CENTRE FOR
BIOSECURITY AND
BIOPREPAREDNESS

biological security threats

situation report on biological attacks, weapons development and misuse

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Published by:
Centre for Biosecurity and Biopreparedness
Statens Serum Institut
5 Artillerivej
DK-2300 Copenhagen S

www.biosikring.dk/eng

Graphic design and layout:
Koch & Falk

Printed by: Pekema

1. edition, 2016
ISBN: 978-87-998137-3-5

1
foreword

Photo: CBB

Biological threats can be a huge challenge to national or even international security. Natural outbreaks of infectious diseases happen regularly and are part of the natural order of things. New infections appear all the time, because existing microorganisms are continually changing and adapting to their surroundings, of which humans are a part. Preparedness against infectious diseases must therefore be continually updated, because the risk scenario is changeable rather than static. In addition, human activity increases the risk of infectious outbreaks. The excessive or unnecessary use of antibiotics can increase the occurrence of resistant microorganisms, and technological developments increase the likelihood of pathogenic microorganisms being deliberately misused.

Technological developments, especially with regard to knowledge of microbiology and training in laboratory skills, have made it possible for more and more people to manufacture and use biological toxins or pathogenic microorganisms for criminal, terrorist or military purposes. The threat of use of biological weapons can be so frightening that the mere suspicion of its presence can start a war. This report contains a review of some recent situations in which the use of biological weapons has either been made possible, been suspected, or actually taken place. The purpose of this report is to provide an overall and balanced assessment of the threat of harmful biological attacks or release of weapons-relevant materials.

The Centre for Biosecurity and Biopreparedness is continually monitoring biological incidents and technological developments to stay abreast of biological security threats. The purpose of this is

1) to focus preventive biosecurity measures on the most relevant biological security threats and
2) to adjust biological preparedness in order to counter incidents should they take place. Natural outbreaks of infectious diseases are therefore not included in this report unless they contain specific security issues.

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Director, MD, DMSc

2 summary

In this publication - *Biological Security Threats – situation report on biological attacks, weapons development and misuse,* the Danish Centre for Biosecurity and Biopreparedness presents an overall assessment of current biological threats and risks. All sources and references in this unclassified report are available to the public.

- Chapter 3 is an introduction.
- Chapter 4 deals with natural outbreaks of disease and the extent to which the growing number of infectious diseases increase the risk of development of biological weapons. This chapter also looks at the risk of misinformation about natural outbreaks of disease.
- Chapter 5 reviews current trends in life sciences and looks at the extent to which technological developments increase the risk of biological weapons development.
- Chapter 6 presents the risks of accidental, uncontrolled release from laboratories. This chapter will also discuss the threat of uncontrolled release due to sabotage (the "insider" threat).
- Chapter 7 is a historical overview of states' interest in biological weapons. It also discusses the technical difficulties involved in developing biological weapons and explains why these weapons, in spite of the difficulties, can be attractive for certain types of regimes.
- Chapter 8 examines the historical interest in biological weapons among terrorists and criminals. It explains the technical barriers to creating this type of weapon and demonstrates how technological developments in certain areas can increase the likelihood of low-tech biological attacks.
- Chapter 9 is a conclusion.

In general, the likelihood of a biological attack is low, but a successful attack can have very serious social consequences. Chapters 4-8 will therefore also describe how Danish biosecurity helps prevent various types of biological threats, and how Danish biopreparedness can respond to the consequences of a successful biological attack or an uncontrolled release of biological substances.

Mosquitoes can be natural hosts for countless infectious diseases such as malaria or zika virus. Photo: Colourbox

3 intro duction

The Centre for Biosecurity and Biopreparedness (CBB) was established in 2001 as a national preparedness organisation against biological security threats in Denmark. In 2008, the Danish Parliament enacted a law that requires all facilities that work with controlled materials (i.e., materials that can be misused to develop biological weapons) to adhere to certain security regulations and to obtain a license from CBB to perform this work. Today, CBB is the agency responsible for biosecurity and biopreparedness in Denmark.

In *Biological Security Threats – situation report on biological attacks, weapons development and misuse,* CBB has developed for public use a single overview of current biological threats and risks. This report contains no classified information, and all sources and references are therefore publicly accessible. The main focus is on biological threats of an intentional nature, i.e. bioterrorism, but the report also includes other factors that can affect the overall biological security situation. This publication will therefore also include:

- Security aspects of natural outbreaks of disease
- Technological developments
- The risk of an uncontrolled release of a dangerous biological substance

Biological weapons have been used in armed conflicts throughout history, including both world wars. Biological weapons are today internationally prohibited, but there is no international control mechanism that can enforce this prohibition. This is partly because many materials – including biological substances – can serve peaceful purposes as well as being misused in weapons production. This is called "dual use", and it is an obstacle to international enforcement.

Even though biological weapons are often called weapons of mass destruction, the term can to some extent hide the fact that biological warfare agents can be used very flexibly. A biological weapon can be used to assassinate an individual, to target a few persons or to harm farm animals or crops. A biological weapon can also target an entire population and lead to mass death. There are also biological weapons such as *Bacillus anthracis* that can contaminate an area of land for years or decades. It should also be noted that biological weapons can – and historically have been – used in ways that can be mistaken for natural outbreaks of disease. Even an allegation that a state is developing biological weapons can therefore have great political consequences, as seen with the invasion of Iraq in 2003.

Biological weapons
A biological warfare agent combined with a delivery system. A warfare agent is biological material that could, for example, be robust, contagious or deadly, and which has been turned into a weapon (weaponised). A delivery system could be a technical device that disseminates the biological warfare agent – for example a spraying device on an airplane or an unmanned aerial vehicle (UAV or "drone").[1]

The overall purpose of this publication is to describe how biological weapons might be used, and by whom. In general, the likelihood of a biological attack must be viewed as small, but a successful attack could have huge social consequences. The most likely candidates to use a biological weapons are certain states as well as certain politically or religiously motivated terrorist groups or individuals. Each chapter begins with the description of a specific problem that is further explained with analyses and historical examples. Each chapter will also include CBB assessments and a conclusion explaining how biosecurity and biopreparedness can prevent and address biological threats. The report as a whole will also provide an overall conclusion on the status of biological threats.

1 "Terminologi" at www.biosikring.dk

Laboratory. Photo: CBB

4 natural outbreaks of disease and the threat of bioterrorism

Throughout history, humanity has been plagued by infectious diseases. For a number of reasons, there is at present a growing risk from familiar as well as from entirely new infectious diseases. It is highly unlikely that terrorists could misuse an epidemic or pandemic to gain access to biological substances for use in bioterrorism. A state would, however, have greater opportunity to weaponise materials from a specific disease outbreak.

Misinformation is seen at regular intervals alleging that outbreaks of disease are really caused by a deliberate biological attack. In most cases these allegations can be dismissed as groundless, but in a high-tension situation, such statements can cause panic and violence. It is therefore necessary to be able to make quick and precise assessments to determine whether an outbreak of disease is natural or intentional.

The bat in the tree

In December 2014, a two-year-old boy, Emile Ouamouno, fell ill and died within a few days in the West African state of Guinea. No one in his village, Meliandou, or anywhere else, suspected that he was probably the first person to be infected with Ebola in Guinea. Neighbours later recalled that the boy had often played near a tree where bats were living. Bats are well-known host animals to many viruses (although it has yet to be proven that Ebola is one of them), and somehow the boy had gotten infected, fallen ill and died. Later his sister, his mother and his grandmother died of Ebola. And from there the virus spread like ripples in water. An infected health worker went to a hospital in Macenta, where he infected another 15 people. An epidemic had begun which would cost 11,323 human lives and sicken 28,646 people in Guinea, Liberia and Sierra Leone in 2014 and 2015.[5]

The West African Ebola epidemic came as a surprise to the international community. The Ebola virus was discovered in Zaire (today The Democratic Republic of Congo) in 1976 and has long been a notorious cause of serious illness and high mortality (sometimes up to 88 percent of infected patients) among humans. There are some experimental vaccines against Ebola, but none have been approved for use in humans. Earlier outbreaks of Ebola had typically occurred in isolated areas and stopped after a short time. The West African epidemic of 2014-2015 was both widespread and prolonged. It has furthermore been shown that this virus – even after a patient seems to have recovered – can survive for months in such material as semen.[6] This is probably why there were still sporadic outbreaks of Ebola in West Africa in 2016.

Infectious diseases
Illnesses caused by infection from a microorganism or parasite. Until the 1800s, infectious diseases were responsible for high mortality in Europe, and this is still the case in many developing countries. Vaccinations and medical treatment can combat most of the serious infectious diseases. Better living conditions, including improved nutrition, hygiene and housing also play an important role.[2]

Ebola is a deadly disease, but it has never yet developed into a pandemic (a global epidemic). Some of the most well-known pandemics include:

- The Justinian Plague (caused by the bacteria *Yersinia pestis*), which in the 500s spread from Asia to Europe. The pandemic probably cost over 25 million human lives in the area around the Mediterranean Sea.

- The Black Plague (also caused by *Yersinia pestis*), which spread from Asia to Europe in the 1300s and probably wiped out 60 percent of the European population.[7]

- The Spanish Flu (caused by the H1N1 influenza virus), which in 1918 cost some 50 million human lives in a six-month period.[8]

A few decades ago it was a widespread notion that modern science – including the development of new medical treatments and vaccines – had brought the threat of infectious diseases under control. But the Ebola epidemic in West Africa was a reminder that this notion is incorrect. Ebola is a so-called zoonosis – an illness that is transmitted from animals to humans. Bats in particular are known as natural host animals for countless zoonoses that can infect humans.[10] There are today seven billion people on the earth. All of them need space, food and energy in order to survive. Humanity is bound together by a global network of 50,000 airports, 32 million kilometers of roads and hundreds of thousands of ships that crisscross oceans every day.[11] This brings both new and familiar viruses and bacteria in close contact with humans who, thanks to modern means of transportation, can unwittingly spread disease to new countries and continents within a few days or weeks.

Although modern medicine continues to make progress, the threat of infectious disease will probably continue to grow in the years to come. The outbreak of new infectious diseases, including zoonoses such as HIV/AIDS, SARS or Zika, all point in that direction. So it is not so much a question of whether there will be a new, deadly pandemic. It is a question of when. It can be assumed that climate change will in various ways exacerbate this trend. A disease outbreak caused by *Bacillus anthracis* spores in Siberia in the summer of 2016 was most likely caused by unusually high temperatures that thawed frozen animal cadavers. *Bacillus anthracis* spores can survive in frozen human and animal corpses for decades, and the normally-frozen Siberian earth has

An improvised sanitary station with disinfectant liquids during the Ebola outbreak in West Africa. Photo: Kamimoto, CDC

Anthrax
Anthrax is caused by the bacteria *Bacillus anthracis*. It is primarily a disease among larger, plant-eating animals, but it can also infect humans. If the infection is not treated in time with antibiotics, it can be deadly. Vaccines against anthrax exist. But the bacteria can under certain conditions produce robust spores that are extremely resistant to boiling and irradiation, for example. For this reason, *Bacillus anthracis* has often been developed and used as a biological weapon. [9]

made it impossible for the local population to bury their dead very deeply in the ground. It is estimated that there are about 7,000 animal cemeteries in northern Russia which could contain frozen cadavers with *Bacillus anthracis* and other potentially harmful microorganisms.[12]

Smallpox as a biological weapon

The international community has in the last century managed to eliminate two infectious diseases and bring others to the edge of extinction – polio, for example. But this success story also contains a paradox. The moment a deadly infectious disease is exterminated, the same microorganism can become an attractive biological weapon. One of the worst infectious diseases in history – smallpox (caused by the virus Variola major) – killed an estimated 300 million people in the 20th century alone.[13] Smallpox was once among the few infectious diseases that occurred solely among humans, and it was therefore possible to eradicate the disease through a systematic programme of vaccination in the 1960s. In May 1980, the World Health Organisation (WHO) declared smallpox eradicated.[14] The Soviet Union played a major role in this eradication, but even as WHO released its declaration, the virus was secretly being weaponised for military use in the Soviet biological weapons programme. Soviet scientists tried to strengthen the virus, making it resistant to irradiation so it could be used as a biological weapon even after a nuclear war. In July 1971, things very nearly went wrong when the crew of a fishing boat in the Aral Sea was infected with smallpox which had most likely spread through the air from a military weapons project on a nearby island. The crew brought the disease back to the town of Aralsk, where others were infected. The Soviet security agency KGB managed to keep the episode a secret, and the incident did not come to light until after the Soviet collapse.[15]

Today the smallpox virus is officially stored in just two places: in Atlanta, USA at the *Centers for Disease Control and Prevention* (CDC) and at the *Vector Institute* in Novosibirsk, Russia. The virus is stored on behalf of WHO in accordance with extremely strict biosecurity and biosafety rules. But the finding of a cardboard box containing live smallpox virus in a storage room in Maryland, USA in 2014 proves that the virus may quite possibly also be found elsewhere.[17] This uncertainty has caused WHO to delay the final destruction of the smallpox virus several times. Instead, due to the fear of bioterrorism, new vaccines are being developed and manufactured.

Since 2004, Denmark has had a smallpox plan developed by CBB and the Danish Health Authority. It was, in particular, the fear of a terrorist attack using the smallpox virus that motivated this plan, which describes how an outbreak of smallpox could quickly be ascertained, and how patients could quickly be hospitalized and isolated. It also covers quarantine and communication strategies as well as vaccinations to stop the disease.[18] In 2013, CBB was asked to assess the likelihood of a smallpox outbreak in Denmark. It concluded that the risk is extremely small (statistically speaking, one incident in 200,000 years), and that an older, commercially developed type of vaccine would be able to contain an epidemic relatively quickly. The existing smallpox plan is therefore regarded as sufficient protection of the Danish population against a biological attack or an uncontrolled release of smallpox.[19]

Terrorists and infectious diseases

Sovereign states are not the only entities that are interested in misusing naturally occurring infectious diseases. In 1992 the Japanese doomsday sect Aum Shinrikyo tried to send people to Africa to find and isolate the Ebola virus during a smaller epidemic in Zaire (today The Democratic Republic of the Congo). The mission failed, and members of the sect did not obtain any weapons-grade virus material (read more in chapter 8).[20]

The American researcher W. Seth Carus of the US National Defense University has investigated 33 examples of misuse of biological substances by criminals and terrorists between 1990 and 2002. In only six cases could it be proven that criminals or

Biosecurity and biosafety
Biosecurity is defined as the prevention of deliberate misuse of certain biological agents, toxins, equipment, knowledge and skills for offensive purposes.

Biosafety rules at facilities with biological substances are designed to protect employees against accidents.[16]

terrorists had tried to obtain biological material from "natural" sources – that is, from patients or diseased animals. One of the reasons for this is probably the fact that few infectious diseases are caused by microorganisms that are suitable for weaponization. An American study shows that of 1,099 epidemics between 1988 and 1999, only four percent involved microorganisms that are suitable for use in biological warfare or bioterrorism.[21]

The Ebola epidemic in West Africa in 2014-2015 was caused by a biological substance that could be used in biological warfare or bioterrorism. Furthermore, the epidemic took place in poor, war-torn countries whose state institutions are weak. In at least one case, a taxi in Guinea that was transporting patient samples containing Ebola was robbed. There is no indication that the robbers were specifically interested in the patient samples, which were stolen along with mobile telephones and cash from the passengers in the taxi. In another case, an angry crowd attacked a clinic for Ebola patients in Liberia and stole mattresses, sheets and medical equipment that were contaminated with patient blood.[22]

The above examples demonstrate how deadly pathogens from a natural outbreak of disease can fall into the wrong hands. But even if a terrorist organization were to try to obtain blood samples from a patient with a deadly disease, it would in practice be difficult to transform it into an efficient biological weapon.

Natural outbreak or deliberate attack?

Every so often, allegations are made that a natural outbreak of disease is really the result of a deliberate attack. During the Korean War in 1950-1953, for example, communist North Korea and China claimed that the US used biological weapons against them. The allegations were widely publicised in the 1950s, but after the Cold War they were exposed as misinformation.[24]

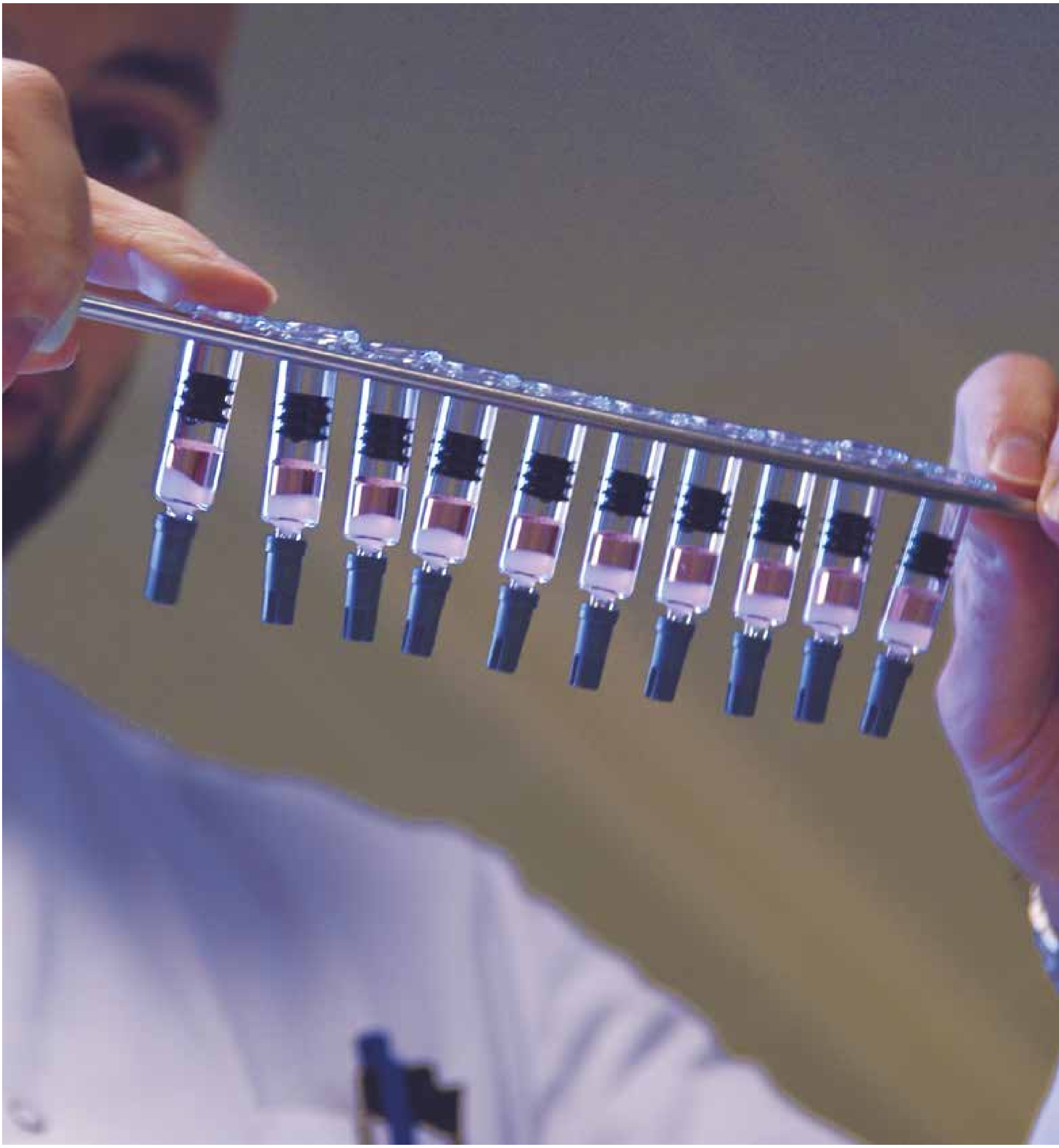
In 1994, India was hit by an epidemic of plague (the first in 28 years), during which 238 people were infected and 56 died. The epidemic occurred at a time when tensions were running high between the country's Hindus and Muslims. In 1992, the destruction of a mosque in the city Ayodhya in northern India created unrest throughout the country, and 190 persons were killed

**CBB assessment:
Misuse of infectious diseases**

In principle, a terrorist could infect another person with patient blood that contains a deadly microorganism. But this is not a very effective way to start an epidemic, although the terrorist could no doubt create a panic. It is also possible for a terrorist to try to infect himself with a deadly microorganism, and then spread the disease to others. But the terrorist would find it difficult to work out how long he could continue to infect others before he himself becomes too ill to move around. The most promising method would be to isolate the microorganism and weaponise it. Weaponisation of biological material requires special scientific expertise. See chapter 5 for more information.

An important exception is the virus that causes foot and mouth disease (FMD) in cloven-hoofed animals such as cattle and swine. The disease is not dangerous to humans, nor is it normally deadly for cloven-hoofed animals. But it is extremely infectious and causes permanent damage, including a higher frequency of miscarriages and reduced milk production among cattle. An FMD epidemic would typically cause significant financial loss to the farming industry because infected animals must be put down, and because an epidemic would immediately result in an export embargo. A widespread FMD epidemic in Great Britain in 2001 was almost certainly caused by infected meat or meat products being used as feed for a herd of pigs on a farm (Burnside Farm) in Northumberland. The FMD virus can survive in bone marrow for six months – and perhaps as long as several years – if the meat product is frozen. No special expertise is needed to infect animals with FMD-infected material, and the resulting economic loss to agrobusiness could be considerable.[23]

A decision to destroy the smallpox virus has been postponed several times by WHO. Instead, due to the fear of bioterrorism, new vaccines are being developed and manufactured.
Photo: Bjørn Wennerwald/SSI



CBB assessment:
Epidemic signature analyses

There are several methods with which to determine whether an outbreak of disease occurred naturally or was the result of a biological attack. These methods examine the disease outbreak from every angle (biological, epidemiological, medical and social) and can thus contribute to an overall assessment of whether the outbreak could have been caused intentionally. CBB has used the monitoring system BioAlarm for several years. The system notifies CBB of suspicious outbreaks of disease and can thus help identify a possible biological attack in its earliest stages. BioAlarm monitors such things as emergency calls and ambulance dispatches. BioAlarm cannot stand alone, but it can serve as an important element in an epidemic signature analysis.

An epidemic signature analysis can, for example, address the following questions:

- Is the biological material internationally recognised as a potential biological weapon, and has the biological material previously been used as such?
- Is the strain/type an unusual one that is not found in the natural environment of the area?
- Is there a clear target (political, religious, etc.) for a possible biological attack?
- Have any strains of the agent in question been reported stolen?
- Have any terrorist groups or individuals taken responsibility for the outbreak?
- Are there unusual symptoms, or are there more cases than could be expected in a natural outbreak?

Questions about infection routes, geographical dissemination, etc. should also be addressed.

Because the investigation of an outbreak will unfold and develop continuously during the outbreak, with new information constantly being added (for example when new patients are identified, or blood samples are analysed), it is usually a good idea to perform the epidemic signature analysis several times until the source of the outbreak has been identified.

during riots in the large city of Surat. When reports emerged in September 1994 about cases of plague in Surat, a panic ensued that was further fuelled by rumours that the water supply in the city had been poisoned. Shops were emptied of water bottles, half a million people fled, and some Muslims fanned the flames by declaring that the epidemic was a divine punishment against Hindus. Today it is certain that the epidemic was as a naturally occurring outbreak in a village, from which it spread to the slum areas of Surat. But the rumours of a biological attack not only caused the panic in 1994 but could also have unleashed renewed sectarian violence in India. Luckily, this was avoided.[25]

It can still be a challenge to distinguish between a natural outbreak of disease and a biological attack. Even a few cases of illness and death can be highly destabilising for a country and can cause serious economic losses if it represents a biological attack. A so-called epidemic signature analysis can help determine whether an outbreak occurred naturally or was intentional. The analysis will examine such things as whether or not the illness is normally seen in the affected area, and whether the disease has an unusual dissemination pattern that hits certain population groups harder than others. An epidemic signature analysis should also be able to rule out the possibility of a natural source of infection. In a tense political situation where the risk of violence lies just below the surface, a quick epidemic signature analysis can be crucial for determining whether a disease outbreak occurred naturally or was caused by deliberate actions.

What CBB is doing

There are countless outbreaks of infectious diseases in Africa, and a great many microorganisms have therefore been isolated at laboratories throughout the continent. In collaboration with the Danish Ministry of Defense, the Ministry of Foreign Affairs and the Ministry of Health, CBB is working on a project in eastern Africa called “The Danish Partnership Programme”. Its purpose is to develop a biosecurity system, beginning in Kenya and with regionalisation to follow. Elements of the programme include the creation of a handbook on biosecurity, an examination of how dangerous biological substances are stored in over 100 Kenyan laboratories, and the training of key personnel. The idea is to address both man-made biological threats and the threat of natural outbreaks of disease, thus creating a platform for improved public health, economic growth and security.

Via the Danish Ministry of Foreign Affairs, Denmark is also placing CBB’s operative capacity at the disposal of the UN Secretary General’s mechanism for investigation of alleged use of biological weapons. If it is suspected that an outbreak of disease could be intentional, CBB can help with the investigation. In this context, a Field Investigation Team can draw upon CBB’s analytical capacity to examine whether an outbreak was man-made or a naturally occurring event.

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Certain areas of research give special cause for concern.
Photo: Bjørn Wennerwald/SSI

5

technological developments – a shortcut to new biological weapons?

Technological developments in the life sciences are moving in a variety of directions. Today it is possible to reconstruct extinct microorganisms or create mutations that could make a virus more deadly. The latter can provide greater insight into the point at which a given microorganism could reach pandemic potential. One day it will probably be possible to create "tailor-made" microorganisms through so-called synthetic biology. This could, for example, lead to better and cheaper medicine.

At the same time, a "democratisation" of the life sciences is taking place that will enable ordinary people to work with biological material. Technological developments are continually making biotechnology cheaper and easier to work with, enabling so-called "biohackers" to experiment with biological materials and develop their own technological solutions.

Both trends have the potential for great social benefit, but they can also be misused. Biosecurity measures to secure and regulate a peaceful scientific development are therefore necessary.

Migrating grey geese. Virologist Ron Fouchier developed mutations of the H5N1 virus (avian flu) that made it infectious among mammals. Photo: CBB

The H5N1 controversy

At a scientific conference in Malta in September 2011, Dutch virologist Ron Fouchier announced that during an experiment with the H5N1 virus (popularly known as avian flu), he had created a series of mutations that made airborne infection possible among mammals. The H5N1 virus occurs naturally among birds and has sometimes infected humans. It has a mortality of 60 percent (meaning that 60 percent of the infected will die), but the virus is rarely transmitted from human to human. Among the pandemic threats to humanity now being monitored by scientists, avian flu is regarded as one of the greatest. Fouchier's experiment showed that a series of mutations could make airborne infection possible between mammals, including humans. At about the same time, an American virologist, Yoshihiro Kawaoka, achieved similar results. Towards the end of 2011, both scientists submitted scientific articles about their H5N1 discoveries to the journals *Science og Nature*.[26]

These events created an international stir. A *New York Times* editorial warned that this virus could kill millions if released or stolen.[27] A Danish tabloid described the new virus as the "satanic variation" with the headline "World's most evil influenza: Can kill millions".[28]

The US National Science Advisory Board for Biosecurity (NSABB) reviewed the articles and recommended that specific methods and other technical details be deleted due to the threat of bioterrorism. A few months later, in 2012, Fouchier and Kawaoka received national permission to publish uncensored articles, but the controversy continued. A number of accidents with dangerous biological substances in the US caused the US government in October 2014 to suspend funding for the so-called gain-of-function experiments (in which mutations provide microorganisms with new or improved characteristics) in relation to several viruses with pandemic potential.[29] In May 2016, the NSABB published some suggested guidelines for how gain-of-function experiments could be done with US state funding.[30] At the time of this writing, these suggestions are being reviewed by the US government.

The question of regulation

The reason the H5N1 controversy became so intense is that it touches on some fundamental questions. On one side are scientists who believe they should be able to investigate anything they want with a minimum of regulation. On the other side is the opinion that scientists do not adequately understand the risk of others misusing their discoveries for bioterrorism. Complicating the debate is the fact that it often moves from being about biosecurity (protection against deliberate misuse) to being about biosafety – the risk that experiments with particularly virulent microorganisms could accidentally infect humans and perhaps escape from a laboratory. Although they seem similar, the two issues are fundamentally different.[31]

In 2004 the so-called Fink Committee issued a report in the US identifying the following areas of research as sources of special concern:

I. Experiments that can make a vaccine ineffective
II. Experiments that can increase resistance against medical treatment
III. Experiments that increase the virulence of a microorganism or make a harmless microorganism virulent
IV. Experiments that augment infectiousness
V. Experiments that change the characteristics of a microorganism
VI. Experiments that make it possible to avoid the proper detection and identification of a microorganism
VII. Experiments that make it possible to weaponise a biological substance or toxin.[32]

The degree of regulation for these types of experiments is another issue. In 2000, the US National Commission on Terrorism recommended that all work with dangerous pathogens be given as much security as work with weapons-grade nuclear materials.[33] It is doubtful whether things will ever go that far. Instead, the US government established NSABB to advise on this type of research and in some cases be consulted before research results are published. NSABB's first assignment was to evaluate whether an article could be published which described the successful reconstruction of eight viral gene sequences from the Spanish flu that in 1918 killed 50 million people within six months. The viral gene sequences were attached to an ordinary seasonal influenza which then demonstrated much higher mortality. It would thus seem that the scientists had been able to resurrect the original Spanish flu. At the time, NSABB decided that the advantages of publishing the scientific results outweighed the risk.[34]

An alternative to national regulation is for scientists themselves to withhold information. In 2013, US scientists announced in *Journal of Infectious Diseases* that they had discovered a new and extremely toxic variety of the botulinum toxin. For security reasons, the scientists withheld information on the gene sequence containing the key information needed to create the toxin. Scientific periodicals normally require all new gene sequences to be registered in a public database, but in this case the *Journal of Infectious Diseases* accepted that the information could be withheld until a medical treatment for the new botulinum toxin[35] could be developed.[36]

Tacit knowledge

Tacit knowledge is knowledge or skills that cannot be transferred from one person to another in written or verbal form. Instead, years of work and the development of a personal approach are needed to understand and perform a particular technique. Some laboratory techniques have been described as "art" which can only be learned by working with a mentor and repeating a procedure many times. For the same reason, it is no simple matter to read even a detailed description of an experiment in a journal and then repeat the procedure on one's own.[37]

The importance of knowledge and skills

In February 2016, the US Director of National Intelligence James R. Clapper delivered a report to the Senate Armed Services Committee in which he, among a great many other international threats, also warned of the risks involved in new genetic engineering methods. Clapper described genetic engineering as a technology with dual use potential that could benefit humanity through peaceful use, but which could also – by accident or by intent – do irreparable damage and threaten national security.[38] A new method of gene modification called Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR) makes it possible to transfer genes to cells for the purpose of curing human diseases. CRISPR can also give new characteristics to animals and crops. The method is revolutionary in its simplicity and has therefore great potential. But in the wrong hands, it can be misused to create biological weapons.

CBB assessment:
Weaponisation of ricin and other toxins

Ricin and other toxins can be manufactured by a single person with technical background knowledge and practical skills at the level of a Danish laboratory technician. Such a person could create amounts corresponding to at least one million deadly doses per year of production. The equipment needed to manufacture this type of biological warfare agent can be obtained without access to special components for a price of less than DKK 20,000. Production can take place in a facility of less than 30 square metres with access to electricity and running water. Dissemination of the finished warfare agent in an amount corresponding to 1 million deadly doses can be performed with a dissemination efficiency of between 1 and 10 percent using easily-obtainable equipment, and the mortality in enclosed spaces or via fresh food could exceed 1,000 persons. A biological weapon with a potential effect of more than 100,000 deaths could be manufactured within one year using resources which, in addition to those described above, would involve access to specific biological precursors, microbiological expertise at a PhD level and consumables worth about DKK 30,000.[41]

At the same time, it is necessary to nuance this discussion. Work with highly dangerous pathogens still requires years of education, for example at a university. As exemplified in the 1990s by the *Aum Shinrikyo* sect (discussed in greater detail in chapter 8), even a malicious organisation with ample financing cannot make up for a lack of scientific expertise, including so-called "tacit knowledge". Even if an experienced scientist decided to misuse his knowledge of genetic engineering, that person would still face great difficulties. Experience from the Soviet weapons programme shows that progress in one area – for example increased virulence in a microorganism – often leads to diminished characteristics in other areas, for example a reduced ability to transmit infection.[39] It will probably require long and resource-intensive lab work to create a biological weapon with all the right characteristics. The need for secrecy in this work is also likely to be a major barrier. The risks of new technology must not be underestimated, but in practice it is not easy to weaponise biological material.

CBB categories for technology control

A. Immediate weapon production is possible – license from CBB required prior to project initiation

B. Serious potential for misuse in the development of weapons – prior CBB guidance required

C. Less serious and more general potential for misuse – awareness and responsible security culture at the facility.[42]

It is therefore also necessary to be aware of a more likely risk. As technological developments progress, the life sciences have become increasingly "democratised". A budding subculture of amateur biologists, the so-called "biohackers", are working in garages and basements, sharing knowledge and making new discoveries. Among other things, "biohackers" have developed a free smartphone app that can count bacteria colonies and monitor their rate of growth. The trend today is that "biohackers" are taking an increasingly professional approach and are partnering with businesses or universities. "Biohackers" could follow the same trajectory as the computer engineers who in the 1970s developed the world's first personal computers in a garage. As in Moore's Law, which states that the number of components in an integrated circuit will double every 18 months, biotechnological developments are happening at an ever-increasing pace, bringing new opportunities for "biohackers".

As yet there have been no examples of misuse by "biohackers", but it would be unwise to ignore the possibility. It is debatable whether a malicious "biohacker" could create an advanced biological weapon, even with the help of CRISPR. But the person could, for example, use simple methods to weaponise large amounts of a relatively simple biological substance and use it in a biological attack. Compared to a genetically engineered weapon, it is a very low-tech biological threat. But this only makes it more likely that a biological threat will come from a pathogen that is easy to obtain and weaponise.

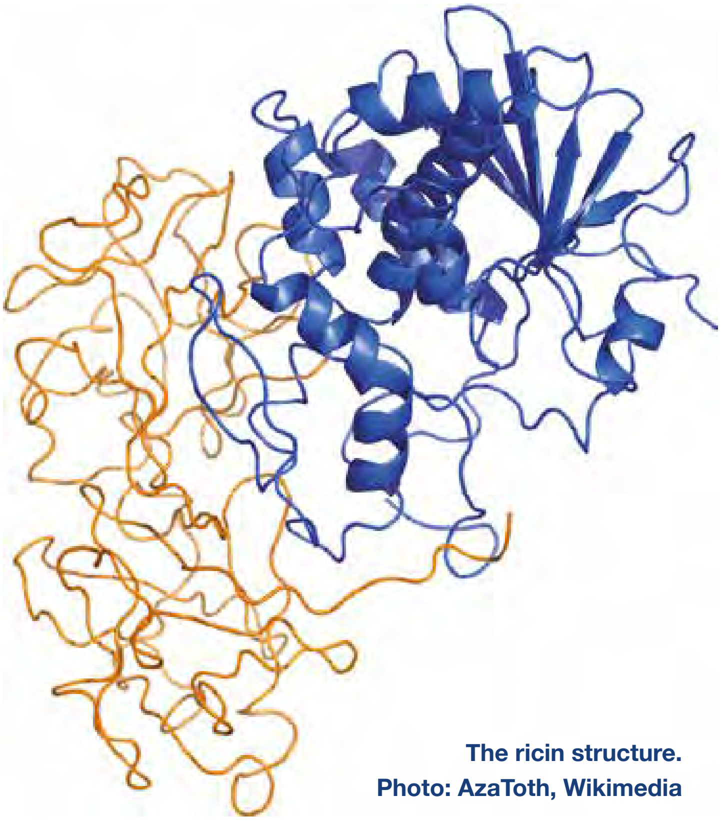
What CBB is doing

Since 2012, CBB has collaborated with Danish universities to educate students pursuing relevant scientific studies. The goal is to enable students to recognise situations in which work or research can be misused, and enable them to act in a way that is ethically correct. To ensure against misuse, one must be aware of who one is collaborating or doing business with. This could involve biological substances as well as technical equipment and written knowledge with dual-use potential. CBB has also sought to engage with the Danish "biohacker" community - not only to stay abreast of developments but also to make the community aware of its bioethical responsibilities.

The Danish biosecurity law requires CBB to regulate facilities that work with immaterial technology perceived as having a potential for. CBB places companies working with these dual-use technologies in one of three categories, A, B or C. If a company or institution does not work with dual-use technology at all, it is placed in category 0.

Since 2015, CBB has conducted targeted inspections to determine which facilities work with dual-use technology. Development of dual-use technology requires a license from CBB if the technology involves an immediate potential for misuse. To obtain this license, the purpose of the technology development must be legitimate, which in this context means that it serves a beneficial purpose such as for example the development and test of countermeasures. Applications for this license are individual and are arranged with CBB on a case-by-case basis. No prior license is required for other technologies, including technologies that have a legitimate purpose but which could also be misused in the development of a biological weapon (dual-use). Companies that develop such technologies must, however, seek the advice of CBB in order to minimise the potential for misuse and strengthen their biosecurity culture. Technology that is already in the public domain is not subject to regulation.

Facilities with dual-use capacity at their disposal must also ensure that sensitive information about new technology does not fall into the wrong hands. This could involve, for example, information on new fermentation techniques or the encapsulation of microorganisms. In this context, CBB helps the individual facility assess the potential for misuse of a specific technology as well as possible ways to manage this challenge.



The ricin structure.
Photo: AzaToth, Wikimedia

26 Koos van der Bruggen: "Biosecurity challenges in the 21st century: the case of gain-of-function experiments". Chapter in Simon Whitby (editor) et.al: "Preventing Biological Threats: What You Can Do: A Guide to Biological Security Issues and How to Address Them". Page 45-46.
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31 Koos van der Bruggen: "Biosecurity challenges in the 21st century: the case of gain-of-function experiments". Chapter in Simon Whitby (editor) et.al: "Preventing Biological Threats: What You Can Do: A Guide to Biological Security Issues and How to Address Them". Page 52.
32 Ibid page 42.
33 Epstein, 1 March 2012, page 20.
34 "Viden forpligter – sikring af teknologi mod misbrug." Page 7.
35 Later it turned out that other research groups could not duplicate the above experiment. A closer review revealed that the toxin was not new, but rather a combination of known botulinum toxins.
36 "Roos, 10 October 2013.
37 Vogel 2013, page 71-105.
38 Clapper, 9 February 2016, page 9.
39 Lentzos 2016, page 57.
40 "Professor i samarbejde med biohackere". Information, 6 February 2012.
41 "Biological weapons production: possibilities and consequences". CBB, 18 January 2013.
42 "Hvad er omfattet af kontrol?"

6
uncontrolled release

A growing problem in working with pathogens is the risk of uncontrolled release. An uncontrolled release occurs if the pathogen is not encapsulated or contained, resulting in an immediate risk that the substance will spread into the surrounding environment. Such an incident can be a great threat to animals, plants and humans.

Two circumstances affect the likelihood of an uncontrolled release. First of all, there is an increasing number of laboratories in the world that work with dangerous pathogens. In the US, the number of laboratories has grown in response to the threat of bioterrorism after 2001. In other areas of the world, the growth is the result of the threat of new infectious diseases (see chapter 4). Secondly, there has been a corresponding growth in the number of employees who work in these laboratories. An uncontrolled release can be the result of an accident, but it can also happen as the result of willful sabotage. Biosecurity is meant to prevent the risk of an uncontrolled release, while biopreparedness must ensure that countermeasures are in place if an incident occurs.

"A biological Chernobyl"

During the night between 2 and 3 April 1979, an accident happened in the city of Sverdlovsk in the Soviet Union. The Soviet military had since 1949 in deepest secrecy operated a biological weapons factory – Sverdlovsk 19 – in a military zone on the outskirts of the city. The factory was in 1979 used to develop and manufacture the *Bacillus anthracis* bacteria for use as a biological weapon. There are several versions of what happened that night. It appears that two so-called HEPA filters in a ventilation shaft had been removed in connection with some routine maintenance, and technicians had left a message that the drying machines (which turned dried suspensions of *Bacillus anthracis* into a fine powder) were not to be used until a new filter was installed. The next work shift did not see the message and resumed production. Even though the missing filter was quickly discovered due to a drop in air pressure, the drying process continued, due to technical issues, for another three hours. Within

Physical security is a suitable barrier against outside threats, but facilities with controlled biological substances also need to build up a security culture to protect against insider threats. Photo: CBB

Biosafety level (BSL)
A biosafety level is the level of biological containment rules required to isolate dangerous substances in a closed laboratory. There are four BSL levels:

- BSL 1 is for facilities working with biological substances that are not known to cause illness in healthy humans, and which present minimal danger to laboratory personnel and the environment.
- BSL 2 is for facilities working with biological substances that present moderate danger to personnel and the environment.
- BSL 3 is for facilities working with biological substances that can cause serious or potentially deadly illness through inhalation or in other ways.
- BSL 4 is for facilities working with biological substances that present a high individual risk of aerosol-transmitted laboratory infections for which there is no vaccine or medical treatment.[45]

that time, between one-half and one kilo of material (which most likely contained one gram of weapons-grade *Bacillus anthracis* spores) was released into the environment. That was enough to infect 95 persons outside the military base with anthrax, and 68 of them died (a mortality of 71.5 percent). Another source places the number of dead at 105.[43] News of the release found its way to Western Europe and the US, but the Soviet security police, the KGB, managed to cover up the incident with an effective smoke screen. It was not until the Soviet collapse in 1991 that western scientists were able to travel to Sverdlovsk (now renamed Yekaterinburg) and uncover the truth of what many have called “the biological Chernobyl.”[44]

Causes of uncontrolled release

The release at Sverdlovsk 19 was a unique event. The case involved a military facility acting in disregard of an international treaty – the biological weapons convention, which the Soviet Union helped create – to produce a *Bacillus anthracis* powder. But there is always a risk of other kinds of uncontrolled release at facilities with dangerous pathogens. An epidemic with the H1N1 virus in 1977 infecting humans in the Soviet Union, China and Hong Kong was most likely caused by an uncontrolled release from a laboratory. The H1N1 virus was genetically identical to a virus seen in 1950 but not seen during later disease outbreaks. This indicates that the N1H1 virus had been stored in a laboratory between 1950 and 1977.[46]

The number of research laboratories with dangerous pathogens is growing. There are several reasons, including the threat of new infectious diseases and the threat of bioterrorism. In 1990 there were 12 BSL 4 laboratories in the world. By 2010 there were 42 worldwide, and the figure is expected to rise in the coming years. Many of these laboratories are in densely populated areas. India, for example, is planning two BSL 4 laboratories in the cities of Pune (pop. 5.5 million) and Bhopal (pop. 1.8 million), respectively. A total of 97 million people, or just under 1.8 percent of the world’s population, lived near a BSL 4 laboratory in 2010. This is four times the number in 1990.[47] The growing number of BSL 4 laboratories also increases the statistical risk of accidents, including accidents involving uncontrolled release.

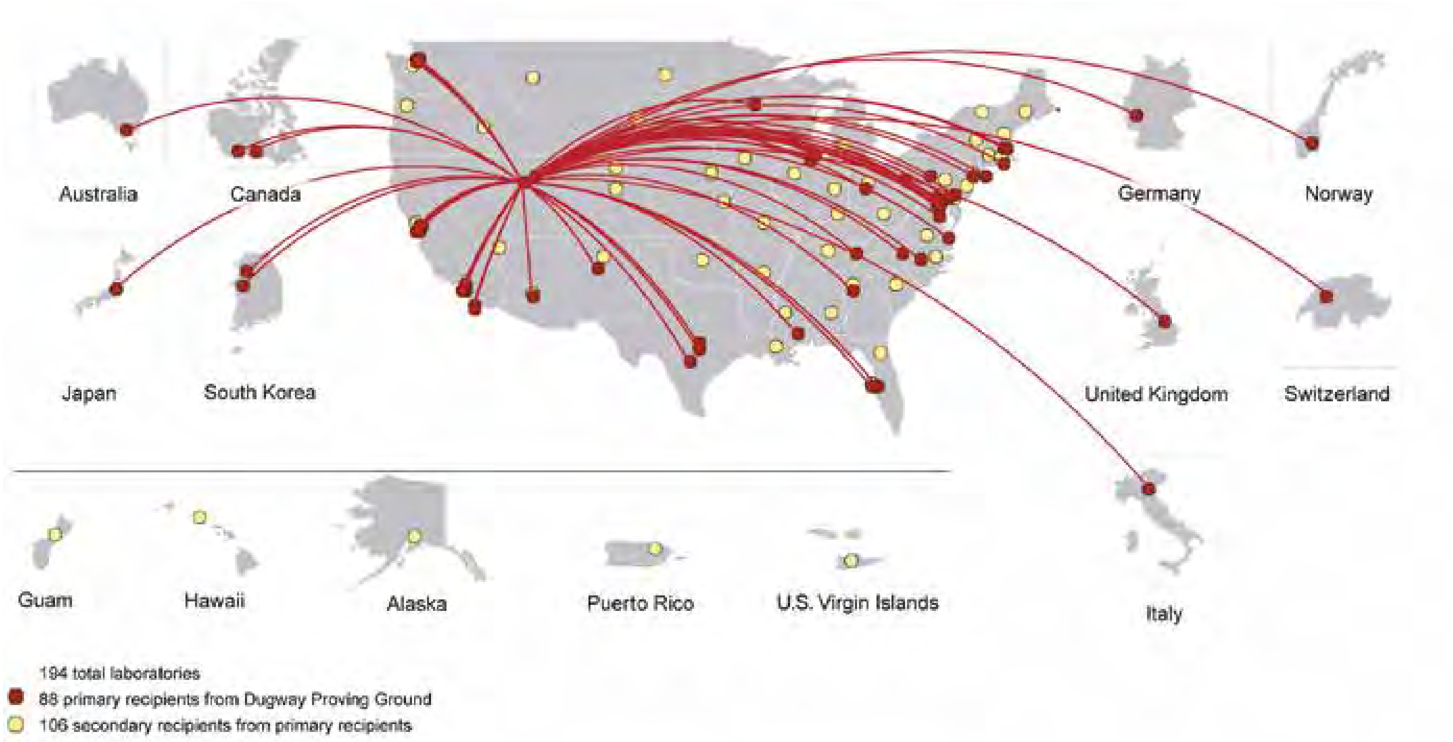
The second-highest level of laboratory security is BSL 3. The number of BSL 3 laboratories in the world is unknown, but the US Government Accountability Office (GAO) has calculated that the number of known BSL 3 laboratories in the US has grown from 415 (at 150 locations) in 2004 to 1,362 (at 242 locations) in 2008.[48] The number of US employees in 2004 with permission to work with controlled biological substances (also called select agents) was 8,335.[49] In 2016, approximately 11,000 US employees had such permission.[50]

Although the growth of BSL 3 and BSL 4 laboratories is a good indication, it should be noted that research using deadly pathogens is also taking place in a number of developing nations, in laboratories that would not be classifiable as either BSL 3 or BSL 4. The number of such laboratories is unknown, but the insufficient containment conditions increase the risk of uncontrolled release. In this regard, there are three situations which – individually or in combination – can cause a release:

- *Human error*
  Example: In 1978, a female laboratory photographer, Janet Parker, died after being infected with smallpox at The University of Birmingham, UK. A respected virologist was doing smallpox research at the university, and it is likely that the smallpox virus was released from his laboratory. The virologist had been working with large quantities of smallpox virus under unsafe conditions and had also given incorrect information about his research to WHO.[51]

- *Technical errors*
  Example: In 2007, a release of the foot and mouth disease (FMD) virus occurred at a BSL 4 laboratory in Pirbright, UK.

GAO analysis of information from USDOD and CDC, 2016, GAO-16-642



The release was most likely due to a defective sewer system that caused the FMD virus to seep out to the earth around the laboratory. Lorries plowed across this ground and brought the FMD virus out to nearby farms, where cattle were infected.[52]

- *Procedural errors*
  Example: Between 2005 and 2015, thousands of seemingly inactive samples of *Bacillus anthracis* were sent to 183 laboratories inside and outside the US from the military biological research facility at Dugway Proving Ground in Utah. The intention was to test the ability of these laboratories to detect pathogens that could be used for bioterrorism. The American military was to have irradiated and killed the pathogen in question, but only five percent of the samples were tested. A later investigation revealed that the inactivation process had an error rate of 20 percent. According to the US health authorities, 74 of the samples of *Bacillus anthracis* from Dugway had not been inactivated.[53]

In the US, there is much debate about the need for greater biosecurity and biosafety. For years, the GAO has criticised the lack of central management of BSL 3 and BSL 4 laboratories in the US, noting that their expansion after the terrorist attacks in 2001 took place without an overall strategy or authority to manage the growing number of laboratories.[54] This criticism received a large boost after US authorities in the summer of 2014 discovered samples of smallpox virus which had been lying for decades in a forgotten storage room in Bethesda, Maryland. Added to this was a series of accidents in 2014-2015 involving employees who were exposed to *Bacillus anthracis*, not to mention other accidents involving Ebola and avian flu.[55] These incidents illustrate the need for clear and uniform rules for biosecurity and biosafety.

The insider threat

There is another type of threat that can lead to uncontrolled release: willful sabotage. This threat was highlighted in the weeks after the terrorist attacks on New York and Washington on 11 September 2001. Immediately after these attacks, the US was hit by a new type of attack in which letters containing powdered *Bacillus anthracis* were sent to American news media and government offices. Five people died, and 17 others became ill.[56] There was speculation that terrorists or hostile states were behind these attacks, but the US Federal Bureau of Investigation (FBI) quickly determined that the *Bacillus anthracis* powder must have come from the American military. The type of *Bacillus anthracis* in question (the so-called Ames strain) was being used by the military in its research to develop better vaccines. Several years of investigation led the FBI to a civilian scientist named

CBB assessment:
The insider threat

The threat from insiders has been growing in recent years, not least due to new technological developments. A single facility employee with the necessary access and expertise can do much more damage today than was possible just 20 years ago because of new technological possibilities. Even highly sensitive facilities such as nuclear power plants can become targets for sabotage, as seen in Belgium in 2014.[58]

In the US, learnings from the anthrax attacks in 2001 have resulted in new federal laws and related guidelines to prevent new cases of misuse of controlled biological substances. An employee must now pass an FBI security check (Security Risk Assessments, SRA) in order to be able to work with controlled biological substances in the US.[59] Since 2012, American facilities with controlled biological substances have also been required by law to perform a so-called Suitability Assessment both before and during a period of employment. The results of these assessments are reported to a security officer (Responsible Official) at the facility with controlled biological substances. If the results of a Suitability Assessment are particularly worrying, federal authorities must be contacted, and the SRA approval can be revoked.[60]

CBB assesses that an insider with the necessary expertise and access to controlled biological substances can be a threat. For this reason it is necessary to include biosecurity rules that can prevent insider threats. At the same time, these measures must be proportional to the potential for misuse. If any misuse – for example, the theft of controlled biological substances – is discovered, the facility must immediately contact CBB.

Bruce Ivins, who was attached to the US military laboratory at Ft. Detrick, Maryland. He committed suicide in 2008, and afterwards the FBI decided to close the case.[57]

Bruce Ivins was what experts today would call an insider threat. An insider is typically a facility employee with access to and knowledge of how something valuable or dangerous can be misused. An insider could be mentally unstable, but could also be driven by religious, political or financial motives. An insider may work alone or together with an outsider – that is, one or more persons who would not normally have access to the facility in question.

Security culture

Security culture is a culture that builds upon a series of values. These values include responsible scientific and work-related principles (“do no harm”), identification of possible misuse potential, individual participation in a facility’s security structure, and a professional, responsible behavior with regard to possible threats.

What CBB is doing

In accordance with the Danish Biosecurity Law, CBB requires facilities that work with controlled biological substances to live up to a series of obligations. These include requirements for physical security, regulation of access to controlled biological substances via personnel categories, and the establishment of a so-called security culture. Facilities with controlled biological substances are placed at one of four security levels, depending on the substances’ potential for misuse. Requirements for physical security and security culture vary according to security level. All facilities with permits for controlled material (including biological substances) must have a biosecurity officer who is responsible for implementing and updating biosecurity at the facility. Facilities should also have an ethical code for their work with controlled biological substances (read more in chapter 8).

If there is a suspicion of an uncontrolled release – regardless of whether it is willful or accidental – CBB has a 24/7 biopreparedness system at its disposal to handle the incident. The system includes an on-duty medical doctor with decision-making authority (chief physician level) and a Field Investigation Team that can gather information, take samples, analyse them quickly,

In 2014, live smallpox virus was discovered in a cardboard box in Maryland, USA. Model photo: CBB

and provide competent medical assistance. Also included in the preparedness system is rapid laboratory analysis at CBB, plus access to specialised Danish and foreign laboratories. The Centre gathers all results and reports its findings, conclusions and recommendations to relevant authorities. Areas affected by an uncontrolled release must be cordoned off until CBB issues an all-clear.

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43 Leitenberg & Zilinskas 2012, page 100-110.
44 Alibek & Handelman 1999, page 105.
45 "Section IV – Laboratory Biosafety Level Criteria".
46 Zimmer & Burke, 29 June 2009, page 282.
47 Van Boeckel, Tildesley et. al., 13 December 2013, page 5.
48 "High-Containment Laboratories: National Strategy for Oversight is Needed". GAO, September 2009, page 25.
49 Ibid, page 29.
50 "Federal Select Agent Program – About Us".
51 Tucker 2001, page 124-129.
52 Klotz & Sylvester 2009, page 129.
53 Young & Brook, 23 July 2015.
54 "High-containment Laboratories: National Strategy for Oversight is Needed". GAO, September 2009 , page 66-69.
55 Young, 23 September 2015.
56 Willmann, 2001, page x-xi.
57 Guillemin 2001, page 239-244.
58 Rubin & Schreuer, 25 March 2016.
59 "Security Guidance for Select Agent or Toxin Facilities". CDC/APHIS, 5 July 2013, page 18.
60 "Guidance for Suitability Assessments". CDC/APHIS, 8 July 2013, page 14-27.

7
state use of biological warfare

There has always been a close interplay between war and infectious diseases. As late as the 1800s, it was typical for more soldiers to die of infectious diseases than in actual fighting. There are also countless historical examples of how warring factions have tried to use infectious diseases against each other. But it was not until the end of the 1800s that humanity gained a scientific understanding of how infectious diseases are transmitted and how they can be managed. From around 1914 until 1975, a number of states developed large or smaller biological weapons programmes that were in some cases used militarily. The Biological and Toxin Weapons Convention (BTWC), created in 1975, prohibited the development of biological weapons. Nevertheless, some countries continued to develop biological weapons until the 1990s. Reports are still heard of state biological weapons programmes, but today it is unclear whether any country is still actually involved in this. As the invasion of Iraq proved, incorrect claims about a biological weapons programme can have serious consequences.

The largest anthrax outbreak in history

In 1978, the white minority government of Rhodesia was fighting for its life. Rhodesia was not recognised by other nations and was supported only by the apartheid regime in South Africa. In the 1970s, pressure was mounting from black rebel groups funded by the Soviet Union and Cuba. The situation became increasingly hopeless, which is probably what motivated the government to try biological warfare. It seems likely that South Africa supported these attacks, although the South African biological weapons programme did not officially begin until the 1980s. Special forces poisoned rivers with cholera and left canned foods poisoned with thallium for the rebels. But the most effective weapon was the *Bacillus anthracis* used on cattle. The regime probably hoped to destroy the livelihood of the black population and thus quell the rebellion. The effort failed, and a peace agreement was signed in December, 1979. Rhodesia then became Zimbabwe.[63]

There are several points of interest in the Rhodesian case. Firstly, it shows the circumstances under which a country may decide to use biological warfare. An isolated, cornered nation is far more likely to use biological weapons. Secondly, the use of these weapons was not proven by documents or witnesses. It was primarily epidemic signature analyses (described in chapter 4) that revealed the probability of man-made rather than natural occurrences. Thirdly, the use of biological weapons in Rhodesia shows how this warfare can destroy fertile agricultural lands. Between 1978 and 1984, Rhodesia was devastated by the greatest outbreak of anthrax in history, with 171,990 infections among cattle and 17,199 infections and about 200 deaths among humans. The anthrax epidemic was 1,400 times larger than normal for this area, which points to the high probability of a deliberate attack.[64]

Early state interest in biological weapons

In contrast to most other weapons, biological weapons are unsuited to a battlefield. Military forces can protect themselves in various ways, and a modern battlefield is too mobile for a weapon that takes several days to manifest itself as a disease outbreak. But biological weapons are highly suitable for clandestine attacks on civilian populations, with effects ranging from individual deaths to the extermination of large populations in an area that could reach the size of a country or a continent. Here are a few examples of how biological weapons were used during the First and Second World Wars:

- In World War I, Germany used biological weapons against transport animals. The weapons (including *Burkholderia mallei* and *Bacillus anthracis*) were used by German agents in neutral countries such as Romania, Spain, Norway and the US. Target animals were the horses and mules that these countries wished to sell to the French and British armies.[65]
- In the 1930s, Japan had a large-scale biological weapons programme headquartered in Japanese-occupied Manchuria. The so-called Unit 731 experimented on humans and later used biological weapons against Chinese civilians. Even though the Japanese methods were primitive, Chinese historians estimate that 580,000 people died as a result of human experiments combined with actual biological attacks.[66]
- The Polish resistance, led by the exiled Polish government in the UK, made large-scale use of biological weapons against German occupation forces from 1940-1944. Gestapo headquarters in Warsaw received anthrax letters, food served to Germans in restaurants was infected, and pathogens were spread in German leave trains bound for Germany. According to a report from the Polish resistance to the exile government in London in March 1941, biological attacks resulted in 1,784 cases of illness and 149 deaths among German soldiers.[67]

Not least the Japanese use of biological weaponry demonstrated its capacity for mass death. More deaths were caused by Japanese biological weapons in China than were caused by the American nuclear bombing of Japan in 1945. During the Cold War, a number of major powers tried to develop biological weapons with effects similar to those of nuclear weapons. In 1968, the US performed a test in the Pacific Ocean that demonstrated how a single F4 Phantom fighter plane could spread a biological weapon over an area of about 1,600 square kilometres.[68] Biological weapons were seen as being cheaper than nuclear weapons and could also be manufactured in a number of different versions. For

Project Coast

In the 1980s, the South African apartheid regime feared that communist-supported black rebel movements would overrun the country. Therefore, in 1981, a chemical and biological weapons programme (code named Project Coast) was initiated. Researchers worked with agents including *Bacillus anthracis, Vibrio cholerae,* the botulinum toxin and the Marburg and Ebola viruses.[61] The weapons programme also included research within gene technology and research in relation to biological weapons that could only target black people.[62] Project Coast was abandoned with the dismantling of the apartheid regime in 1990-1994.

A Soviet SS-20 missile with multiple warheads on display at the National Air and Space Museum, Washington. Photo: CBB

The Soviet weapons programme
The Soviet biological weapons programme was established in 1928 and expanded rapidly in the 1970s and 1980s with a view to exploiting new genetic technologies. At its peak, the programme involved 40,000-65,000 individuals. By comparison, the US biological weapons programme (abandoned in 1969) had just over 8,000 individuals at its disposal. The programme had both military and civilian facilities, including seven so-called mobilisation plants that were to be activated for mass production of biological weapons in case of an impending war.[72]

example, the US weapons programme differentiated between deadly biological weapons and so-called "incapacitating" biological weapons that caused illness but rarely resulted in death.[69]

The Soviet weapons programme

In principle, countries can mobilise enormous resources for biological weapons production. But they often run into problems with weaponisation (preparing pathogens for use in warfare). Biological substances are sensitive to such things as heat, humidity and solar UV radiation. Disseminating the microorganisms and ensuring that they keep their pathogenicity can also be a challenge. Japanese forces in China also experienced several incidents in which they were hit by epidemics from their own biological attacks.[70] Biological weapons may have great potential, but in practice they are difficult to manufacture and use for military purposes.

A weapons programme can also be hampered by political, military and social factors, as illustrated by the massive Soviet biological weapons programme. The need for secrecy placed so many restrictions on some Soviet facilities that scientists in one department were not allowed to speak with scientists in other departments. Nor were they allowed to seek information at public libraries. In one case, a scientist and others spent several years developing a technique for infecting and raising mosquitoes, only to find that a similar technique had been available in English-language literature for a decade.[71]

Rivalries were also a hindrance. In 1982, a mobilisation plant at Stepnogorsk in Kazakhstan was opened. The plant had a civilian cover – an organisation called *Biopreparat* – and was to produce *Bacillus anthracis* for the Soviet military. Although the customer was the military, the Soviet Ministry of Defense regarded the plant at Stepnogorsk as a rival to military laboratories. The ministry decided therefore to withhold critical information about the production of *Bacillus anthracis*. So the Stepnogorsk plant was forced to start from scratch and develop its own production method for weapons-grade *Bacillus anthracis*. It succeeded, and in 1987 the plant was certified to produce 300 tons of *Bacillus anthracis* in one year. The success was due in large part to the management's use of innovative methods and cross-functional cooperation. The demands for secrecy and barriers to communication were in this case set aside.[73]

It is unclear what the Soviet Union hoped to achieve with its biological weapons programme. It has not been possible to find a doctrine or a strategy showing any rationale. In light of the amount of allocated resources, however, it is clear that the Soviet leadership regarded biological weapons as a strategic tool on a par with nuclear weapons. It would also seem that Soviet leaders viewed biological weapons as a kind of "last-resort" arsenal that could be used even after a nuclear war.

The effect of weapons control

The first attempt to regulate biological warfare took place in Geneva, Switzerland in 1925, when a number of states signed an agreement prohibiting the use of chemical and biological weapons. Research and development was still legal, and most countries chose therefore to regard the use of biological weapons as a legal instrument of retribution.[74]

In 1969, US President Richard Nixon decided to close the American biological weapons programme. There were several reasons for this, including criticism of the country's use of herbicides during the Vietnam War, the fear that biological weapons could become an easily obtainable weapon of mass destruction, and the belief that nuclear weapons provided better and more effective security. Last but not least was the increasing moral resistance to a weapon with limited military value that could be used against civilian populations.[75]

A few years later, in 1975, the previously mentioned Biological and Toxin Weapons Convention (BTWC) came into force, prohibiting the development of biological weapons. The treaty's weakness is that it has no verification mechanism – it is based solely on mutual trust. Even though the Soviet Union signed the treaty,

Regulation of biological weapons
1925: The Geneva Convention prohibits offensive use of biological weapons.

1975: BTWC prohibits the development and production of biological weapons.

2004: UN Security Council Resolution 1540 requires all Member States to regulate materials suitable for weapons of mass destruction.

it is clear that the Soviet programme continued in secret until 1991. South Africa and Iraq also continued their much smaller biological weapons programmes.

So at first glance the BTWC looks like a failure, but the treaty is an important symbol of the norm that makes the manufacture of biological weapons both illegal and illegitimate. The treaty is also a hindrance to countries that might want to violate the BTWC. As mentioned, biological weapons production is in itself technically challenging. The BTWC forces countries interested in biological weapons to establish several layers of secrecy which will presumably provide further obstacles to their success. Finally, the BTWC is the foundation for several other disarmament initiatives meant to obstruct the development of weapons of mass destruction. The 2004 UN Security Council Resolution 1540 requires Member States to enact national laws to prevent non-state entities from developing weapons of mass destruction (read more in chapter 8).

Curveball

In 1999, the Iraqi citizen Rafid Ahmed Alwan al-Janabi fled from Iraq and sought asylum in Germany. He claimed to be an engineer who had worked in mobile biological weapons laboratories in Iraq. Under the code name *Curveball*, he delivered information to the American intelligence agency CIA until 2003. Information from *Curveball* was used when US Secretary of State Colin Powell presented faked "proof" of Iraqi violations of several UN resolutions. It was not until after the invasion of Iraq that *Curveball* was exposed as a fraud who had apparently gathered his information from open sources (the Internet) about UNSCOM inspections in Iraq in the 1990s.[77]

Intelligence and misinformation

Due to the absence of any control mechanism in the BTWC, it is often necessary to trust intelligence reports about state biological weapons programmes. But it has often proven difficult to find reliable information. It is easy to hide the development of biological weapons under a cloak of legitimate activities. A fermenter can be used to cultivate microorganisms for antibiotics as well as for biological weapons development. Furthermore, the BTWC recognises the right of a country to develop countermeasures to biological weapons. This means that it is actually legal to do research on biological warfare agents in order to develop protective equipment or vaccines, for example. This makes it difficult to determine whether or not a state intends to develop biological weapons for offensive use.

**While giving a speech in 2003 at the UN Security Council, former US Secretary of State Colin Powell held a tube to illustrate how anthrax looks like.
Photo: Getty Images**

Filtrators for gas masks. Hungarian CBRN equipment factory. Photo: CBB

There is, therefore, a long list of intelligence failures with regard to biological weapons. The extent of the Soviet weapons programme was not uncovered until after the Cold War. The South African weapons programme (Project Coast) was not revealed until after the peaceful demise of the apartheid regime. In the 1980s, Western intelligence agencies overlooked Iraq's growing biological weapons programme, which it apparently intended to use. In August 1990, the Iraqi army occupied Kuwait, and the US assembled a large, international coalition to force the Iraqis out. Threatened with war, the Iraqi dictator Saddam Hussein ordered the country's biological arsenal made ready for action. Bombs and nuclear warheads were filled with biological weapons, but none of them were used during the Gulf War of January and February 1991.[76]

After 1991, the UN forced Iraqi leaders to disarm all their weapons of mass destruction. The UN established an organisation called the United Nations Special Commission (UNSCOM) to investigate the extent of the Iraqi weapons programmes and document the destruction of all illegal weapons. UNSCOM was met with much Iraqi obstruction and had to abandon its work in 1998. In the US and other western countries, it was feared that Iraq had continued its biological weapons programme in secret. Misinformation, not least from an Iraqi refugee in Germany, would play a disproportionately important role in American assessments of the Iraqi biological weapons programme.[78] Not until after the invasion of Iraq in 2003 would it become clear that the Iraqis had destroyed their entire arsenal of weapons of mass destruction a decade earlier. For unknown reasons, Iraqi leaders decided to hide this fact. A possible explanation is that Saddam Hussein hoped to resume the country's production of weapons of mass destruction as soon as the opportunity presented itself. From Hussein's perspective, the weapons programme was merely on stand-by, although it had in fact been destroyed. For strategic reasons, he chose to frighten his enemies by upholding the illusion that Iraq still had biological weapons.[79]

The Iraqi example shows how incorrect intelligence and misinformation about biological weapons can have a decisive influence. The best antidote to this is a scientifically-based analytical capability that can review this type of information. An example illustrates how this might be done: In 2015, an American organisation claimed that a biopesticide factory (Pyongyang Bio-tech-

CBB assessment:
Nations and biological weapons in the 21st century

The only country that is publicly known to have worked with biological weapons in recent years is Syria. In 2014, the Syrian government admitted that the country had a facility at its disposal for the production of ricin. It is not known whether this facility has been dismantled or destroyed during the country's ongoing civil war.[81]

Three other trends should be mentioned:

- In 2016, several German states announced in their annual intelligence reports that Iran had illegally tried to purchase material suitable for weapons of mass destruction from German companies. In an interview in July 2016, the head of German intelligence (Verfassungsschutz) in the state of Thüringen accused Iran of illegally purchasing materials suitable for biological weapons.[83]
- Russia took control of the massive Soviet biological weapons programme in 1991. It is a source of concern that Russia has in recent years denied that it inherited any weapons programme from the USSR.
- Russia is more or less directly accusing the US of violating the BTWC. The presence of US-supported military-biological laboratories in several former Soviet republics has been mentioned as a cause for concern in relation to Russia's national security strategy of December 2015.[84]

The CBB assessment is that all states – upon reaching a given level of development – are capable of producing biological weapons. Technological developments in the 21st century have made it possible to create biological weapons with completely new properties. New biological weapons can be cheaper, more reliable and may be used more flexibly than before. The response to these developments must be a stronger international cooperation based on the BTWC, and a greater openness that can promote trust among nations. If individual countries should continue their attempts to manufacture biological weapons, they will be forced into so many layers of secrecy that their chances of success will be reduced, and the risk of getting caught will be much greater.

Restricted area in northern Germany. Photo: CBB

nical Institute) outside the North Korean capital of Pyongyang had a dual-use capacity. Photos taken during an official visit from the North Korean leader Kim Jong-Un supposedly proved that the facility could also produce weapons-grade *Bacillus anthracis*. CBB chose to analyse the photos and concluded that the facility may well be a new biopesticide factory. But there was no reason to believe that it could be used to create weapons-grade *Bacillus anthracis*. This does not rule out the possibility that North Korea – as claimed by South Korea and the US – has a biological weapons programme. But the photos could not prove this claim.[80]

What CBB is doing

It is considered important that the BTWC will be strengthened over the coming years - ideally by creating a control mechanism that can establish whether or not a country has a biological weapons programme. But there are also other ways of strengthening the BTWC. For example, the establishment of a new BTWC organ to monitor technological developments is being considered that could keep the convention updated on new dual-use technologies and possibilities for misuse.

It is also important to highlight the Danish partnership project in East Africa (mentioned in chapter 4) as an initiative which, based on the BTWC and the Global Health Security Agenda (GHSA), will help African countries in the peaceful development of their economies and prevent the misuse of biological material. CBB has also initiated the development of a European biosecurity forum, the European Biosecurity Regulators Forum (EBRF). Its purpose is to help create common European standards for biosecurity regulation.

The Australia Group and control of spray driers

Via CBB, Denmark is involved in the so-called Australia Group, an association of countries that work together to harmonise export control regulations and national biosecurity with respect to materials and technology that are suitable for production of weapons of mass destruction.

In 2012, following a series of tests and experiments at CBB which demonstrated that spray driers have a significant potential for misuse in weapons production, a Danish proposal to include spray driers on the list of regulated technologies was adopted by the Australia Group and included in binding EU regulations. This is a specific example of a Danish contribution to international efforts to prevent the spread of technologies that can be used to develop biological weapons of mass destruction.

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8
biocrime and bioterrorism

After the end of the Cold War, the fear began to grow that terrorist groups or criminals could make and use biological weapons. But only a few biological terrorist attacks have actually taken place. One reason is probably the obstacles involved in the manufacture and weaponisation of biological material. A single Norwegian right-wing extremist, Anders Behring Breivik, carried out a bomb attack in Oslo and a massacre on the island of Utøya in 2011. Breivik said in a manifesto that he had considered using biological warfare agents (anthrax in particular), but concluded that he did not have the necessary expertise. Instead, he carried out a conventional attack with explosives and firearms.

The consequences of even a small biological attack can be considerable. Added to this are the new technological developments and the proliferation of expertise which can facilitate weaponisation of biological substances. With the advent of the internet, it is today possible to order toxins online and thus circumvent the weaponisation process.

Abrin
Abrin is a protein derived from the paternoster pea *Abrus precatorius*. Abrin is closely related to ricin. The route of infection is via injection or ingestion of purified abrin from *A. precatorius*, alternatively by ingestion of the seed or roots of *A. precatorius*. Abrin blocks the protein synthesis in cells by inactivating ribosome activity. Depending on the way in which the toxin enters the body, death can occur in 36 to 72 hours. If the patient survives 3-5 days, he or she will usually recover.[87]

The abrin case
In June 2014, a 34-year-old Dane was sentenced to three years in prison by a municipal court in Randers. The court found that the man had intended to kill an unidentified Ukrainian with a small, illegally purchased amount of abrin. The amount was enough to kill 2-20 persons. The seller was a 19-year-old man in Florida who sold weapons and toxins via *Black Market Reloaded* on the Tor network. FBI agents arrested the seller and secured information about the Danish abrin buyer. This enabled Danish police to arrest the 34-year-old Dane and confiscate the toxin.[88] The court case in June 2014 is interesting because it was the first time anyone had been sentenced under the Danish biosecurity law.

This case is not unique. In a similar instance, a British citizen from Liverpool tried to make an internet purchase of 500 mg of ricin, which would have been enough to kill a great many people. Instead, he came in contact with an FBI agent who sold him a harmless substance hidden in a toy automobile. The buyer was then arrested and sentenced to eight years in prison.[89] In a third case, a man in the US, Jeff Levenderis, produced 35.9 grams of ricin – enough to kill over 250 persons. This led to his arrest and a prison sentence of six years.[90]

None of these cases involve terrorism. They are about private persons who, with the assistance of the internet, illegally produced, sold or purchased biological substances. The danger is that this illegal internet market could develop into a market with pathogens of interest to terrorists.

Terrorist use of biological weapons
Currently, in Denmark, there is only very limited capacity for executing a terrorist attack with biological materials.[91] The first publicised example of a successful biological terrorist attack was in 1984, when a religious cult in Oregon called Rajneeshee tried to influence the outcome of a local election by large-scale food poisoning. Members of the sect visited several restaurants, where they poisoned salad bars with the *Salmonella typhimurium* bacteria. Although the sect did not change the election results, 751 people were poisoned. One of the sect members worked as a nurse, which enabled her to order *Salmonella typhimurium* from a legal seller. It is also worth noting that the outbreak of illness was not recognised as a terrorist attack to begin with. This did not become clear until a sect member told of the incident.[92]

The *Ricinus communis* plant produces beans from which the toxin ricin can be extracted.
Photo: Colourbox

Biosecurity means that in Denmark and other Western countries, only facilities with legitimate requirements may purchase controlled materials. Photo: CBB

In the 1990s, the Japanese sect Aum Shinrikyo made several attempts at biological terror in Japan. The sect's charismatic leader, Shoko Ashara, preached an apocalyptic religion, and the sect had considerable financial resources (a billion US dollars in 1995). It spent some 10 million dollars on laboratory equipment, field trials and biological attacks with *Bacillus anthracis* and the botulinum toxin. All attacks failed, partly because the sect had mistakenly purchased a vaccine strain of *Bacillus anthracis*. The special subculture of the sect was also an obstacle. For example, the sect had secured a so-called PCR machine that could have been extremely useful in weapons production. But the machine was instead used for rituals in which Shoko Ashara's DNA was isolated so that sect members could drink it. The sect was also known for its use of narcotics to ensure internal control, and there was widespread paranoia among members. Their numerous attack failures caused them to focus instead on chemical weapons. Thirteen people died in a poison gas attack executed by Aum Shinrikyo in 1995 in Tokyo's metro system.[93]

In 2001, a series of letters containing *Bacillus anthracis* were sent to news media and politicians in the US. Five people died and 17 became ill. The case has already been discussed in chapter 6 and is only mentioned here to illustrate how even a single individual can mount a successful biological attack if the right prerequisites are in place. In this case, the perpetrator was a well-educated and experienced scientist with access to weapons-grade *Bacillus anthracis*.

During the invasion of Afghanistan in 2001, US soldiers discovered a primitive laboratory used for biological weapons research by the terror network Al Qaeda. A Pakistani microbiologist was to lead the research, and laboratory samples showed traces of *Bacillus anthracis*. The same year, American troops captured a Malaysian technician who had tried to obtain weapons-grade biological material and a variety of equipment for this terror network.[94] Al Qaeda has in several cases encouraged the use of biological weapons. In 2010, Al Qaeda's English-language publication *Inspire* urged individuals to carry out attacks using chemical and biological weapons. Those with technical expertise were told to use the Botulinum toxin, while non-experts were told to use ricin and cyanide.[95] The spiritual leader Anwar al-Awlaki proclaimed in an *Inspire* article that chemical and biological attacks on population centres are allowed according to Islam.[96] Despite these activities, there are no publicly known examples in which Al Qaeda has actually succeeded in creating biological weapons.

Recent developments

After the terrorist attack in France in 2015, French Prime Minister Manuel Valls outlined the specific possibility of chemical and biological attacks being carried out by the organisation often referred to as Islamic State (ISIS).

It is certain that ISIS has a rudimentary chemical weapons programme which enables the organisation to produce chlorine gas and mustard gas, and there have been several substantiated examples of poison gas usage by ISIS.[97] There are only a few doubtful indications of ISIS interest in biological weapons. It can with greater certainty be noted that ISIS has tried to recruit highly educated engineers, chemists, physicists and biologists.[98] There have also been reports of ISIS being able to recruit doctors from Sudan and Uzbekistan. [99]

In Kenya in 2016, police arrested hospital employees and several students of biochemistry, microbiology and medicine on suspicion of having ties to ISIS.[100]

The recruitment of persons with the right scientific qualifications is vital for non-state groups seeking to develop biological

Homemade explosives documented by CAR (Conflict Armament Research). Photo: CAR

**CBB assessment:
Possibilities for offensive use of biology by groups or individuals**

Groups and individuals without scientific training and without access to controlled biological substances will encounter significant obstacles if they wish to mount a biological attack.

However, it is possible to carry out relatively simple but destructive biological attacks with a single toxin that is weaponised and produced in large quantities (read more in "CBB assessment: Weaponisation of ricin and other toxins" in chapter 5). It is also possible to take a highly contagious pathogen such as the hoof and mouth disease virus and misuse it without weaponisation (read more in "CBB assessment: Misuse of infectious diseases" in chapter 4). The development of an illegal market for buying and selling pathogens via the internet can in some cases make it easier for groups or individuals to get hold of a dangerous microorganism that is suitable for offensive use. Finally, if an employee at a facility with controlled biological substances misuses his or her access and expertise, this will improve the chances of being able to carry out a biological attack (read more in "CBB assessment: The insider threat" in chapter 6).

Rules for biosecurity must reflect this threat context and be continually developed. To ward off threats, international biosecurity cooperation is necessary. If preventive efforts fail, biological preparedness is needed in order to contain and manage the consequences of a biological attack.

weapons. It is therefore important to be aware of such tendencies.

Motives

There are several reasons why biological weapons can be attractive for terrorists. Pathogens can unleash mass death, and even a few cases of illness can create considerable panic. Disease-causing microorganisms can also trigger a special kind of fear-based reaction which firearms or bomb attacks cannot. Fear of disease can cause people to isolate themselves and flee from large cities. It can also undermine the belief that authorities can protect the population from contaminated food, water and air. As such, a biological weapon can be effective for groups seeking to attack existing social structures.

It cannot be ruled out that some terrorist groups will consider using biological weapons because it can be done in secret. Biological attacks can easily be mistaken for a natural outbreak of disease, which could be an advantage for groups who wish to attack a target and then avoid taking responsibility for it.

As previously mentioned, there is also the possibility that criminal groups or individuals may use biological weapons. It must be assumed that the motive in such cases would only relate to a specific target – revenge or blackmail against a particular person, for example – rather than being politically motivated.

Obstacles

For terrorist groups or criminals interested in biological weapons, there are several obstacles to overcome:

- It is necessary to obtain a biological substance that is suitable for weaponisation
- The substance in question must then be weaponised
- The substance must be disseminated without itself being affected by exposure to the environment
- The substance must be capable of infecting or poisoning the target group
- The substance must cause illness and death despite the efforts of authorities to provide medical treatment, vaccination, quarantine, etc.

In practice, it is the most ambitious and far-reaching biological attack plan that bears the greatest risk of failure. Aum Shinrikyo in Japan had a very ambitious biological weapons programme, but failed on several counts. As noted before, sect members failed to secure a weapons-grade biological substance and did not manage to weaponise it, either. Efforts to disseminate biological substances as an airborne aerosol also failed, despite numerous attempts. It should also be noted that the head scientist in Aum Shinrikyo – Seiichi Endo – was a molecular biologist, not a microbiologist. In other words, Endo did not have the necessary knowledge (including the "tacit knowledge" mentioned in chapter 5) for weaponising *Bacillus anthracis* or the botulinum toxin. This explains a great deal of the sect's failure.[101]

On the other hand, the Rajneeshee sect in the US had a much simpler approach. As noted before, the sect purchased a biological substance from a commercial dealer and could manufacture it in large quantities thanks to an experienced laboratory technician. The means of dissemination - contaminating salad bars at restaurants - was simple and effective. The goal was not to cause the end of the world but to influence a local election by means of a salmonella epidemic. These and other circumstances meant that the Rajneeshee's rather simple biological attack was (from a technical perspective) a success.

What CBB is doing

Danish biosecurity legislation gives CBB the authority to require physical security and other safeguards at facilities that work with the biological substances most likely to be used for bioterrorism (the so-called controlled biological substances). These security measures include rules for regular inventory control and the reporting of any new purchase of biological materials. CBB also requires inventory control and reporting of related materials that are well-suited for the production and weaponising of biological substances. This could include fermenters, filtration equipment and centrifuges. All facilities with a permit from CBB must also have a trained biosecurity officer who can teach relevant employees about biosecurity and help build a security culture (read more in chapter 6). CBB conducts regular inspections of facilities (announced and unannounced) to ensure that biosecurity laws are respected.

With regard to prevention, ethical guidelines are important. In 2005, The Interacademy Panel on International Issues (IAP) published a code of ethics for the life sciences which has been endorsed by scientific academies in 74 countries.[102] CBB encourages all facilities with controlled biological substances to endorse this code or similar guidelines for responsible scientific behaviour. This ethical code calls upon individuals to work for ethically responsible and beneficial progress in the development and use of scientific knowledge; to refrain from research whose purpose is to promote biological warfare or terror; to protect discoveries and knowledge against misuse; to make the public or relevant authorities aware of unethical research or other activities for which there are reasonable grounds to believe that they contribute to biological warfare or terror; to ensure that only conscientious persons receive access to biological substances that could be misused; to limit the spread of knowledge that can be misused for biological warfare; to ensure that research activities always outweigh risks; to abide by all applicable laws and rules, as long as they can be regarded as ethically correct; to recognise the right of anyone – without reprisal – to refuse for reasons of conscience to participate in research if it may be regarded as ethically or morally offensive; to share this code with all like-minded persons who work in the life sciences.[103]

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9
conclusion

Security barrier, SSI.
Photo: CBB

The overall likelihood of a major biological terrorist attack must be viewed as relatively low at the moment, but a successful attack could have grave consequences for societies. Danish businesses and research institutions that work with dual-use materials or knowledge can risk being misused as suppliers of biological weapons components. To address this threat, and be able to respond to an actual attack, further development of both biosecurity and biopreparedness is necessary. In this context, there are three types of entities that could be interested in the development and use of biological weapons:

- **States:** It is not publicly known whether any state is still working on biological weapons, but new technological developments can form the basis for new, more effective and manageable biological weapons. If the number of conflicts between states increases, and if the prohibition against weapons of mass destruction continues to be undermined (as seen with the use of poison gas in Syria and Iraq), it can increase the incentive for states to develop biological weapons. The most likely states to develop such weapons are those that are internationally isolated and militarily weak. The advantage of biological weapons is that they can be produced in many forms, and states can claim that they are the result of naturally occurring outbreaks of disease. This could reduce the risk of a military counterattack.

- **Terrorist groups:** A terrorist group will encounter many challenges if it tries to develop advanced biological weapons. This would explain why previous attempts at large-scale biological attacks have been unsuccessful, despite much preparation. The chance of success is greater if the group uses simple substances (a toxin such as ricin, for example) and produces the toxin in large quantities. Chances are further improved if the group has access to weapons-grade biological material and to persons with great scientific and technical expertise. The most likely candidates to develop and use biological weapons are groups that are driven by an extreme ideology, are isolated and have access to laboratory facilities and relevant experts.

- **Criminals:** This category can consist of groups as well as individuals who for non-political and non-religious reasons can seek to develop and use simple biological weapons. Motives (for example revenge or blackmail) are usually very specific and limited. There is usually no desire to harm a large number of people. It has been ascertained that criminal individuals have both manufactured and sold toxins such as abrin or ricin via the internet in quantities suitable for biological attacks.

The response to these threats must be national solutions as well as stronger international cooperation. States have the obligation – as stated in UN Security Resolution 1540 – to take steps to prevent the misuse of material suitable for weapons of mass destruction. This includes biological substances as well as materials and technologies with the potential for misuse. In Denmark, steps have been taken via the country's biosecurity laws and a 24-7 biopreparedness system that can respond to uncontrolled releases and actual biological attacks.

At the same time, Denmark cannot stand alone. The results of a biological attack anywhere in the world will also affect Denmark – through economic losses, illness and, at worst, deaths on Danish soil. This underscores the necessity of international cooperation and a united approach to prevent the growth of biological threats. This is also a prerequisite for continued, responsible biotechnological research and development that can address current and future challenges.

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