Hello, everyone. Welcome to another Q. And a about history of science and technology.
I see various questions saved up here one from Graham.
Would Newton have loved AI, or been totally freaked out by it?
You know I've sometimes thought, how would people from past ages have viewed modern technology. I even had this idea, oh, a few decades ago, of trying to write a sort of semi-fictional book about what it would be like to show up as a sort of time traveler back talking to various interesting characters of the past with a laptop
and talking about things, and I kind of have wondered what would various kinds of notable thinkers from the past have thought a laptop was
I mean, for example, I could imagine Pythagoras, who was thinking a lot about souls, and so the transmigration of souls and so on, would have wondered, kind of whose soul
is in this laptop.
which is an interesting question, because it's kind of like. It's the souls of many programmers in some sense, who are sort of the things that in some abstract sense populate the laptop. And it's probably, you know, Pythagoras, for example, might have gotten that idea, even though the sort of the details of what's happening in kind of in the laptop are very different from sort of 5th century BC. Type story. And I just suppose in antiquity
people like I don't know Euclid, Plato, these kinds of people who thought a bunch about kind of the the kind of the
logical inference of things, even though maybe they didn't yet have the definitions of logic that we have today. This idea that this thing is sort of just automatically executing. It's kind of like an automaton that's automatically doing things. Certainly in
antiquity, with things like the antikythera device kind of a clockwork type sort of simple computer. One might have the idea that there could be a thing that would sort of automatically execute actions. And I think, although I would imagine that those folks would have been sort of holding the laptop up to their ear to see whether you could hear kind of cogs going around inside it. Perhaps.
Newton, I don't know what Newton would have made of a laptop. I think you know the display of the laptop he might have was aware of things like, well, you know Newton's rings on, you know, when you have oil on on the surface of water, you can see these interference fringes from where the light kind of is going back and forth, trapped between the
in that film of oil and so on, and he might have imagined that perhaps the display was something a bit like that kind of phenomenon.
not not quite right, but not completely wrong in terms of what
the the if one could show old Isaac Newton. You know Wolfram language or mathematica, you know what would? What would? What would he have thought about that?
It's
And I suppose.
in terms of yeah, it's a funny thing to imagine. I mean, I think one observation that I was interested to make a few years ago was about Leibniz, who was a contemporary of Newton's late 16 hundreds, and so on.
Leibniz was very much more into kind of sort of formal symbolic stuff than Newton was. Newton was much more kind of geometrically oriented. Leibniz built himself a mechanical computer. It was a sort of a 4 function
plus

minus times divide, attempted sort of mechanical computer. It took him. He spent like 30 years trying to perfect this thing, and never really quite made it. But any case, I remember seeing this a few years ago at Leibniz's archive, and I was realizing that in Leibniz's time he had will have only seen
a very small number of computers, the one that he was building. Maybe he saw a few others that people have made. Pascal have made a computer a few decades earlier, a little mechanical device, not not a computer in the sense that we have them today, but
at least something that was a mechanical, calculating device, and I and I sort of realized that for Leibniz he will have seen only these handful of computers
today. We have computers everywhere.
But it's a question of what will seem kind of out of date in the future that we see today, so to speak. And what I, what I sort of imagine is that people will be surprised that everything wasn't made of computers.
In other words, we have computers, but they're discrete things. Computers are starting to be sort of integrated into more and more devices. But it's not as if the materials that we work with are intrinsically computational. The materials we work with they might be natural materials, like wood or something. They might be artificial materials, like plastic, but nevertheless, they have very simple arrangements of molecules, or they have. Wood doesn't have such a simple arrangement of molecules, because it's leveraging the kind of molecular computation that's done by life.
But the things we materials like plastic, that we kind of make, have simple molecular structures. And I think the what one can imagine is that at some time sort of every detailed molecular structure will be set up to essentially be a computer, just like in us in biology. That's kind of what's happening, that there's some sort of bulk orchestration of molecular processes
that's leading some kind of computation-like thing to be happening in every molecular piece of every cell, and so on.
and I think it will be surprising to people of the future that there was a time when everything wasn't already made of computers, so to speak. They'll observe that actually, life had already discovered that. But people hadn't yet been able to kind of emulate that in technology.
And I think, the the thing that
So that's kind of a it's interesting to to imagine what one couldn't imagine back in the past, and how that reflects to what we can't imagine today about what will happen in the future.
But back to Isaac Newton and AI and kind of
So you have to remember that at that time, if you wanted to communicate.
you were talking to a person face to face, there were no telephones. The only form of distant communication was, you would write something down and somebody else could read the thing you wrote down, or maybe you'd write something down, and somebody could recite the thing you wrote down. But there wasn't a notion that the kind of notion that there would be sort of a a disembodied distant form of communication just didn't exist at that time.
I think. The idea that one could sort of generate
kind of a well in some sense. If somebody says, You know, this is a document that was generated in some mysterious place, perhaps in hundreds of years earlier. You know, this is a document. It just sort of arrived here, in a sense, that's you know, at that time that feels a bit similar to what one would say AI was doing. It's just like, here's this document. It came from somewhere. We don't really know where it came from. Here it is.

so I'm not sure that that would have been so surprising. I mean the concept that something was sort of typing itself automatically on a page. Well, that's a different kind of thing. And that would have been very surprising. I mean, I think, that there are sort of the surprise of the content, and there's the surprise of the form of of kind of the how is it delivered? This? It might be that to some. In, in some situations it's kind of like when when kids
young kids, for example, see something. And you say, this is the most amazing thing, and you're very impressed with some particular thing, and the thing they notice is the carrying case that the thing was in, because they just really don't know what to concentrate on, so to speak. They don't know what's significant. It's like, you know, this this piece of rock is really very, very significant, but
the Kid doesn't know that. And what the kid sees is this very elaborate thing that's this container to keep the rock safe, or whatever, and that seems like the more interesting part. And I could imagine that back, you know, a few 100 years ago, the things that we have today. And we'd say, Well, look at this amazing AI, and the main thing the person will be really surprised by is the sort of precision engineering of the laptop
that it's running on, or the or the or the light of the display that is like, how do you generate this kind of light in the display, when all you know about for making light is either the sun, or things like things burning, or candles or whatever.
So a few thoughts on that. It's always interesting to imagine what would happen if you translate ideas and technology of today into past times, how people would react to it. Because it's really a proxy for seeing the things that we're missing today. That will be obvious in the future.
Let's see.
gosh! Susan asks, what was the process for writing books in antiquity? Were there publishing companies, or mostly self-publishing and promotion? Well, in antiquity people were not writing books. They were writing things on scrolls, and there were libraries of scrolls like the Library of Alexandria was a big library of
tens of thousands of scrolls, and I don't know. I don't think it's known what the kind of organization scheme for such libraries was. I think you asked the librarian, so to speak, although libraries in those days were more like kind of university campuses today, they were sort of places of learning with actual humans, having knowledge as well as the scrolls having knowledge.
But you could go there and study the scrolls, and probably somebody would say, Oh, yes, you know you want a scroll from Democritus. Oh, yes, we know where that one is. It's it's here. You pull it out, you! You open the scroll up you, you read through it, and so on
People. There were obviously in antiquity. There weren't printing presses, so the only way you got copies of skulls was to have somebody copy them for you to have a copyist, a scribe actually do the copying.
And it was a complicated thing people would come through, and they would be people. I think there were sort of sellers of scrolls who would kind of come with a whole collection of scrolls, and they would come through different places, and they would be be able to sell you scrolls, or you could get the scroll would be delivered, and then you would have some local copying person copy the scroll for you.
and then you'd have your own copy of it. So it was very much a thing where you're going from. It's sort of a personal transmission kind of thing.
How did these things get famous?
Well, I think they were mostly things got particularly famous when there was sort of an institutional structure around them. Whether it was, you know, Plato's Academy in Athens,

whether it was plays performed in big amphitheaters, in in the Greek or Roman world. Those kinds of things. I think that the kind of
you know you also got famous. If you were kind of a a political leader, because your your face might be on every coin that's produced.
It is sort of interesting, as I think about it, that coins were clearly made with moulds, and the fact that that wasn't done as a way to to produce
kind of to print things. It's a little surprising now that I think about it now. Of course, in those days paper wasn't known yet, at least not in the West, and probably not even in China, where it was, I believe, invented. But what was known was papyrus, where you would take these reeds, and you would kind of make mats out of these reeds, and then you could use ink that came from things like squids, and so on
to to write on the on the papyrus.
and that was sort of the dominant form of of how you would, you would make these things, and then you roll them up, and that was sort of a convenient way to carry them around. I think the idea that
there would be kind of a a seller of these things, I think people found well, there was a, you know, something popular, and people would make lots of copies of it, and people would go around and and try to sell them, and so on, and people would go and visit places, and they would come, and presumably they would bring
their scribes to libraries and or to private collections and have them make a copy of things. I mean, it's kind of a different story today when you go somewhere and you just get out your phone and you're making. And you're taking pictures of the thing. Even that is something that's of comparatively modern times, I mean, back in the day the scanning a document was a lot less trivial.
and certainly the I I I remember
Well.
trying to take pictures back in the 19 sixties, early 19 seventies, taking pictures of things to try and be able to record them. That wasn't very easy to do. You didn't tend to. It was a big effort to make a large photographic picture of something. Also, I remember many, many experiments of trying to take pictures of television screens was surprisingly difficult.
because the refresh rate, compared to the speed of the cameras and so on, didn't really work out you'd end up with little partial pieces of images and things like this. I never quite trusted it but that you could just take a picture of a screen with your generic camera and our phone, and that it would always work. But of course it does these days, because everything is running much faster and so on. But
yeah, so so I think that's You know, when when you look at publishing.
even after the invention of the printing press. It was very much, you know. A book was sold in a particular place. So, for example, like Isaac Newton's Principia Mathematica, it it was printed, and it was. There was a description in the book that says, you know, it's sold at this particular place that is, at this particular, this particular wall. I forget what it is in some particular street in London.
and I think, in the case of Newton's Principia, I remember this a bit because I once thought about buying a copy of the Principia, and so I did a bunch of research on what the details of how it was printed, and so on, and how many copies there were, what had happened to them. I think there were like 1,500 copies of that printed.

of which about half were tagged as being export copies that were intended to be sent around to different places and people, presumably other booksellers in other countries, and so on, and half were intended for local use, which meant they were being sold from this particular little stall somewhere in London
and the, I think a few 100 copies of the Principia have survived. To this to now. But it was something where sort of book selling was in a sense a fairly personal activity. I would imagine that the booksellers, the individual booksellers, will be saying, Oh, there's this amazing work by, you know this this chap who's now by. Well, in 1687, when that was published he was just a professor in Cambridge, and I wonder what the booksellers said about about him now. Sometimes in these books they would have kind of advertisements
talking about how terrific the books were, and also a lot of things about how the
who the kind of the sponsor of the book was because one of the things once there were printing presses, there was this whole question of who was allowed to use a printing press a little bit like who was allowed to print money, or who was allowed that was before paper money. And well, actually, when did paper money come into
in England, for example, I don't know but I think in in the time of Newton, for example, all money was was silver and gold money, and or some alloys and things, and there was sort of a question of how much you could put
sort of copper and things into the coins, which was a lot cheaper than the gold and silver, and so on. But I think the idea of who gets to have a printing press was again not a trivial thing. You had to be sort of sponsored by the King, or something to be able to have that I mean a little bit like what happened many years later in the Soviet Union, and so on.
where there was sort of a desire to control the mass distribution of information, or what happens even today in many places with, oh, I don't know, you know, if you're in China, you have to have an Icp number for your website. It has to be kind of a Government sanctioned thing to have sort of that broad distribution of information.
Well, let's see.
Other questions here.
and Rudo is asking was the idea of Pascal's triangle invented several times definitely. It was, the idea of, you know, going 1, 1, 1, 2, 1 adding up pairs of numbers and having them be the the 3rd number that's definitely been invented a bunch of times. Pascal, I think, invented it in connection with kind of probability.
questions about probability, and counting the number of paths, the number of ways that you can get, sort of down, some kind of pegboard to get to a particular place, I think, in connection with kind of studying things like games of chance, and so on. But it certainly was known in China, and I think it was probably in other places as well.
I don't know whether Fibonacci in early 12 hundreds. I don't think, specifically wrote it down. It is funny which of these kind of things about numbers have been invented many times. The Fibonacci series, for example, invented many times since antiquity.
The Pascal's triangle invented many times. I don't know how many times, independently, the notion of primes was invented that was certainly known in antiquity. I don't know whether it was invented many times.
It's always been a big surprise to me that a lot of things I've ended up discovering that are sort of simple computational rules that produce interesting behavior like cellular automaton rules, and and so on. It's always been surprising to me that those things were not invented in antiquity because they have no conceptual complexity that would prevent them from being invented in

antiquity. I think what prevents these inventions is just the total lack of context. For why would one care about this kind of thing, I think.
Now, in the case of Pascal's triangle, I think it was sort of adding up possibilities and things. you know a thing that surprised me quite a bit. I was just noticing recently was, I was looking at a book from when was it the 16 hundreds? I guess that was about
that was talking about essentially cryptography, and it was a book that was kind of describing how cryptography was was being seen as a secret art, and this book was kind of apparently some particular person had died, and they really didn't want to reveal their secret art of cryptography. That was a little bit like magic tricks to people.
And it was this book was somebody else sort of picking up what that person had known and open, sourcing it in a sense, telling the world how this cryptography worked, which was the book was sort of indicating, was sort of a shocking and scurrilous thing. I think it was partly a by this book. You're learning secret knowledge from it. Type thing.
But here's the thing that really struck me about it.
The book described a bunch of ciphering methods that are to our view today extremely simple. like the so-called Caesar cipher that perhaps was actually used by Julius Caesar, where you take a text in English, for example, and you just tell people 5, for example, and that means take every letter like an A and go 5 letters forward BCDB, CDEF,
and say, Replace a by F and B, by G, and so on. Just shift everything 5 letters forwards.
So
back in the day at least, one assumes that the dispatches that Caesar was sending out which were Caesar ciphered people couldn't read them. And in this book from the 16 hundreds it was again. It's like, well, when you in cipher things this way, it's it's really hidden.
Now. The thing is that in today's world, if you imagine seeing such a message.
I think a decent fraction of people would have the idea that you could look at well, which letter is most common. Oh, that must be the encryption of an E. For example, that must be the cipher for an E. But what's the second most common, a T, and so on.
But that actual idea, those ideas of cryptanalysis were certainly out and about. By the early 20th century they got kind of formalized a bit in information theory. In 1948.
It had been developed a bit earlier than that, but that was when it was published. But the thing that really surprised me was that the typical person, let's say, in the 16 hundreds who was kind of a I don't know the sophisticated techie of the 16 hundreds, and so on, that it wouldn't be just taken for granted that you could do that kind of sort of statistical estimate
and then break the cipher.
And I think it's sort of interesting the extent to which these ideas about statistics, let's say, or the ideas about sort of combinatorics, counting things set of all possibilities. All those kinds of things just weren't things people were thinking of at that time, I mean the very concept of statistics, the sort of numerical data of the State did come into existence, and it was certainly known a little bit in the 16 hundreds, I mean, I think
was a guy called John Graunt, if I remember right, who had this thing. The bills of mortality kind of a grim story during the Black Death in London in the 16 hundreds. It was kind of like a sort of a tally of kind of who died of what
during during that period of time, and I think it continued after that. But it was sort of a characteristic of of sort of numerical data about the State, not the particulars of of the individual people with their names, but rather just a a total numerical representation of that.

But anyway, I found it interesting that that in the 16 hundreds things which I think many, you know. Certainly high school level sort of somewhat quantitatively oriented kids would kind of figure out about how to break the Caesar cipher was something where you couldn't expect. You know the the Phoenician generals, or something on the other side, to be able to do that. Interesting to me that that was a thing which seems so obvious today, yet seemed so kind of you know you could base your whole military, you know strategy on the fact. People couldn't break this in those days.
So
let's see. So I think the things that there has to be the sort of conceptual framework for thinking about things and lots of things I've discovered about simple programs and what they do once you have computer displays. And you have the idea of programs sort of obvious to try these things. But maybe it was very unobvious before.
even though you can find some examples of where people have created things like mosaics according to rules, I mean, most mosaics that got created were created in antiquity on, I mean, the very earliest mosaic, I think, is in
city of Ur, I think, in
I guess in what's now Iraq, the Babylonian part of the Babylonian Empire, or whatever
it said, that the Gilgamesh himself.
of epic of Gilgamesh fame, supposedly produced some the mosaic that's in some that was a mosaic described as being something decorating some temple. I believe that actual mosaic is now in a museum in Berlin. The but I think
the so. Mosaics were a thing from, you know, a couple 1,000 years BC. And so on, and I think but the question is, how do you lay out the stones in the mosaic and the vast majority of things. Well, some things were simple patterns like that one, and and from, I think, is in is in kind of a periodic pattern.
Subsequently lots of kind of
representational art in mosaics, you know, in Roman mosaics and things. You see a lot of kind of, you know, pictures of people and lions and things like this. A different branch was some Islamic art, because in Islam there was sort of a prohibition on, on representing, on on showing natural forms in these kinds of in in art. And so there was more of an emphasis on
kind of abstract forms that might be a little bit reminiscent of nature, but weren't a direct representation of nature.
And that led to things that sort of looked
had had more complicated patterns, more complex. But they were typically periodic patterns of various kinds. The
I have to say one time I was really curious because there was a pattern that was basically an array of squares that exists in some mosque somewhere from I don't remember from maybe 1,000 ad something like this, maybe a little, maybe 1,100 and
it was. It looked like this sort of array of pixels, and I was very curious. What is this array of pixels? It seems like it could be some elaborate mathematical structure, or it could be something based on some unknown cellular automaton like computational rule. I was very curious. I was very confused for a little while until I realized that actually, it's a verse from the Quran, written in a very sort of idealized, formalized
Arabic script, a thing called Square Kufic.
where you basically are taking the letters in Arabic. And you're writing them in this kind of on a square grid. And then you're taking the actual text, and you're sort of curling it around in a in a

kind of a sort of square fashion, or even a spiral kind of kind of way, and that's how the pixels were made, so to speak. And so it wasn't math. It was actually text
but
then then I mean in terms of things following rules, and so on. The earliest example I know of things like nested patterns beyond periodic patterns comes from around 1,200 Ad. Where there was a family of mosaic layers, called the cosmati, who did
did mosaics in all kinds of places in Rome, in Westminster Abbey, in England, and all kinds of places had their their mosaics, and some of their mosaics contain nested patterns. One thing I always found interesting is, there's a fair amount of art history that's been written about their mosaics. And until recently that art history just was silent about all of the nested patterns that show up. They talk about the representational art.
They talk about some of the periodic patterns, but when they're a nested pattern they just don't say anything about it.
And because there wasn't sort of a context for talking about nested patterns until recently, but I was curious when those nested patterns 1st arisen, and I'm pretty sure they 1st arose around 1210 Ad. And they are to be found in a crypt in a place called the Nagni, in some distance from Rome, in Italy. I think Anagni was a place where, at some point when the Pope was expelled from Rome, they hung out there for a while.
but now, and the cosmati, I think, may have even come from there. And there's a church there that has a lot of mosaics, nested mosaics, and sort of under the main area. There's a sort of a crypt where you can see these kind of patterns being made because there's there's sort of an early version, because it's mosaics which stay there for a thousand years without trouble.
You know, kind of see an early version where they haven't quite figured out how you make the Sifinski type pattern, and then over on the other side of the of the room, they figured it out, and that also happens to be the place where a bunch of the
cosmati. This family of mosaic layers were buried, and so there's a there's a there's some inscription there. I forget it now. But in Latin which, of course, conveniently, one can still read that talks about how I think it was cosmo cosmati, and they weren't all called cosmo cosmati. They were. I think there was a Luca cosmati and various other
other cosmati, but it seemed like cosma. Cosmati might have been the one who actually figured out the nested pattern, maybe around 12 0, 8, something or 1210 ad. It's kind of interesting when you can see the creation of these things in that form.
But then, after the cosmati, after their nested patterns.
these things disappear until the 20th century, there just aren't similar kinds of patterns that seem to show up in art. I did well back in the day. This was before the web, when I was working on the in the early years of working on my new kind of science book. And then, in the early 19 nineties, I was doing all these searches, and looking through all these art history books to try to find
earlier versions of things like nested patterns. Or maybe even I thought, you know, a cellular Thompson pattern. I didn't find it. I actually haven't. I've done image searches, but I haven't done. Modern AI assisted such searches for these things. Perhaps I should try that again.
Let's see.
Gosh! Many questions here.
Hyvee asks, do you think today's scientists are more or less creative than scientists a hundred or 500 years ago? Well, there are an awful lot more scientists today.

The bar for deciding to become a scientist is a lot lower today than it was back in the day. I mean, there were always, it depends what you actually, there's a different effect.
The scientists that we know even were around 500 years ago, are a very select set.
The fact is, in any age. If you look at the books that were being produced, and so on.
we say, Oh, gosh! There must have been only these very wonderful books that were produced back in the day. But actually, if you look at the complete collection of books were produced back in the day, it was full of all kinds of things that have just disappeared.
It's like, for example, if you think about, I don't know antique furniture or something, you might say. Well, it must have been wonderful. Everything must have been wonderful back in the day, but that's because the stuff that was wonderful survived, and the stuff that wasn't nobody. People just threw it out.
I think, and the same with books, and probably the same with a lot of science. There was a lot of science that got done. That was well, I've certainly looked through lots of kind of the the sort of the typical books of science in the 17 hundreds, 18 hundreds. There's a lot of garbage.
Frankly, that didn't didn't survive and shouldn't have survived. There's a lot of back in those days. The one of the common problems was very sort of fancily presented polemical kinds of things that were said. And when you ask, Well, what are they actually talking about? What did they actually say here? The answer is pretty much nothing.
Well, I think that often about academic papers that I read today, it's like there's a lot of. There's a lot of kind of presentational stuff. And then what are they actually saying? Well, I can't really tell if it's anything actually.
But the presentation is a bit different. It's sometimes more charming to us today to see the presentation of the very sort of ponderous things written in the early 18 hundreds that didn't really say anything relative to the very kind of formalistic, technical kind of things that don't really say anything today.
So in terms of whether you know, I I think the
I think there certainly is.
Good science gets done today. There was good science that was done in the past. I don't think it's obvious
that there's a
If you get sort of the the most surviving science, I suspect it's sort of comparable. The tools changed
the and
sort of the kinds of things that we can do today, particularly with computation. And with automated experiments and things like this, there's just a further you can reach
than was possible before. But there were always tools that could get used. I mean people when you're doing chemistry. In a sense, the molecules are doing the work for you. You stir up 2 chemicals together, and you know tens of trillions of molecules will be doing their thing. You just sit back and watch, just like today, I might start some program.
And my computer will do, you know, a trillion operations. And I'll just see the results, so to speak.
So I think I would tend to think that just like sort of we humans have been kind of the same for quite a while I think that there's a certain stratum of science that's been kind of the same for a while.

Science is much bigger now. So there are many more sort of huge multiples, more papers, and things like that being written. I think the concentration of really interesting stuff is probably a lot lower today than it was in the past, just because the whole field is much bigger.
But there was certainly it wasn't the case that everything that was being written in the 18 hundreds about science made sense, either, but probably the fraction was higher. I think. Also, well, there are things like, Yeah, that's
let's see, pack is asking is art as important as science and technology in history?
It's an interesting question. I mean, one feature of science and technology is that it tends to be very accretive, that is, something is discovered. Something was discovered in antiquity. It was built on in the 16 hundreds, was built on in the 18 hundreds. It's being built on today, we're kind of at the top of a tall tower there.
Same largely true of technology, not entirely true of technology. Sometimes there are technologies where people very elaborately constructed sort of the most sophisticated possible horse carriage or something. But then the whole horse carriage idea mostly went away. And so that whole technology stack wasn't relevant. The same is also true about some ideas. I mean, there are ideas where people had developed elaborate stories about alchemy.
which all kind of mostly went away.
Usually there's a residue that gets left over from these things, you know. The carriage maker turned into the automobile maker. The alchemist turned into the chemist, so to speak, and things that came from that previous way of thinking about things did get carried over. But to me it seems like there's a very definite sort of towering effect in science and technology of what was there in the past is built on in the future. With art.
it's less completely obvious, although there is still some of that kind of effect. It can be the case that there are periods of time when well it when sort of art goes in a particular direction, and then it goes in another direction.
And and the art from that earlier period, in some cases, although, as I'm trying to think about it, it's the the number of kind of styles of art that just completely disappeared. Is perhaps an exception of some boats more modern art
is not so great. I mean the things where people were doing kind of the sculptures and the architecture in antiquity that very much got translated. I mean, I would say that, for example, architecture has absolutely had a similar effect to technology where the inventions of architecture in antiquity certainly got carried through to today with different interpretation, with different materials, and so on.
But there are plenty of places where there would be a, you know a columned facade that looks just like the ones that were developed in in, let's say Greek architecture or something. So you know, there's a similar effect there of kind of the of things, sort of this tower of of of of inventions. Now, a different thing is in art.
There tends to be more of. There's 1 of it, and everybody says that's terrific.
You know. There's 1 Parthenon. There's 1 I don't know, Mona Lisa. There's 1 this or that thing, and it feels much more like a kind of a personal
thing that was just. It was produced. And then everybody sees that one sort of personal thing, whereas in science it's much more of a something. An idea happens or is injected into. Science, gets poured into this kind of vat, and then gets used there. Now. Sometimes ideas have names attached to them, or one knows the name of the inventor.
And then that's a way in which there's sort of a personal aspect to it. But in terms of here's a thing.

And we're going to look at this thing as an actual thing. That's not what tends to happen in science. It tends to be the case that it's sort of an idea that gets mutated. And the core idea is there. Maybe it's attached to some particular inventor, but it gets sort of twisted around. It's not. It's not like. It's the particular thing.
It's something I sometimes notice that there are. There are things where there's sort of a particular. There's a particularity of some sort of piece of creative output that one has which is different from an idea. I mean, if you look at a bunch of things I've I've done. You know, some of those are actual, particular things like a document. You write a picture you produce? Some of those are more like
ideas in technology or in science, that you know an idea in technology, for example, doesn't you know some idea that I might have invented decades ago that got used by people a lot, but has no real connection that anybody knows to the invention that I made of that idea, and it's sort of a different thing from saying, Well, there's this particular artwork, and here it is, and you can. You can see what happened.
I will say that in terms of sort of the construction of the modern world that sort of decorative art doesn't feel to me as as relevant to the construction of the modern world as the sort of tower of science and technology that got built things like architectural forms. Those are certainly significant in sort of the construction of the modern world, as the world is today, so to speak.
sk asks. You say that the system of science, the scientific method, and so on, was natural. Or was that what one would consider a real insight?
You know it may be a bit apocryphal, but it's said that Francis Bacon, courtier to Elizabeth I kind of invented this idea of the scientific method as a way to establish a way to deliver facts to the people, so to speak, in a way where nobody would dispute the fact, because, after all, it was based on the scientific method. So in a sense, maybe a little bit apocryphal, but I don't think it is entirely so that this notion
that you can base it on science. It's not just something I made up, or I thought about philosophically. It's based on science and observation, and so on, as a way to say. And it must be true.
was the thing that that came to us from the from the 15 hundreds or something 16 early 16 hundreds. I think
the the idea that you can kind of
do experiments and conclude things from them. Well, certainly, in antiquity people were well aware of the fact that you could sort of describe how things were in the world. Now, this notion of whether you could have a theory about how things worked, and then deduce whether that theory was right. By doing experiments, I think that was less clear. I mean, you know, Aristotle, for example, would say things like
things fall towards the earth just because there's a place they want to be, so to speak. He sort of had. He didn't have this this notion of a mechanism of gravity, or anything like that. I think the forms of explanation were a little different. I mean, it's sort of interesting to me that in the time I've been sort of
doing science. The mechanism explanation has changed. So, for example, and something, I've been much involved with the idea that programs are a type of explanation in science that there is a rule, a kind of computational rule that determines how something works. And that's why it works that way.

That wasn't really so much of a thing before the 19 eighties, and before I think a bunch of things that that I pushed. You know it had been the case that people would say, Well, this is what it does.
or or
from the 16 hundreds and things the surprise of there's a mathematical formula which can describe what it does, and that's how we know what it does. But the notion that there could be kind of a an underlying rule, perhaps a very simple rule that is repeated many, many times, and that's what produces what it does. That's kind of a a sort of a form of explanation of things that I don't think really was a thing before about the 19 eighties, and so on.
And so when you ask about the scientific method and the idea that you would sort of do something and think of it and have a theory, and then do an experiment to see if the theory was right. If that was the workflow of what you were doing. I think that was a thing people hadn't enunciated like that. Now, an interesting point of modern times is computer experiments, something I've spent decades working on and doing, and
spent a long time building tools for doing those kinds of things. But computer experiments have their own kind of rhythm, of how they work and what you do with them.
and the extent to which you have a hypothesis. It's a little bit like the scientific method, but it has some differences. I'm not sure that they've been, and I should do it fully codified. What really is sort of what constitutes a good computer experiment. I've talked about that actually a bunch of times. And it's like a good scientific experiment that you you want to be concentrating on one phenomenon
and not have any other sort of confounding things going on. You want to be able to say, this is what I'm talking about, and I'm going to do an experiment that's specifically about this.
And I think in so you know, you might say, actually, in terms of, was the scientific method obvious? Were computer experiments. Obvious? I think. No.
because if they were obvious, the world's a strange place. Because I started doing these things in the beginning of the 19 eighties. I sort of done a little bit actually in the in the 19 seventies as well.
And they were not obvious. I mean in the sense that that as a methodology was really not something that people had seriously cottoned onto. There were some precursors. There were a few experiments done in the 19 fifties on computers, but they were very rare, and they were done sort of in. There wasn't a lot of rhetoric around them as computer experiments. They were done kind of in the service of other kinds of things.
So I mean, that's an interesting example. Because there really wasn't anything. Once there were any computers doing computer experiments wasn't a difficult idea. But yet it wasn't what people were mostly doing. People were mostly using computers to do computations that they sort of already had a flow or workflow for doing them that came from other kinds of hand calculation, or whatever else. So that's a that's a good analog of the invention of the scientific method of sort of theory followed by experiment.
was as computer experiments. And I would say, based on that experience, it sort of wasn't that obvious?
Now, you know, later on there came ideas like this, falsifiability idea, which I think most philosophers of science kind of hate. And you know, as as this criterion. For what constitutes kind of valid science is, can you falsify it? Can you have a hypothesis where you could do an experiment? And the result wouldn't be

wouldn't be correct. Now, you know, there are many, many examples, whether it's natural selection, whether it's lots of other kinds of theories which are very important in in science which don't have that rhythm of being. Oh, you make a hypothesis, and then you falsify it.
It's a different kind of thing. You could also say that about lots of things which are in sort of in computer science. It's not really. That's not the nature of what you do of the way you do those kinds of sciences. And so it's a
Yeah, it's a different type of thing.
Des is asking. You could say that the invention of photography created modern art. It's interesting claim. So I mean, photography is what 18 thirties or something like that. The
I I don't know. I mean it. It seems like people were
People's idea of what constitutes art.
And this kind of notion that
well, okay, so the thing to understand. Back in the day before there were photographs and so on. If you wanted a representation of a thing that wasn't in front of your eyes. Somebody had to draw it or paint it for you to be able to see it.
or or somehow, or make a a you know an etching or
what do they call them? Wood blocks that you print in books, and so on.
Woodcuts the I think.
So, you know. For a long time there was a sort of that was a a form of communicating what things looked like that you couldn't see, and I think.
then, the kind of the segue that happened in sort of, I think, particularly the late 18 hundreds of sort of when everything was becoming abstracted and virtualized in a sense, whether it was mathematics, or whether it was art, where it was kind of like, what was the essence of the thing? What is the abstract essence of the thing, not the kind of the representation of the thing, but what was its abstract essence? And could you communicate an idea, so to speak.
rather than communicating an appearance, or or some as such aesthetic quality. And I think then, you know, by the time you got to the you know this is an empty paper bag, and it's an artwork that has to be a story of an idea, not a story of the actuality of the empty paper bag. Because it's kind of that. I think that's something that came as part of the sort of move towards modernity in the late 18 hundreds. And it's kind of the kind of get to the essence of things, the abstract essence of things. I have to say. I think
that it's sort of an interesting thing for me in the arc of science that I've done, that I've been very much trying to get to the foundations, the essence of things. So it's sort of an ultimate irony.
Well, for me personally, it's something of an irony, because that, in a sense, is deconstructing kind of the human factor in everything one does. Yet I'm a person who is interested in people and sort of believes in people, so to speak.
rather than a pure sort of cold, abstract person, although I've done lots of kinds of abstract science, and so on. But the thing that sort of the ultimate irony there is. It's become clear in the last few years that the observer is a critical part of the story of what science you actually have. And so in the end, even though I've sort of tried to abstract things to the most ultimate level of things like the Rouliad, and so on. What ends up being. The thing that is, the science that's relevant to us is something that is, that is deeply dependent on the way we are as observers of what is sort of abstractly out there. So, in a sense, that's kind of the sort of the turnaround of the move towards abstraction that happened well, 100 and something years ago, big move towards abstraction. Now, I think

we probably drilled pretty deep in what you can get from abstraction. And then we realized that what matters to us as observers of that abstraction are things that depend on our nature as observers.
Let's see, Park asks, would today's peer review methods have helped or hurt discoveries back in the day.
Well, I mean.
for sure they would have hurt discoveries. The the institutionalization of science has made innovation much more difficult. I mean, there are 2 effects. There are more people doing science. So there are sort of more more monkeys typing on keyboards, so to speak.
But there are also. It's harder for the the innovative idea to make it out of the institutionalized structure that says you'll only get funded for doing something for which there's a funding program, and that's accepted by your peers in a popularity contest type thing. That's not a formula for being able to successfully get innovative things to prosper
at a time when science was much smaller there was much more of. Oh, this person has been. We're betting on this person, because they're a jolly good fellow type thing, and we're going to give them this university fellowship or professorship, or whatever it is. And you know that person will just do whatever they do, and they'll put out what they put out. I think that the idea I mean I you know Peer Review, is a mess. I think people who say it's sort of a magic
you know, prover of of of of value for things they're deluding themselves. It's completely. Not true.
I mean, it's Peer Review is mostly a kind of a machine for producing more of the same. And I think you know, the cynic would say, the strategy of peer review for a peer reviewer is, does this paper treat my work nicely? If yes, accept, if no reject.
and you know it's sort of a and I think the idea that oh, it has been. You know this paper has been carefully checked. If it's gone through peer review. Nonsense. I mean rarely. There are people who actually do a diligent job of checking papers that they review. But that's a tiny minority. The vast majority of the time. People are not reading things they can't be bothered. There's no real motivation for them to do that, and so on.
I mean, I'm not a believer at all in anonymous peer review. I think that's a that's a particularly disastrous concept. I think you have a small possibility of people taking seriously their responsibility and checking something if it says, you know, this was reviewed by so and so, and I think it's
but I think the main thing that happens is, as soon as there's a barrier to entry. The things that make it past the barrier are better than if there isn't a barrier. In other words, if if anybody can post something anywhere, and it's easy to do that and sort of it all, then there'll be a bunch of stuff that that wasn't really that interesting that got posted there. If there's some sort of whole thing that you have to, you have to do this, and you have to do that
then things will be better. I mean, it's like, for example, with books and the publishing of books insofar as it cost a bunch of money to do a print run. You don't see as much stuff that definitely wasn't worthwhile printed because somebody had to invest the money to print the book.
whereas if it costs 0 to put that content out there. There's no similar kind of constraint, and I think things the whole machinery of kind of how you get things out into the world. The fact that there's effort put in some directions of getting things out kind of is some level of filter.
even though it's not the filter one might think it is, namely, it's not the kind of somebody checked it carefully, and it's it's and so on. I mean, I think Peer review in its current form would not have

been doable in science of the of the distant past, because there just weren't enough scientists. And I think that
there was much more. You know. Some learned societies had the idea that you know they would have a member of the Society would communicate some some paper, and although I think a lot of the time, it was just the sort of the membership in those societies wasn't, as I mean these days, most of the kind of honorific societies only elect people when they're at the very end of their careers.
That wasn't the case. Back in back in the day in the day, you know, you could be a member of the Fellow of the Royal Society, or something that would be typically something you would. You would become early in your career if you were doing sort of interesting stuff.
whereas now I think it's mostly the very ancient who are. Finally, everybody thinks they're they're not going to do any harm. So they win the popularity contest and get elected to some honorific society or another. I think
it's kind of a I have. I have started taking it as a sign that people think one is firmly over the hill. If one gets sort of elected to some honorific thing it's like at a point where people still think. Gosh! This person might actually do something that might be, you know, that might not tow this particular line it's like, no, no, no, we don't want to. We don't want to.
you know. Have them part of this honorific, whatever it is. It's after after you after you get over the hill.
Then it's like, okay, harmless. It's, you know. It's good for the Honorific society to have this person associated with us, and they're not going to do anything that that harms us, so to speak. It's perhaps a slightly cynical point of view, but I don't think it's entirely wrong, and it's a different dynamic than what was the case in in much earlier years of of science
left? Asks, Would you have sought to collaborate with Einstein. If you lived in the same era, I definitely would have
tried to meet up with Einstein, and I'm not a great one for collaborating in in science I tend to. I'm I'm too much of a
I don't know. I I work with people, but I don't. I don't tend to be on the let's do this project as a joint project. Kind of kind of thing.
I think a story that I've told a number of times. I I so you know, I started doing science when I was a
started doing science in a kind of a an externalized way when I was a mid teenager. So you know, I started publishing papers and things when I was maybe 15 years old, and I would go to lots of oh, I don't know physics, seminars, and things like this.
And so I met a lot of the kind of the generation of physicists who were still around in the mid 19 seventies, and one of the things in terms of people I might have met or not. One of the people I should have met was Werner Heisenberg.
and this must have been 70
5, or so somebody said to me, Oh, you know, Werner, Heisenberg is giving this talk in Cambridge, you should go and see it
and meet him, because they said he always likes meeting younger young folk.
and I was like, I don't care. He's an old guy, and you know, I don't think his. I think his most interesting work was in the 19 twenties or something. And now it's the 19 seventies, and you know it's all. It's all washed up. Type thing. Of course you'll remember the web didn't exist in those days, so what I knew about Heisenberg was was very attenuated, but as it was so, I was like, no, I'm not going to bother

big mistake. That would have been interesting, particularly interesting in view of things. I now know that Heisenberg did, but also just interesting. Because you get you get a lot of information. I think you can get a certain amount by studying somebody's works and and other biographical kinds of information. But I think you get a lot of information and a lot of sort of more intuition about the way people think about things by actually meeting them.
and I don't know whether I don't know how live streams do on the and the ranking of of learning about how people think about things. Maybe they're they're somewhere intermediate there.
But yes, it would have been. It would have been interesting
with what I know now about Einstein, and what I've thought about myself, about things that he tried to think about. It would have been interesting to meet him if you'd asked me that question back when I was much younger I would have been like, I don't know. Everything that is interesting that one could learn from him is already in the textbooks. Type thing. That's not what I think. Today.
I think there's a lot of kind of ambient information and a lot of things that sometimes people's best and most creative ideas never make it to the textbooks. They never get developed. They never get kind of flesh on the bones, because.
for one reason or another, because methods to do that didn't exist at that time, or because they never got around to it. Other kinds of things, I mean something that I certainly would have been interested to ask Einstein about was about sort of the structure of space and discreteness in space, and so on, which I know Einstein thought about in the 19 tens, and it would be interesting to
I'd be sort of fascinated to know the perspective from from that. And Einstein, you know, as I've come to understand now.
one of Einstein's biggest sort of points was this almost philosophical approach to thinking about physics, the idea that you could figure out things in physics by doing thought experiments, by by having this kind of conceptual framework sort of conceptual framework 1st rather than mathematical equations first, st or experiments first, st
and I think that's a form of thinking that you know I've used a fair amount in my time, although I think one could use it even more like. I strongly suspect that the whole construction of the Rouliad and observers and laws of physics from that and so on, can probably be constructed in a much more Einstein like way
than than the way that I've constructed it from kind of computer experiments and mathematics and things like this. So that would be a fascinating thing to you know. I think there's more to learn there that we don't. I don't know, at least just from reading the sort of published works
Brady asks, could AI or Llms fix peer Review?
I really doubt it. I mean, I think that's kind of like the perhaps the deadliest of the things I mean. It's a by now. Some fraction of papers are getting generated by with by Llms. And people are sort of churning them out and putting them out into the stream, so to speak. And you know it's it's sort of ais all the way down. If you start using ais to do peer review. And I think
you know what what you can do for sure is to say given. And I've done this many, many times, even from weeks after chat Gpt appeared is like, Okay, summarize this paper for me.
They do quite well at that. I don't know. You know what you get, so so just to say a couple of things about Peer review.
So back. I haven't done it for a long time, but back when I did it long, long ago. I always used to take various points of view. I was.
I thought my mission was, try and help the authors of this paper to write a better paper, and

you know that might have been. Don't publish this paper. This paper is no good, but you can write a better paper, I mean, I always would write reports that said, this is what you should do. even if you know maybe what you are doing is great, fine, or you know, if it's not fine, this is what you should do. I don't think most people have that point of view. I think most people are just like thumbs up, thumbs down, you know. Oh, you didn't reference, my friend, enough. So thumbs down type thing, or whatever else. Or, frankly, I just didn't understand this paper, and so, you know, it shouldn't be published, whatever that. Why, I don't know.
But I always took the point of view that that sort of the goal was to make a positive contribution. I think. And actually, I found a report that I wrote years ago. Slightly interesting story. This must have been
1984, 3, something like that.
There was a paper by chap. Paul Benioff.
It was about quantum turing machines. This was before anybody talked about quantum computers. I had thought about quantum computers. I'd done some work with Dick Feynman, which we never published about quantum computers. I think he wrote stuff about it, but I never wrote anything about it at that time. And anyway, I got this
this paper and the paper was a real model.
The idea of a quantum turing machine was interesting. And so I wrote, I said, Look, this idea is interesting. So you know, sure, publish the paper. But let me give the author the advice. This paper is incomprehensible. And here's how you could actually structure this argument, so it would actually make sense, and so on.
Well, needless to say, the the author of the paper ignored this, and the paper got published, and nobody's ever heard of this person in connection with quantum computers, because nobody understood that paper.
I recently found the report that I wrote, and I found a few years ago. Now the person who the author of the paper was then 95 years old or so, and still alive and kicking, and so I sent him this. At the time I was still doing anonymous peer review. I stopped doing that probably very soon after that time, and insisted on signing my reports. If I produced them. Some journals wouldn't let me do it.
Which I never really understood. The logic of that just didn't make any sense to me. That
But in any case, the you know, and it was some so I I had the chance to sort of say, well, this was my attempted contribution. I I think you sent me back a nice nice note kind of
as I recall agreeing that. Yeah, it's a shame you didn't take my advice. Type thing, because it would have been a much, you know, people would have understood quantum turing machines a bunch earlier.
You know, I have to say my own experience. When I was writing academic papers. I haven't written an academic paper like in an academic journal since 1986, because I stopped doing it because I thought it wasn't a good distribution channel for ideas that I had and part of what happened
when I was doing. That was every paper that I wrote that was kind of, you know, kind of sort of followed the line of what people have been doing, and it was kind of just another step in that line. Those papers got published. No problem.
any paper that had real ideas in it was like the, you know. The response of reviewers was pretty much the, you know that they didn't understand it, and so it couldn't possibly be right because they didn't understand it. Now, of course, in the Peer Review world it's much more scurrilous

than that. In the actuality of peer review people are always stealing things that they get sent for peer review, and so on. I had a lovely incident. Actually, this is
1978,
when I was a young young person. I wrote a paper. This is when I was still in England I wrote a paper. It was about cosmology. It was early paper and so particle physics meets cosmology and send it into a journal, and the the journal sort of there was some fussing, but eventually they published the paper. But then I was moved to the Us. And I was at Caltech and
the there was some that's right. Some other paper got published. That was kind of a a pale version of the paper that I'd written in the sense that I've done a bunch of calculations that needed a computer, and they were a little bit complicated, and some there was sort of a pale version that was just like, well, we can estimate this and that thing and come out with more or less the same answer. Why, those estimates will be valid. Well, you couldn't really know that without actually doing the computations. But anyway.
so then I forget how I know all the pieces of this. But the
the the main author of that, the the shadow paper, so to speak. It turned out, had been the reviewer of my paper.
but then that person showed up to give a talk.
and gave this talk, and had these kind of curves that they put up on the, you know, on the overhead projector type thing, and they were curves from my paper, just sort of lifted from from the paper.
and so I
sort of put up my hand and sort of said, where did you get those results from.
And so the sort of interpretation of that was well, how do you, you know, compute those things? And it was like, Well, there's this equation and this blah blah blah blah. And so I was kind of like, well, but look, that's a differential equation, and it has this, you know, it's a stiff equation. And it's not, how did you actually get it to get those results?
And there was this moment when the when the person giving this talk, who's no longer around but where, I could tell, this person had kind of figured out.
oh.
whatever this is, you know this young chap who's asking this question, who has a British accent must be the person who wrote that paper that I kind of lifted this thing from. And it was like, Oh, let's talk about this afterwards.
and, needless to say, after the talk was like, disappeared immediately.
So that was was, that's 1 example. I have to say. There were a sequence of these examples, which were a little bit shocking. If you believed in kind of the the perfection of the scientific enterprise, I suppose it was. It was probably good that
you know I was. I guess I was young, but not as impressionable as I might have been. Well, I was impressionable in a sense, in the sense that I kind of decided. It's very scurrilous out there. and you know it's so. My strategy after a while, was to become an editor of various journals, and not go through the whole Peer Review process at all. And then I started a journal of my own, and then I stopped publishing academic papers, and haven't really done that since then.
So but but it's certainly a very
I would say. Now, you know, when we think about scholarlessness in, in science
it is to be clear, scarless in science, has scarlessness in science has been around forever. This is not a new phenomenon, I mean Newton and Leibniz, having their big feud where Newton, you know, was putting in place some committee at the Royal Society to study the Newton Leibniz

feud. But actually, Newton was the person behind the committee, and so on, or people where you know the inventor, the Cardano, the
discover the solution to the cubic equation, where there was a whole sort of tale of woe, and I think ultimately litigation between the what was it, Ferrara? And this was about, I think, Quartex, if I remember correctly, had a whole kind of secret knowledge. You know thing going. This is around 1,500
so you know, scarless inside. Scarlessness in science is, is absolutely a a thing that
has been with us for forever. And I think it's it's true of ideas are particularly sort of.
Particularly have these kinds of problems in my observation. There's more scurrilousness in academia than there is in the tech industry.
and people find that in having having seen both cases, I suppose, in the tech industry there are more checks and balances because people eventually sue each other, and things like this, whereas in Academia it's more of a kind of behind the scenes scurrilousness that tends to happen.
So I think it's some, and.
you know scurrilousness is negative for science, I mean I for sure it's something where?
You know I have.
you know, long ago. It's certainly something that made me not do certain kinds of things and not share certain kinds of things because of scurrilousness. I kind of decided in more recent times that I just don't care, but you can see the scurrilousness now. I mean I was. I was like it. When people
send me things that talk about how much they learned from some piece of work of mine, and they've written some academic paper, and they don't mention my work. And it's kind of like, what do you mean? I mean, what's the point?
So
it's not that I think it makes any difference. So I'm not. It doesn't doesn't really matter. It's just just something that doesn't doesn't make one feel that sort of people are doing the things they should do, so to speak.
Okay, so I think,
yeah, no, the we were talking about peer review, and I was then talking about scarlessness in science, and that's I don't think I've had a chance to talk about scarlessness in science. I suppose there are many stories I could tell, some of which I probably shouldn't tell.
although I don't know why not?
The.
I have seen much scurrilousness in science, and and some of the most surprising forms are times when it would seem to me in terms of the sort of world at large that the deck was so stacked against.
Whatever the scurrilators, whatever whatever the right noun form is, that it was just, very, very, very surprising
that people would have
sort of tried it on, because it just seemed like it couldn't possibly work. I remember one time very bizarre time. Maybe I'll tell the story sometime
where just a crazy, crazy thing that happened where
Well.
the end of the story was was you know I sort of said to this person, why, exactly did you think you would get away with this?
And the person said, It's kind of interesting answer.

because you're not part of our field.
In other words, you're not part of the sort of social click of this particular micro subfield of of whatever.
And I think that that's which is odd, I mean, I think that was a genuine answer, and I think it was it was kind of like. Well.
you know, because you're not part of this tribe.
it's you know the tribe will protect itself. Didn't in that particular case. The the tribe kind of realized it was very much the wrong thing. But
so you know, I don't know. It's it's some. But the thing.
the thing that I mean it gets complicated because there are also situations where somebody hears an idea and they forget where they heard the idea, and then they sort of resurface that idea. But but there are plenty of cases where it's not just an idea. It's it's a it's a ton of material that actually exists out in the world. And it's kind of like.
like, you know, what what did you do with this material, or whatever there's there's much to say about scarlessness in science, and I would say that that
It's I mean, there's many different forms of scarlessness. That from
from kind of stealing stuff to making stuff up to, to sort of playing the institutional games of the sort of institutional structure, and so on
to just just many, many different kinds of things. It feels like it's been sort of like many other domains that have been around for a long time. It's been sort of games to the hilt.
so that, you know, depending on what you think. The point is, if you think the point is to sort of publish as many papers as possible, or to get the you know, the right kind of awards, or whatever, or grants. For that matter. Then, you know, there is a way to gain the field so that you get to that end point, even if
that avoids the the oh, and we really want to discover the
you know the most interesting science.
The okay. There's a comment here, but but from Dougie
about, I assume, about stories of scarlessness, saying they think it would be a good thing to tell stories about scarlessness, because I don't know if it puts people off from even considering doing science, but I think it's
you know. As I say, I think it's a feature of of a of a of a kind of a long developed area where it's been sort of gamed to be able to sort of get to endpoints without necessarily going through the steps. It's kind of like, learn to the test type thing and don't don't do anything different.
Anyway, I hate to end on such a comparatively negative note. I mean, I have to say that there's, you know, one of the challenges for science and the doing of science is, there are people who are really interested in and and good at doing science. What's the best environment
for the world to provide for those flowers to bloom, so to speak.
It's something which I think is in a state of transition right now it's gone through several different epochs of support from the government support from sort of universities support in different forms. And I think there's sort of a new epoch that's beginning a little bit, maybe.
That that's a bit different in character, I mean, I know for myself.
I've been very just do it my own way, kind of thing, and I've had the good fortune for the last. I don't know 4 decades or so to be doing science in a sort of, I think, fairly effective way, but in a way that's pretty much independent of the institutional structures that exist. That sort of have made it difficult to do innovative science for many people. But so I think there's a certain amount that I hope

maybe people can even learn. And maybe that's a good reason for me to tell tales of scurrilousness from the past, perhaps things to learn. And we've been trying to take some of those lessons for our Wolfram Institute, for example, about sort of how to actually do science in a way that isn't sort of held back by some of the structures that have been built up around institutionalized science. I think it's you know. I will say
that. You know I've certainly had a great time doing. Science. Science is a is a really fun thing to do. And I think
one wouldn't want, you know, the fact that there's a certain amount of scurrilousness in it should not put one off
and maybe I should
stop there and look forward to answering some more of the very interesting questions that I could see coming in here another time.
Thanks for joining me and bye, for now.