Meeting of the States Parties to the Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on Their Destruction

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Standing agenda item: review of developments in the field of science and technology related to the Convention

Advances in science and technology related to the Convention

Background information document submitted by the Implementation Support Unit

Summary

The Seventh Review Conference decided that the 2012 to 2015 intersessional programme would include a Standing Agenda Item on review of developments in the field of science and technology related to the Convention. This paper expands upon and updates the background information document on scientific and technology that have potential benefits for the Convention prepared for the 2012 Meeting of Experts (BWC/MSP/2012/MX/INF.3), and updates the overview of advances in enabling technologies provided to the 2012 Meeting of Experts (BWC/MSP/2012/MX/INF.1). The paper also outlines the arrangements made by the Implementation Support Unit to make available to States Parties as much information as possible on relevant advances in science and technology.

I. Advances in science and technology

A. Introduction

1. The Seventh Review Conference decided that under the Standing Agenda Item reviewing developments in the field of science and technology related to the Convention States Parties will consider:

"(a) new science and technology developments that have potential for uses contrary to the provisions of the Convention;

(b) new science and technology developments that have potential benefits for the Convention, including those of special relevance to disease surveillance, diagnosis and mitigation;

(c) possible measures for strengthening national biological risk management, as appropriate, in research and development involving new science and technology developments of relevance to the Convention;

(d) voluntary codes of conduct and other measures to encourage responsible conduct by scientists, academia and industry;

(e) education and awareness-raising about risks and benefits of life sciences and biotechnology.

(f) science- and technology-related developments relevant to the activities of multilateral organizations such as the WHO, OIE, FAO, IPPC and OPCW;

(g) any other science and technology developments of relevance to the Convention."[1]

2. The Seventh Review Conference also decided that "the following topical scientific subjects will be considered in the years indicated:

"(a) advances in enabling technologies, including high-throughput systems for sequencing, synthesizing and analyzing DNA; bioinformatics and computational tools; and systems biology (to be considered in 2012);

(b) advances in technologies for surveillance, detection, diagnosis and mitigation of infectious diseases, and similar occurrences caused by toxins in humans, animals and plants (to be considered in 2013).

(c) advances in the understanding of pathogenicity, virulence, toxicology, immunology and related issues (to be considered in 2014);

(d) advances in production, dispersal and delivery technologies of biological agents and toxins (to be considered in 2015)."[2]

3. This background information document provides an overview of:

(a) advances related to dealing with disease, updating background information provided in 2012 on advances with potential benefits for the Convention (BWC/MSP/2012/MX/INF.3);

(b) advances in enabling technologies, updating background information provided in 2012 (BWC/MSP/2012/MX/INF.1); and

(c) arrangements made by the Implementation Support Unit to gather and make available to States Parties, on a more frequent and continuously updated basis, relevant developments in science and technology.

[1] BWC/CONF.VII/7, Part III, paragraph 22.
[2] BWC/CONF.VII/7, Part III, paragraph 23.

B. General trends and advances in basic life science

4. The background document on advances in science and technology compiled for the Seventh Review Conference[3] identified six trends: convergence between disciplines; increasing understanding of the underlying principles and mechanisms of the life sciences; shifting focus of priority areas within commercial biotechnology; a greater geographical distribution of capacity; open science; and media, perceptions and interactions with society. New data on these trends continues to become available, for example, in relation to the growing geographical distribution of capacity.[4] Data was also provided earlier in 2012 that research and development investment in parts of Asia has tripled in the last 15 years, as has the number of science and engineering journal articles.[5] There is also data illustrating a dramatic increase in the number of individuals from the region obtaining degrees in the natural sciences.

5. One additional trend that can be identified is an increased use of research collaborations. As biology becomes more dependent upon advanced technologies, scientists are working together more closely to get access to the "barrage of high-end equipment that no one laboratory can afford".[6] For example, such collaboration in structural biology in Europe is being formalised into the Instruct network to enable more systematic sharing of resources.

6. The background information document compiled for the Seventh Review Conference also identified a number of advances in basic life science. There have been a number of important developments since, including:

(a) Establishing that transcription factors demonstrate a greater range of binding behavior than previously thought and as a result that genes are not simply switched "on" or "off";

(b) The functional importance of non-coding DNA, including its role in differentiating between primates;

(c) The identification of a much broader range of cell structures than previously thought;

(d) The use of x-ray crystallography to reveal the mechanistic details of how DNA polymerase replicates DNA;

(e) Improved understanding of the way in which long RNA molecules regulate genes;

(f) Additional evidence that certain biological functions, like photosynthesis, rely upon quantum effects; and

(g) tools and techniques that enable studying the impact of spatial organization of genes in a three-dimensional space on their function and impact, including interactions across chromosomes.

[3] BWC/CONF.VII/INF.3 and addenda.

[4] Rezaie et al, Innovative drugs and vaccines in China, India and Brazil, Nature Biotechnology, Vol.30 No.10, October 2012, see: http://www.nature.com/nbt/journal/v30/n10/full/nbt.2380.html

[5] Reich, Research in Asia heats up, Nature, Vol.481, 26 January 2012, see: http://www.nature.com/news/research-in-asia-heats-up-1.9885

[6] Callaway, Structural biologists share their toys, Nature, Vol.483, 1 March 2012, see: http://www.nature.com/news/structural-biologists-share-their-toys-1.10122

II. Advances in dealing with disease

A. Mechanisms of disease

7. There have been a wide range of advances relevant to better understanding the mechanisms of disease, including in: the identification of new, emerging or re-emerging diseases; the healthy functioning of the immune system; interactions between pathogens and hosts; how prion diseases work; the impact of a healthy microbiome; progress in working with unculturable pathogens; making use of existing health data; and on horizontal gene transfer.

B. Detection

8. A number of advances will help detect that a disease event is occurring, including through: the use of DNA nanostructures to organize more sophisticated enzymic cascades which could enable analytical devices for use in medical diagnostics and environmental monitoring; improvements in integrated sensor systems to detect harmful and unwanted bacteria; and the development of methodologies to distinguish biological agents that might be used as a weapon from their genetic relatives.

9. There have been advances which assist in tracking a causative agent, disease surveillance and epidemiology, including:

(a) evidence linking robust disease surveillance, such as well developed national diagnostic and human capacity combined with effective international reporting, to mitigating the impact of significant disease events;

(b) new avenues for near real-time disease tracking after proof of correlations between internet activity, such as Google Flu trends, and clinical indicators of disease in hospitals;

(c) the use of novel molecular epidemiology techniques in investigating disease outbreaks;

(d) novel genomic-based epidemiological approaches, drawing directly on enabling technologies reviewed in 2012, to investigate and manage disease events and for real time disease tracking;

(e) real-world case studies of the utility of genomic epidemiology in outbreaks involving *Escherichia coli* 0104, antibiotic-resistant *Klebsiella pneumoniae*, a novel coronavirus, and methicillin resistant *Staphlococcus aureus*; and

(f) a thorough review of global mapping of disease outbreaks and proposals for rapid improvement of needed capabilities.

10. There have been advances in platforms capable of detecting disease prior to the onset of symptoms, including: sensors that generate a signal that is larger when the concentration of the target molecule is lower; and the identification of gene expression signatures that correspond with viral and bacterial infections.

C. Diagnostics

11. There have been advances in the production of cheap and portable equipment for diagnosing diseases, including repurposing of existing laser technologies for low-cost, accessible laser scanning microscopes for blood analysis and cellular imaging.

12. There have been advances which enable better point-of-care diagnostics, including: to differentiate between viral and bacterial infections, allowing for more specific treatment; improvement in the polymer technologies used to create test kits; disease-specific test kits, including for H5N1; and progress towards functional "lab-on-a-chip" technology.

13. There have been advances which will help speed up diagnosis, including: improved use of sequencing to identify bacterial pathogens; new methodologies for using existing enabling technologies, including some reviewed in 2012, to detect and quantify viral pathogens; the development of nanotechnology-enabled detection chips capable of separating and concentrating target proteins from complex biological samples; the use of metagenomics approaches to identify pathogens without needing to culture them; use of molecular diagnostics to identify potential factors influencing drug efficiency; efforts to compile barcode databases of viral diseases enabling the identification of novel mutations; and the development of software tools to identify pathogens from sequence data, including to help identify food-borne pathogens.

14. There have been advances which enable a greater degree of accuracy in diagnosis, including through the use of whole genome sequencing.

D. Prevention and prophylaxis

15. There have been advances in developing new vaccines, including more advanced conjugate vaccines and creation of an entirely novel synthetic vaccine for foot-and-mouth disease. There have been a range of advances in developing vaccines for intoxination, especially related to ricin, including: the development of active and passive vaccination strategies; strong candidates for humanized monoclonal antibodies which can be used as both prophylactics and therapeutics; and novel recombinant subunit vaccines.

16. There have been advances which might provide novel approaches to pre-empt disease, including: the identification of bacterial processes to disrupt biofilms connected with both pathogenicity and antimicrobial resistance; and recognition of the importance of behavioural and social aspects in increasing the uptake of important, but often unused, health care interventions.

17. There have also been advances which could enable the production of vaccines and prophylactics, including: influenza vaccines grown in insect cells; and plans for a more distributed production capacity.

18. There have been advances in delivering vaccines and prophylaxes, including: the creation of new microneedle patches; progress in using DNA scaffolds to create customised nanostructures which increase the uptake of drugs; progress towards creating self-assembling protein cages which could be used to deliver drugs; the use of silk proteins to reduce the need for refrigeration of drugs; and the development of nanoparticles for difficult to deliver drugs and in forms suitable for inhalation. Many of these advances are also applicable for the delivery of therapeutics.

E. Therapeutics

19. Advances related to novel antibiotics include an increased understanding of inter-bacterial signalling and its role in enabling bacterial populations to survive exposure to antibiotics. Advances related to anti-viral therapy include evidence of novel resistance to existing anti-virals but continuing sensitivity to a novel candidate drug. Advances in therapeutics to deal with toxins include: a strong candidate for a humanized monoclonal

antibody to treat ricin; and a new antitoxin to treat botulinum toxin. Advancse in prion therapies included the identification of existing drugs that show anti-prion activity.

20. There were advances for novel approaches in treating disease, including: including the identification of a chemical that blocks the pumps that some bacteria use to rid themselves of antibiotics, making some resistant bacteria sensitive once again; therapies that prevent host inflammatory responses caused by certain pathogens; using bacteria to control vectors associated with disease; improved models and computational approaches to predict drug effects and drug-drug interactions; a more sophisticated understanding of interaction between therapeutics and gene expression which affects the efficacy of drugs; and significant progress in gene therapy, including the European Union approving the marketing of the world's first gene therapy drug and research demonstrating the use of genetically engineered T cells to attack tumours.

21. There have been advances in identifying counterfeit therapeutics, including the production of a handheld detector.

22. There have been advances in our understanding of resistance to therapeutics, including: the identification of three sub-populations of the malaria-causing parasite *Plasmodium falciparum* resistant to artemisinin; characterization of the emergence, evolution and global spread of methicillin resistance in *Staphylococcus aureus*; indications of how vancomycin resistance developed in *Staphylococcus aureus*; the role of biofilms in promoting the horizontal transfer of anti-biotic resistance; and indications that developing resistance to therapeutics, including some still under development, could also confer resistance to aspects of innate immunity.

F. Response capacity

23. There have been advances in restricting the spread of a disease event, including: evidence that a breakdown, or lack, of public health infrastructure is the most prominent driver of disease outbreaks and that "there is a mismatch between the drivers of public health events and current trends in public health spending and pandemic prevention"[7]; a more sophisticated understanding of the aerosol transmission of certain diseases, such as influenza, and the effect of wearing surgical masks; and insights into the efficacy of quarantine as a control strategy.

24. There have been advances in decontaminating and cleaning up after a disease event, including laboratory-scale assessments of remediation of outdoor surfaces contaminated with *Bacillus anthracis* spores.

25. Advances which could improve the efficiency of responses to disease events include: studies of past control strategies, drug stockpiles and vaccine development during an outbreak, including for H5N1, H1N1 and H7N9 influenza outbreaks; assessments of the cost-effectiveness of different types of interventions; the application of mathematical techniques developed for the banking and investment industries to help identify who to treat and with what; and research helping to prioritise risks and uncertainties connected with a biological weapons attack.

[7] Tiffany L. Bogich et al, Preventing Pandemics Via International Development: A Systems Approach, PLOS Medicine, Vol.9 Iss.12, December 2012, see: http://www.plosmedicine.org/article/info%3Adoi%2F10.1371%2Fjournal.pmed.1001354

III. Advances in enabling technologies

A. Characterizing biological systems and networks

26. There have been advances in genomics, including: standardisation of practices, such as for the use of quantitative PCR data in research publications; development of relevant guidelines, for example, in conducting genome-wide association studies; parallel technological developments in improving the accuracy of describing relevant information and the contexts in which it is found; identification of additional factors influencing genomics, such as the importance of 3-dimensional topography; and the use of genomics approaches to identify novel function, for example those related to infectivity and cell-entry for pathogens

27. Advances in transcriptomics, include: the application of new analytic approaches, such as for differential analysis, to overcome complicating factors in sorting signals from background noise; and the application of cloud-based artificial neural networks to find patterns in gene expression profiles to diagnose diseases, such as cancer.

28. There have been advances in proteomics, including: the launch of the Chromosome-centric Human Proteome Project, which has, for example, already yielded a preliminary map of the proteome of chromosome 8, and details of disease-related proteins on chromosome 4; the creation of a roadmap for the development of key technologies to further capacity in proteomics; as well as new high-throughput approaches combining quantitative proteomics and size exclusion chromatography to measure temporal interactions.

29. Advances in metabolomics include improvements in baseline data for genetically engineered lines of mice enabling enhanced assessment of complex metabolic traits and disorders.

30. There have been advances in epigenetics, which are heritable changes in gene expression that do not involve alterations to the DNA sequence, including the development of new experimental strategies to investigate healthy functioning and connections with disease.

B. Manipulating biological systems and networks

31. Advances in RNAi technology include: improved understanding in function; a reduction of off-target effects; improvements in polymer-based delivery techniques; enhanced screening approaches using shRNAs; improvements in purification; the use of nanoscale microspheres to improve cellular entry; new producton techniques, including enabling production in bacteria; and significant investment from agricultural biotechnology companies.

32. There have been advances in Zinc Finger Nucleases (ZFN), including custom services offering purpose-built products to target human, rat and mouse cell lines and animals, as well as the creation of cell lines tailored for use by the biopharmaceutical industry in product development; and promising early data on using ZFNs as therapeutics for infectious diseases such as HIV/AIDS.

33. Transcription activator-like effector nucleases (TALENS) have also been identified that home in and cut specific sequences. TALENS bind to single nucleotides allowing their use anywhere on the genome. They are cheaper to develop than ZFNs but there remain challenges in getting high levels of expression. Recent developments have included: applying TALENS technology to the development of therapeutics; and the publication of a

high-throughput method of construction. Identified applications for TALENS include: better characterization of model organisms; improvement of important plants and livestock; cell-based disease modelling; and therapeutics.

34. Bacteria use Clustered Regularly Interspaced Shaort Palindromic Repeats (CRISPR) RNAs to guide silencing of invading nucleic acid. They then use CRISPR Associated protein 9 (CAS-9) to cut the target DNA. An August 2012 paper highlighted the potential to use the system for programmable genome editing. Two papers, one in January 2013 and the other in February 2013 elucidated how to do this. Together they demonstrated that this approach to genome editing was sequence specific, could be used in various cell types, facile, robust and multiplexable. Additional research adapted the system for use in human and mouse cells, demonstrated there were minimal alterations made at unintended sites and used it to failitate homoly-directed repair. A later paper illustrated how to adapt the system for use in yeast and reported an almost 100% recombination rate. This system, although in early stages of development, is more specific and cheaper than ZNFs and more efficient than TALENS.

35. There have also been improvements in other genome editing tools, including: recombinant adeno-associated virus genesis; and RNA-based editing tools.

C. Engineering biological systems and networks

36. There have been advances demonstrating the increasing sophistication of synthetic biology, including: the creation of synthetic biofuels that mimic fossil fuels currently in use; improved understanding of the mechanisms involved with transitioning from single cells to colonies; the application of synthetic biology approaches to animals; examples of refined application of engineering principles; and there are indicators that it will soon be possible to reboot a synthetic chassis with a synthetic genome to create the first fully synthetic organism. Synthetic biology approaches are also beginning to be used by the citizen science movement. For example, a crowd-sourced project is attempting to create a glow-in-the-dark version of the plant Arabidopsis.

37. A recent inventory of existing and possible synthetic biology products produced by the Synthetic Biology Project details 68 products under development.[8] Half of these are expected to be realised in the short to medium term. Product areas include biofuels, chemicals (both bulk and fine), materials, food, animal food, and medicine. A further ten student projects with potential for commercial application are also discussed.

38. There are also strong indicators of the industrial application of synthetic biology, including: the industrial production of semi-synthetic Artemisinin; the industrial production of synthetic biofuels; and a growing number of companies running demonstration facilities for the industrial production of synthetic biofuels.

39. There have been advances in protocols, including: a new methodology for automatable, high-throughput assembly of standard biological parts; the development of a new standardised, interchangeable module-based genetic engineering platform; and the release of kits of modular part for high school and postsecondary students and the interested public to experiment with genetic material. Advances in design tools include the Archetype tool developed by Synthetic Genomics, which is a package for storing, managing and analyzing biological sequence data. It was developed for internal use, was used in much of Synthetic Genomics own work in recent years, and now is being made available for others to use.

[8] http://www.synbioproject.org/process/assets/files/6631/_draft/synbio_applications_wwics.pdf

40. There have been advances in chasses, including the creation of a fully synthetic viral capsid for foot-and-mouth disease that has been used to create a new vaccine. Much of the past work has focused on bacterial chasses and whilst they provide useful research tools, they are limited in their ability to construct certain structures found in eukaryotes and are often not optimised for larger scale production. There has been a series of advances in using yeast, rather than bacteria, as chasses, including: the development of a framework for programming eukaryotic transcription factors to facilitate the design of synthetic circuits in yeast; a method of transferring whole genomes from bacteria to yeast; and progress in characterizing genome-reduced fission yeast strains. Perhaps of greatest note is progress in the international collaborative project to build a synthetic yeast genome.[9] The first international coordination meeting took place in April 2013 in China. The second coordination meeting will take place in the United Kingdom in July 2013.

41. There have been advances in components, including: the creation of bioequivalents of AND, NAND, OR, XOR, NOR and XNOR logic gates; the creation of bioequivalents of NOT, AND, NAND and N-IMPLY logic gates; and synthetic regulatory RNAs.

42. Advances in confronting how to contain genetic material from engineered products, include the role played by a healthy human gut microbiome; and the impact of inflammation of horizontal gene transfer in the gut.

43. There have been advances in dealing with the dyanamic and noisy nature of biology, including: efforts to compartmentalize metabolic pathways in organelles; proof in yeast that such compartmentalization can increase yields; and improvements in ability to control the expression of a gene over many cell generations with quantitative accuracy.

44. Building upon past work to on enzyme design which provided some capacity for de novo computational design and re-engineering, there have been advances in: developing iterative approaches to computational design; and being able to design specific protein cavities for catalysis. A May 2012 review of designed biocatlysis published in Nature identified 20 enzymes developed by the pharmaceutical industry, which included ketoreductases, transaminases, hydrolases, oxidative enzymes, and aldolases.[10]

45. There have been advances in designing structures, including: computational design of self-assembling protein-based nanostructures; refined control of 3-dimesional folding to create complicated self-forming shapes, such as tetrahedrons; construction and use of molecular motors, such as to control chiral space in a catalytic reaction; and developing molecular machines designed to mirror biological function, such as to synthesize sequence-specific peptides.

46. A recent review of biosafety considerations in the international Genetically Engineered Machines competition (iGEM – an undergraduate synthetic biology competition) found "an increase in the number of teams reporting safety aspects and a general improvement in the safety assessment of their projects". In 2013, the iGEM safety committee, which also considers biosecurity issues, has revised the safety and security process required to participate. All teams now have to provide basic safety information. Any project requiring anything other than the most basic safety precautions will undergo a more thorough review. Any project with safety issues still pending after the second review will be placed under greater scrutiny. All projects will require approval from the safety committee before the work can be undertaken.

[9] http://syntheticyeast.org

[10] http://www.nature.com/nature/journal/v485/n7397/full/nature11117.html

D. Gathering and manipulating biological information

47. There have been advances in bioinformatics and computational biology, including: in developing tools for, and identifying existing shortcomings in, analyzing very large data sets; new algorithms for searching for gene sequences in genome databases; and the increasing potential to generate false positives with increasing data generation.

48. There have been advances in modelling and simulation, including the creation of the first whole-cell computer model, which happens to be of a human pathogen and allows prediction of the physical manifestation of genetic manipulation; and the creation of a computer model for predicting possible side effects.

49. There have been advances in software and tools, including in the creation of screening tools that improve the ability to align sequence data to the organisms of origin. This should also improve efforts to screen commercially synthesised gene orders.

E. Converting biological information to digital data and back

50. There have been advances in sequencing technology including: success in overcoming problems that prevented the release of the MinION USB stick sequencers discussed in the 2012 review; the advent of tools for genome-wide detection of single-nucleotide and copy number variations in single human cells; improvements in compiling raw sequence data into complete genomes; and approaches for sequencing RNA directly. There have been efforts to compare leading sequencing technologies. New data has also been released on the performance of benchtop technologies. There have been advances in using sequencing capacity, including using it to identify human ancestry.

51. Advances in synthesis technology have included: the creation of a prototype DNA laser printer (although the lasers are actually used to sort the synthesised materials) which could potentially reduce synthesis costs by several orders of magnitude; and the creation of desktop approaches to make better use of genetic sequences already present in laboratories which when twinned with improvements in automation, allow users to compile desired synthetic genes from material they already have. Advances in the use of synthesis technology have included: application for data storage; and streamlining the provision of outsourced laboratory services.

F. Generic enabling technologies

52. Underpinning many of the advances discussed throughout this paper are a range of technologies that make it easier, cheaper, faster or more reliable to do many of the basic procedures and practices involved in expanding the limits of understanding and creating new applications. For example, there have been advances in high-throughput single-cell microfluidics, including: in improved droplet physics; cell encapsulation methods; sensing and actuation methods; and for high-throughput application in improving areas such as droplet size, capsule density, and droplet viscoelasticity. This enables research efforts to be performed at a smaller scale offering benefits for cost, speed and the number of candidates that can be explored.

IV. Identifying and handling information on relevant advances

A. Identifying potentially relevant advances

53. In 2012, background information on relevant advances in science and technology drew heavily on information generated by States Parties, international and non-governmental bodies and the ISU in the lead up to the Seventh Review Conference. This material is now up to eight years old and may no longer represent current capacities in science and technology. Future reviews may not be able to draw upon it so heavily. It remains unclear from where, and by whom, relevant advances will be identified and the necessary background information developed. The decisions of the Seventh Review Conference do not specify specific procedures for review of developments in science and technology, beyond the inclusion of the Standing Agenda Item in the 2012–2015 intersessional programme.

54. At reviews undertaken at the five-yearly review conferences, a limited number of States Parties have provided information (see Figure 1). At the Meeting of Experts in 2012 six States Parties submitted working papers on this issue and 22 States Parties, one regional organization, one international organization and three guests of the meeting made interventions during the consideration of this Standing Agenda Item.

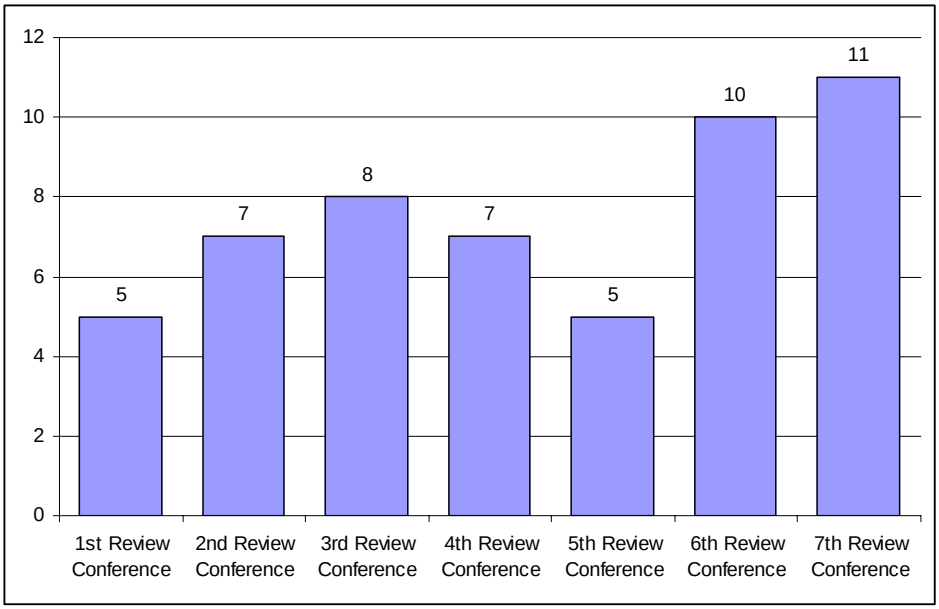

FIGURE 1: The number of States Parties providing information on relevant advances in science and technology to past review conferences.

55. Prior to each of the reviews of science and technology conducted by States Parties at the review conferences, international organizations, professional scientific bodies and non-governmental experts have provided information on the advances they consider might be relevant. No resources were made available by decision of the Seventh Review Conference to support such efforts. Such resources have been made available for these reviews in the past on a voluntary basis by some States Parties. As far as the ISU is aware, no meetings were convened by, or funding provided to, such bodies to identify advances relevant to the work of States Parties in 2013.

56. A decision was taken by the Seventh Review Conference that the ISU is to "support, as appropriate, the implementation by the States Parties of the decisions and recommendations of this Review Conference", including the decision on reviewing developments in the field of science and technology. The ISU, to the fullest extent possible with the resources at its disposal, will continue to provide background information on relevant advances. At the Seventh Review Conference, no staff or funds were specifically made available to undertake such work. No voluntary contributions have been received to support this work. This limits the scale and scope of advances the ISU can examine. In the past, the ISU has been exposed to a wide range of advances through its participation in meetings and workshops as detailed in its annual reports. Participation in these meetings was, and remains, possible because of voluntary contributions. In combination with the de facto reduction of staff members of the ISU at present, the Unit has less capacity to identify potentially relevant advances now than it did during the previous intersessional work programme.

B. Handling information on advances

57. Given the rate of advance in science and technology, it is necessary to bring relevant advances to the attention of States Parties as rapidly as possible. Modern information technology allows platforms to provide such information in near real time. The ISU has updated the relevant section of the BWC website to accommodate information on relevant advances in science and technology (www.unog.ch/bwc/science). These pages have been structured to present relevant advances in a similar format to this paper, background information provided to the 2012 Meeting of Experts and the Seventh Review Conference.

58. In each of the areas covered by the background information documents, details on specific advances are provided, including a link to a relevant research paper, review or other sources of information, details of the advance, as well as thoughts on possible relevance to the Convention.

59. The ISU will update these pages regularly by adding details of any advances it identifies, as well as those provided by States Parties, international organizations, professional scientific bodies or other relevant non-governmental experts. Those providing such information are invited to examine the advances already posted online and to follow a similar format.