people have said, I'm going to put this raft in the middle of the Pacific. Well, people have said this, but nobody's done it in a serious way, to put kind of a raft in the middle of the Pacific and say, I'm going to have my house here.
In terms of things that are not kind of using the float-on-air type technique, where you actually have to have powered flight.
well, that requires that you really be able to have, sort of, very free power. I mean, if you start to have, kind of, the fusion reactor that actually works, or something like this, or the infinitely more capable,
photovoltaic.
kind of system, then you could get that. Actually, it's worth commenting that I think for high-altitude drones, like flying at 60,000 feet and so on, I do believe the numbers even work out today, that you can have a drone that is electrical and powered by sunlight, and that
in most latitudes on the Earth, not too far north or south.
the drone can fly continuously, just powered by the sun. And, it's, it's kind of, it can get enough energy from sunlight that it can run its motors to keep it aloft.
So… so that's the case. So if you're prepared to hang out at 60,000 feet, maybe the economics works out to let you just, be there all the time.
I think the real, the real issue is, you know, who wants the, who wants the flying house? I'm kind of reminded of this very charming movie, Up, that features a house flown with balloons.
It's, I think that is, I… well, I'm not immediately seeing the use case for that.
Let's see… Oh, so Memes is commenting on Up, yes. The, let's see…
Well, there's a question here, should wrap up fairly soon here, about, what technology is needed, sorry, from men in. Can you talk about the future of smart glasses?
Oh, boy. Virtual reality and augmented reality are things that have been technology that's almost here.
For at least 40 years.
I mean, I remember at the beginning of the 1990s, playing with early virtual reality systems and trying to convince people at our company that, yeah, we should build stuff for virtual reality.
They've reminded me of that many times since, as virtual reality has kind of crashed and burned many, many successive times.
I think the,
a few comments about that. I mean, I think there are sort of form factor questions. People don't like having stuff on their heads. You know, stuff, a big thing on their head.
It's, there have been details, like, well, if you turn your head, does the image really keep up? If it doesn't, you get motion sick.
Those kinds of things. Those are gradually getting solved.

Then the question is, well, okay, let's say you really could have something just like the glasses that I'm wearing right now that were smart, and where I could see an image that was superimposed on my visual field.
Would that be useful? I think the answer is absolutely yes. I think that, I had worked out years ago, actually, all sorts of things about optimal label placement on a visual scene, you know, you don't want to have, you know, if you're talking to somebody, you don't want to have the label that tells you about something about the person be right in the middle of their face. That would be a bad idea.
But above their head, sure, it's kind of the halo effect, so to speak, of people. Everybody has a halo, at least in your augmented reality, because they've got, you know, it would be kind of a strange thing. You could have something where the group of people
And, you know, they're kind of,
the image lights up with different people, with different colored halos. That could be a terrible kind of socially cohesive or divisive thing.
But in any case, I think the idea… there are many use cases for, sort of really good form factor, smart glasses. I mean, one is just annotating your visual field. It's like, remind me about, you know, who is this person? What did I talk to them about before? Those kinds of things. You walk into a room, you want kind of a visual diff, what's changed in this room?
Where do I have to… you know, this room is a mess, I want to tidy it up. Where do I have to put things back to make it agree with what it looked like yesterday?
Or things where you're looking at things outside of normal human vision.
You have something which is measuring hyperspectral properties of materials, so you know, oh, I can tell that that's titanium and not aluminum, for example, because I can see, sort of, hyperspectrally, things about the material that distinguish those. Or things where I can look at a piece of food, and I can tell, wait a minute, that piece of food is kind of bad, maybe I can tell that.
directly, but I can tell hyperspectrally rather easily.
Or things about, oh, you know, that thing I'm about to touch is really hot. You can see that if you can, or really cold, you know, you can see that if you have infrared, if you have, if you can see in the infrared, so to speak.
I think there are all sorts of use cases. I mean, the…
The bad case use case is the world is full of virtual ads. You know, you're walking around, and everywhere there's a post-it note, so to speak, that's advertising something on every different object, and you don't get to see the natural world, so to speak, because everything has a… has a, you know, has an ad placed on it.
But, I think the main issue
So, you know, in terms of how to make smart glasses work, I think the hardware has gradually been getting better, although I haven't seen any big advance in probably 6, 7, 8 years. I mean, I think the, you know, there are things where you can have
displays that sort of paint a laser directly on your retina. That means you're not having to fill a… fill the visual field with anything, and you can also deal with a focus question, because you want to, you know, if you have a thing that's in your glasses.
you don't… you know, if I wrote on my glasses.
with a pen or something, I would never see that when I have my glasses on my nose, because it's out of focus. And so you can't use… you have to have something that focuses the light to be able

to get it to be something that images on your retina, and you can do that by painting directly with a laser, very low-intensity laser, onto your retina.
So there are… there are things like that, but I have to say, I haven't seen… I… I… you know, I'm sort of waiting for the Consumer Electronics Show, where some year, it's like it's all smart glasses on every aisle, so to speak, and the problem is solved, but that hasn't happened yet. Still, I think there's some power supply issues, and there are some, you know, it's generally, they're not small enough yet.
All right, well, I think it's probably time for me to… wrap up,
Oh, I'm gonna answer one more question, and then wrap up here. Peter is asking, as we improve our telescopes, will we be able to witness in greater and greater clarity events that happen further away? Can you imagine watching life developing many years ago, many light years away?
Sadly, physics is not in one's favor in this regard, because the resolution of a telescope More or less.
is limited by diffraction and by the wavelength of light. There's a criterion. It's usually the resolution, the angular resolution of a telescope is about 1.2 times lambda, the wavelength, divided by D, the diameter of the telescope.
So, you have a small enough wavelength
And a big enough telescope, then in principle, you can get high resolution.
But…
the issue is that, you know, how big can the telescope be? And if you're dealing with visible light, you're fixed with a particular wavelength. Now, there are some very big telescopes, one can imagine.
Some of them use gravitational lensing, use the fact that you can, have gravity bend light
One of the more extreme ones would be to use the sun as a gravitational lens device. You go out… if you go far enough out in the solar system, it's a long way out.
But I think it's less far than the further spacecraft are out, which is,
One light day now. That's, a thousand astronomical units, I think, a thousand times the distance from the Earth to the Sun.
But I think in less distance than that, you can be at the focus of using the sun as a gravitational lens and to focus light from further away.
So, I mean, I suppose in principle, if you have a big enough telescope, you might be able to get higher resolution. The other question is, can you cheat diffraction?
And that's an interesting question, where the obvious answer is no, but that answer is probably wrong.
There are many things in physics where there's sort of a statistical argument that you can't get there from here. You can't beat the second law of thermodynamics. But you can if you can compute things precisely enough and predict things precisely enough.
In the case of lots of telecommunications.
things, you can't get that higher communication channel speed because you can't sort of deal with the noise well enough. But then you understand the noise better, and you're able to deal with it.
So, it is not obvious to me that if you have detectors that can be… that are sensitive to individual photons, it might very well be that you can beat the diffraction limit. In fact, I know there are some cases where you can beat the
fraction limit by doing that. So, you know, the question is, could you, with a sensitive enough detector of individual photons and so on on the Earth, be sort of detecting, you know, be watching the television from a different star system or something.

By doing that. We don't know how to do that right now. We are… the only way we know how to focus light is with telescopes with mirrors and lenses and things like this.
And with that, you're stuck with this diffraction limit, or so it seems. So I think we're not in a position to do that at this time. I mean, it has been the lesson of instrumentation that things which seem sort of too small, too…
too microscopic to be accessible to instrumentation, eventually we figure out how to do it. Eventually, we figure out how to detect that individual molecule, that individual photon, and so on. So I wouldn't say never on this kind of thing.
And yes, that would be a very cool thing to be able to kind of watch the photons. I mean, I think there is a limit, because you can just ask the question, how many photons did we get from Alpha Centauri in the last year
to the Earth? And did we get enough to form, you know, what resolution of image could we get from those photons? I don't know the answer, I'll probably work it out in a few moments here.
It's always very complicated. These things that have just large numbers involved with them, you know, the number of photons streaming out
From, well, let's say the photons that, let's say, interacted with a planet
Well, let's think. You know, sometimes these big numbers kind of fool one. My guess is that the total number of photons we've had
From, sort of, that region on that planet in that period of time is very modest, only enough to form, you know, a 10-pixel by 10 pixel display, even if we could collect every photon and decode what happens to every single photon.
Anyway, interesting question. A few, a few thoughts there.
Well,
Thank you for joining me. I'm going to be refactoring some of these livestreams a bit, so there will be some new series of livestreams coming up, particularly some related to philosophy, that I hope people will find interesting, some philosophy, and some somewhat more technical and technological, that, will be coming up.
So, I'm looking forward to those, and look forward to chatting with you another time.
Bye for now.