Hello, everyone. Welcome to another episode of Q&A about History of Science and Technology. I want to say I'm going to be refactoring some of these live streams in a little bit, so we're going to have some different topics coming up, including, I hope, some discussions about philosophy and so on.
Which I'm looking forward to, and also probably some more hands-on, technical kinds of things about, our technology and computational language and all those kinds of things. But today.
We have, an episode about Q&A, about history of science and technology, and I see a variety of questions here.
There's one from an anonymous,
Who was the first effective science communicator?
It's an interesting question. I mean, I think that… the…
There's a question, when did science originate?
there's a question of what does it mean to communicate it. I think it is a phenomenon of modern times that you need a science communicator, so to speak. It's a phenomenon of modern times that science written for scientists is different from science written for everybody else.
I mean, if you look at a modern academic journal, it's… in many fields, it is not really accessible to somebody who isn't steeped in the jargon of that particular field, and often in the prejudices and knowledge of that particular field. But that's not how it was in the past.
I mean, when, I don't know, Charles Darwin, 1859, writing Origin of Species. Now, Charles Darwin had written many, kind of, a number of, sort of, popular travel account-type books. He'd also written some much more, kind of, academically-oriented books about different types of barnacles and things like this.
But, you know, the book that he wrote of Origin of Species was… was… Not really a book. For, you know, there wasn't sort of the academic crowd that he was writing to separate from the general intellectual public who could absorb the book.
I think it's a phenomenon of modern times that there's this big distinction between things written for the experts and things written for the world.
Now, it's an interesting question. If you go back to antiquity, and you look at, oh, somebody like Archimedes, okay, wrote a piece, a little article called The Sand Reckoner, which is a very, very amusing piece. He's trying to figure out how many grains of sand fit in the universe.
And to be able to talk about that, he has to be able to describe very large numbers. At the time, kind of the representation of numbers, the idea of scientific notation, all this kind of thing, didn't really exist. And Archimedes had to kind of construct these ways of sort of building up to bigger and bigger numbers.
the sand reckoner used, kind of, the mathematical technology of its time, probably to its utmost. But nevertheless, I think the sand reckoner was probably readable
by, sort of, anybody who cared to read it at the time. It wasn't something where there was a small group of, you know, math experts who were the ones who could read it and other ones could not. I think the same is true. I mean, Archimedes was one of the more, sort of, technical writers. Something like Euclid, for example. The, you know, Euclid wrote
rather austere book of geometry, which just sort of stated… stated theorems. Later on, the proofs were filled in by other people. But the… to be clear, what we mean by, sort of, science communication, you know, for a long time, the Euclid's
books, Bucha's book on geometry, was the second most singular, most, single most popular book Printed.

the most popular was the Bible, but after that came Euclid's geometry. And Euclid's geometry was the many people who sort of quoted, oh yes, I like to keep a Euclid's geometry around. I think a famous example was Abraham Lincoln.
who had this statement, I, you know, I can't validate that this was a correct statement rather than just a personal positioning statement, but that he liked to, you know, whip off a few proofs from Euclid right before he had to do some big debate to kind of sharpen his mind type thing.
So, in those days, the, you know, even in this is,
1800s, the, it's… the idea that this would be a, you know, that Euclid was a book for the experts, distinct from a book for the general intellectual person, wasn't really a thing. I think that this
That distinction really probably got started
More… well, when the academic journals got started, that was in the 1600s.
But by the 1700s, when things were being published in journals rather than in books, I think perhaps there was more of a distinction between the journals that were intended for an audience that was really the experts, as compared to the general public who could just go to a bookseller and buy the book type thing.
You know, I have to say, when I wrote my big book, A New Kind of Science, published in 2002, I kind of had this issue. Who was I writing for? Was I writing for some small but undefined kind of group of people, since the point of my book was to introduce a new kind of science, almost by definition, that meant there were no experts in that particular area. I mean, there were people who had actually followed things I'd done in the 1980s who, had… were certainly on the… on a good… should have been on a good on-ramp.
for that kind of science, but it wasn't, that was sort of a small piece. So what I ended up doing was trying to write something which was intended to be readable by the general intellectual public.
In addition to by the experts.
And I think that worked really well. I think the number of people who've told me and who I can see were kind of influenced by that book and understood what was in the book was very large. It worked really well. It had a bit of a backlash in the following sense, that some of the sort of expert scientists were like, wait a minute, this isn't as hard to read as it's supposed to be if it's an expert science book.
How can it be saying something that's important to me as an expert scientist if I can actually understand what you're saying?
And, I think that's a… that's a kind of a strange, kind of backward phenomenon of modern times, that the way I see it, if you really understand what you're talking about, and really put the effort in, you can make even very, sort of, what start as very complex ideas, things which are
Things which are really understandable to people who want to put in the effort to understand them.
You know, it's something I'm remembering back when I was probably 20 years old or something, and a young
physics person at Caltech, I gave some fancy colloquium or something about some topic about cosmology. It was a fairly interesting topic, I thought.
But a thing that was kind of one of these comments people make that stick with one, somebody who was a graduate student, I think, there, afterwards said to me, you know, the thing I was most impressed about that talk was that I understood it.
And… which I thought was a, you know, I've repeated that comment to people since, because I think that is a thing that, you know, one should be impressed by that. But there's a certain

tendency for some people to say, no, no, no, science is a closed shop, you shouldn't be impressed unless it's so complicated I can't understand what you're talking about.
Which is kind of a paradoxical, in my view, a very… the wrong interpretation Of, of things.
So, but in terms of, you know, what happened, I would say, in…
the 19… well, 1980s, particularly, there started to be this kind of strand of science communication sort of separate from the… the doing science. Now, there was some of that before… before that time. I mean, in… in… well, if we go back
to…
go back into the 1700s, 1800s, and so on, you certainly find people who were saying, I'm not really trying to tell you something new, I'm trying to explain something that already is there.
One of the things that one is always hard to understand from history is, if you look at the books that people know about from, let's say, the early 1800s, it's a certain selected set. If you say, I'm going to look at all books that were out there in the early 1800s.
you see a lot of stuff that's really pretty terrible, that's, like, it didn't survive, and there's good reason it didn't survive. It was kind of fluff, it was…
ponderously talking about things in very weird ways, and so on, and just not… you know, it deservedly didn't survive. But that makes it a little confusing what was really going on there, because you don't see the whole story.
Now, I would say that, by the time, well, for example, for Charles Darwin, you know, Huxley became sort of the explicator of Darwin. And Huxley, for example, was part of a movement in England, sort of an interesting historical thing, that, the,
Trying to remember all the details of what those things were called, but this is, kind of mid-1800s.
And… there was, in England at the time, there were the fancy universities like Oxford and Cambridge.
where a certain set of rather gentrified people would go to those universities, often still intending to be, you know, going to the church, going to the law, whatever else. But then there was a… the Industrial Revolution.
Had, which, you know, is sort of started to happen around that time, was sort of minting a whole, whole different classes of people. And, you know, it wasn't just folks working on farms, it was people sort of in the cities working in factories, and it was people managing the work in factories, et cetera, et cetera, et cetera.
I don't know the full dynamics of what happened, but there started to be these, oh gosh, what were they called? I think they had some terrible name, like, working men's Colleges or something, which were kind of the precursors of later polytechnics and things like this.
But they were things where people who were, you know, working at the factory during the day or something would, in the evening, come and hear lectures about interesting intellectual kinds of things. And I think Huxley was much involved in that kind of movement.
Of, sort of, spreading intellectualism among more than just the gentrified classes and so on.
And that was, that was something that… that eventually turned into
you know, actual universities and things in places like the UK, but I think that led to a sort of… a type of presentation of material a little different than had existed before, because it was kind of trying to present to the intelligent, but not necessarily educated folk
As opposed to people who were sort of expected to have gone through a certain educational path.

And, you know, I don't know… I think there were… there were plenty of books that came out of that kind of thing, and that continued into the 20th century, and there were certainly people who were known as expositors of science.
as much or more than, sort of actual scientists. Actually, going back to the 1800s, I'm remembering that one of the well-known expositors of science was Mary Somerville, who was sort of first
came to notice as a translator of Laplace's Celestial Mechanics book, and then started writing, sort of, books of her own, sort of explaining things about science. This is now 1830s, maybe. that kind of time frame. Ada Lovelace was sort of a bit of a mentoree of Mary Somerville, and saw herself potentially going in that direction of becoming an expositor of science. So that was sort of a thing of that time.
I have to admit, I don't think I've read anything that Mary Somerville wrote, have I? Not sure. But, I have the impression that she did a good job of explaining, kind of explaining science, so to speak, to the general, you know, intelligent person.
I think in the 20th century, well, people like George Gamoff.
was a kind of well-known expositor of physics. You know, in the end, Albert Einstein sort of got into the act, writing little books like The Meaning of Relativity and so on.
I don't know to what extent the typical high-end scientist of the early 20th century, I don't think most of them
Well, I think… well, I'm not sure. I think most of them were not really involved in the exposition of science to the world at large. I think they were mostly involved in just the doing of science with scientists. Now, there were some exceptions, like I think Ludwig Boltzmann.
Most known for his contribution to physics, but later in life, actually themed as a philosophy professor, he did give public talks, I know, that were sort of intended for the general public about, kind of, the concepts of science and so on.
So, I think, but the real, sort of, in the 1980s.
There started to be a whole, sort of, industry of popular science books written by, sort of, oh, if you'd done some science, well, then you could, the theory was, make some money by writing a popular science book.
The most notable of those was probably Stephen Hawking's Brief History of Time, which was a very successful book.
I think, there was sort of many… there were many, kind of, other sort of efforts. So the interesting point was that there have been different sort of traditions in the way that science exposition worked.
One had been, sort of, even the Mary Somerville tradition of, I'm not trying to be a scientist, I'm trying to be an expositor of science. People like George Gamoff, a little different.
Because he was a physicist.
very much involved in things like alpha decay and radioactivity, and involved in the early thinking about how stars work, and things about the Big Bang and the early universe and so on.
But nevertheless, he was writing, I think he had a whole thing about Mr. Tompkins
It was a Mr. Tompkins in paperback. I think Mr. Tompkins was kind of a figure who was experiencing physics in various ways, but those were sort of intended as popular books, so to speak.
And then there were people who were sort of, as I say, there was this sort of question of, was the science of exposition written by scientists, or was it written by people who were reporters of science, not doers of science?

So one of the bigger, sort of, areas where science exposition happened in the middle part of the 20th century was the magazine Scientific American, which, had a very definite model. It had a, Gerard Peale, I think, was its editor for a long time, and he had this particular model.
Which was, find, sort of, the top scientists around, and work with them to get articles written with their bylines.
And when I was a kid, you know, I read many of these articles, and they were really pretty good. They were, you know, they were sort of frontier descriptions of things going on in science, with the sort of insight that you would expect from people who were leading people in the field.
Now, often, sort of the giveaway was, those people would write their one article for Scientific American and nothing else that was general public exposition.
Years later, 1984 it was, actually, I ended up writing an article for Scientific American, and I came to understand what their process was, which was sort of ask the scientists, sort of interview the scientist, and then their editors would try and write the piece, and sort of say to the scientist, is this correct, is this not correct?
I kind of rebelled, for various reasons. My setup was a bit different, and I kind of insisted on writing every single word of the piece that got published under my name instead of American, which was actually a pretty good piece in the end, and I think it was probably helped by their editorial poking,
was actually the piece in which I introduced the term computational irreducibility, which is kind of a… and I think that the effort for me
to do that exposition that was intended for the general public was very useful in sort of crispening up my ideas. I don't know whether other people found that. But in any case, that was sort of the tradition of the, well, from the 1960s to the mid-1980s, I would say.
Later on, that magazine became much more commercial and, kind of, I think, lost its way.
But, and I think stopped doing this kind of get the leading people in the field to try and write things more… it was kind of get journalists to write things and so on, or get people who are sort of themed as expositors of science to write things. Probably less work for the magazine, but less of a unique and good contribution to things one can understand in the world.
But then… There are… there's this whole, kind of, raft of,
Of books, particularly circling around this literary agent who I knew for many years, John Brockman.
Who would just sort of go to scientists and say, you're a scientist, you can make some money by sort of writing a popular book about what you're doing.
Sometimes that didn't end well. Often the books were really not very good, and but it was a thing that led to a sort of a lot of shelf space about science, and a kind of a concept of the popular science book.
it was a concept that, when I started writing New Kind of Science, I really wanted to understand, did this make sense? You know, what was I really doing? And the book that I wrote was not of that type.
Because it was a book of primary science that I had gone to the great effort to make understandable to the world at large, which I liked. It helped me write a better book to have that constraint. I think it's helped the world to understand more science to have done that.
Let's see…
probable is commenting, I would surely mention Aristotle and Plato. They were surely among the most cited thinkers in Western history. I agree, I was going to mention them. I thought Archimedes was a more interesting example, because what Archimedes wrote was more

technical and less, kind of, you know, less obviously presented for people at large. I mean, both Plato and Aristotle
We're kind of writing for people at large.
they were not… there wasn't really an imaginable sort of in-group that they were writing for. I mean, it's worth remembering that Aristotle
you know, was really, sort of pushed by, through Aquinas and people like that, by the end of Catholic Church, and had not been as widely read until that time.
I think that… but both… both of those folks, obviously did, did a lot to kind of explain what they were talking about, and, and their works are still perfectly readable today.
Lindsay is asking, back then, how did scientists even reach the public without TV, podcasts, or YouTube? Boy, how the world changes. They mostly wrote books.
I mean, that was the books, and to some extent, public lectures. Now, in population centres like London, there were sort of traditions of public lectures, like the Royal Institution in London.
is a place where there were, routinely, public lectures. Like, Michael Faraday was in charge of the Royal Institution for a while, and he gave these kind of, I think, very good sort of exposition of science lectures, you know, some, I don't know, some evening every week.
In, I think it was probably his analog of, of my live streaming efforts was, showing up every… I'm making it up, Thursday evening or something, and, in this lecture room, which actually I happened to visit just recently, it's a, it's a very… it's one of these very,
sort of amphitheater-type lecture room. It's not a huge place, but it's something where it was a… very much a theater where you could see what was going on, and I think Faraday would show up and do experiments. You know, the Royal Institution was a place which had sort of some resident scientists, and sort of right behind the room where these presentations were being given, there was a lab.
And so I think Faraday would just bring out his, you know, candle or something that he was demonstrating, and say, let me show you this demonstration to this theater full of people. Now, sort of that motif of the theater full of people, very much an amphitheater kind of setup, I have to say, one of the pieces of that sort of
Theater presentation of science was something that is a very grim piece of history, which is medical operating theaters, where sort of surgical operations were done sort of in public view, as sort of a way to let
the, you know, the doctors-to-be, so to speak, understand what might happen if this or that thing was done. So that was kind of a motif that sort of carried through to these sort of ordinary, you know, these scientific demonstrations.
But, Yeah, so, I mean, I think it was books, it was, there were also,
journals that were more like magazines, more like, kind of, the New Yorkers of their time type thing. I mean, I think,
why am I thinking of Ladies Home Journal was one, I think. But there were others that were… were, often very,
a lot of British ones, probably ones in other countries as well, where they were kind of, they would publish, sort of, articles on a variety of things, and sometimes those were scientific articles.
I think… the,
But as I was saying, in population centers like London, there were definitely series of lectures, and then New York and so on, there were series of lectures which were, sort of, concentration points

for, for essentially the exposition of science. The same was true, I mentioned these kind of things, I think they were called working men's, something around those.
Those were much more in the north of England, for example, in the places where the, where the factories were in the Industrial Revolution and so on.
Now, I know that, there were other things that were going on, like, for example, there was a famous, debate between Huxley and a chap called Wilberforce, that was about theory of evolution.
And, amusingly enough, those… I know where that debate was, because it was in a lecture theater in Oxford, where I happened to give a talk sometime back in the 1990s, and I was… just noticed this plaque.
saying this was where the Huxley-Wilberforce debate took place. And I have to say, it was… it would have been better, perhaps, if the… if the event
that I was doing there had turned into some elaborate debate, but it wasn't. It was, it was, talking about technology we made and so on. Nice audience, but, not probably the same as the type of audience that was there for the Huxley-Wilberforce debate. But that was something where… was kind of a… I know that was sort of a public debate that was in Oxford, so not quite in the sort of center of things in London.
And so on.
I think that, the fact that it's possible
to do things like livestreamed discussions of things. My… my version of, kind of, the Faraday weekly, you know, demonstration, I suspect his were… were… well, his will have been prepared. I would assume, I don't think he will have done
Well, you know, he will not have gone unprepared and started saying, let me show you how magnetic lines of force work. I bet he tried those experiments first.
let's see… I will say, social media, is an interesting case, because when my book, New Kind of Science, came out, that was before social media. It was 2002, and there wasn't really energetic social media yet at the time. And that meant that… that actually
had a bad dynamic, because it meant people could, like, write things, and they would say, you know, write some review in some place, and say, oh, I don't believe this or that, whatever it is. There was no way to respond to that.
Had social media existed at that time, a lot of those kinds of, wait a minute, how does this possibly work, would have been answered very quickly. As it was, it took a lot longer for those things to be like, yeah, yeah, that…
The book answered that already, you just didn't bother to read that part of the book type thing. But that took longer to work through, and it would have been faster, more efficient with modern social media, despite the fact that there would have been all kinds of insanity probably said on social media as well.
Let's see… Pauline is asking, is it okay to simplify science if it helps more people understand it? Here's the big challenge. If you're trying to explain some complicated idea, I…
Go to a lot of effort.
To say something which is correct.
But… to not dive into all of the footnotes and details. Like… I'll say…
Such and such a thing is largely blah blah blah blah blah.
Okay, that largely hides 3 pages of footnotes that an expert might say, you know, yes, you've got to talk about those things, but if you talk about those things, then nobody understands what

you're talking about. But if you don't put in the word largely, and you say, blah blah blah is blah blah blah.
Then, experts will rightly say, hey, wait a minute, do you know what you're talking about?
But what I've found is that with effort, it's possible to say things so that they can be understood, because, you know, the person who isn't the expert just reads right through the word largely.
And just, okay, that's what it basically is. And they don't care whether it's, like, true in every single case, or whether that's the basic story, or whatever. The experts do care about that, and they see the word largely and say, okay, yeah, he's hiding a bunch of footnotes there.
And, you know, what I found is with effort, you can explain science correctly, Without dumbing it down.
By, sort of, being careful about where you tread.
And I believe very strongly that that's the thing one could do, and I put lots of effort into doing that myself. I think it's worked pretty well.
So, I think that people who say, you know, I don't know, let's take an example of, take almost any example, I mean, I don't know,
What is a good example? I mean, most science, and I've certainly done this a lot in these livestreams, you know, it's complicated. There are footnotes, there are issues, there are… it's not a straight story.
It's like, and sometimes there are things one doesn't know, and it's like, well, you know, one has to say, this is what one knows, this is what seems to be true, and, you know, then if one can describe what the boundaries of knowledge are, that's good.
I think, quite often, people get themselves in trouble because the people who are explaining the science don't know the boundaries of knowledge, and so they very confidently assert something that is actually… has an awful lot of footnotes and an awful lot of bounded knowledge.
But they're just asserting it, and they're doing it in a way that, oh, this must be true, and so on, and it makes the whole thing… it's sort of… it sort of… it… it…
It's misleading, it often leads to terrible problems, because people come to believe that in the public sphere, so to speak, and that's really not what the science says.
Let's see, Powell is asking,
Pauline is asking, which old-school science communicators would do well on social media today?
Oh, I have no idea. I mean, I don't think I know… I don't think I know social media today well enough.
I would say that, Aye.
Yeah, I really don't know. I mean, I think,
You know, I think Socrates would have done well in social media.
from what one knows of Socrates, from what Plato wrote about him. You know, I think some of these wits of old would have done well. I think, you know, maybe Democritus, very few of his works have survived. He's one of the early people in atomism.
He was, he was always, I think he was characterized as the, the, what was it, the merry philosopher or something.
you know, always kind of being very upbeat about things. I don't know, but, so I'm… I'm not sure about that.
Probable has asked, do you think popularizing science to the public has improved the quality of science? They say, because I see a big gap between scientific journalism and actual science.

for me, my efforts to explain science have definitely improved the science I've done. I mean, I mentioned the fact that… the fact inventing computational irreducibility
as a result of trying to explain what was going on, at least I think it's true that I invented it for that purpose. It might have been a paper that I wrote right around the same time, I'm not sure. But it certainly appeared… I think it appeared first in that article inside of the American, and sort of the effort to say, what is the real point?
was an important one for me, and was forced by the need to do exposition, or the desire to do exposition. So I think it can be a very powerful tool for making people reflect on what is the actual point.
It can also be a thing where people sort of just peel off from the science the exposition layer without letting that feed back into the science itself, and that's a different kind of thing. When it comes to science journalism, there's good science journalism, and there's lazy science journalism, as there is in almost everything.
And, you know, what… I see… I mean, one thing in modern science journalism is that… it's… well, there used to be a lot more science journalism than there is today. It was very much more popular in the 1980s, 1990s. It kind of shriveled up a lot in today's world. There are blogs that are good and so on, but the actual venues for… you know, there used to be a lot of magazines where, you know, science journalism was published.
Newspapers used to have science columns and so on. Very few do now, today. I think it's not… and that was probably a self-inflicted wound by science, that those things became not very interesting, and so on.
And I would say that there is, you know, there's science journalism which… Sort of just… there's science journalism that really makes a good effort to explain things, and there's science journalism that's just sort of who… sort of who, what, when, where, sensationalistic statement type thing that I don't think does very well.
I mean, I think the thing that is a little complicated is that there's a certain amount of money flow going on in some science journalism.
Where, you know, it'll be some…
Oh, whether it's a pharmaceutical company or something else that's sort of promoting some particular angle in science journalism and sort of sponsoring those kinds of things. So I don't know… I personally don't know all of that money flow, but I think that that has not helped, kind of, some of the quality of science journalism.
I mean, it's also the case in,
you know, doing good exposition is hard work, and not so many people are signed up to do it.
And I think in, so, I mean, I think that,
that's… that's a, you know, that's… science journalism is not in particularly fine shape, except in things like blogs and so on, where I think quite a lot of good stuff gets… gets written.
Lindsay asks, was reading and writing a necessity for practicing science, or were there people who experimented and relayed ideas to others?
I would strongly suspect that most science developments that we know about through history were by people who were very much literate and could write.
I think… that…
There was a certain amount of folk information that was known by the trades, the guilds, and so on, in

in the Middle Ages, for example, where, I mean, some of those people absolutely knew how to read and write. I'm not sure that all of them did. I would be not too surprised if some people who discovered, you know, chemical processes.
metallurgical kinds of things were artisans who weren't particularly reading and writing type folk, and that what they did was then harvested by other people, but I don't know that for sure.
Pablo was asking, how did they write their texts? They said, when I write something, I need to delete and correct it 100 times. How did they do that with ink and paper? Well, back in antiquity, people had, you know, wrote on wax tablets and so on, and, you know, I think you could scratch it out after you'd written it.
I mean, back when I was younger, yes, it was ink and paper, or typewriters. And what were the mechanisms? Well, I can tell you the mechanisms.
in,
for… there was this lovely liquid, which, at least in England, was marketed under the name Tipeax, and it was a white
stuff.
That you would… when you wrote a word you didn't like.
You would get out this little bottle of Topex, it smelled rather, rather, pungently, and, you would sort of paint over that word, and it dried pretty quickly, and then you could write over that word.
And that was sort of a way of correcting what you were doing. Now, when I wrote, for example, the manuscripts of early papers of mine, which I still have, what I tended to do was I would write a paragraph
And then I would have these, these, labels, you know, sticky labels, I guess often in the US at least called Avery labels.
That, I would, you know, sometimes I would cover up a word, and sometimes I'd be thick in labels, because I'd corrected the thing many times. And then sometimes I would take a paragraph from my text that I liked, and I would cut it out with scissors, and I would stick it on with scotch tape onto another page, and sort of assemble this whole, whole thing.
from those pieces. And then, to kind of clean it, I would put in a photocopier and make a copy of what was visible on that, on that sort of stacked page.
When it came to typing, there were… you could either use kind of a little… these little sheets of white
that, so ordinarily on a typewriter, you have the sort of hammer thing of the typewriter that's hitting a ribbon that, like, say, a black ribbon that hits through the black ribbon onto the paper.
But you can also, instead of doing that.
You can have these little pieces of white paper that are like a white, sort of.
fragment of a ribbon, you put that in place behind the ribbon, then you press the key on the typewriter, and if you typed a G before, it will make the exact same impression of a G, but now the impression of a G will be sort of printed in white ink, and will white out the G you typed before.
And sometimes some electric typewriters, like IBM Electric's electric typewriters, actually had a backspace key that used a white ribbon to go and erase what you had… what you'd previously typed by just filling it in with white.
So that was a mechanism. It was, I would say, less effective than hitting the backspace key, but it was nevertheless a thing. When it came to, to things where you would just handwrite them out, and as I say, for me, my technology stack

was literally stacks of paper scotch-taped onto pages and things to deal with the corrections. But if you were doing something like you were writing some school essay or something like that, I think most people would just cross things out. I did tend to use this whiteout
liquid, for whatever meticulousness reason, I don't know. But that's… that's how it was done back in the day.
And also, people… back in antiquity, as I say, people were often writing on these wax tablets, where you could literally just erase what you'd written. Also, one tended sometimes, I didn't do this very much, but people would write in pencil
And then erase for a while, and then, after they'd written, the, the thing in pencil.
they would ink it in. In fact, I know, for example, Ada Lovelace, the things she wrote,
the letters where she wrote, you know, she'd obviously been writing the thing in pencil, and correcting it with an eraser, and so on, and then at the end, she would ink it, and she had her husband ink some of her stuff.
And that was, you know, it was like the husband is helping, you know, he's inking my, my paper, so to speak.
So that was… that was a thing people would do as well.
Let's see…
Greg asks.
Did people back in the day argue about science the same way we do now, or did everyone just accept what the authorities said?
Well.
That was… the question is when and who were the authorities? I mean, the fact is, I think Francis Bacon, this 1500 or so, was… was like, we'll just say it's science, and then people will believe us. That was, I think, a thing he pitched to Elizabeth I at some point.
I don't know how that really worked out in that case, but no, there was… there was plenty of public debate about things. I mean, the… the main entity that was kind of like, let's tell you, we'll tell you what's true, and that's all there is to say about it, was the church.
Where there was a lot of, particularly, I would say, the Catholic Church was like, we have this schtick.
And this is what's the case, and, you know, it's written in the Bible. Every other religion had the same kind of thing, you know, it's written in the Quran, whatever else.
that's the story, and that's… I mean, some religions, I would say, are probably more argumentative than others. I mean, my impression is, you know, the Jewish religion, for example, is a bit more argumentative, a bit more of, like, no, no, no, we gotta argue about it, rather than, you know, what's written in the sacred book is what's the case. Maybe I'm wrong about that. That's just my impression from a little bit of a distance.
But in any case, the, you know, the Catholic Church, for example, was very much, sort of, this is the story. Now, I think for the Catholic Church, the, you know, a lot of what's written in the Bible, let's say, was, you know, what was important about it was the way to conduct one's life.
it was sort of backed up by… and there's a theory of science that's in here as well, and we get credibility from the fact that the book starts with the creation of the universe type thing, or the Bible starts with the creation of the universe kind of thing, and… but I'm not sure that was… I think that wasn't really
the main point, so far as I could…
could tell of, you know, the main thrust of what was being communicated, but it sort of… it removed the authority of the church. If somebody was saying, well, actually, the stuff that's in

the first book of the Bible is nonsense, you know, then it's like, well, how are you supposed to believe all the other stuff that's written there, too?
So, you know, what happened in the 1600s, well, this had started a bit earlier than that. I mean, the kind of… it's sort of… there's science, and it's saying different things than what it says in the Bible. And how is this supposed to work?
And, you know, Copernicus, Who was,
This is 1500s, was, you know, was a, was a priest, was a cleric. And, you know, he didn't want to publish his book about the revolutions of, of the planet, so to speak, until he died.
You know, he thought it was too kind of incendiary a story.
Well, then Galileo, in Italy, picks this up in the 16…
what was it? Probably early… first decade of the 1600s and so on, and says, this is great!
And Galileo was a… was a, I think, a rather much of an activist kind of guy. Small, red-haired guy, very pugnacious fellow, I think.
And,
Not that that physical manifestation, you know, tells one that, but kind of gives one a little bit more of an image of the, you know, Galileo, the fighter, so to speak, showing up in different places and going around the place, giving sort of fiery lectures about how, you know.
the Earth is going around the Sun, and what it says in the Bible is wrong.
Meanwhile, there were fiery, sort of, priests going around, giving speeches about how what it says in the Bible is right, and Galileo is full of it.
And that kind of Galileo sort of brought it upon himself that he ended up in a sort of pitched battle with the church.
And I think that was an example of where, kind of, who were people supposed to believe? You know, Galileo, the fighting scientist, or the thousand years of history of the Catholic Church, or whatever. And I think, kind of, the notion of that
Kind of, that… that tension between the scientists and the… the then-established, kind of, the church.
was something that sort of echoed down the centuries. I mean, that was, I would say, in England, at the time of Darwin, that was the next sort of big, big poke, I would say, of kind of, you know, what it says in the Bible isn't literally what happened type thing, or what people, you know, infer that it says in the Bible.
isn't what actually happened. I mean, I don't think that the, you know, when you, when you read, you know.
the opening lines of Genesis, and you imagine, how would somebody describe, you know, the Big Bang or something, using, sort of, Hebrew of, of, you know, the, you know, millennium BC, or something like this? You know, what would you write?
You know, you don't get to write things about how the, you know, this was a high gravitational field, high temperature, you know, whatever thing.
You know, you have to write it, even if you knew what was going on, which of course one didn't at that time.
It was, so, you know, the fact that one is writing some origin story, and that origin story is necessarily couched in terms
that are, you know, very… they're not the terms a physicist of the 20th century would use, is something to realize. It's, you know, it's not really intended to be something of the type
that should be compared with, let's say, 21st century physics, or something like this. But in any case, I think the next

kind of big poke.
was, you know, the whole Darwin story, and I would say that in the UK, my impression is that the UK was, you know, the UK's whole religious story had been damaged, even from the time of Henry VIII.
Because, the, the, Second.
The, Because,
because of the break from the Catholic Church, where the Church of England was created, which had a somewhat different character from… from kind of the… the main line, I think, of the Catholic Church. But I think by my… my… my vague impression is that, sort of, the level of Of, sort of, precise
adherence to kind of, you know, the Bible describes science thing was already a bit decayed in the UK, by the late 1800s. I think in the US, there were certainly components where it was much less decayed.
And so, notably, you know, from 100 years ago now, the SCOPS trial was an example of, kind of, that… that sort of conflict,
Just one second.
Puh.
the, you know, my impression of that… that story… so, the story is this. The, I think… maybe it was the ACLU, American…
Civil Liberties Union… I got that right. Maybe an early version of that. Was… kind of…
the question was, you know, was the sort of religious story of the Bible and the… and so on, was that kind of the right story or not? And it's like, let's have a showdown of,
of kind of the traditional folks who believed in that with the modern scientists. And so, sort of a collection of celebrity folks on each side, kind of lined up.
found this, fairly sort of unassuming school teacher in Tennessee, I think.
And, you know, showed up for this kind of celebrity trial of could this person, was this person allowed to teach the theory of evolution in public schools in, I think it was Tennessee.
And, the,
you know, that was a messy kind of story, but it was also a story which… which was very much a put-up story. I don't think that was really the full zeitgeist of the times. I think it was a story that was sort of a manufactured story. But I think that was… that…
that was probably a watershed point for, kind of, were the… the cold scientists going to win against the, against the kind of, sort of, religious fundamentalists and so on? You know, I have to say.
When I was a kid in England, I was,
I was at boarding school at Eaton in England, and sort of a fancy top school, and every Sunday, there would be these folks who would show up on the street with these big placards about various kinds of religious
you know, ideas and so on, and a lot of… a lot of stuff about, you know… I don't even think they referred to Darwin. It was just like, you know, the world is 6,000 years old, which had been some estimate of some… some… based on some Bible extrapolation and so on. And they would show up.
and the 12, 13-year-old, 13-year-old me or something would… for a while, I was like, wait a minute, this is just nonsense. I'm gonna debate these people. But I learned very quickly that
You know, you would make some point.

And they were just… and eventually, I think that the moment at which I sort of gave up was they're like, but we just don't believe in logic.
You know, logic is one of these things that's a creation of science that we just don't believe in. And it's like, well, that's my worldview, and if you really don't get that part of the worldview. you know, we can't talk, more or less, and so I gave up. But it was sort of interesting that this was in the early 1970s, that was still very much a thing, maybe it still is a thing, I don't know, that that was a, you know, that that was sort of a thing that was going on.
Let's see…
Okay, RBS comments, referring to my comments about social media. Social media did exist, pointing out internet relay chat.
If it can be considered social media.
And, RBS comments that they actually heard about cellular automata and me first on Internet Relay Chat. I don't think I ever used Internet Relay Chat. I used, I mean, if you… the ARPANET, which was the predecessor of the internet.
Which had 112, or was it 256 computers on it?
I started using that in 1976.
And I mostly used a computer at MIT. I was based in England at the time, but you could just connect to that computer. It was computer number 236 on the ARPANET, and you would type at 0236, and you would get connected to that computer.
On that computer, there was always a kind of a, you know, there was a chat system, and there was an email system, and you could communicate with people. That computer was based at the MIT,
lab… what became the lab for computer science. I think maybe it already was. But,
it was always kind of characteristic of what it was like. You would log into the computer, and it would always say, you know, welcome to MITMC, or whatever, and it would always say something like, 17 losers, L-U-S-E-R-E,
S, you know, L users. And, you know, somebody… that was somebody's idea of a joke, that that was the number of users who were currently logged into that timeshared computer, but it was always such and such a number of losers. And there were a lot of other kind of whimsical aspects to, to that,
to that computer. I do remember that when I first logged into that computer, sometime in 1976, I was 16 years old, and, I, was, you know, it said, create an account.
And so I thought, okay, I'm gonna be SW.
And, but that was taken.
And so I picked SWOLF, S-W-R-F, which for many, many, many years was my… was my login on computers. And many years later, I… did I meet, or did I run across the… the person was an administrative person at MIT, I think.
Sylvia Wood, something like that, I don't remember, who was the person who got the SW handle on, on that, on that computer. But yes, those things existed at that time. There's certainly messages that I certainly still have copies of that I exchanged with people on that computer. By the time
There were… by the time there was… Well, there was email
more global email that existed that I was certainly using by,
beginning of the 1980s, I was always much more connected to the kind of
professional, sort of scientific use of computers, and not so much to the home use of computers. Like, I never had a personal computer of the Apple II,

Atari, et cetera, family. I… at the time when those computers were the thing, I was using mostly minicomputers, that were, like.
quarter million dollar minicomputers that were big things, you know, that got bought by government contracts and so on. And then later on, by the… by 1980,
3 or so, I was using workstation-class computers, which were sort of things that sat on your desk, and were vastly more powerful than personal computers, and I really… I never really used personal computers. I had,
for, I bought an Osborne 1, which was the very first, supposedly portable computer about the size of a small suitcase, and, you know, you needed to plug it into the wall, and it ran, the, ran an operating system called CPM, which was kind of a predecessor of the MS-DOS operating system.
And, it had, you know, it wouldn't run unless there was a floppy disk, unless you had sort of a boot floppy in one of its floppy disk drives and so on. It was, but I… and I used it a few times to do word processing, but not for more than that.
And I… I really… I kind of missed the early personal computer era, because I was using kind of professional-grade computers at the time. And so I think I also missed the sort of early, kind of, early interactions on the internet that were kind of, you know, sort of,
public discussions on the internet, and… and for me, it was only kind of email, that was going, because for a long time, there was email at universities and things like this, but there wasn't email. It was,
what was it? CompuServe was a thing which was sort of an early, you can dial up to get access to the internet. I never had a CompuServe account, because my connection to the internet was always through, sort of, professional connections to the internet.
I think, you know, there was a time, this was, oh gosh, even into the early 90s, there was a time when at bookstores, or at software stores, they would be selling these things, like, you know, web browser software on floppies that you would…
connect up to your computer and use modems and so on to connect to things like CompuServe and later AOL, America Online, and so on. I have to say, I missed most of that stuff. I really wasn't using it at that time.
Let's see…
There's a question here from Ollie, perhaps referring to what I was saying earlier. If a scientist disagreed with traditional religion, could they say so openly? It was very place-dependent.
I mean, I think that…
for example, the Netherlands were a place of, of, sort of where there were lots of dissenters who went there in the 1600s and other times, where kind of… I mean, I think it's sort of ironic that certain things there are now more locked down than other places.
But back in those days, my impression is that, you know, if you kind of didn't agree, you could go there and people wouldn't hassle you.
And that was true in some other places as well, but there were plenty of places where, you know, if you didn't agree, that was bad news, and of course, it's still true in the world today. I think it's a very place-dependent thing.
I think that there were people like Isaac Newton, for example, had a rather wacky view of religion. I mean, to be a professor, as he was at Cambridge University at that time.
you had to kind of sign on to various kinds of religious principles. In fact, it was true up until the 20th century, until into the 20th century, that at Oxford and Cambridge, you kind of had to buy into certain

religious principles if you wanted to be a fellow of a college in those places. And so I think Isaac Newton, for example, had a… had a wacky view of the Holy Trinity.
that he kind of hid from people, because he didn't want, sort of, that to be… to be an issue, but, but he wasn't, you know, so… so that was a case where, sort of, that was something he… he suppressed. I think…
in… it really is very much dependent on time and place. I mean, I think if Galileo had been living in the Netherlands at the time when he was living in Italy, I don't think anybody would have hassled him.
I think that, in, you know, I don't think…
you know, somebody like Huxley in England, sort of, going bulldogging against religion on behalf of, sort of, Darwin and evolution and so on, is, you know, I don't think anybody, you know, people were debating him, but nobody was trying to burn him at the stake or anything like that.
Certainly at other times in history, you know, people who had, sort of, un… you know, scientific views that went against the orthodoxy, you know, would literally get burnt at the stake.
And I think that that's… and that was, you know, it was a, forget kind of the cancel culture of more modern times. That was… which is, you know, that was a much more extreme version of… of that, I suppose. But, you know, it's…
It's somehow the, this question of, you know, to what extent can people say what they believe, and people will debate them and argue with them, versus people
trying to lock them up, or whatever else. That is, you know, that's a thing that has changed through history, and unfortunately, one might hope, I would hope.
That, sort of, the world gets to be more of a place where people can say what they think, and then debate it if people don't agree. But unfortunately, it's not… certainly not a uniform trend in history, that that's become a,
a thing one could do. I think that in terms of, sort of the, the, the, the…
Sort of religion and science and, I would say that by…
The early part of the 20th century, the…
I think there was a certain subset of scientists who were very much, you know, I believe in religion, and I do science, and they don't particularly… there's no particular conflict there, but there were an increasing number of, kind of, the I-don't believe in religion type scientists.
Growing up, starting in the 20th century, in the 19th century, I don't think that was the case. I think most scientists would have had a sort of generally positive view of religion, and so on.
I think that, sort of, the moment of, kind of, atheism in science or something probably peaked in the 1990s,
And, you know, a lot of, kind of, everybody was making, sort of, a big, sort of, cause out of, you know, could one talk about, sort of, religion and science and their conflict, or whatever else, if there was indeed a conflict?
And that was, you know, that was something people were very, sort of, talked about a lot, particularly in the 1990s, I think. My impression is
that people just… maybe I'm too much of a kind of a simplifier of this, that sort of it's like, people think religion has things to say about certain kinds of things, science has certain things to say about certain kinds of things, and there might be some overlap.
But it's not, you know, they're not sitting on top of each other. I mean, I have to say that when it comes to what was said about, kind of.

biological evolution and the sort of Darwin story and so on, I think the scientists kind of really overplayed their hand.
Because they were sort of saying, look, you know, everything that happens in biology is the result of natural selection. Natural selection is the almost theological force that leads to the forms of biological organisms as we see them today. Say, well, how does that actually work? And it's like, well, you know, we can come up with anything, you know, the neck of the giraffe, the stripes of the zebra, the spines on the… the spikes on the stegosaurus, and we can tell a natural selection-type story about those things. You say, is that really the most important thing that happened that made the spikes on the stegosaurus?
Well, actually, I don't think it was. I think that there are many other dynamics of the development of organisms, and even things that I think I've figured out in recent years, actually, about sort of the mechanics of biological evolution and the relationship to computational irreducibility and so on, that explain how you get all this complexity in biology.
And when people were saying, it's got to be natural selection, everything is just natural selection. They frankly didn't know what they were talking about. And that was overplayed, and so it was not entirely wrong for people to say, wait a minute, scientists, you know, that isn't really, you know, there's something wrong with what you're saying. They were right, there was something wrong.
I don't think that the story was the fossils were put in the, you know, in the rocks 6,000 years ago.
That's not the right story, but to say the story as told by the scientists didn't really hang together was not a wrong thing to say.
And I think it's sort of a pity that there came this time where it's like, if you don't believe every chapter and verse of the biological evolution and natural selection story, then you're not a real scientist.
That was a mistake, that was an overplaying of that idea on the part of the scientists, and that's happened again with other kinds of things. And I think that's a… you know, when it comes to scientists who criticize
kind of religious orthodoxy, I think there is plenty of criticism to be given about scientific orthodoxy as well. I think the true stories tend to be more nuanced. I think I've tried to do my small part
In trying to tell those more nuanced stories, rather than just sort of saying, it's all on the side type thing.
Let's see…
Many interesting questions here. Let me just see whether there's,
A question here…
Okay, question from Pauline. How much stuff, how much science was lost because it wasn't written down, or because it was written on fragile stuff?
I don't think we know.
I think there are occasional big surprises, like the Antikythera device from 2,000 years ago, this cog-based computer that was found on a ship… from a shipwreck that wasn't really recognized what it was until the 1980s. That's a big surprise. Nobody knew that existed.
People thought that those kinds of devices had not originated until the 1600s.
And so I think the, there are no doubt surprises to be had. I mean, many of the books that Euclid wrote have been lost. Many of the, you know, we have almost none of the writings of Democritus, let's say.

You know, I think one of the things that's remarkable is that archaeology makes progress. Things get discovered. You know, there's this effort now to try and recover these, scrolls, maybe 10,000 scrolls.
that were carbonized in the eruption of Vesuvius in 79 AD, that, you know, with lots of machine learning effort and so on, maybe it's possible, and CT scanning and so on, maybe it's possible to reconstruct what was written on those scrolls, and maybe there will be lots of science that we just didn't know about.
That was understood. Now, you know, what ends up happening in science is that big paradigms get built, and often.
the science of earlier times really didn't stand a chance without that big paradigm having been built. And so even if people were sort of vaguely saying this or that, the real stepping stone, the real thing that you can build on didn't really exist at the time. And my guess is
There are not very many big scientific paradigms that have been lost. There are probably specific scientific results that absolutely have been lost. Whether some of those scientific results are deeply revealing, I don't know. I would tend to think probably not.
But I'm not sure. I mean, I could imagine…
Well, what areas could I imagine would have survived from antiquity? I mean, there are… there might be some processes, like, how do you make that… that kind of alloy that's really wonderful? My guess is that we're past that right now, that we know, you know, metal alloys we know better now than anybody knew, even at the time when they were making that… that amazing sword back in antiquity or something.
I suspect that there aren't areas where… trying to think whether there might be areas where there was, something that had been sort of figured out in antiquity and lost ever since that time. I think there would mostly be things where one would say, gosh, if people had taken that seriously, it would have changed the course of scientific history by hundreds of years.
For example, if people had taken kind of the idea of computation that was sort of implicit in the Anglicathera device, if that had been taken more seriously, we might not have developed the kind of mathematical approach to science that got developed in the 1600s, at least in the same way.
Angst says, To my knowledge, scientists from the current time have average income.
Was it always like that in history? It's an interesting question.
So… Who did science back in the day?
Mostly, people did science as a hobby, as I do.
mostly people made a living, you know, I think, you know, they had vineyards, they advised kings, they did things that were made a living some way, and science was kind of their hobby.
when did professional scientists start to develop? Well, it was, I think, a phenomenon of the universities, so the first universities were in the 1200s, but they were getting sort of more serious by the 15, 1600s.
my impression is, I mean, if you look at the scientists we know about, like, you know, Newton was a… Isaac Newton was a professional scientist for much of his life. He was the Lucasian professor of mathematics. I think he was, like, the third Lucasian professor, and so some chap called Lucas
had put up the money to endow the Lucasian Professorship in Cambridge.
And Newton did that for a living. Later on in his life, he became controller of the Mint, which was sort of a government, you know, the treasury-type position, and that was a different kind of thing.

But… and I would say it's an interesting question whether, you know, Isaac Newton
I don't think made a particularly good living from being the Lucasian Professor of mathematics in Cambridge.
I think when he died, he'd made a moderately good living, but mostly that was from his gig as controller of the Mint, where he actually, you know, it's kind of like finance business of today. He was close to the money, quite literally. He was, you know, dealing with the question of forging of coins and all this kind of thing.
I think I have to…
Let go rather soon here, yes. And, so… I think…
you know, there were particular gigs that people had, like Faraday had the gig of being at the Royal Institution. That was… there were sort of these various endowed gigs, and then at universities, and I think this developed more in Germany, where the university system developed, you know, in a strong way in the 1800s and so on.
This idea of being a Private doesn't, kind of a private professor.
where you would make a living by giving lectures to the people who would be at the university, and they would, you know, it was a pay-for-performance type thing. Forget, rate my professors of modern times. If the people didn't like their lectures, you just wouldn't get paid. The, and that was sort of a step. You had to get a license from the government
to be able to lecture, but once you had that license, you could collect this money from lecturing, and that was how people supported themselves. And so, you know, it's been a… the phenomenon of the truly professional scientists and so on, I think is… is… a lot of that is a post-World War II type phenomenon.
And, where… The, you know, the, the…
The government labs, the universities, supported by government money, things like this. And… the…
the kind of… the scale of, of, you know, how much do the scientists get paid? I have to say, when I was in the business of being a professor and so on, it was…
you know, I would say it was, as you say, it was a kind of average-ish income. I think that at the fancy universities, the sort of… the top professors started to get paid really a lot, and that happened probably 20 years ago, 25 years ago, maybe a little bit more. I mean, I remember the time when there was sort of the big shocker
of the first physics professor who got paid more than $100,000 a year. That must have been in the…
In the 1980s. Early 1980s, probably.
And, you know, but I think my impression is that for the top performers, it's kind of like there's a… there's… it's quite a lucrative business. And, it's,
Anyway, but it's an interesting question of, sort of how did people get paid to do science? Maybe that's a thing to address for another time.
Well, thank you all for lots of interesting questions. As usual, I had better depart here, and look forward to chatting another time.
Bye for now.