Biotoxins: a reference guide

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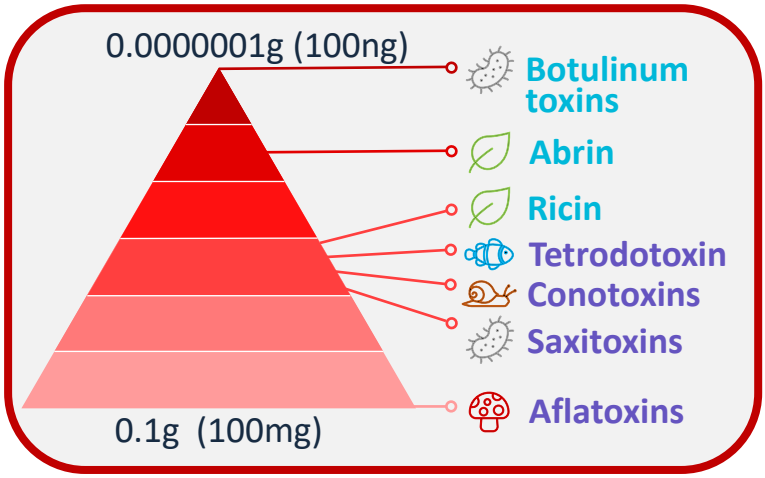
What are biotoxins?

Biotoxins (also referred to as biological toxins, or simply toxins) are toxic chemicals usually obtained from biological sources, such as microorganisms or plants. Biological materials may produce a single biotoxin, such as ricin, or family of toxins, such as the botulinum neurotoxins. Biotoxins are not infectious in nature, like bacteria or viruses, and cannot self-replicate.

There are many hundreds of known biotoxins, with many more that have yet to be identified. They can generally be grouped into two classes based on size: **low molecular weight** (LMW) and **high molecular weight** (HMW).

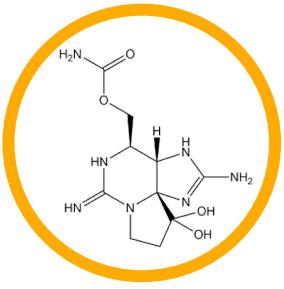


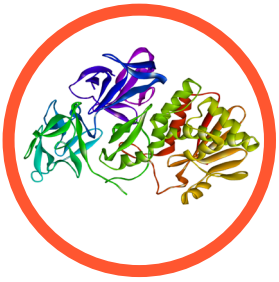
Relative lethal doses of common biotoxins

Many biotoxins are as toxic as, or more toxic than, traditional nerve agents. Less than 1 milligram of ricin can kill someone if it is ingested, inhaled, or injected. One of the botulinum toxins is considered the most toxic substance in the world.

Biotoxins and the CWC

Two biotoxins are listed in Schedule 1 of the Annex on Chemicals to the Convention: ricin and saxitoxin. Whilst there are only two scheduled biotoxins, under the general purpose criterion the use of any toxic chemical (which includes biotoxins) as a chemical weapon is a violation of the Convention.

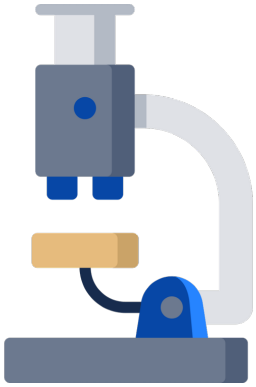




Saxitoxin		Ricin
LMW		HMW
Aquatic microorganisms		Castor beans
Affects nerve transmissions		Prevents cells making proteins
No antidote		No antidote
Death in hours		Death in days

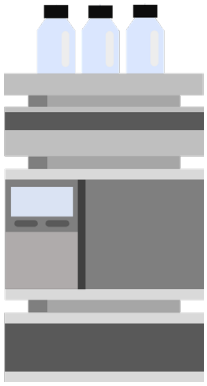
How do biotoxins differ?

There is great diversity in the field of biotoxins. Whilst they are all toxic, with a biological organism as their origin, they are all extremely different in terms of size and chemical properties. Purely synthetic chemical warfare agents do not exhibit such a wide range of diversity.



One of the principal differences between biotoxins and traditional Schedule 1 chemical warfare agents is the **difficulty in detecting and identifying their presence in the field**. There is no universal instrument or detector that can be used for wide-area monitoring of biotoxins.

Unambiguous identification of biotoxins can be more challenging than that of traditional chemical warfare agents and **there is no single analytical technique which can be applied**. Consequently, there are few labs that are skilled in the characterisation of both LMW and HMW biotoxins.



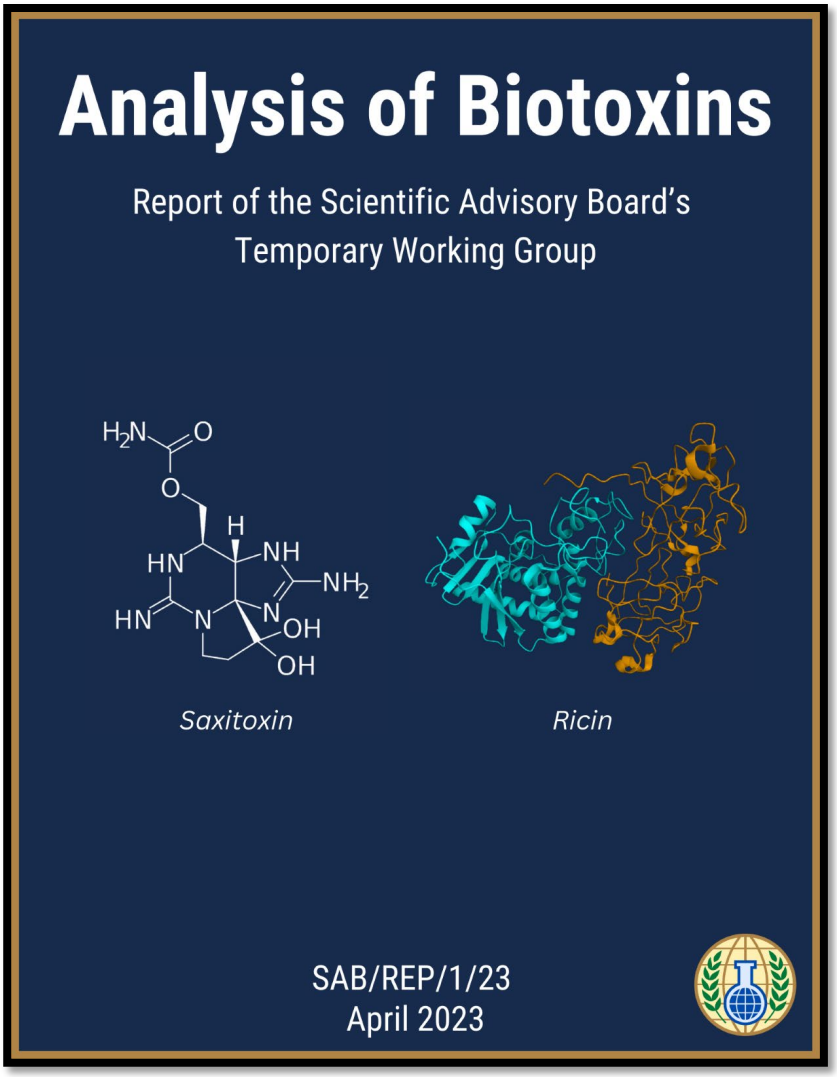
Temporary Working Group

There is a risk of biotoxins being used as chemical weapons and there have been several cases of misuse in recent years, especially by non-State actors. **It is therefore essential that the OPCW is prepared to investigate and/or provide technical assistance to States Parties in allegations of misuse of biotoxins**, regardless of whether they are scheduled. This involves ensuring inspectors are properly trained and equipped to investigate situations involving biotoxins as well as having the analytical laboratory capability to confidently and resolutely analyse biotoxin-related samples.

The Director-General established the Temporary Working Group (TWG) on analysis of biotoxins to conduct an in-depth review of the relevant science and technology and identify considerations to be taken into account in investigations of alleged use of biotoxins.

TWG's recommendations

The end of mandate report details the TWG's scientific findings relating to analysis of biotoxins, in addition to setting out 23 thematically grouped recommendations. While the TWG views all 23 recommendations as important, it deemed that nine warrant prioritised consideration and are thus marked as 'strong' recommendations.



Learn more:

Detection / identification

1

The OPCW should compile and disseminate information on the diagnosis and treatment of biotoxin exposure, including through convening a technical workshop on this topic involving clinicians and veterinarians with relevant experience, Technical Secretariat staff, and representatives from the TWG on the analysis of biotoxins. Not only would early clinical diagnosis assist in identification of the agent used, but dissemination of information on diagnosis and treatment of biotoxin casualties would contribute to the OPCW's efforts on assistance and protection.

Forensic considerations

2

The OPCW should adopt a comprehensive forensic approach to every investigation of alleged use of biotoxins (e.g., determining naturally occurring versus deliberate release, recombinant production, and sample provenance or batch matching via a comprehensive molecular analysis of the sample).

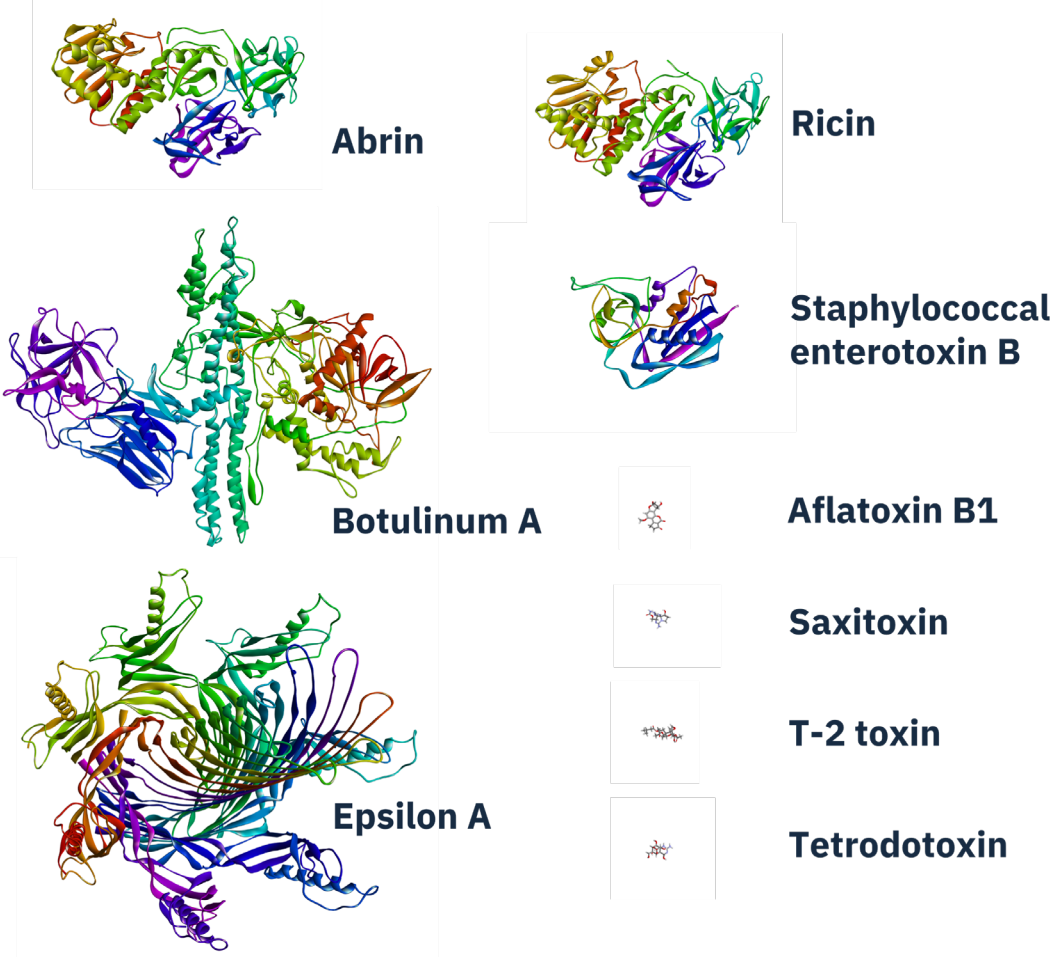
Most relevant biotoxins

Based on the factors outlined by the TWG, the OPCW's efforts to develop its capabilities for investigation of alleged biotoxin use should focus on the **nine "most relevant" biotoxins** listed below. Recognising that seven of these nine biotoxins are not listed on Schedule 1 in the Annex on Chemicals to the Convention, the OPCW should plan to draw on sophisticated biotoxin analysis capabilities that may exist in other fields. The "most relevant" biotoxins are:

3

Abrin	**Aflatoxins**	**Botulinum toxins**
Epsilon toxin	**Ricin**	**Saxitoxin**
***S. aureus* enterotoxins**	**T-2 toxin**	**Tetrodotoxin**

Most relevant biotoxins



Relative sizes of the nine most relevant biotoxins

4

The OPCW should, in the near term, survey existing literature and recognised experts in biotoxin analysis to identify laboratories that possess specialised capabilities for analysis of each of the "most relevant" biotoxins. The OPCW should consider convening a workshop as part of this effort.

Laboratory analysis

5

In its activities related to analysis of biotoxins, the OPCW should take fully into account that the technical requirements for analysis differ widely between LMW and HMW biotoxins.

a) For LMW biotoxins, the OPCW should generally rely on traditional mass spectrometry-based techniques, such as liquid chromatography-mass spectrometry.

b) For HMW biotoxins, the OPCW should employ a combination of mass spectrometry-based techniques and orthogonal techniques, such as immunological methods and biotoxin activity assays. For HMW biotoxins present in samples at a very low level (nanogram/millilitre or below), the combination of immunoaffinity enrichment-based methods and functional methods (such as biotoxin activity assays) may be the only combination of methods with sufficient sensitivity for the analysis. Both approaches should be used, as long as enough sample material is available.

Laboratory analysis

6 The OPCW should develop minimum specification requirements for performance criteria of immunological and activity assays for the analysis of HMW biotoxins. This should include minimum specification for the immunological components (antibodies) as well as the overall immunoassay and activity assay performance criteria. It is strongly recommended that this is conducted in partnership with the UNSGM laboratory network.

Best practices

7 The OPCW should document and disseminate best practices for the unambiguous identification of specific biotoxins included in analysis exercise programmes to support the further development of analytical capability among laboratories.

Designation

8 The OPCW should consider a proficiency test regime for biotoxin analysis that enables a laboratory to seek separate designation for the analysis of saxitoxin or of ricin.

International cooperation

9

The OPCW should work closely with the UN, drawing on the relationship agreement for cooperation between the two organisations (EC-MXI/DEC.1, dated 1 September 2000), along with any other interested organisations and laboratories from different sectors (e.g., food safety) to establish an informal network for biotoxin analysis to facilitate building international capabilities for forensic analysis of biotoxins, including in such areas as:

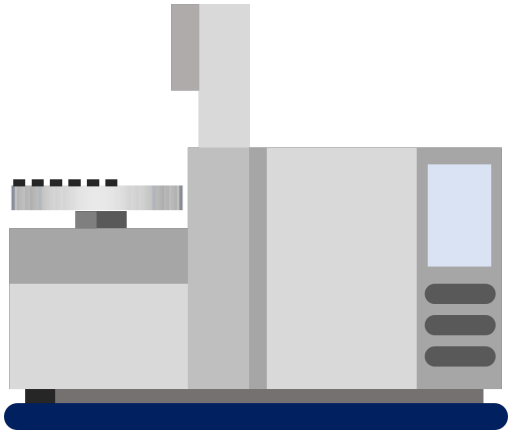
a) common guidelines and best practices for biotoxin analysis to be used by the OPCW and the UN in international investigations

b) coordination of requirements for quality assurance management systems for acceptance of biotoxin analysis data in investigations

c) development of a reporting format acceptable for OPCW and UNSGM missions for reporting results of biotoxin analysis, including definition of performance and acceptance criteria for a range of relevant methods

d) coordination of efforts to minimise gaps and unproductive duplication, including analysis exercises and proficiency testing

ChemTech Centre



In light of the growing concern over the risk of misuse of biotoxins, the Technical Secretariat is developing more comprehensive analytical detection techniques at the Centre for Chemistry and Technology (ChemTech Centre).

Objectives

Enhance the OPCW's ability to respond to incidents of alleged use of biotoxins

Develop analytical techniques to detect biotoxins in environmental and biomedical samples, as well as develop methods for the detailed characterisation of biotoxins and their crude extracts

Strengthen the OPCW's relationship with the UNSGM

Activities

Launch a biotoxin proficiency test and designate a network of labs

Develop tools for biotoxin forensics

Develop a validated ricin detection test kit

Convene stakeholder meetings with the UNSGM network of labs

Learn more

Scientific Advisory Board

Scientific Advisory Board documents (including TWG reports)

ChemTech Centre

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