Réunion des États parties à la Convention sur l'interdiction de la mise au point, de la fabrication et du stockage des armes bactériologiques (biologiques) ou à toxines et sur leur destruction

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Évolutions de la science et de la technologie présentant un intérêt potentiel pour la Convention

Document d'information soumis par l'Unité d'appui à l'application*

Résumé

La septième Conférence d'examen a décidé que le programme intersessions de 2012 à 2015 inclurait, dans son ordre du jour, un point permanent consacré à l'examen des innovations scientifiques et techniques présentant un intérêt pour la Convention. Elle a également décidé qu'au titre de ce point de l'ordre du jour, les États parties examineraient les évolutions récentes de la science et de la technologie présentant un intérêt potentiel pour la Convention, y compris celles qui concernent plus particulièrement la surveillance, le dépistage et l'atténuation des maladies. Au cours des consultations des groupes régionaux tenues début juin, les États parties ont souhaité disposer d'un document d'information sur la question. Le présent document donne un aperçu des progrès susceptibles de présenter un intérêt. Il repose sur le document de fond sur les progrès scientifiques et techniques récents présentant un intérêt pour la Convention, établi pour la septième Conférence d'examen (BWC/CONF.VII/INF.3). L'annexe, en anglais seulement, dresse un état des lieux plus détaillé assorti de références renvoyant aux publications scientifiques pertinentes.

* Soumission tardive, le document ayant été demandé par les États parties après la date limite.

Merci de recycler

I. Dépistage

1. Être en mesure de déceler qu'un épisode de maladie survient, de suivre la trace des agents en cause et de mettre en place les pratiques de diagnostic avant l'apparition des symptômes permet de raccourcir les délais requis pour mettre sur pied une intervention. L'impact d'un épisode de maladie peut s'en trouver réduit, tout comme l'opportunité de provoquer en premier lieu une flambée de maladie. Les progrès récents de la science et de la technique ont offert nombre de nouvelles possibilités dans ce domaine, notamment: la diversification des approches; la recherche en matière de systèmes d'alerte précoce et d'intervention rapide en interne[1]; l'exploitation des données satellitaires[2]; l'identification des indicateurs précliniques de maladies[3]; l'utilisation de bactéries de synthèse qui brillent en présence d'un agent biologique stressant[4]; les capteurs visuels pour le traçage des agents pathogènes et des toxines[5]; ou encore le perfectionnement de la détection des agents dans l'environnement[6].

II. Diagnostic

2. Un certain nombre de progrès ont été marqués récemment dans la production d'équipement portatif à bas prix aux fins du diagnostic des maladies[7]. Certains appareils pourraient permettre de constituer les capacités de diagnostic rudimentaires dans les régions du monde qui n'en disposent pas encore. Ils offrent aussi des possibilités intéressantes s'agissant de déplacer certains outils et procédés de diagnostic sur le site où les soins sont prodigués − du moins dans un contexte régional plutôt que national[8]. Les capacités de diagnostic rapide ont elles aussi progressé, donnant les moyens d'intervenir plus vite, plus efficacement et de façon plus adaptée, notamment grâce aux nouvelles méthodes de différenciation entre les infections bactériennes et les infections virales[9], au génotypage d'agents pathogènes et à l'identification de phénomènes de réassortiment[10], à l'identification de particules isolées d'agents pathogènes ou de toxines[11], au diagnostic en temps réel de pathogènes fongiques[12], au plus grand recours à la spectrométrie de masse, aux progrès dans la technologie de microscopie et à l'utilisation de la capacité de séquençage comme instrument de santé publique[13]. On a également progressé dans la mise au point de techniques d'analyse plus rapides pour les toxines[14].

[1] http://www.nti.org/gsn/article/researchers-designing-wmd-shield-for-buildings/.
[2] http://www.economist.com/node/13688152.
[3] http://www.biomedcentral.com/1471-2105/9/486.
[4] http://www.nti.org/gsn/article/researchers-develop-lab-on-a-chip-technology-to-test-water-safety/.
[5] http://www.spectroscopyonline.com/spectroscopy/article/articleDetail.jsp?id=376468.
[6] http://daccess-dds-ny.un.org/doc/UNDOC/GEN/G10/639/27/PDF/G1063927.pdf?OpenElement.
[7] http://www.newscientist.com/article/dn14410-ipodsize-microscope-could-become-lifesaving-gadget.html.
[8] http://www.popsci.com/technology/article/2010-02/fingerprint-sized-paper-lab-chip-costs-just-penny.
[9] http://pubs.acs.org/doi/abs/10.1021/ac200596f.
[10] http://wwwnc.cdc.gov/eid/article/17/4/10-1726_article.htm.
[11] http://www.eurekalert.org/pub_releases/2006-11/uog-sbu111506.php.
[12] http://www.ncbi.nlm.nih.gov/pubmed/15893831.
[13] http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0023400.
[14] http://aem.asm.org/content/74/14/4309.full.

III. Prévention et prophylaxie

3. La création de vaccins à large spectre et la mise au point de nouvelles approches dans l'élaboration de vaccins ont progressé[15]. Divers mécanismes novateurs permettant de prévenir la maladie sont également mis au point. On a par ailleurs découvert des moyens d'améliorer nos systèmes immunitaires naturels[16]. Les chercheurs font également état d'améliorations dans les techniques d'administration des substances prophylactiques[17].

IV. Traitement

4. La mise au point de nouvelles capacités antibiotiques demeure une priorité dans la lutte contre la maladie. Ces dernières années, de nouvelles classes d'antibiotiques sont apparues, on a avancé dans leur caractérisation, les essais d'amélioration de leur efficacité ont abouti, de nouvelles cibles ont été identifiées, on a mieux compris la façon dont les bactéries résistent aux antibiotiques, et les outils de découverte ont été perfectionnés. En matière de thérapie antivirale, les progrès marqués ont trait à: la mise au point d'un médicament panviral; la découverte de nouveaux médicaments; l'amélioration de la compréhension du mode de fonctionnement des virus; la découverte d'un virus antiviral; les protéines virucides; les protéines qui perturbent l'adhésion du virus aux cellules hôtes; les protéines qui perturbent la réplication virale; ou encore les réactifs de liaison à forte affinité qui manifestent une activité antivirale. La bioprospection a permis de déceler de nouveaux composés thérapeutiques potentiels, et l'on a également enregistré des progrès en matière de toxines, avec notamment la manipulation génétique des mécanismes hôtes, les nanoparticules destinées à piéger les toxines, ou encore les approches mettant en jeu les anticorps pour les évacuer du corps.

V. Capacité de réaction

5. On a progressé pour ce qui est de déterminer si ce sont des agents pathogènes de culture et non des agents pathogènes naturels qui sont en jeu dans les épisodes d'une maladie[18], pour ce qui est des procédés statistiques appliqués pour séparer des ensembles de données composites[19], ainsi que pour la mise au point de moyens d'investigation médico-légale microbienne − tous progrès susceptibles d'aider à déterminer s'il y a bien eu attentat et qui en est à l'origine[20]. Les travaux menés ont également montré l'importance des mesures de quarantaine efficaces pour limiter les effets[21]. Les nouvelles techniques de décontamination, notamment les mousses antibactériennes et le recours aux nanoparticules, pourraient fort bien faciliter le nettoyage après une attaque[22].

[15] http://www.plospathogens.org/article/info%3Adoi%2F10.1371%2Fjournal.ppat.1000921.
[16] http://www.nature.com/nature/journal/v476/n7361/full/nature10356.html.
[17] http://www.technologyreview.com/news/419880/a-flu-vaccine-without-the-needle/.
[18] http://news.rice.edu/2010/08/16/telltale-signs-of-bioterror/.
[19] http://www.sciencemag.org/content/322/5898/44.1.full.pdf.
[20] http://www.pnas.org/content/early/2011/03/01/1016657108.abstract.
[21] http://wwwnc.cdc.gov/eid/article/16/8/09-1787_article.htm.
[22] http://www.koat.com/print/29135497/detail.html.

Annexe

[English only]

Developments with possible beneficial consequences: a more detailed review

I. Detection

1. Being able to detect that a disease event is happening, to track causative agents, and start diagnostic practices prior to symptoms speeds up the timeframe in which a response can be organized. This can reduce the impact of a disease event and possibly reduce the desirability of instigating an outbreak in the first place. Recent advances in science and technology have provided a range of new capabilities in this arena, including: different approaches, such as through native air sampling techniques;[23] research into in-building early warning and response systems;[24] partial prediction systems for normal disease events based on satellite data;[25] the identification of pre-clinical disease indicators, such as the expression of switch-like genes;[26] the use of engineered bacteria that glow when in the presence of a biological stressor, such as a pathogen;[27]the use of membrane immunofiltration analysis with visual sensors for tracking of pathogens and toxins;[28] as well as improvements in environmental detection of agents by nanowire sensors or by immunographic methods.[29]

II. Diagnostics

2. There have been a number of recent advances in the production of cheap and portable equipment for diagnosing diseases.[30] Some of these devices may enable the creation of rudimentary diagnostic capabilities in parts of the world currently lacking such capabilities. The also offer interesting opportunities to move some of the diagnostic tools and techniques currently in use to the point of care - or at least into a regional, rather than national, context.[31] Relevant developments include: the creation of image sensing chips that could lead to the development of highly portable microscopes, similar technology has since been integrated into lens-less microscope prototypes that works with mobile phone technology; a cheap (US$10), pocket size polymerase chain reaction (PCR) machine that runs off two AA batteries which can be used to identify a number of pathogens; as well as the development of paper-based diagnostic 'chips' through advances in microfluidics and the use of silica nanoparticles.[32]

[23] http://online.liebertpub.com/bsp.
[24] http://www.nti.org/gsn/article/researchers-designing-wmd-shield-for-buildings/.
[25] http://www.economist.com/node/13688152.
[26] http://www.biomedcentral.com/1471-2105/9/486.
[27] http://www.nti.org/gsn/article/researchers-develop-lab-on-a-chip-technology-to-test-water-safety/.
[28] http://www.spectroscopyonline.com/spectroscopy/article/articleDetail.jsp?id=376468.
[29] http://daccess-dds-ny.un.org/doc/UNDOC/GEN/G10/639/27/PDF/G1063927.pdf?OpenElement.
[30] http://www.newscientist.com/article/dn14410-ipodsize-microscope-could-become-lifesaving-.
[31] http://www.popsci.com/technology/article/2010-02/fingerprint-sized-paper-lab-chip-costs-just-penny.
[32] http://www.popsci.com/technology/article/2010-02/fingerprint-sized-paper-lab-chip-costs-just-penny.

3. There have also been advances in rapid diagnostic capabilities, which would also enable a faster, more efficient and tailored response, including through: new approaches to differentiate between bacterial and viral infections;[33]the use of real-time reverse transcription PCR to genotype pathogens and identify reassortment events;[34] the use of Surface Enhanced Ramen Spectroscopy (SERS) to measure the change in frequency of a near-infrared laser as it scatters off viral DNA or RNA allowing the identification of single particles of pathogens or toxins;[35] the real-time diagnosis of fungal pathogens through Selected Ion Flow Tube-Mass Spectrometry (SIFT-MS);[36] as well as the use of sequencing capacity as a public health tool to identify causative agents as well as viral subtypes and reassortment events.[37] There have also been advances in developing faster assays for toxins, such as for the Clostridium botulinum Neurotoxin Type A.[38]

III. Prevention and prophylaxis

4. Certain recent advances have led to the identification of new vaccines. Progress has been made in the creation of broad-spectrum vaccines, such as a pan-influenza vaccine.[39] Genome wide analysis has also shown promising signs for the development of broad spectrum vaccines for bacteria, such as a single vaccine for common E. coli infections. [40] New approaches for vaccination have also been developed. One group reported having identified a standardised approach for genetically manipulating pathogens to make them harmless, whilst still inducing immunity in a mouse model. Another group discovered that they could prevent the replication of a variety of bacterial pathogens, such as those which cause tularaemia, plague, melioidosis, and brucellosis, by exposing a host to cationic liposomes non-coding DNA complexes (CLDC) mixed with pathogen membrane factors.[41]

5. A range of novel approaches to pre-empt disease are also being developed, including making use of advances in the understanding of infections to enable non-pathogenic bacteria to protect against pathogenic viruses, as well as efforts to improve how our immune systems function.[42]

6. Efforts to improve the immune system have included: building self-replicating killer cells from a disabled form of HIV-1 and human T-cells capable of killing target cells, multiplying inside the host and patrolling against relapses and subsequent infections (which has shown dramatic results in three patients to date);[43] building genetically-modified antibodies against specific pathogens by reprogramming human B-cells and assisted by engineered T-cells;[44] advances in our understanding of how the immune system uses antibodies to respond to viral infections after they enter host cells, opening up new opportunities for improving upon the natural process;[45] as well as through the modulation of

[33] http://pubs.acs.org/doi/abs/10.1021/ac200596f.
[34] http://wwwnc.cdc.gov/eid/article/17/4/10-1726_article.htm.
[35] http://www.eurekalert.org/pub_releases/2006-11/uog-sbu111506.php.
[36] http://www.ncbi.nlm.nih.gov/pubmed/15893831.
[37] http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0023400.
[38] http://aem.asm.org/content/74/14/4309.full.
[39] http://www.technologyreview.com/news/421253/a-long-lasting-universal-flu-vaccine/.
[40] http://www.ncbi.nlm.nih.gov/pubmed/20439758.
[41] http://www.plospathogens.org/article/info%3Adoi%2F10.1371%2Fjournal.ppat.1000921.
[42] http://www.nature.com/nature/journal/v476/n7361/full/nature10356.html.
[43] http://stm.sciencemag.org/content/3/95/95ra73.abstract.
[44] http://hplusmagazine.com/2010/02/02/re-engineering-human-immune-system/.
[45] http://www.ncbi.nlm.nih.gov/pubmed/21045130.

the gut microbiome to both reduce the chances of infection and reducing the adverse side-effects of antibiotics.[46]

7. There have also been advances in delivering vaccines and prophylaxes, including through trans-dermal patches.[47]

IV. Therapeutics

8. Developing novel antibiotic capabilities remains a priority for the fight against disease. The last few years have seen the creation of novel classes of antibiotics, e.g. Ceftobiprole.[48] It has also seen the initiation of programmes to develop targeted antibiotics that sense and attack specific pathogens.[49] Researchers have also identified a range of new targets for antibiotics, including: manipulating the cell walls of multi-drug resistance bacteria;[50] disrupting flagella and motility;[51] structural elements in RNA polymerases;[52] as well as disrupting quorum sensing systems.[53] Papers published in the last few years have shown how previously uncharacterized antibiotic systems, such as the aminoglycosides, actually work.[54] This might enable the development of improved systems and conformationally similar drugs developed. Research has also identified additional mechanisms by which bacteria overcome antibiotics - both at the genetic level and functionally, such as through the use of nitric oxide-producing enzymes.[55] There have also been advances in new antibiotic discovery technology, for example, through nanotechnology cantilevers to enable high-throughput screening.[56]

9. Perhaps the most promising recent development in anti-viral therapy has been the possibility of developing a broad-spectrum antiviral drug that could kill any cell infected by a virus.[57] Researchers redesigned the enzyme that detects long strands of RNA (which is only produced during viral transcription and replication), which binds to the RNA blocking further production of viral proteins and initiates an extreme self-destruction response. Laboratories trials have shown these drugs to be effective against 15 human pathogens ranging from those that cause the common cold to haemorrhagic fevers. A range of more traditional anti-viral drugs have also been discovered, including: squalamine, a compound that protects sharks from viral infections; RNA interference (RNAi) therapies for Ebola in non-human primates;[58] as well as the identification of novel monoclonal antibody therapies for influenza infections.[59] Research over the last five years has also helped further our understanding of how viruses work, which in turn opens now opportunities for therapies. One group has published, for example, how Ebola infects cells. A second team used a more sophisticated understanding of Ebola to create a siRNA protocol designed not to cure Ebola but to hold its replication in check until the hosts immune system could begin to respond

[46] http://www.ncbi.nlm.nih.gov/pubmed/18197175.
[47] http://www.technologyreview.com/news/419880/a-flu-vaccine-without-the-needle/.
[48] http://newswire.rockefeller.edu/2008/07/02/new-antibiotic-beats-superbugs-at-their-own-game/.
[49] http://www.nature.com/news/2010/100414/full/464970a.html.
[50] http://www.cbc.ca/news/health/story/2010/10/08/bacteria-cell-wall-trick.html.
[51] http://www.ncbi.nlm.nih.gov/pubmed/20676082.
[52] http://www.cell.com/abstract/S0092-8674(08)01190-2.
[53] http://www.newscientist.com/article/dn16563-new-antibiotics-would-silence-bugs-not-kill-them.html.
[54] http://www.cell.com/abstract/S0092-8674(08)01195-1.
[55] http://www.sciencemag.org/content/321/5887/365.abstract.
[56] http://www.newscientist.com/article/dn14912-nanolevers-could-speed-up-hunt-for-superbug-drugs.html.
[57] http://www.plosone.org/article/info:doi%2F10.1371%2Fjournal.pone.0022572.
[58] http://www.thelancet.com/journals/lancet/article/PIIS0140-6736(10)60357-1/fulltext.
[59] http://www.cidrap.umn.edu/cidrap/content/influenza/panflu/news/feb2309monoclonal-br.html.

effectively, which in turn allowed a monkey to recover from the disease. In 2008, researchers discovered virophages - viruses which spread at the expense of other viruses. Such a discovery offers possibilities for the design of anti-viral virus therapies.[60]

10. There have also been relevant advances in developing therapies to deal with toxins, including: the identification of genetic sequences in hosts required for intoxication by ricin and Pseudomonas exotoxin (offering treatment opportunities by blocking the functionality of these genes);[61] nanocarriers designed to allow toxins to be flushed from the system;[62] nanoparticles designed to trap toxins and carry them to the liver for destruction;[63] compounds designed to prevent the uptake of toxins into certain cell types, such as botulinum toxin into nerve cells;[64] as well as small binding agents designed to latch on to toxins enabling them to be identified by antibodies, also allowing it to be flushed from the system.[65]

11. Several research groups have also been developing more unusual therapeutic approaches. Developments in the understanding of human metabolic network topology in disease have led to the development of multi-target drugs designed to disrupt disease-related molecular networks.[6667] Equally, advances in sequencing capabilities have enabled the use of comparative genome wide analysis to identify novel targets for drugs. One research group has developed non-biological nanofactories designed to prevent bacterial replication offering an entirely new approach for therapeutics via nanomaterials. Another group built a nanoparticle that disrupts bacterial cells walls and shows promise in treating bacteria that have become multi-drug resistant. There is also an ongoing research project to develop adjutants that help break up bacterial infections into single cells, making them more sensitive to existing antibiotics.[68]

V. Response capacity

12. Over the past five years there have been advances that improve capabilities to investigate if an attack has taken place and who might be responsible. Researchers are currently working on a way to identify cultured pathogens (as opposed to those that have evolved in nature).[69] This would help determine that a disease event has a deliberate or accidental origin, rather than being caused naturally. New statistical methods have also been developed to identify individual genotypes from samples comprised of mixed genetic data or from aggregate SNP data enabling better tracing of specific agents during investigations.[70] Perhaps most importantly, recent years have also seen the release of some of the microbial forensic procedures and practices used to investigate the use of B. anthracis filled envelopes as a weapon in the United States.[71]

[60] http://www.nature.com/nature/journal/vaop/ncurrent/full/nature10380.html.
[61] http://www.asiaone.com/News/AsiaOne+News/Singapore/Story/A1Story20110724-290762.html.
[62] http://www.ncbi.nlm.nih.gov/pubmed/18654405.
[63] http://pubs.acs.org/doi/abs/10.1021/ja102148f.
[64] http://www.ncbi.nlm.nih.gov/pubmed/21832053.
[65] http://news.tufts.edu/releases/release.php?id=156.
[66] http://www.pnas.org/content/105/29/9880.
[67] http://www.ncbi.nlm.nih.gov/pubmed/18985027.
[68] http://www.ncbi.nlm.nih.gov/pubmed/18985027.
[69] http://news.rice.edu/2010/08/16/telltale-signs-of-bioterror/.
[70] http://www.sciencemag.org/content/322/5898/44.1.full.pdf.
[71] http://www.pnas.org/content/early/2011/03/01/1016657108.abstract.

13. Data published since 2006 also has implications for restricting the spread of a disease event. A paper published in August 2010, for example, demonstrated that quarantine methods are effective in preventing secondary outbreaks. Although enforced quarantine is a traditional disease control measure, relevant legislation in many countries has not been updated recently and may be inconsistent with subsequent developments in rights and freedoms.[72]

14. There are also advances which will help clean up after a disease event. One group, for example, reported in 2011 having developed a decontamination foam capable of killing pathogens such as that which causes anthrax, using nothing more than chemicals found in common household materials.[73]

[72] http://wwwnc.cdc.gov/eid/article/16/8/09-1787_article.htm.
[73] http://www.koat.com/print/29135497/detail.html.