**Open science now!**

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Well, good afternoon, everybody. Thank you all very much for coming along today. I'd like to begin my talk with a story. It's a story that begins, but does not end, with a mathematician named Tim Gowers. Gowers is one of the world's most renowned mathematicians. He's a professor at Cambridge University and a recipient of the Fields Medal, often called the Nobel Prize of mathematics. Gowers is also a blogger, and in January of 2009, he used his blog to pose a very striking question: Is massively collaborative mathematics possible?So what he was proposing in this post was to use his blog to attack a difficult unsolved mathematical problem -- a problem which he said he would "love to solve" -- completely in the open, using his blog to post his ideas and his partial progress. What's more, he issued an open invitation, inviting anybody in the world who thought that they had an idea to contribute to post their idea in the comment section of the blog. His hope was that by combining the ideas of many minds, he could make easy work of his hard mathematical problem. He called this experiment the Polymath Project. Well, the Polymath Project got off to a slow start. In the first seven hours, nobody posted any comments. But then, a mathematician from the University of British Columbia named Jozsef Solymosi posted a short comment. And this seemed to break the ice, because a few minutes later, a high school teacher named Jason Dyer posted a suggestion. And a few minutes after that, another mathematician named Terence Tao, also a Fields medalist, posted an idea. And things really started to move quickly at this point. Over the next 37 days, 27 different people would post 800 substantive comments containing 170, 000 words. I was not a serious participant, but I was following along closely from the start, and it was just amazing. The speed with which an idea would be tentatively proposed and then really rapidly developed by other people and improved, sometimes discarded -- it was just amazing. Gowers described the process as being to ordinary research "as driving is to pushing a car. "(Laughter)At the end of the 37 days, Gowers used his blog to announce that they had solved the core problem; in fact, they had solved a harder generalization of the problem. The Polymath Project had succeeded. So what the Polymath Project suggests, at least to me, is that we can use the internet to build tools that actually expand our ability to solve the most challenging intellectual problems. Or, to put it in another way: we can build tools which actively amplify our collective intelligence in much the same way as, for millennia, we've used physical tools to amplify our strength. OK? So what I'd like to talk about today, or what I'd like to explore today, is what this means for science. It's much more important than just solving a single mathematical problem. It means an expansion in the range of scientific problems we can hope to attack at all. It means, potentially, an acceleration in the rate of scientific discovery. It means a change in the way we construct knowledge itself. So, before I get too overexcited, however, I would like to talk about some of the challenges, some of the problems. Particularly, I'd like to describe a failure of this approach. It occurred in 2005, or started in 2005. A grad student at Caltech named John Stockton had a very good idea for what he called the "Quantum Wiki, " or "Qwiki" for short. (Laughter)OK? It's a great idea. What he did with the Qwiki was -- the idea of the Qwiki was that it was going to be a great repository of human knowledge, much like Wikipedia. But instead of being focused on general knowledge, it was going to be focused on specialist knowledge in quantum computing. It was going be kind of a supertextbook for the field, with information about all the latest research, about what the big open problems in the field were, people's speculation about how to solve the problems, and so on. Like Wikipedia, the intention was that it would be written by the users, in this case, by experts in quantum computing. I was present at the conference at Caltech in 2005, when it was announced. And some of the people who I spoke to were very skeptical, but some of the people were very excited by the idea. They were impressed by the implementation; they were impressed by the amount of initial seed materialwhich had been put on the site; and most of all, they were excited by the vision. But just because they were excited, didn't mean they wanted to take the time themselves to contribute. They hoped that other people would do so. And in the end, nobody, essentially, was really all that interested in contributing. If you look today, except in a few small corners, the Qwiki is essentially dead. And, sad to say, this is quite a common story. Many scientists, in fields ranging from genetics to string theory, have tried to start science wikis along very similar lines. And typically, they've failed for essentially the same reason. It's not just science wikis, either. Inspired by Facebook, many organizations have tried to create social networks for scientists, which will connect scientists to other people with similar interests. So they can share things like data or code, their ideas and so on. Again, it sounds like a good idea. But if you join one of these sites, you'll quickly discover that they're essentially empty. They're virtual ghost towns. So what's going on? What's the problem here? Why are these promising sites failing?Well, imagine that you're an ambitious young scientist. In fact, I know some of you here are ambitious young scientists. Imagine you're an ambitious young scientist. You really would like to get a job -- a permanent job, a good job -- doing the work that you love. But it's incredibly competitive to get such jobs. Often, there'll be hundreds of very highly qualified applicants for positions. And so you find yourself working 60, 70, 80 hours a week, doing the one thing that you know will get you such a job, and that is writing scientific papers. You may think that the Qwiki is a wonderful idea in principle, but you also know that writing a single mediocre paper will do much more for your career and your job prospects than a long series of brilliant contributions to such a site. So even though you may like the idea and you may think it will advance science more quickly, you find you just can't conceive of it as being part of your job. It's not. The only things which can succeed in this kind of environment are projects like the Polymath Project, which, even though they employ an unconventional means to an end, they have an essential conservatism about them. The end product of the Polymath Project was still a scientific paper. In fact, it was several papers. Right? So unconventional means, but conventional ends. So there's a kind of conservatism about it. And don't get me wrong -- the Polymath Project is terrific, but it is a pity that scientists can only use tools which have this kind of conservative nature. So let me tell you a story about an instance where we moved away from this conservatism. It's a rare story where the conservatism has been broken. It occurred in the 1990s, when, as you know, for the first time, biologists were taking large amounts of genetic data to collect in the Human Genome Project. And there were sites online which would allow biologists to upload that data so it could be shared with other people around the world and analyzed by other people. Probably the best known of these is the site GenBank, which some of you may have heard of or used. And these sites, like GenBank, had the problem in common with Qwiki that scientists -- they're not paid or rewarded for sharing their data. It's all about publishing papers. So there was a considerable reluctance to actually upload the data. Yet, everybody could see that this was silly -- it was obvious that this was the right thing to do. But just because it was obvious didn't mean that people were actually doing it. So a meeting was convened in Bermuda in 1996 of many of the world's leading molecular biologists. And they sat and they discussed the problem for several days, and they came up with what are now called the Bermuda Principles, which state that:first, once human genetic data is taken in the lab, it should be immediately uploaded to a site like GenBank; and two, that the data would be in the public domain. And these principles were given teeth, because they were taken by the big scientific grant agencies -- the US National Institutes of Health, the UK Wellcome Trust -- and actually baked into policy. So it meant that if you were a scientist who wanted to work on the human genome, you had to agree to abide by these principles. And today, I'm very pleased to say, as a result, you can go online -- anybody here -- and download the human genome. So that's a terrific story. But the human genome is just a tiny, tiny fraction of all scientific knowledge. Even just in other parts of genetics, there is so much knowledge that is still locked up. I spoke with one bioinformatician who told me that he'd been "sitting on the genome of an entire species for more than a year. " An entire species. And in other parts of science, it is routine that scientists hoard their data. They hoard the computer code that they write that could be useful, potentially, to other people. They hoard their best ideas. And they often hoard even the descriptions of the problems that they think are most interesting. And so, what I and other people in the Open Science movement would like to do is, we'd like to change this situation. We would like to change the culture of science so that scientists become much more strongly motivatedto share all of these different kinds of knowledge. We want to change the values of individual scientists so they start to see it as part of their jobto be sharing their data, to be sharing their code, to be sharing their best ideas and their problems. So, if we can do this, this kind of change in values, then we will indeed start to see individual scientists rewarded for doing these things; there will be incentives to do them. It's a difficult thing to do, however. We're talking about changing the culture of entire large parts of science. But it has happened before once in history, right back at the dawn of science. Galileo, 1609: he points his telescope up at the sky towards Saturn, and he sees for the first time in history what we now know are the rings of Saturn. Does he tell everybody in the world? No, he doesn't do that. He writes down a description, privately, and then he scrambles the letters in the description into an anagram, and he sends that anagram to several of his astronomer rivals. (Laughter)And what this ensures is that, if they later make the same discovery, he can reveal the anagram and get the credit, but in the meantime, he hasn't given up any knowledge at all. And I'm sad to say that he was not uncommon at the time: Newton, Huygens, Hooke, Leonardo -- they all used similar devices. OK? The printing press had been around for 150 years by this time. And yet, there was a great battle in the 17th and 18th centuries to change the culture of science, so that it became expected that when a scientist made a discovery, they would reveal it in a journal. Now, that's great that that change has happened. It's terrific. But today, we have new technologies, we have new opportunities to share our knowledge in new ways and the ability to create tools that actually allow us to solve problems in entirely new ways. So we need to have a second open science revolution. It is my belief that any publicly funded science should be open science. How can we achieve this change? Well, if you're a scientist -- and I know many of you are not scientists, but if you are a scientist, then there are things that you can do. You can get involved in an open science project, even if it's just for a small fraction of your time. You can find forums onlinewhere you can share your knowledge in new ways, ways that allow other people to build on that knowledge. You can also, if you're more ambitious, start an open science project of your own. If you're really bold, you may wish to experiment with entirely new ways of collaborating, in much the same way as the Polymath Project did. But above all, what you should do is be very generous in giving credit to those of your colleagues who are practicing science in the open and to promote their work. It is only conservative scientific values that look down on these activities -- the sharing of data, the blogging, or using of wikis and so on. You can reject those conservative values and engage your scientific colleagues in conversation to promote the value of these new ways of working, to emphasize that it takes bravery to do these things, particularly by young scientists. It's through such conversation that the culture of science can be changed. So if you are not a scientist, there are also things that you can do. My belief is that the single most important thing that we can do to give impetus to open science is to create a general awareness amongst the population of the issue of open science and of its critical importance. If there is that general awareness, then the scientific community will inevitably find -- it will be dragged by the population at large in the right direction. There are simple things you can do. You can talk to your friends and acquaintances who are scientists and just ask them what are they doing to work more openly. Or you can use your imagination and your personal power to raise awareness in other ways. We're talking about changing not just what scientists do but what grant agencies do, what universities do and what governments do. And you can influence all of those things. Our society faces a fundamental question: What kinds of knowledge are we going to expect and incentivize our scientists to share? Will we continue as we have done in the past? Or will we embrace new kinds of sharing, which lead to new methods for solving problems and an acceleration in the process of science, entirely across the board? My hope is that we will embrace open science and really seize this opportunity that we have to reinvent discovery itself. Thank you.