Ethics, Neuroscience and Public Policy: A Case Study of Raising Neuroscientists' Awareness of the Problem of Dual Use

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Abstract.

The revolution in neuroscience, based on the recent development of novel techniques such as brain imaging that allow greater insight into the working of the central nervous system, will be accelerated by the injection of major funding in state-level brain research projects around the world and will undoubtedly lead to great benefits. However, the results of the research may be subject to hostile misuse, which in the context of chemical and biological weapons has been called the problem of dual use. An example could be the development of novel so-called non-lethal incapacitating chemical and biological agents that attack the central nervous system based on the knowledge derived from benignly-intended civil brain research. Unfortunately, most practicing neuroscientists are not aware of this problem and therefore cannot add their expertise to efforts to prevent such misuse. This paper reviews an attempt to test whether a Team-Based Learning (TBL) active learning exercise could be used to raise awareness of the problem of dual use amongst a group of practicing neuroscientists. It is concluded that TBL is a useful approach, but to effectively engage neuroscientists in helping to deal with dual use it would need to be incorporated within a co-ordinated national, regional and international educational initiative.

Introduction

This Chapter notes that innovation in neuroscience raises new ethical problems and dilemmas. It argues that such problematics are best addressed through collaborative initiatives involving scientists, professional associations, state-level security and policy-makers, ethicists, and educators. In the light of concern about dual-use emerging at the international level, and with reference to calls from professional science societies that such challenges should be met, it considers a European state-level project on the societal impact of innovation in neuroscience, and it identifies the value of active learning approaches as a means to engage the wider neuroscience community in awareness-raising and education initiatives that address innovation.

Scientific and technological revolutions inevitably produce results that lead to difficult ethical problems. The current revolution in neuroscience is no exception as has been pointed out by a number of authors recently.[1] Moreover it is clear that these problems extend to issues of national and international security, for example by providing opportunities for those with hostile intentions to develop novel forms of chemical and biological weapons.[2] The recognition by important states such as the United States, China, Japan and the European Union that advances in neuroscience are likely to lead to significant improvements in dealing with pressing problems of mental illnesses has also led to the initiation of a series of well funded new research programmes in neuroscience[3] that are certain to accelerated the rate of discoveries and therefore potentially generate ethical problems that will have to be dealt with in the end by public policy.[i]

While they do not, of course, bear all of the responsibility for dealing with the ethical problems their benignly-intended work produces, scientists, because of their special expertise, must take some part in helping society to find acceptable solutions. Nowhere is this clearer than in regard to the problem of dual use: the aspect of potential misuse related to the possible development of

[i] One such set of problems concerns how to maintain and develop the international agreements – the Chemical Weapons Convention (CWC) and the Biological and Toxin Weapons Convention (BTWC) that ban the use of chemical and biological weapons of mass destruction. Changes to these conventions will require agreements to be reached at the international level and then implemented within nation states.

novel chemical and biological weapons based on advances in our understanding of the operations of the central nervous system.[4] As the Scientific Advisory Board of the Organisation for the Prohibition of Chemical Weapons noted in 2012, "[T]he types of chemicals and pharmaceuticals known to have been considered as incapacitants from open-literature sources were discussed. Most are centrally acting compounds that target specific neuronal pathways in the brain. All of them emerged from drug development programmes undertaken from the 1960s to the 1980s."[5] Unfortunately, it is clear that practicing neuroscientists remain largely ignorant of the problem of the possible misuse of their work for hostile purposes. Thus, in order to engage their expertise in seeking solutions to this problem the first step has to be to raise their awareness that there is a problem that needs their attention. As the United Kingdom Royal Society recommended in 2012:[6]

> "There needs to be fresh effort by the appropriate professional bodies to inculcate the awareness of the dual-use challenge (i.e. knowledge and technologies used for beneficial purposes can also be misused for harmful purposes) among neuroscientists at an early stage of their training."

As explained below, the fact that the general level of awareness of the dual-use challenge amongst life scientists has not improved much during the last decade despite the clear concerns of States Parties to the Chemical Weapons Convention (CWC) and the Biological and Toxin Weapons Convention (BTWC) indicates that achieving the objectives set out by the Royal Society will not be an easy task. One reason for the difficulty has been found to be that lecturing ethics to scientists is not often successful. Scientists are used to seeking clear answers to explicit questions, not to think about questions that have different answers depending on the ethical framework within which they are approached. Thus, more active forms of learning which aim first to engage the participants are usually required.[7]

Some of the state-level brain projects have components covering ethical issues. The European Union Human Brain Project (HBP), for example, includes consideration of the impact of advances in neuroscience on society through its Ethics and Society work packages on: Foresight Analyses and Researcher

Awareness; Neuroethics and Philosophy; Public Dialogue and Engagement; Ethics Management; and Scientific Coordination.[8] The HBP also has an education programme run by a group at the Medical University Innsbruck which has three main objectives: to provide young European scientists with transdisciplinary knowledge and skills; to connect young researchers within the HBP and beyond; and to build awareness of the projects work and results.[9] As part of its work the programme has produced a series of open online courses one of which deals with ethical issues and within that course one of us (Dando) contributed a video lecture on the problem of dual use.

Following on from making that video lecture we were asked if we would contribute another lecture on dual use to the 1st HBP Curriculum Workshop on *Research: How to Deal with Animals and ICT in Science – An Ethical Approach, Ethics and Societal Impact: Responsible Research*. This workshop was organised by the Karolinska Institute and Linnaeus University at the Karolinska Institute in Stockkholm and the EU Human Brain Project's Education Programme Office on July 10 -12, 2017. We were also asked if we would like to supplement the lecture with a Team-Based Learning (TBL)[ii] exercise on dual-use. This seemed to be an important opportunity to see if TBL would be a useful way in which to help raise the awareness of young practicing neuroscientists about dual use so we were happy to take up the opportunity. What follows in this paper is therefore an account and analysis of what we did in Stockholm. We will explain below why we think this should be seen as a hard test of whether TBL can be used in such circumstances and of what further might be done with this method of awareness raising for neuroscientists.

Background to the TBL

We were involved in a research a project that followed the attempts to strengthen the Biological and Toxin Weapons Convention[iii] during the 1990s.[10]

[ii] Team-Based Learning is a special form of collaborative learning that uses a specific sequence of individual work, group work and immediate feedback to create a motivational framework whereby the focus is shifted from conveying concepts by the instructor to the application of concepts by student teams.

[iii] The Biological and Toxin Weapons Convention (BTWC) adds a series of prohibitions, for example on the development of biological and toxin weapons, to the ban on use embodied in the 1925 Geneva Protocol. The Convention was negotiated in the 1970s and although its prohibitions

When that effort failed in 2001 states parties began a process of annual meetings in which they attempted to reach agreement on more tractable issues, and amongst these issues was the role and responsibilities of life and associated scientists in relation to the Convention at a time of rapid scientific and technological change.

We therefore thought it worthwhile to find out what scientists thought about the issue. So, in collaboration with Brian Rappert (University of Exeter) we sought the views of UK scientists working on acetylcholine. This seemed a sensible point to start given the importance of nerve agents in the arsenals of major States during the Cold War.[iv] We discovered to our surprise then that few practicing scientists knew much about the BTWC or the recently agreed Chemical Weapons Convention. A series of grants from the UK Economic and Social Research Council and the Carnegie Corporation of New York allowed us to show that this lack of knowledge was pervasive both in the UK and in 15 other countries around the world.[v]

So before 2010 we began to develop material that might be used by University lecturers to include some BTWC/CWC related topics in their courses for life scientists. We produced an Education Module consisting of a series of lectures in power point slides with explanatory notes and references in cooperation with colleagues at Japan's National Defence Medical Collage under funding from the British Council and a great deal of supporting material with funding from the UK Wellcome Trust. Most of the debate on dual use has concerned microbiology/immunology but we also produced some similar power point slides and supporting material in lectures specifically for neuroscientists in

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are sweeping in concept it suffers from serious deficiencies in implementation despite decades of efforts by states parties to strengthen it for example by improving its verification provisions and organisational support.

[iv] Chemical weapons of increasing lethality were developed and used during the First World War. In the 1930s chemists doing civil work on pesticides discovered the first of the nerve agents and these were weaponised but not used by Germany in the Second World War. Then during the Cold War even more deadly nerve agents were developed, again after discoveries by civil scientists and huge stocks of these agents were built up particularly by the United States and the Soviet Union. These agents were also used for example in the 1980s Iran-Iraq War and recently in the Syrian Civil War.

[v] In total, we discussed the problem of dual use with several thousand practicing life scientists in universities in 16 different countries. We used a form of focus group to structure the discussions. It was very unusual for us to find anyone who had knowledge of the problem. This finding has been replicated and reported in official papers and statements at meeting of the BTWC and the CWC.

collaboration with colleagues at the University of Manchester. All of this material was made openly available on the Internet, but our estimation is that the take up and use of this material, and similar material produced by other groups, remains limited.[11]

For the reasons explained above we became convinced that part of the reason for the limited use of such material was that scientists find non-scientific subjects (for example ethics) far from easy to deal with unless active learning techniques are used. So when we recently finished editing the set of essays on dual use for the UK and Canadian Governments titled *Preventing Biological Threats: What You Can Do*[12] Tatyana Novossiolova, one of the authors and editors, also developed a set of Team-Based Learning exercises for each of the chapters.[13] When we were asked to include an exercise in addition to our lecture for the meeting in Stockholm it therefore seemed a good idea to run a TBL based on the introductory chapter in *Preventing Biological Threats* which deals with the debate on gain-of-function experiments[vi] in microbiology and dual use in recent years,[14] and ask participants for feedback on how it might be improved. TBL exercises take considerable work to design, but a major advantage we believe is that once designed they can be used repeatedly to help raise awareness of quite large groups of people without the need for extensive training of the organisers of the exercise. These exercises have been used extensively in university course and in efforts to raise the awareness of dual use amongst microbiologists in a number of countries.[15] If found to be effective for neuroscientists TBL could therefore be an efficient method of beginning to engage them in helping to protect their work from hostile misuse.

Organising the TBL

Team-Based Learning has been used extensively in a variety of subjects in University level courses. Usually students are grouped into small teams of 5 to 7 people and remain in those teams throughout the course. This has been found to encourage engagement of all students in the course as teams are marked, in part,

[vi] Since the beginning of the century there has been increasing concern about experiments with dual-use implications, such as those with the mousepox virus and highly pathogenic influenza. The experiments to make highly pathogenic influenza virus contagious by the airborne route became known as gain-of–function experiments.

by the work of the whole team. Electronic systems are used in many courses so that individual students and the teams can report their answers back to instructors immediately, and the instructors can follow the performance of students in order to make effective interventions to facilitate learning by the students. Two concepts are clearly stressed in the literature, first that design of the exercise is centred on starting with the key learning objectives and then working out how to present material to the students to achieve these objectives, and second that the instructor is there to facilitate the students' understanding of the key learning objectives not to tell them what they should learn.[16]

Clearly, we did not have established teams for the TBL exercise in Stockholm nor did we have an elaborate electronic system at our disposal. However, we knew that it is possible to work with groups in such circumstances from previous studies[17] even if we were unsure that it would be possible with the very diverse practicing scientists – ranging from molecular biologists to information technologists - that have now become involved in neuroscience. Neither did we know the participants in advance, or they know us.

In these circumstances, we made a number of adjustments to the standard form of a TBL exercise to help familiarise participants with what was being undertaken. Normally, as described below, students are required to familiarise themselves with some pre-reading and then their knowledge of this material is tested by them completing an iRAT (individual readiness assurance) test. Then each team is required to answer the same questions in a tRAT (team readiness assurance) test informed by a prior group discussion of the questions and answers within the group. It is expected that the rate of correct answers will increase in each team as they debate their different views. After that there are two application exercises each followed by a discussion that allow students to apply and debate their answers to more complicated questions and this is followed by an essential wrap-up discussion (de-brief) of the whole TBL exercise (see the section below on running the TBL exercise). Throughout this process the instructor has to keep the key learning objectives in mind and find ways of highlighting these for the students. We varied this standard structure first by giving students a one-page summary based on the previous section of this paper as a backgrounder on who we are and what the exercise was about as they entered the room for the exercise, and we started the exercise with a brief overview of the exercise in a power point presentation. The first slide in this presentation attempted to clear up the distinction we needed to make between laboratory-based biosafety and biosecurity and the dual use problem we were addressing. The slide stated that:

> "Biosecurity and Biosafety (and Biorisk Management) make vital contributions to a wider concept of 'biological security' that is made up of a web of integrated and complementary elements that reinforce each other…. [This] refers to a 'web of prevention' that locates biosafety and biosecurity in the context of a range of 'biological security' measures that go beyond the laboratory door that include: *international and national prohibitions, disease detection and prevention, effective threat preparedness, export controls, oversight of life science activities, and biosecurity education and codes on conduct*, the latter ensuring that all those engaged in the life sciences whether in government, industry or academia are aware of their responsibilities to protect their work from misuse to counter the threats to humans, animals, and plants posed by states, non state actors or other entities."

In this initial presentation, we made every effort to ensure that participants understood that the TBL was concerned with this wider view of biological security and not just with laboratory biosafety and laboratory biosecurity by stressing the aspects and giving examples of measures shown in italics in the slide described above from our presentation. We also made clear in a power point slide that our key learning objectives were that participants should at the end:

1. Understand the meaning and impact of the concept of dual use research;
2. See and understand how this concept of dual use research is applied in a concrete case;
3. Get insight into and understand the ethical, legal and social responsibilities of scientists; and
4. Get to know different and divergent arguments as well as the interests of involved parties (scientists, government, citizens).

Running the TBL

As we had to run the TBL entirely with paper copies of questions and answers we were much dependent on our colleagues at the Medical University Innsbruck who provided all the paper material and our colleagues at Linnaeus University who helped us by analysing the answers so that they could be quickly and effectively fed back to the participants. Only the pre-reading chapter from *Preventing Biological Threats* was sent out digitally in advance to participants and even that was also provided in hard copy at the start of the TBL.

Unfortunately, a number of the expected participants were unable to attend the workshop because of delays with their visas. However, 13 attendees about half of which were members of the HBP and half not took part in the TBL. The group was also roughly divided into half male and half female and their ages ranged from mid-20s to early 50s. The countries represented were Germany, Ireland, Netherlands, Portugal, Sweden, Switzerland, and the UK. Standard practice in TBL exercises is to try to make each team as diverse as possible to encourage debate between different perspectives within the teams and we attempted to do this in advance from the information available about the background disciplines of the participants. We had received pictures of the room where the exercise was to be carried out in advance and had agreed how teams would be arranged around tables to encourage discussion within groups and debate later between different groups. Participants were informed of which team they were in as they entered the room for the exercise. We were fortunate that three members of the group of speakers for the workshop volunteered to take part in the TBL and we therefore had five teams taking part in the exercise overall.

The TBL took place on the afternoon of the first day of the workshop and as participants had been given two lectures in the morning session we decided to run the TBL first and then give our lecture on dual use after the TBL. Experienced users of TBL exercises stress the need to keep to the designated timetable in order to allow participants to have time to contribute effectively. So, in a departure from standard practice we set out our intended timetable clearly in a slide in our initial introductory presentation (Figure 1).

Figure 1 here

We kept closely to this timetable, although the break between the two exercises for refreshments gave us some flexibility with the time for discussions of the exercises. To help participants we also had power point slides relevant to each of the stages of the exercise in the initial presentation and we put these up on the screen at appropriate times during the exercise.

The exercise began with participants being asked to complete the iRAT question forms. These questions related to the pre-reading material as shown in Figure 2.

Figure 2 here

It will be noted that the questions were not intended to be straightforward as this one asks what is false. Additionally, a research-informed approach to learning and teaching dictated that we would need to present course participants with questions that challenged received knowledge they possessed about their subject. This was done through the adoption of a 'threshold concepts' approach and through the inclusion in the subject-matter, and in the orientation of the questions, of concepts that have the potential to be 'transformative', 'irreversible', 'integrative', 'bounded' and 'troublesome'. Indeed, Meyer and Land[18] recognise that certain concepts are often central to the mastery of a subject. An example of a threshold concept for a biologist would be Darwin's ideas on evolution by natural selection. Once this is understood it really is difficult to see the world in any other way. It could be argued that in trying to raise awareness of the challenge of dual use we are attempting to get neuroscientists to see their work in an entirely different way. The concept of 'biological security' set out above is perhaps and obvious example of a threshold concept that is relevant to neuroscience and to the area of dual use. The available evidence clearly indicates that the vast majority of practicing life scientists, including neuroscientists, do not consider the wider social implications of their work. Thus, getting them to engage with these wider implications, particularly the possibilities of hostile applications of the results of their work can be seen as using biosecurity (as defined) as a threshold concept. The inclusion of questions specifically oriented to lead TBL participants to address both the consequences of their work, as well as their duties as responsible life science practitioners, can, we argue, facilitate the engagement of neuroscience practitioners in applied ethical discussions leading to an introduction to, and an appreciation of, some of the main schools of thought (consequentialist and deontological approaches) that are often involved in ethical deliberation. That is not just to induce some caution about what is done, but additionally to take up a serious responsibility towards how advances in neuroscience are implemented by society. Indeed, to see the Biological and Toxin Weapons Convention and the Chemical Weapons Convention as 'their' Conventions, towards which their expertise can be applied, requires that they have a special responsibility.[vii]

There were 5 questions on the iRAT and we allocated 4 marks to each correct answer. In total, the *participants* scored 58% correct answers on the iRATs. When the process was repeated with the *teams* each answering the same questions on the tRATs (Figure 3) the correct answers rose to 80% thus indicating a reasonably high level of understanding of the essential pre-reading material that they needed to be familiar with in order to undertake the application exercises.

Figure 3 here

This finding is in line with what is expected as the teams share their answers to the questions and argue out the correct answers. However, we asked teams to reveal their answers to each of the questions simultaneously. That provided a means of opening up a cheerful discussion that further helped to ensure that everyone was familiar with the pre-reading material (Figure 4).

[vii] The problem of dual use is complex and will require a diverse set of solutions. In some instances, experiments could be of such concern that they should not be carried out, but these will likely not be frequently encountered so legally banning experiments is unlikely to solve the problem in itself, particularly as we all want civil work intended to help people who are ill to be carried out. Therefore, lesser restrictions such as codes of conduct and effective education throughout a scientist's career seem more appropriate, but given the complexity of the science the expertise of scientists and their professional organisations will be needed to help decide what best can be done. Moreover, what is best to be done could change quite rapidly give the pace of advances being made in neuroscience.

Figure 4 here

The First Application Exercise presented a much different challenge by giving teams the following instructions:

> "This exercise involves choice of one option from a list.
>
> You need to agree, write down and submit your best answer for the task AND your rationale for the answer e.g. why you have chosen an option, the criteria for your choice, or the points you considered when reaching a decision.
> You need to nominate a spokesperson, who will speak for the team during the feedback time. This role should be shared around the team as much as possible. Reveal your answers as directed."

The question and options available to the participants are set out in Figure 5. The aim of this application exercise was to show that there were a range of other stakeholders involved in the debate besides the scientists and that they had differing views on what should be done and by whom.

Figure 5 here

The teams were asked to reveal their answers simultaneously as in the responses to the tRATs. Clearly the answers varied with the teams voting as follows: Team 1:A; Team 2:C; Team 3:F; Team 4: F and Team 5:E. These different results provoked a vigorous discussion, both about the answers and about the precise meaning of the questions. As might be expected given that the participants were mainly practicing life scientists there was little use of overtly stated ethical arguments in the discussion.

The Second Application Exercise attempted to focus directly on the question of biosecurity responsibilities outside of the laboratory by posing the following question:

> "As noted in Chapter 2[the pre-reading], scientists have broader responsibilities to society to ensure that their work does not pose unnecessary risks.
> The Figure presents a timeline with the different stages of a research process – from the conceptual phase of the research to its final

> publication. For each stage identify the responsibilities of the life scientists conducting the research with regard to biosecurity, and suggest at least one action that could be taken to address any potential biosecurity concerns."

The Figure mentioned in the question set out the stages of the research process as shown in Figure 6.

Figure 6 here

It is quite clear from the list in Figure 6 that participants were required to think about possible actions well beyond the laboratory door. The teams were encouraged to make posters and to present their answers in sequence to the rest of the teams. As shown in Figure 7 the teams did not confine themselves to the initial stages of the research process but attempted to engage with the problem of minimising misuse across the full range of the stages.

Figure 7 here

Our only major problem with the whole exercise was that we could have done with much more time for these final presentations and to have a more extended discussion of the implications of the suggestions for action that participants had made. However, we tried to address some of these issues in the following lecture on dual use particularly in regard to the dangers that advances in neuroscience will open up possibilities for novel chemical and biological weapons and how the CWC and the BTWC might be strengthened to help prevent such dangers to society.

Lessons Learnt and Implications of the Exercise

Clearly, we were pleased with the TBL in Stockholm in that a diverse group of people were able to take part and engage in the exercise and that we were able to complete the intended sections in the time available. We did not ask specifically for written feedback but our impression was that participants found it interesting as well as enjoyable and in assessing the whole workshop six people mentioned the TBL specifically: one found it "difficult"; one "enjoyed it a lot" one said "great activity" and two found it "excellent".

So, if we return to the key learning objectives of the exercise which we set out as follows:

1. Understand the meaning and impact of the concept of dual use research;
2. See and understand how this concept of dual use research is applied in a concrete case;
3. Get insight into and understand the ethical, legal and social responsibilities of scientists; and
4. Get to know different and divergent arguments as well as the interests of involved parties (scientists, government, citizens).

It might be argued that there was a good chance of participants going away with an understanding of some of these objectives. However, we think that only an initial beginning had been made on objective 3 for many of the practicing scientists involved in the exercise if the wider societal impacts of advances in neuroscience are considered.

In our view, therefore there are some obvious conclusions to be taken into account if this exercise is repeated for neuroscientists. First, of course, there needs to be the development of some specific dual-use TBLs for neuroscientists to follow on from this type of more general dual-use material. Secondly, very much more specific questioning has to be developed to make full use of the Second Application Exercise where broader societal questions are in focus. We felt that much more could have been made of the excellent presentations made by the participants in the second application exercise for example by raising questions about the different ethical approaches that could be taken to dealing with their responsibilities. Indeed, it might have been a better idea to have two TBLs separately at the workshop with one near the beginning going through to the First Application Exercise and discussion and then a separate session later on dealing specifically with the Second Application and a much broader discussion.

Given that the workshop was in an ethics series this might also have been an opportunity to bring some specific ethical reasoning into the debate.

If more time was available a better idea, perhaps, would be to have a short course in which four linked TBL exercises were run in sequence. This sequence could begin with the dual-use TBL used successfully in Stockholm, but then followed up with more specific examples of the misuse of neuroscience. For example the paper on the hijacking of benignly-intended neuroscience research in the development of the novel and very dangerous spice cannabinoids could be used to ask more generally about the responsibilities of neuroscientists.[19] That could be followed with a specific example of dual-use by focusing on the confirmation of the use of derivatives of the opioid fentanyl[viii] to break the Moscow theatre siege in 2002, with the loss of over 120 of the hostages' lives because of the effects of the fentanyl.[20] Finally, the general issue of the responsibilities of scientists could be dealt with by finishing with the TBL in the *Biosecurity Education Handbook* on Chapter 3 of the *Preventing Biological Threats* that deals in detail with Advances in Science and Technology and the Evolution of Bioweapons Capability and describes in considerable detail how civil work in the life sciences has been used in the last century to develop novel chemical and biological weapons..[21]

So far so good then, but what lessons have been gained besides the knowledge that a one-off TBL on dual use can be carried out within a neuroscience workshop? More importantly how does this help us with the task of widespread raising of awareness of the dual-use challenge set out in 2012 by the Royal Society report on *Neuroscience, conflict and security*? The longer-term aim must be to bring the challenge of dual-use into the regular university training of all neuroscientists as part of their consideration of the responsible conduct in the global neuroscience enterprise.[22] The Stockholm TBL might best be seen as a small step along that road.

[viii] Fentanyl is a synthetic chemical with actions similar to morphine, but it is much stronger in its effects. Again, this chemical was developed by civil scientists for benign purposes, but then used for other purposes in the theatre siege.

We have long argued that Team Based Learning can be an effective and efficient means of awareness-raising and education about the problem of dual-use for scientists,[23] but that there is also a need for coordinated national, regional and international action[24] to achieve the level of awareness implied by the UK Royal Society in *Neuroscience, conflict and security*. Exactly what needs to be done was set out by the Ukraine and the UK in their joint proposal of language for inclusion in the report of the 8th Review Conference of the BTWC in 2016. As they put it:[25]

> "18. The Conference should therefore adopt the following language in the Final Declaration text for Article IV:
>
> The Conference stresses the critical importance of biosecurity education and awareness-raising in achieving effective implementation of the Convention, which should be put into effect through national implementation measures, as appropriate, in accordance with the constitutional process and practices of each State Party.
>
> 19. The Conference notes that such measures could include:
>
> . (a) encouraging the promotion of a culture of responsible science among those working in the biological sciences and other relevant scientific disciplines;
>
> . (b) promoting among those working in the biological sciences, and other relevant scientific disciplines, awareness of the obligations of States Parties under the Convention, as well as relevant national legislation and guidelines;
>
> . (c) promoting the development and implementation of training and education programmes as well as training guides, handbooks and course materials, including raising awareness of the implications of dual use research and technology, for those granted access to biological agents and toxins relevant to the Convention, and especially for those with the knowledge or capacity to modify such agents and toxins;
>
> . (d) encouraging the development, adoption and promulgation of codes of conduct to promote awareness among relevant professionals in the private and public sectors and throughout relevant scientific and administrative activities."

This along with many other good ideas for strengthening the Convention were lost in the failure of the Conference to agree much other than to meet again in late 2017 to see if it was possible to find agreement on such issues. Fortunately, in the December 2017 follow up meeting of states parties to the BTWC it was agreed that the annual meetings through to the next Review Conference in 2021 would have a working group on science and technology[26] and that this working group would have as one of its topics "[D]evelopment of a voluntary model code of conduct for biological scientists and all relevant personnel, and biosecurity education, by drawing on the work already done on this issue in the context of the Convention, adaptable to national requirements." Thus, there is a real chance that progress can be made in raising the awareness of neuroscientists about the problem of dual use and further engaging them in dealing with the problem in coming years and that TBL exercises can be useful in that regard and in opening up more detailed ethical deliberations about this issue in the scientific community.

Figure 1. Timetable for the TBL

Formation of Groups and Introduction (1:30 – 2:00)
iRATs (2:00 – 2:15)
tRATs (2:15 – 2:30)
Feedback and Discussion (2:30 – 2:50)
First Application Exercise/Discussion (2:50 – 3:30)
Tea Break (3:30 – 4:00)
Second Application Exercise/Discussion (4:00 – 4:30)
Review by Participants (4:30 – 5:00)

*Figure 2. iRAT/tRAT Question 1**

1. Which statement about gain-of-function experiments is FALSE?

a) There are strict international guidelines on how information about such experiments involving influenza has to be conducted and communicated.

b) Such experiments are generally daily practice in the modern life sciences, and are not, in themselves, a cause for concern.

c) Studies that seek to enhance the biological properties of biological agents, such as virulence and transmissibility, are examples of gain-of-function experiments.

d) The creation of mammalian-transmissible H5N1 virus in 2011 constituted a gain-of-function experiment.

* From reference 12

*Figure 3. Team 5 working together on the tRAT**

* See enclosed figure

*Figure 4. Answers to the tRAT**

*See enclosed figure

*Figure 5. Question for and Possible Answers to the First Application Exercise**

Based on the H5N1 controversy described in Chapter 2, identify which of the following stakeholders bears the chief burden of responsibility for the prolonged debate?

A. The media who spread panic following the initial report on the findings presented by Ron Fouchier at the conference in Malta in September 2011;

B. The funding agencies who should have demanded that the applicants submit a detailed risk-benefit analysis of the proposed studies related to biosecurity;

C. The local institutional biosafety committees that should have insisted that scientists conduct thorough risk assessments with regard to biosecurity prior to, during and after the experiments;

D. The scientists who should have ensured that measures were in place to address any potential biosecurity concerns likely to arise from the experiments, before submitting their funding proposals;

E. The National Science Advisory Board for Biosecurity (NSABB) who should have allowed the publication of the manuscripts after having reviewed them in December 2011;

F. The security community who should have developed guidelines for what kind of life science research should be subject to restrictions in terms of publication;

G. The editorial boards of *Science* and *Nature* who should have published the papers without consulting the US Government and the NSABB;

H. The US Government who should have classified the manuscripts when the editorial boards of *Science* and *Nature* consulted them.

*From reference 12

*Figure 6: Stages of the Research Process**

Stage 1: Project Concept and Design

Stage 2: Funding Application and Award Process

Stage 3: Institutional Approval

Stage 4: Ongoing Research

Stage 5: Development of Manuscript and Other Research Product

Stage 6: Publication of Manuscript or Other Research Product

*From reference 12

*Figure 7. Presentation of Application Exercise 2**

*See enclosed figure

[1] Blank, R. H. (2013) *Intervention in the Brain: Politics, Policy, and Ethics*. MIT Press, Boston.
[2] Moreno, J. D. (2006) Mind Wars: Brain Research and National Defense. Dana Press, New York.
[3] For an account of these programmes in, for example, the EU, the USA, China and Japan see the special issue of the journal *Neuron* volume **92,** November, 2016.
[4] Australia (2014) *Weaponisation of Central Nervous System Acting Chemicals for Law Enforcement*. C-19/NAT.1, OPCW, The Hague, 19 November.
[5] OPCW, *Report of the Scientific Advisory Board on Developments in Science and Technology for the Third Special Session of the Conference of the States Parties to Review the Operation of the Chemical Weapons Convention*, RC-3/DG-1, OPCW, The Hague, 29 October 2012, 1-31, p. 4.
[6] Royal Society (2012) *Brain Waves Module 3: Neuroscience, conflict and security*. The Royal Society, London.
[7] See for example, Immersing students in responsible science through active learning pedagogies: lessons from educational institutes in the MENA region, by Lida Anestidou and Jay Labov, and Interactive biosecurity: Team-Based Learning in action by Tatyana Novossiolova in *Preventing Biological Threats: What You Can Do.* Available at http://www.brad.ac.uk/social-sciences/peace-studies/research/publications-and-projects/guide-to-biological-security-issues/

[8] For details see https://www.humanbrainproject.eu/en/open-ethical-engaged/
[9] See https://education.humanbrainproject.eu/web/hbp-education-portal/about/
[10] See for example Wheelis, M., Rozsa, L., and Dando, M.R. (Eds.) (2006) *Deadly Cultures: Biological Weapons Since 1945*. Harvard University Press, Harvard.
[11] See SBTWC: Web of Prevention Clearing House at http://www.opbw.org.
[12] Whitby, S., Novossiolova, T., Walther, G., and Dando, M. R. (Eds.) (2016) *Preventing Biological Threats: What You Can Do.* Available at http://www.brad.ac.uk/social-sciences/peace-studies/research/publications-and-projects/guide-to-biological-security-issues/

[13] Novossiolova, T. (2016) *Biological Security Education Handbook: The Power of Team-Based Learning.* Available at http://www.brad.ac.uk/social-sciences/peace-studies/research/publications-and-projects/guide-to-biological-security-issues

[14] van der Bruggen, K. (2016) Biosecurity challenges in the 21st Century: the case of gain-of-function experiments. Available at http://www.brad.ac.uk/social-sciences/peace-studies/research/publications-and-projects/guide-to-biological-security-issues/

[15] For details see Chapter 20 on Interactive biosecurity: Team-Based Learning in action by Tatyana Novossiolova in *Preventing Biological Threats: What You Can Do*. Available at http://www.brad.ac.uk/social-sciences/peace-studies/research/publications-and-projects/guide-to-biological-security-issues/

[16] Charles Gullo, Tam Cam Ha & Sandy Cook (2015) Twelve tips for facilitating team-based learning, Medical Teacher, 37:9, 819-824, DOI: 10.3109/0142159X.2014.1001729

[17] Novossiolova, T. (2018) The Role of the Non-Governmental Life Science Community in Combatting the Development, Proliferation and Use of Chemical Weapons. Chapter 18 in M. Crowley, M. R. Dando and L. Shang (Eds.), *Preventing Chemical Weapons: Arms Control and Disarmament as the Sciences Converge.* Royal Society of Chemistry, London (in press).

[18] Meyer JHF and Land R (2003). Threshold Concepts and Troublesome Knowledge –Linkages to Ways of Thinking and Practising. In C.Rust (Ed), *Improving Student Learning –Ten Years On*. OCSLD, Oxford.

[19] Wiley, J. L. *et al* (2011) Hijacking of Basic Research: The Case of Synthetic Canabinoids. *Methods Rep RTI Press*, November; 2011: .doi:10.3768/rtipress.2011.op.007.1111.

[20] Riches, J. R. *et al* (2012) Analysis of clothing and urine from Moscow theatre siege casualties reveals Carfentanil and Remifentanil use. *Journal of Analytical Toxicology*, **36**, 647-656.

[21] Novossiolova, T. (2016) *Biological Security Education Handbook: The Power of Team-Based Learning.* Available at http://www.brad.ac.uk/social-sciences/peace-studies/research/publications-and-projects/guide-to-biological-security-issue

[22] InterAcademy Partnership (2016) *Doing Global Science: A Guide to Responsible Conduct in the Global Research Enterprise*, Princeton University Press.

[23] Novossiolova, T., Mancini, G. and Dando, M.R. (2013) *Effective and Sustainable Biosecurity Education for those in the Life Science: The Benefits of Active Learning*. Briefing Paper No 7 (Third Series), University of Bradford, June.

[24] Novossiolova, T. and Pearson, G.S. (2012) *Biosecurity Education for the Life Sciences: Nuclear Security Education Experience as a Model*. Briefing Paper No 5 (Third Series), University of Bradford, October.

[25] Ukraine and the UK (2016) *Awareness-raising, education, outreach: An example of best practice*. BWC/CONF.VIII/WP.10. United Nations, Geneva, 19 October.

[26] Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and Their Destruction (2017) *Report of the Meeting of States Parties*. United Nations, Geneva, December.