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SCIENCE AND TECHNOLOGY IN SOCIETY FORUM: 4TH ANNUAL MEETING

New Frontiers of Science and Technology – Closing Plenary Session Summary

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It is both a great pleasure and honour to report on the absolutely fascinating discussions of the past few days under that were held under the banner of New Frontiers in Science and Technology on the three themes of: nanotechnology, ICT, and how computational capabilities are changing research.

When Richard Feynman delivered his famous lecture in 1959, entitled, "There is Plenty of Room at the Bottom", he triggered the race to the bottom in the field of nanoscience and nanotechnology. He said "Why can't we write the entire 24 volumes of the Encyclopedia Britannica on the head of a pin"? With that, Feynman launched us on a journey from scientific curiosity to a technology with enormous promise.

The predictions that the market for Nanotechnology could be $1 trillion by 2020 of course generated enormous hype. Thus, the question we were trying to address is this: Hype or Hope? Evolution or Revolution?

The convergence of nanotechnology, biotechnology, information technology and cognotechnology will produce significant breakthroughs. Nanotechnology is a tool kit for developing intelligent materials and devices with hitherto unseen properties - driven by compelling needs in medicine, energy, ICT, agriculture and other areas.

While the last few years have been evolutionary we are definitely on the cusp of a revolution as the efforts begin to mature. No, it is no longer hype.

Although the epochal developments are yet to come, we have already benefited from many results. Extraordinary infrastructure such as STM and AFM are allowing scientists to manipulate atoms and visualize materials and devices on a nano-scale.

Let me give you some real life examples of achievements. Nano-scale printing; new nano-optical materials for photonic applications are emerging. Nano-medicine is exploding.

At the National Institute for Nanotechnology at the University of Alberta, interdisciplinary collaboration and extraordinary infrastructure are resulting in breakthroughs. The Lab-on-a chip, named "'FISH on a CHIP", allows fluorescent- insitu-hybridization analysis for chromosal variations from blood and urine that now provide results in hours instead of weeks, enabling early detection of types of cancer which could lead to tailored treatments. It is expected that this invention will be commercialized within 5 years.

New methods to integrate neurons, catalysts, molecular electronics and sensing elements with semi-conducting and conducting materials are generating nano-tools for studying neuro-degenerative disease and are acting as catalysts for new methods of oil sands development.

Another example is nano-based solar cells - the development of porous thin films for organic solar cells and hydrogen storage materials. High Tc superconductivity is a reality. In California $150M has been committed to a solar cell venture.

Individuals and corporations are investing in hundreds of companies. And, while environmental issues and public awareness are critical, we need to identify the ethical, environmental, economic, legal and social issues.

Information and Communication Technologies

Now, let us move to new developments in ICT.

(i) Networks for researchers to undertake massive collaboration.

Cyber infrastructure, which consists of HPC, super computers and sensor networks are allowing large amounts of data to be shared. This includes particle physics, genomics, earth observation, atmospheric sciences, and underwater exploration.

The next challenge is to process, visualize and distribute the data to a large numbers of researchers who can mine this information to develop suitable theories and new understanding. Up to now, with the exception of physicists, arrangements for sharing the data and mass collaboration have not been well established in many fields.

(ii) Extension of the Digital Search capability to our physical world.

There was a considerable debate over the past few days on the ethics of digital searches and the power of search engines to rank information in a search. This has enormous economic and social consequences. It is important to consider and deal with the ethical concerns. How do we ensure proper governance of the internet? This is such a vital piece of our global infrastructure and the question is how do we keep it running effectively?

This discussion went beyond the digital to physical searches such as the use of ICT to locate people in times of great catastrophe. We only need to consider Hurricane Katrina or the London Bombing. And now, in the face of global warming where millions could be displaced by rising oceans, our digital power can be translated into the capability to search the physical world. Can we deploy massive numbers of low-cost sensors and technology? There are privacy and ethical issues that will need to be resolved before we deploy this kind of capability.

The growth of interactive media and the availability, target ability and programmability of communication devices will be required to make this possible.

The younger generation, and in fact most of us, no longer want to be passive consumers of information. Believe it or not, e-mail is now old technology! The next generation is using SMS, text messaging, Facebook and Flickr to make public what was once private. These social networking tools are allowing everyone to sharing everything all the time and in real time.

The word "book" or "reference" is changing. Documents are becoming alive so the community can update and enhance information and thoughts over time. Two examples are the ability to access and contribute to book reviews on Amazon and the advent of information and idea sharing through wiki-based sites.

In science, significant investments have been made to secure large amounts of scientific data, but we do not have the capacity to organize and share this data. Conversely, the Internet is better organized even though there is a great deal of poor quality information. Thus, the target ability and programmability of the medium is becoming of greater importance.

In making improvements and upgrades in these areas, understanding the *user* will be essential. I would suggest that we will need a new science to understand all of this. What makes an on-line community grow? What makes it collapse? What are the mirco-economics of the internet?

Access for developing nations, and especially for the poor, to ICT and its potential to transform these users' conditions through education and poverty reduction methods must be accelerated.

We have also heard about the digital divide and some novel methods to create a virtual nation with virtual money to provide opportunities for the poor.

(iii) Another mega-trend is the convergence of the mobile internet, computing and broadcasting all being supported by the evolution of wireless.

- Will this lead to wearable computers that are ubiquitous or will the handset becoming the medium of choice? Currently there are 1 billion PCs and 5 billion handsets!

- Next generation networks for multimedia service require high-speed broadband, the convergence of mobile terminals, the convergence of telecom and broadcasting, and fixed and wireless systems.

- We are moving to personal communication hubs. These ubiquitous devices will offer voice, data, video, camera, HD-TV, m-commerce, m-health care and more and will allow us to be connected to any device at any time and anywhere. Are we going to see devices in our built environment, such as our clothes, furniture and appliances?

- The evolution of optics on communication and printing of information. There is a need for extremely large transmission capacity.

- We also need technology to progress in order to give us higher density and smaller devices, sensors and communications devices.

Computational Capabilities are Changing Science and Research

We have entered an era of enormous computing capability which will allow us to interact differently with computers. We are building supercomputer capability in the order of 100 terra flops. The challenge is to mine and manage peta flops of data for extremely complex processes.

Mathematics is a champion among sciences because it can allow one to develop mathematical models of complex phenomena based on vast amounts of data and in turn the model can be used in a predictive capacity to shed new light on extraordinarily important issues.

There are many other important areas where this applies such as meteorological processes for weather forecasts, genetic algorithms, climate change and pandemics. There is virtual reality, Avatars and ambient intelligent environments; are now all within reach.

There is potential for collaboration in biology. 3-D models of certain biological molecules can be shared and annotated allowing for the development of drugs for cancer. TeleHealth is developing rapidly as our Expert System for a variety of applications to capture tacit knowledge.

Computational capacity helps reduce costly experiments, optimize production cycles, increase quality control and lead to new products. One of the major questions that arises is ‘Do these large-scale models of complex phenomena like the climate represent reality?’ Indeed, there are times when partial models can be more realistic than hugely complex models where errors could be multiplied.

An area that is underdeveloped is mining information from papers in the scientific community to facilitate research and creativity. In neuroscience 100,000 papers are published each year and an individual can only read about 100. How can we utilize computational capacity to manage these challenges?

But we must remember that computational power is not a panacea for good scientific thinking and hypothesis generation must be validated. This is difficult and it poses an ethical and intellectual dilemma in that if the model is being used to make decisions that affect the lives of millions of people, caution needs to be exercised.

Let me close on an optimistic note.

The human brain is the frontier of the 21st century. Even with its complexity of 100 billion neurons there is the potential that we will be able to model the human brain. Supercomputing power can be used generate models of the various aspects of the human brain which might help synthesize the vast amount of data being generated. We should use this to test against reality.

As those of us in the room age and become demented or succumb to neurodegenerative disorders we need to understand how the brain functions and what goes wrong. However, it is equally important to understand why we stand alone as a creative species capable of language, laughter and memories with the ability to advance civilization and technology.

The words of Blake best capture the human quest.

To see the world in a Grain of Sand
And a Heaven in a Wild Flower
Hold Infinity in the palm of Your Hand
And Eternity in an hour.