

Botulinum Toxin: Lethal Weapon or Magic Bullet?

Introduction

Botulinum Toxin: Lethal Weapon or Magic Bullet? is a series of learning activities that will bring exciting scientific research to the classroom. The activities focus on the botulinum toxin and its potential uses in medicine, biowarfare and aesthetics. These six activities have two central objectives. The first is to use the botulinum toxin as a vehicle to teach basic scientific principles and concepts of cell biology, specifically intracellular trafficking and receptor-mediated endocytosis. The second is to stimulate student interest in science by exploring the relationship between scientific research and contemporary social issues. The greatest mark of success in this objective is when students become active learners rather than passive consumers of information.

On the scientific front, much has been learned about the toxin's structure, host cell targets, and enzymatic activity. It is part of a family of proteins whose genes have been sequenced and whose molecular roles have been analyzed. Over the last decade, we have seen a number of scientific reports that describe how standard biochemical and cellular techniques were used to elucidate the mechanism of toxin action--proteolytic cleavage. On the social front, the word "Botox" has become a household name due to its cosmetic applications, but its continued use as a biological weapon requires us to grapple with ethical issues relevant to both the practicing scientist and society as a whole.

The activities in this teaching module draw upon a broad array of resources related to the toxin: from informative pieces in the press and television, to textbook excerpts, to the secondary and primary scientific literatures. Instructors will need to decide which of the suggested readings/media items seem most appropriate for their students. The suggested primary literature was chosen to help students appreciate that science is a gradual process: a series of experiments built on previous findings, conducted by members of a community who strive to increase their understanding about the world around them. The suggested secondary literature was chosen to place these incremental advances in scientific understanding within a larger context of prior research. These articles summarize the impact of the present findings, highlight unanswered questions and point to future experiments and applications.

Regardless of which readings and activities instructors choose, the topic readily lends itself to a wide variety of learning experiences, from basic discussions of the social issues to more advanced scientific activities such as planning new experiments. Perhaps most exciting is that the story, on both the scientific and social fronts, is not yet complete. The identity of the toxin host cell receptors and the method of membrane translocation remain unknown. Thus, students can pose questions and design experiments to address these areas of research. And with new applications for the toxin in development, both therapeutic and harmful, many questions regarding the social impact of science remain pressing. Ideally, by unraveling these complex scientific and social issues for themselves,

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students will start to teach themselves the basic science and reflect upon its social relevance.

Each of the six activities has been developed modularly in order that it can be used on its own, in combination with another activity or activities, or as a complete series. For each activity, the "Teaching Notes" provide step-by-step instructions for implementation. The "Teaching Notes" overview the activity itself, the assigned readings and media assets, implementation plans and assessment opportunities. In order to accommodate a wide variety of teaching environments, the activities are designed to be as flexible as possible, with many suggestions for alternatives. While these "Teaching Notes" provide a detailed suggested guide, instructors are encouraged to modify the activities, swap components or simply use the suggested media resources to complement a course.

For instructors, the "Botulinum Toxin Background" reading provides the necessary scientific and historical foundation needed to administer the learning activities. Other instructor resources include recommended media clips, timelines, references and answer keys. For students, the activity assignments are all available online with active links and as PDF files to be printed and distributed. Additional student resources include the numbered resources for self and peer assessment and self-reflective reading and writing guides. A fuller description of these may be found in the **Introduction to CBL**.

Finally, because some schools have limited access to journals, citations refer to freely available papers whenever possible, but primary references are included in the resources and bibliography.