DOWNLOAD PDF THE FUTURE OF SCIENCE

Chapter 1 : INTERNATIONAL SCIENTIFIC CONFERENCE :: SCIENCE OF THE FUTURE

Thinking the future is a defining aspect of the human condition, with science and technology increasingly serving as key propellers to articulate our visions of the future, in public discourse and individual lives alike.

This ensured that if someone else made the same discovery, Hooke could reveal the anagram and claim priority, thus buying time in which he alone could build upon the discovery. Hooke was not unusual. Many great scientists of the age, including Leonardo, Galileo and Huygens, used anagrams or ciphers for similar purposes. In the meantime, Leibniz developed and published his own version of calculus. Imagine modern biology if the human genome had been announced as an anagram, or if publication had been delayed thirty years. Why were Hooke, Newton, and their contemporaries so secretive? In fact, up until this time discoveries were routinely kept secret. Alchemists intent on converting lead into gold or finding the secret of eternal youth would often take their discoveries with them to their graves. A secretive culture of discovery was a natural consequence of a society in which there was often little personal gain in sharing discoveries. The great scientific advances in the time of Hooke and Newton motivated wealthy patrons such as the government to begin subsidizing science as a profession. Much of the motivation came from the public benefit delivered by scientific discovery, and that benefit was strongest if discoveries were shared. The result was a scientific culture which to this day rewards the sharing of discoveries with jobs and prestige for the discoverer. Today, when a scientist applies for a job, the most important part of the application is their published scientific papers. The adoption and growth of the scientific journal system has created a body of shared knowledge for our civilization, a collective long-term memory which is the basis for much of human progress. This system has changed surprisingly little in the last years. The internet offers us the first major opportunity to improve this collective long-term memory, and to create a collective short-term working memory, a conversational commons for the rapid collaborative development of ideas. The process of scientific discovery â€" how we do science â€" will change more over the next 20 years than in the past years. This change will not be achieved without great effort. From the outside, scientists currently appear puzzlingly slow to adopt many online tools. The first part of this essay is about these barriers, and how to overcome them. The second part of the essay illustrates these ideas, with a proposal for an online collaboration market where scientists can rapidly outsource scientific problems. Toward a more open scientific culture How can the internet benefit science? How can the internet improve the way we do science? There are two useful ways to answer this question. The first is to view online tools as a way of expanding the range of scientific knowledge that can be shared with the world: Many online tools do just this, and some have had a major impact on how scientists work. Two successful examples are the physics preprint arXiv , which lets physicists share preprints of their papers without the months-long delay typical of a conventional journal, and GenBank , an online database where biologists can deposit and search for DNA sequences. But most online tools of this type remain niche applications, often despite the fact that many scientists believe broad adoption would be valuable. Two examples are the Journal of Visualized Experiments , which lets scientists upload videos which show how their experiments work, and open notebook science , as practiced by scientists like Jean-Claude Bradley and Garrett Lisi , who expose their working notes to the world. There is a second and more radical way of thinking about how the internet can change science, and that is through a change to the process and scale of creative collaboration itself, a change enabled by social software such as wikis, online forums, and their descendants. There are already many well-known but still striking instances of this change in parts of culture outside of science [1]. These examples are not curiosities, or special cases; they are just the leading edge of the greatest change in the creative process since the invention of writing. Science is an example par excellence of creative collaboration, yet scientific collaboration still takes place mainly via face-to-face meetings. With the exception of email, few of the new social tools have been broadly adopted by scientists, even though it is these tools which have the greatest potential to improve how science is done. Why have scientists been so slow to adopt these remarkable tools? Is it simply that they are too conservative in their habits, or that the new tools are no better than what we already have? Both these glib answers are wrong. A failure of science online: Inspired by the success of amazon. The trial was not a success. There was a significant level of expressed interest in open peer reviewâ€¦ A small majority of those authors who did participate received comments, but typically very few, despite significant web traffic. Most comments were not technically substantive. Feedback suggests that there is a marked reluctance among researchers to offer open comments. The Nature trial is just one of many attempts at comment sites for scientists. Physics Comments was built a few years later, and discontinued in A more recent site, Science Advisor , is still active, but has more members than reviews It seems that people want to read reviews of scientific papers, but not write them [2]. The problem all these sites have is that while thoughtful commentary on scientific papers is certainly useful for other scientists, there are few incentives for people to write such comments. To grasp the mindset here, you need to understand the monklike intensity that ambitious young scientists bring to the pursuit of scientific publications and grants. To get a position at a major University the most important thing is an impressive record of scientific papers. These papers will bring in the research grants and letters of recommendation necessary to be hired. Competition for positions is so fierce that 80 hour plus work weeks are common. The pace relaxes after tenure, but continued grant support still requires a strong work ethic. The contrast between the science comment sites and the success of the amazon. The disincentives facing scientists have led to a ludicrous situation where popular culture is open enough that people feel comfortable writing Pokemon reviews, yet scientific culture is so closed that people will not publicly share their opinions of scientific papers. Some people find this contrast curious or amusing; I believe it signifies something seriously amiss with science, something we need to understand and change. Wikipedia Wikipedia is a second example where scientists have missed an opportunity to innovate online. In the early days few established scientists were involved. Just as for the scientific comment sites, to contribute aroused suspicion from colleagues that you were wasting time that could be spent writing papers and grants. But if you take a broader view, if you believe science is about discovering how the world works, and sharing that understanding with the rest of humanity, then the lack of early scientific support for Wikipedia looks like an opportunity lost. But how strange that the modern day Library of Alexandria had to come from outside academia. This is ironic, for the value of cultural openness was understood centuries ago by many of the founders of modern science; indeed, the journal system is perhaps the most open system for the transmission of knowledge that could be built with 17th century media. The adoption of the journal system was achieved by subsidizing scientists who published their discoveries in journals. This same subsidy now inhibits the adoption of more effective technologies, because it continues to incentivize scientists to share their work in conventional journals, and not in more modern media. The situation is analogous to the government subsidies for corn-based ethanol in the United States. In the early days these seemed to many people to be a good idea, encouraging the use of what people hoped would be a more efficient fuel. But now we understand that there are more energy-efficient alternatives, such as grass-based cellulose ethanol. Unfortunately, the subsidies for corn-based ethanol are still in place, and now inhibit the adoption of the more efficient technologies. This means everything â€” data, scientific opinions, questions, ideas, folk knowledge, workflows, and everything else â€" the works. Such extreme openness is the ultimate expression of the idea that others may build upon and extend the work of individual scientists in ways they themselves would never have conceived. The challenge of achieving a more open culture is also being confronted in popular culture. People such as Richard Stallman , Lawrence Lessig , Yochai Benkler , Cory Doctorow , and many others have described the benefits openness brings in a networked world, and developed tools such as Creative Commons licensing and free and open source software to help promote a more open culture, and fight the forces inhibiting it. As we have seen, however, science faces a unique set of forces that inhibit open culture â€" the centuries-old subsidy of old ways of sharing knowledge â€" and this requires a new understanding of how to overcome those forces. How can we open up scientific culture? To create an open scientific culture that embraces new online tools, two challenging tasks must be achieved: The necessity of accomplishing both these tasks is obvious, yet projects in online science often focus mostly on building tools, with cultural change an afterthought. This is a mistake, for the tools are only part of the overall picture. It took just a few years for the first scientific journals a tool to be developed, but many decades of cultural change before journal publication was accepted as the gold standard for judging scientific contributions. None of this is to discount the challenge of building superb online tools.

To develop such tools requires a rare combination of strong design and technical skills, and a deep understanding of how science works. The difficulty is compounded because the people who best understand how science works are scientists themselves, yet building such tools is not something scientists are typically encouraged or well suited to do. Scientific institutions reward scientists for making discoveries within the existing system of discovery; there is little place for people working to change that system. What about the second task, achieving cultural change? Let me describe two strategies that have been successful in the past, and that offer a template for future success. The first is a top-down strategy that has been successfully used by the open access OA movement [3]. The goal of the OA movement is to make scientific research freely available online to everyone in the world. Perhaps most notably, in April the US National Institutes of Health NIH mandated that every paper written with the support of their grants must eventually be made open access. The second strategy is bottom-up. It is for the people building the new online tools to also develop and boldly evangelize ways of measuring the contributions made with the tools. Unfortunately, the committee has no easy way of understanding the significance of these contributions, since as yet there are no broadly accepted metrics for assessing such contributions. The natural consequence is that such contributions are typically undervalued. To make the challenge concrete, ask yourself what it would take for a description of the contribution made through blogging to be reported by a scientist on their curriculum vitae. How could you measure the different sorts of contributions a scientist can make on a blog â€" outreach, education, and research? These are not easy questions to answer. Yet they must be answered before scientific blogging will be accepted as a valuable professional scientific contribution. The example is the well-known physics preprint arXiv. Since physicists have been uploading their papers to the arXiv, often at about the same time as they submit to a journal. The papers are made available within hours for anyone to read. The arXiv is not refereed, although a quick check is done by arXiv moderators to remove crank submissions.

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Chapter 2 : Thirteenth World Conference - The Lives to Come -

speculations on the future of science (KEVIN KELLY:) Science will continue to surprise us with what it discovers and creates; then it will astound us by devising new methods to surprises us. At the core of science's self-modification is technology.

What will the next 10 years hold for science? How many more amazing scientific discoveries will we see by the end of the next decade? And how will these change our lives? Titan has lakes of liquid methane instead of water. Cracking the mysteries of the universe. CERN We are learning about our universe more rapidly than before and the next decade could herald some exciting discoveries, says Colless. These results and the Planck cosmic microwave background observations could solve the mystery of dark matter and dark energy," Lineweaver says. A grand unifying theory of biology. While discovering the Higgs-boson particle may help us understand how our universe works, a new science called interactomics may help us understand the meaning of life on Earth. Once upon a time, we thought genes could explain everything we observe in biology. Then epigenetics came along, revealing that our appearance and function are the result not just of our genes but also their interaction with their environment. Interactomics â€" a grand unifying theory of biology â€" could help us predict how a system will behave based on information about the individual components that make up that system, says Professor Stephen Simpson from the University of Sydney. Achieving such a synthesis is one of the greatest challenges in modern biology, with immense practical implications," Simpson says. New bodies But what of our own biology? What will the human body look like a decade from now? Fat is the new thin, size 18 the new Your entire DNA sequenced for the cost of a new lounge suite. Theoretically this information could be used to predict diseases, cancer and obesity years ahead of when they actually develop," says Georges. New genomics technology will also transform forensics, making it increasingly difficult for perpetrators to remain unconnected to their crime scene and victim. And by , laboratories will have sequenced the full genomes of 10, organisms, providing a wealth of data to help understand how organisms function, how they respond to the environment and ultimately how they evolve. Any wound can be healed by combining tissue engineering, bioengineering and nanotechnology. Self-assembling nanoparticles will restore the tissue framework, and ultimately in-situ tissue regeneration will become commonplace. Soldiers will be 40 per cent biology, 60 per cent technology. New technology will deliver more than physical benefits in the next decade. Remember the implantable memory chips in the science fiction classic Neuromancer? Well, the reality of having direct access to cyberspace via implants in the brain is closer than you think, says Professor Vaughan Macefield from the University of Western Sydney. A life-size replica of your best friend. A projector will create an image of your friend sitting next to you. Fourier Transforms are sure to play a role in creating these holograms. Fast internet connected living. These might include telemedicine, where medical information is transferred through the internet to use for consulting, remote medical procedures or examinations. And we could monitor every dam, river and reservoir and combine this information with weather forecasts, allowing us to predict not only how much water we have today, but how much we will have in the future. Cities supported by sustainable technology "Unless we adopt clean technologies the prospects for human civilisation are bleak" - Ian Lowe Source: Lowe envisions Australian cities will be powered by clean energy, and have the capacity to turn energy and other resources efficiently into services within 10 years. But sometimes science supplies not just the means but also the end itself, he says. For those who share this view Colless predicts the next decade will be "an age of wonders and keen pleasures".

Chapter 3 : The Future of Science | Michael Nielsen

The map focuses on six big stories of science that will play out over the next decade: Decrypting the Brain, Hacking Space, Massively Multiplayer Data, Sea the Future, Strange Matter, and Engineered Evolution.

It is the domain with the most scientists, the most new results, the most economic value, the most ethical importance, and the most to learn. Deep realtime simulations and hypothesis search will drive data collection in the real world. Triple-blind experiments will emerge through massive non-invasive statistical data collection no one, not the subjects or the experimenters, will realize an experiment was going on until later. The Internet already is made of one quintillion transistors, a trillion links, a million emails per second, 20 exabytes of memory. It is approaching the level of the human brain and is doubling every year, while the brain is not. It is all becoming effectively one machine. And we are the machine. It will take all possible species of intelligence in order for the universe to understand itself. Science, in this way, is holy. It is a divine trip. Science will continue to surprise us with what it discovers and creates; then it will astound us by devising new methods to surprises us. New tools enable new structures of knowledge and new ways of discovery. The achievement of science is to know new things; the evolution of science is to know them in new ways. What evolves is less the body of what we know and more the nature of our knowing. Technology is, in its essence, new ways of thinking. The most powerful type of technology, sometimes called enabling technology, is a thought incarnate which enables new knowledge to find and develop news ways to know. This kind of recursive bootstrapping is how science evolves. As in every type of knowledge, it accrues layers of self-reference to its former state. New informational organizations are layered upon the old without displacement, just as in biological evolution. Our brains are good examples. We retain reptilian reflexes deep in our minds fight or flight while the more complex structuring of knowledge how to do statistics is layered over those primitive networks. In the same way, older methods of knowing older scientific methods are not jettisoned; they are simply subsumed by new levels of order and complexity. But the new tools of observation and measurement, and the new technologies of knowing, will alter the character of science, even while it retains the old methods. A sensible forecast of technological innovations in the next years is beyond our imaginations or at least mine , but we can fruitfully envision technological changes that might occur in the next 50 years. Based on the suggestions of the observers above, and my own active imagination, I offer the following as possible near-term advances in the evolution of the scientific method. Compiled Negative Results â€” Negative results are saved, shared, compiled and analyzed, instead of being dumped. Positive results may increase their credibility when linked to negative results. We already have hints of this in the recent decision of biochemical journals to require investigators to register early phase 1 clinical trials. Usually phase 1 trials of a drug end in failure and their negative results are not reported. As a public heath measure, these negative results should be shared. Major journals have pledged not to publish the findings of phase 3 trials if their earlier phase 1 results had not been reported, whether negative or not. Triple Blind Experiments â€” In a double blind experiment neither researcher nor subject are aware of the controls, but both are aware of the experiment. In a triple blind experiment all participants are blind to the controls and to the very fact of the experiment itself. The way of science depends on cheap non-invasive sensor running continuously for years generating immense streams of data. While ordinary life continues for the subjects, massive amounts of constant data about their lifestyles are drawn and archived. Out of this huge database, specific controls, measurements and variables can be "isolated" afterwards. For instance, the vital signs and lifestyle metrics of a hundred thousand people might be recorded in dozens of different ways for years, and then later analysis could find certain variables smoking habits, heart conditions and certain ways of measuring that would permit the entire 20 years to be viewed as an experiment â€” one that no one knew was even going on at the time. This post-hoc analysis depends on pattern recognition abilities of supercomputers. It removes one more variable knowledge of experiment and permits greater freedom in devising experiments from the indiscriminate data. Combinatorial Sweep Exploration â€” Much of the unknown can be explored by systematically creating random varieties of it at a large scale. You can explore the composition of ceramics or thin films, or rare-earth conductors by creating all possible types of ceramic or thin films, or rare-earth conductors , and then testing them in their millions. You can explore certain realms of proteins by generating all possible variations of that type of protein and they seeing if they bind to a desired disease-specific site. You can discover new algorithms by automatically generating all possible programs and then running them against the desired problem. Indeed all possible Xs of almost any sort can be summoned and examined as a way to study X. None of this combinatorial exploration was even thinkable before robotics and computers; now both of these technologies permit this brute force style of science. The parameters of the emergent "library" of possibilities yielded by the sweep become the experiment. With sufficient computational power, together with a pool of proper primitive parts, vast territories unknown to science can be probed in this manner. Evolutionary Search â€” A combinatorial exploration can be taken even further. If new libraries of variations can be derived from the best of a previous generation of good results, it is possible to evolve solutions. The best results are mutated and bred toward better results. The best testing protein is mutated randomly in thousands of way, and the best of that bunch kept and mutated further, until a lineage of proteins, each one more suited to the task than its ancestors, finally leads to one that works perfectly. This method can be applied to computer programs and even to the generation of better hypothesis. Multiple Hypothesis Matrix â€” Instead of proposing a series of single hypothesis, in which each hypothesis is falsified and discarded until one theory finally passes and is verified, a matrix of many hypothesis scenarios are proposed and managed simultaneously. An experiment travels through the matrix of multiple hypothesis, some of which are partially right and partially wrong. Veracity is statistical; more than one thesis is permitted to stand with partial results. Just as data were assigned a margin of error, so too will hypothesis. An explanation may be stated as: A matrix also permits experiments with more variables and more complexity than before. Pattern Augmentation â€” Pattern-seeking software which recognizes a pattern in noisy results. In large bodies of information with many variables, algorithmic discovery of patterns will become necessary and common. These exist in specialized niches of knowledge such particle smashing but more general rules and general-purpose pattern engines will enable pattern-seeking tools to become part of all data treatment. Adaptive Real Time Experiments â€” Results evaluated, and large-scale experiments modified in real time. What we have now is primarily batch-mode science. Traditionally, the experiment starts, the results are collected, and then conclusions reached. After a pause the next experiment is designed in response, and then launched. In adaptive experiments, the analysis happens in parallel with collection, and the intent and design of the test is shifted on the fly. Some medical tests are already stopped or re-evaluated on the basis of early findings; this method would extend that method to other realms. Proper methods would be needed to keep the adaptive experiment objective. AI Proofs â€” Artificial intelligence will derive and check the logic of an experiment. Ever more sophisticated and complicated science experiments become ever more difficult to judge. Artificial expert systems will at first evaluate the scientific logic of a paper to ensure the architecture of the argument is valid. It will also ensure it publishes the required types of data. This "proof review" will augment the peer-review of editors and reviewers. Over time, as the protocols for an AI check became standard, AI can score papers and proposals for experiments for certain consistencies and structure. This metric can then be used to categorize experiments, to suggest improvements and further research, and to facilitate comparisons and meta-analysis. A better way to inspect, measure and grade the structure of experiments would also help develop better kinds of experiments. Wiki-Science â€” The average number of authors per paper continues to rise. With massive collaborations, the numbers will boom. Experiments involving thousands of investigators collaborating on a "paper" will commonplace. The paper is ongoing, and never finished. It becomes a trail of edits and experiments posted in real time â€” an ever evolving "document. Tools for tracking credit and contributions will be vital. Responsibilities for errors will be hard to pin down. Wiki-science will often be the first word on a new area. Some researchers will specialize in refining ideas first proposed by wiki-science. Defined Benefit Funding â€” Ordinarily science is funded by the experiment results not guaranteed or by the investigator nothing guaranteed. The use of prize money for particular scientific achievements will play greater roles. A goal is defined, funding secured for the first to reach it, and the contest opened to all. The Turing Test prize awarded to the first computer to pass the Turing Test as a passable intelligence. Defined Benefit Funding can also be combined with prediction markets, which set up a marketplace of bets on possible innovations. The bet winnings can encourage funding of specific technologies. Zillionics â€” Ubiquitous always-on sensors in bodies and environment will transform medical, environmental, and space sciences. Unrelenting rivers of sensory data will flow day and night from zillions of sources. The exploding number of new, cheap, wireless, and novel sensing tools will require new types of programs to distill, index and archive this ocean of data, as well as to find meaningful signals in it. The field of "zillionics" â€” - dealing with zillions of data flows â€” - will be essential in health, natural sciences, and astronomy. This trend will require further innovations in statistics, math, visualizations, and computer science. Zillionics requires a new scientific perspective in terms of permissible errors, numbers of unknowns, probable causes, repeatability, and significant signals. Deep Simulations â€” As our knowledge of complex systems advances, we can construct more complex simulations of them. Both the success and failures of these simulations will help us to acquire more knowledge of the systems.

Chapter 4 : Future science: the next 10 years â€º Science Features (ABC Science)

The Future of Science is Here. Genentech is supporting tomorrow's scientists today with innovative new STEM education programs. From 5th grade mentorships to college scholarships, we're working to inspire the passion that changes patients' lives.

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Chapter 5 : Future of science: 'We will have the power of the gods' - Telegraph

"If these authors are the future of science, then the science of the future will be one exciting ride! Find out what the best minds of the new generation are thinking before the Nobel Committee does.

Michio Kaku and a robot Roger Highfield Roger Highfield reports Just before Sir Isaac Newton died, he described how humbled he felt by the thought that he had glimpsed only a fraction of the potential of the great scientific revolution he had helped to launch: We have unravelled the molecule of life, DNA. And we have created a form of artificial intelligence, the computer. We are making the historic transition from the age of scientific discovery to the age of scientific mastery in which we will be able to manipulate and mould nature almost to our wishes. Related Articles Who Owns the Future? But will we also have the wisdom of Solomon? Here are their remarkable speculations about how the scientific and technological revolution will transform life and society in the 21st century. This information is teleported over to another system, which assumes exactly that information; therefore it becomes identical with the original. After that, before the middle of the century, we hope to have large-scale fusion power. Now we can grab the machine â€" the protein inside the plant called photosystem, which is responsible for generating energy for the plant â€" and hijack its function to create solar electrical power. Our goal is to provide an alternative to regular silicon-based solar panels. The embryonic stages are here today, and a lot of work is being done. In my view, the advanced form of nanotechnology is arguably the greatest existential risk humanity is likely to confront in this century. Virtually every aspect of our lives is governed by our sense of self and our sense of when we will age, and, of course, when we will die. One really has to think seriously about tampering with the ageing process and what its implications might be. We need a public debate on exactly why we want our children to be perfect and whether that would actually be giving them a happier and more fulfilling life. On the other hand, I would hope that people would want their children to be diverse and interesting and interested in others, rather than everyone the same and everyone perfect. And this is not in some distant, science-fiction future â€" this is now. And we may be able to alter not just our intellectual but also our physical abilities. If we could pass down these genetically enhanced genes, we could evolve in a different way. We could have a display built into any of a number of layers within the eye, or into the optic track â€" or, indeed, into the brain itself. What happens if we assume so many different identities that we begin to lose our own sense of identity? What happens if we begin to prefer virtual social networks to our real social networks? And will the family suffer if we spend more time with our virtual family than our real one? At the same time, our technologies are becoming more biological. There are two scenarios. The optimistic one is that these new superhuman machines are very gentle and they treat us like pets.

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