Biosecurity – The role of young scientists

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The exponential growth of biomedical technology has brought about unimaginable advances in healthcare, accompanied by unprecedented threats to biosecurity. The maintenance of a safe environment is the shared responsibility of scientists, government officials and members of the public. This essay aims to outline ways in which young scientists can contribute effectively to this cause.

Among the various fields in biomedical science, genomics is arguably one of the most rapidly developing areas. The emergence of next generation sequencing has increased the possibility of engineering bacterium with greater pathogenicity or virulence. As junior scientists, many of us were trained in biomedical programmes which placed emphasis on developing skills in genomics, proteomics and metabolomics. This opens up various avenues for the development of solutions to biosecurity problems.

One avenue is through research into methods for detecting and characterising pathogens with potential for nefarious use. Emerging techniques such as whole genome analysis and signature tagged mutagenesis have provided very useful information about such agents, for example, the characterisation of virulence factors in Bacillus Anthracis (Okinaka et al, 2011) and the identification of antimicrobial susceptibility genes in Burkholderia Pseudomallei (Trunck et al, 2009). These two agents are classified by the US Centre for Disease Control and Prevention having highest and second highest priority respectively in terms of risk for bioterrorism.

Such research may also yield unexpected benefits for less developed nations, as some of these potential bioterrorism agents are uncommon in temperate zones, but cause infection with considerable prevalence in tropical climates. For example, Burkholderia infection is endemic in Southeast Asia, causing considerable morbidity and mortality among those predisposed to the disease. Research on effective antimicrobials would certainly benefit these countries, in addition to attenuating the consequences in the event of deliberate dissemination regions where such infection is uncommon.

As early career scientists, I feel that we have relatively more freedom to explore novel out-of-the-box solutions. An example of this is the development of comprehensive phage virulence libraries (Pouillot et al, 2010). This rather unique idea involves the insertion of bacterial host interaction genes into bacteriophages, producing lytic phage banks which can be screened for recombinant T4 particles that infect and destroy bacteria. This allows for rapid response and quick development of antibiotics against infectious agents with high potential for misuse.

International collaboration is particularly important in our efforts to strengthen biosecurity on a global scale. Advances in computational technology have made it possible to transfer massive amounts of data quickly and securely. We should certainly take advantage of this fact to promote data sharing to promote biosecurity. An example of this would be the sharing of data on selected agents with high potential for misuse. While regulations have been developed to monitor laboratory work carried out such organisms, these rules do not apply to DNA sequences, which are relatively easy to obtain. To illustrate this, a Guardian reporter successfully ordered a DNA segment of the smallpox genome for delivery to his home address (Parliamentary office of science and technology, 2009). Several companies involved in synthetic biology have now started screening sequence requests against database of virulent pathogens. One problem is that these databases are yet incomplete, and poorly annotated. This is an area which would be enhanced through international collaboration between biologists, bioinformaticians and computer scientists.

Mathematical modelling is another area that would benefit from international and interdisciplinary collaboration. Making realistic contingency plans for biological attacks is wrought with difficulties in testing out hypotheses experimentally. Such difficulties may be partially alleviated through the construction of detailed models. An example would be the use of differential equations to model containment and control strategies in the event of smallpox release, taking into account individual contact structure and large scale patterns of movement (House et al, 2010). This study confirms that locally targeted ‘ring’ vaccination strategy is optimal for containment while mass vaccination is suboptimal.

I believe that biological security is a shared responsibility with important roles even for who are not working within the field of microbiology or genomics. As scientists, we should all be aware of the dual-use dilemma and help to generate ideas on how security can be improved while minimising the hindrance on research. It is also important to be vigilant for irregular activity which may indicate potential misuse of biological agents. As junior researchers who spend a great deal of time in the laboratories, we are particularly aptly positioned for this role.

To conclude, rapid advances in the life sciences have brought about countless benefits, but have also raised threats. Biological security is a shared responsibility, with specific roles for junior scientists. This essay has outlined a few of them, but it is up to each of us to consider how we can best use our knowledge or skills to further this cause.

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