



# Comics as an Educational Resource To Teach Microbiology in the Classroom<sup>†</sup>

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New educational resources are being implemented as an initiative to foster learning. In order to contribute to the toolkit of innovative educational resources, we developed a microbiology comic book. The aim of this comic is to provide educators with a fun, accessible, and rigorous way to generate awareness of the invisible world that surrounds us and that inhabits us. Bacteria have a reputation as harmful and disgusting entities. Mass media, with advertisements of disinfectants, soaps, and house cleaning products, are sending a distorted message about microbes. We must debunk these misconceptions and emphasize the importance of microorganisms, and particularly bacteria, in the environment and our lives. Education is the means to this end, and therefore this comic is intended to help educators teach microbiology in an attractive, accurate, and straightforward way. Here, we present this educational tool and give some tips on the different themes that can be addressed in the classroom using this resource.

La implementación de nuevos recursos educativos como iniciativa para fomentar el aprendizaje es cada vez más frecuente, y es con esta finalidad que desarrollamos un cómic sobre microbiología. A lo largo de la historia las bacterias han sido concebidas como entidades dañinas y repugnantes. Los medios de comunicación, con sus anuncios de desinfectantes, jabones y productos de limpieza, envían continuamente un mensaje distorsionado sobre los microbios. En este sentido, creemos que es importante refutar los conceptos erróneos y enfatizar la importancia de los microorganismos, y en particular de las bacterias, en el medio ambiente y en nuestras vidas. La manera de incorporar conceptos certeros en el conocimiento es mediante la educación. Por ello, creamos este cómic destinado a ayudar a los educadores en la enseñanza de la microbiología de una manera atractiva, divertida y accesible para los alumnos, y a la vez precisa y rigurosa, como forma de generar conciencia del mundo invisible que nos rodea y que nos habita. En este trabajo presentamos nuestro comic como herramienta educativa y brindamos recomendaciones sobre los diferentes temas que se pueden abordar en el aula con él.

## INTRODUCTION

The traditional teacher-centered educational model is still the main model used in schools, and science is taught accordingly (1). The way in which teachers present content to the students influences their understanding. Therefore, using resources based on their interests can promote and improve learning (2). In this context, alternative resources in science education have been implemented, including educational projects focused on the interests of the children

(3, 4), science corners (5), music (6, 7), interactive platforms (8, 9), comics (10–14), and certainly many more.

Comics have proven to be effective in engaging and shaping student attitudes toward science in a positive way, facilitating their learning and improving their understanding (15). They are an excellent resource to deliver a substantial amount of information in a short, appropriate and effective way. With their narrative and images, comics facilitate learning, stimulate the imagination, and favor the development of logical thinking (16). There are a few examples of comics for science teaching (10, 15, 17), but their quantitative effect on knowledge acquisition remains largely unexplored (18). Most science educational comics are short strips and single-framed concept cartoons (19–22), are intended for English speakers, and are not freely available (23). Science communication with comics is scarcely even addressed in Latin America. The few existing reports come from Brazil and Mexico, and only in the latter were they written in Spanish (24) the second-most spoken language worldwide (25).

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Therefore, we decided it would be a significant contribution to generate a comic book for Spanish-speaking populations.

Education in microbiology receives less attention than other science disciplines, so children are unfamiliar with the subject. In all likelihood, they will grab whatever information they find to build their knowledge about the microbial world (26). That information mainly comes from mass media (27, 28), with a not-so-positive image of microorganisms. Furthermore, microbiology poses a huge additional difficulty for educators: to explain an invisible world, to explain the unseen. To the best of our knowledge, the use of comic books in microbiology communication has only been explored in the book *Microbes* (29).

Here, we present a microbiology comic book created by experts in the field and adapted by experienced illustrator-scriptwriters as an educational resource to help educators teach microbiology and to aid in debunking preconceptions about microorganisms. Our book is an innovative tool, as it is a sequential, character-driven story, the graphics are excellent and attractive, it offers extensive coverage of themes, and it is freely available on the web and can therefore be used by others. To the best of our knowledge, there is no microbiology comic with such characteristics, even in English. Even though the content is adapted to the Uruguayan school curriculum for fourth to sixth graders (10–12 years old), it can be used with children of all ages, as the themes can be approached from different perspectives and in varying depths. The comic was recently released, and therefore its impact on the learning of microbiology has not been assessed. With this article, we hope educators will adopt the comic as an educational resource so it can be used and evaluated worldwide.

## PROCEDURE

The comic was developed by a team of microbiology experts from the Institute of Biological Research Clemente Estable and scriptwriters and illustrators from *Bandas Educativas* (30). The comic is licensed under Creative Commons, non-commercial attribution, no derivatives (CC BY-NC-ND) and can therefore be used by downloading it from [www.comicbacterias.com/comic/](http://www.comicbacterias.com/comic/). As we intend to spread its use as an educational resource, we generated an English version of the script that can be found in the supplementary materials (Appendix I). The story is articulated into four chapters spanning different themes, which we summarize here, providing examples of the content that can be addressed with each chapter.

### Chapter I: Introduction

In this chapter, the reader is introduced to the existence of a microbial world in sequential storytelling, which works particularly well for comics. It introduces Bacteria through two main characters, Coco and Fran, who live in “Bacteritown,” situated in a coffee table. This introduction

leads the reader to realize that the micro and macro worlds coexist (Fig. 1).

“The Great Disinfection” is announced as a metaphor for an ancient catastrophic event, playing a central role in the entire story. With graphical narrative, it is shown as an event that destroyed 99.9% of the bacteria population. This event was intentionally included for the reader to associate with the disinfectant propaganda.

Themes that can be addressed in this chapter include 1) bacteria diversity: phenotypes (i.e., Coco is a coccus and Fran is a bacillus) and functions (the different roles of the characters can be extrapolated to different functions in their niche); 2) the coexistence of macro and micro worlds.

### Chapters II, III, and IV: The Journey

During the journey, the characters will visit different places, including the human gut, water, and soil (chapters II, III, and IV, respectively). This journey allows the reader to understand that there is a microbial world in every imaginable niche, including our own body. It also shows bacteria performing many important functions, which could be used to demystify the well-established popular concept that bacteria are only harmful. One main topic we wanted to address was the use and abuse of antibiotics, which is an alarming problem worldwide. How bacteria acquire resistance is covered in detail using sequential storytelling (Fig. 2). Themes that can be addressed in chapter II include 1) the microbiota and its role in decomposing food, producing nutrients, and training our immune system; 2) antibiotics and their effect on the microbiota; antibiotic resistance, DNA, and horizontal gene transfer.

Themes that can be addressed in chapters III and IV include 1) cyanobacteria and oxygenic photosynthesis, the trophic chain (autotrophy and heterotrophy), eutrophication, reproduction in bacteria; 2) bacteria and their importance to soil and plant health, intra and interspecific relationships (mutualism, symbiosis).

### Additional information

Throughout the comic, many words are highlighted and included in a glossary to facilitate understanding of difficult terminology by a non-expert audience. At the end, the book also provides detailed information about some currently hot topics, such as the correct use of antibiotics and the impact of human activity in eutrophication, among others. We also created a card game, freely available for download at <http://www.comicbacterias.com/micromatch/>, to make microbiology learning even more fun.

## CONCLUSIONS

We developed a new resource for education in microbiology that helps to engage children in learning and in acquiring accurate knowledge about the amazing microbial



world that is all around us. It is also an excellent tool to help educators teach a complex subject and explain an invisible world. It is expected that teachers will be motivated to use the comic as one tool in their students' learning processes. The effectiveness of the comic in knowledge acquisition has not been assessed in the classroom, so it is necessary

to develop systematic evaluation methods. Feedback is welcome at [comicbacterias@gmail.com](mailto:comicbacterias@gmail.com).

## SUPPLEMENTAL MATERIALS

### Appendix I: English version of the comic script



FIGURE 1. Bacteritown. The aesthetics of the city was inspired by biofilms, and its inhabitants exemplify Bacteria biodiversity (top panels). Using a zoom-out, Bacteritown is revealed as being located in a coffee table (bottom panels) showing the coexistence of the macro and micro worlds.



FIGURE 2. Antibiotic resistance. By using sequential storytelling resembling ancient Greek pottery, the acquisition of antibiotic resistance is represented as a fight.

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