

2009 Meeting

Geneva, 7-11 December 2009

Item 6 of the provisional agenda

Consideration of, with a view to enhancing international cooperation, assistance and exchange in biological sciences and technology for peaceful purposes, promoting capacity building in the fields of disease surveillance, detection, diagnosis, and containment of infectious diseases

**BACKGROUND INFORMATION ON SCIENTIFIC AND
TECHNOLOGICAL DEVELOPMENTS THAT MAY BE
RELEVANT TO THE CONVENTION**

Submitted by the Implementation Support Unit*

Summary

This document summarises scientific and technological developments potentially relevant to the Convention that have come to the attention of the Implementation Support Unit in the course of its research in the fields of disease surveillance, detection, diagnosis, and containment of infectious diseases in preparation for the 2009 Meeting of Experts and Meeting of States Parties. Developments covered in this document include continued progress in gene synthesis, automated research, and security-related initiatives by scientific communities.

I. Introduction

1. Reviews of relevant scientific and technological developments are carried out every five years at review conferences. Information is provided on an ad hoc basis by States Parties. The last review was carried out at the Sixth Review Conference in 2006.
2. Relevant scientific and technological developments, identified in 2006, were summarised in a background information document produced by the Secretariat¹. Additional potentially

* Submitted after due date, as soon as required information was available to the Secretariat for inclusion.

¹ Background information document on new scientific and technological developments relevant to the Convention, BWC/CONF.VI/INF.4

relevant developments that came to the attention of the Implementation Support Unit were covered by a background paper for the 2008 Meeting of States Parties². The next comprehensive review will take place at the Seventh Review Conference in 2011.

3. During the course of its activities in 2009 the ISU identified an additional three areas of scientific progress which may be of interest to States Parties: continued progress in gene synthesis; automated research; and security-related initiatives by scientific communities.

II. Continued progress in gene synthesis

4. The 2008 background paper on potentially relevant developments provided information on the use of gene synthesis technologies to facilitate the *de novo* creation of organisms, or the creation of pathogens from nothing more than raw information. Two potentially relevant developments have occurred since then: one related to the synthesis of rare, controlled or extinct pathogens; and the other with regards to the synthesis of bacteria.

5. It was noted in the 2008 background paper that several pathogenic viruses had been produced using gene synthesis techniques, including those that cause polio, SARs and the 1918 influenza pandemic. The 2008 background paper also detailed concerns that it might be possible to use chemical gene synthesis to obtain rare, controlled or extinct pathogens. It highlighted a debate over the feasibility of being able to use this approach to obtain the virus responsible for smallpox. The World Health Organization Advisory Committee on Variola Virus Research has since released a report that suggests that “currently available technology could allow the recreation of a full-length variola virus genome by chemical synthesis”³. This may further heighten proliferation concerns surrounding this pathogen.

6. The 2008 background paper also details efforts by the J. Craig Venter Institute (JCVI) to apply *de novo* synthesis techniques to bacteria. It detailed difficulties researchers were having ‘rebooting’ their synthesised bacterium. Those problems continued throughout much of 2009 but efforts to correct them allowed researchers to develop a significantly more streamlined process (through the use of inherent properties of yeast) for assembling gene fragments into a genome. What was initially designed to be a four step process requiring significant time and resources can now be accomplished in much faster and more cheaply in two steps (and a single stage process is currently under investigation). This simplifies the process for synthesising other pathogens and might prompt additional concerns over lowering technological hurdles to this form of proliferation.

7. In September 2009 in the publication *Science*⁴, the JCVI research team reported having identified the probable reason for their ‘rebooting’ issues and reported a mechanism to circumvent it. The JCVI team believed that the un-methylated state of their synthetic genome

² Background information on scientific and technological developments that may be relevant to the Convention, BWC/MSP/2008/INF.1

³ World Health Organization Advisory Committee on variola virus research, Report of the Tenth Meeting, WHO/HSE/EPR/2008.9, available at: http://www.who.int/csr/resources/publications/WHO_HSE_EPR_2008_9.pdf

⁴ Lartigue et al, Creating bacterial strains from genomes that have been cloned and engineered in yeast, *Science*, Vol.325 No.5948, 25 September 2009, <http://www.sciencemag.org/cgi/content/abstract/1173759>

was allowing it to be cut up by various restriction enzymes designed to protect bacteria against viruses. The new approach involves using the yeast to methylate the synthetic genome before it is returned to a bacterial host, thereby preventing the host from recognising it as foreign genetic material. The research team indicated that this new approach should enable them to produce the first *de novo* bacterium before the end of 2009. Expanding chemical synthesis of microbial agents from viruses to bacteria significantly increases the number of pathogens that might be obtained using *de novo* synthesis.

III. Automated research

8. Both the background information document for the Sixth Review Conference and the background paper for the 2008 Meeting of States Parties discussed various aspects of modern, high-throughput enabling technologies. There has also been some discussion on the application of bioinformatics, computer modelling and systems biology. These disciplines are being combined in a new way to provide for fully automated molecular biology research – to create robot scientists⁵.

9. Advanced modelling software has been used to take partially-characterised biological systems (at this stage from both yeast functional genomics and drug screening) and through the use of artificial intelligence develop theories as to what the missing components of the system might be (both in terms of intermediaries and processes). These computational models are then tested through laboratory experimentation, where all the equipment is controlled by the same computer that developed the theories. Beyond restocking basic expendable laboratory resources, the experiments are conducted without human intervention. The same computer then assesses the outcomes of the experiments and feeds the data back into the model and uses it to improve its theories. This process is then repeated until the system is fully elucidated. The ability of robot scientists to characterise biological systems has been assessed through empirical study. The robot scientists were provided partial data from well characterised networks and asked to deduce the rest. Results from these studies indicated that the robot scientists are capable of characterising discrete biological systems⁶.

10. Not only do robot scientists promise to take much of the drudgery out of basic research but they might also help to address the current bottleneck in identifying function and interpreting raw data. Current high-throughput approaches, such as gene sequencing, have succeeded in producing a great quantity of data - so much so that it has proven impossible to process it all. Advances such as robot scientists should help to address the imbalance and may further facilitate progress in the life sciences. As with many of these enabling technologies whether their impact proves beneficial or malign will be dependent largely upon the uses to which they are put and the intent of their operators.

⁵ University of Aberystwyth, Robot Scientist, <http://www.aber.ac.uk/en/cs/research/cb/projects/robotscientist/>

⁶ King et al, The Automation of Science, Science 3 April 2009: Vol. 324. no. 5923, pp. 85 - 89

<http://www.sciencemag.org/cgi/content/abstract/324/5923/85>

IV. Security-related initiatives by scientific communities

11. As noted in the Report of the Implementation Support Unit⁷, during the course of the year the Unit has participated in a number of events in which scientific communities have attempted to address security issues relevant to the Convention. Of particular note were initiatives: by the companies involved with commercial gene synthesis; on dual use education by the international scientific unions; by the organisers of the internationally Genetically Engineered Machine competition; as well as by the Do-It-Yourself (DIY Bio) or amateur biology community.

Screening gene synthesis orders

12. The 2008 Meeting of States Parties heard two presentations on efforts to develop screening protocols for commercial gene synthesis companies. Efforts to develop these screening practices have continued throughout 2009. Whilst there seems to be an almost industry wide acceptance that screening of orders will be necessary, there emerged two competing views over how to approach screening⁸.

13. The views of the International Association of Synthetic Biology were that the sequence being ordered and the customer details should be screened both automatically (using an automated database driven system) and then in certain cases reviewed by a human (thereby enabling judgements to be made case by case). For gene synthesis, companies prefer a model where screening is entirely automatic.

14. At a meeting in Cambridge, USA in November 2009, the IASB formally adopted a code of conduct for its members that included detailed screening procedures, committed members to developing of a system to award seals to companies demonstrating best practices and established a Technical Experts Group on Biosecurity⁹.

15. Following the adoption of a code by IASB, several of the largest gene synthesis companies founded the International Gene Synthesis Consortium (IGSC). The IGSC has subsequently released its own 'harmonized screening protocol' which is comparable to the code of the IASB¹⁰. As a result, the industry does seem to be coalescing around a two stage screening process that will determine whether a customer is legitimate and whether the order should be filled.

Educating scientists on dual-use issues

16. The 2008 Meeting of States Parties identified a series of common understandings on the importance of raising awareness amongst scientists and educating them as to the security issues

⁷ BWC/MSP/2009/2

⁸ Hayden, Keeping genes out of terrorists' hands, Nature News, 461, 22, 31 August 2009, <http://www.nature.com/news/2009/090831/full/461022a.html>

⁹ IASB, Code of conduct for best practices in gene synthesis, 3 November 2009, http://www.iasb.eu/tasks/sites/synthetic-biology/assets/File/pdf/iasb_code_of_conduct_final.pdf

¹⁰ IGSC, Harmonized screening protocol, http://genesynthesisconsortium.org/Harmonized_Screening_Protocol.html

surrounding their work¹¹. Several international scientific unions organised a meeting to examine, at a practical level, the tools and approaches that would be needed for such a task¹². The workshop on Promoting Dual Use Education in the Life Sciences was held in Warsaw, Poland in November 2009. It brought together experts in the science of learning, new educational technologies (such as distance learning tools) and those already attempting such awareness raising and educational activities. The workshop: surveyed strategies and resources currently available, so as to identify gaps that might be filled; identified a range of new educational materials and approaches that might be used to enhance educational practices; and examined options for including education on dual use issues into the training of life scientists. The workshop will produce a report of its work and a presentation on the event will be made on the margins of the Meeting of States Parties.

Securing iGEM

17. During the course of the 2009 International Genetically Engineered Machine (iGEM) competition, there has been a significant move towards ensuring that all those involved are aware of, and taking into account, the potential security considerations of their work. Several of the teams in this year's competition addressed security related issues. One team developed a guide for participants when dealing with the press (which dealt with issues around biological warfare)¹³. Another team developed a complete set of proposals as to how the security oversight of genetic engineering should be improved¹⁴. This culminated in a security section being added to the competition wiki¹⁵.

18. Three security projects are planned for the 2010 competition. The iGEM wiki, as well as individual champions working with the teams, will provide for greater awareness raising and foster further attention on security issues. Participants will also be invited to help create a code of conduct which would address security concerns and bind all future participants. Finally, teams will be invited to gather details on the oversight and regulatory frameworks governing their work, possibly as one component in the pursuit of the Human Practices prize. This will provide a lasting resource to help guide future teams.

Safety, security and amateur biology

19. Given concerns over amateur biologists¹⁶ practising outside of the regulatory regimes that cover professional institutions, members of the community have reached out to experts in law enforcement, safety and security to help ensure that their activities are not cause for concern. The

¹¹ BWC/MSP/2008/5

¹² The event was organised by the InterAcademy Panel on International Issues, the International Union of Microbiological Societies, and the International Union of Biochemistry and Molecular Biology, with the support of the US National Academies and the Biosecurity Engagement Program of the US State Department and hosted by the Polish Academies of Science.

¹³ University of Virginia iGEM 2009, The Synthetic Biology Researchers Guide to Speaking with the Press, http://people.virginia.edu/~drt5p/VGEM/Virginia-Media_Guidelines_for_Synbiologists.pdf

¹⁴ University of Ottawa iGEM 2009, Security, <http://www.ipm-int.org/boxmode/pdf/Security.pdf>

¹⁵ See: <http://2009.igem.org/security>

¹⁶ See, for example: <http://diybio.org/>

DIY Bio community has founded a safety and security working group¹⁷ and is keen to foster working relationships with those that might have concerns over its activities, in a spirit of transparency and to build confidence.

¹⁷ <http://groups.google.co.uk/group/diybio-safety-working-group?hl=en>