INTRODUCTION

Microbial activities are widely exploited in the manufacture of valuable products. Indeed, industrial microbiology employs microbial metabolism on a large scale to generate numerous commercial products including enzymes, antibiotics, and commodity chemicals (2). However, the many beneficial uses of microorganisms are often overshadowed by negative associations with disease and decay. This article describes an interactive activity aimed at school-aged children and members of the public, which introduces the concept of microbial enzymes and ultimately illustrates how the industrial uses of microbes have a positive impact on everyday life.

It is increasingly recognized that hands-on and interactive modes of outreach are successful in engaging a wide variety of individuals with scientific concepts and research programs (1, 3). “Enzymes in Action” showcases the natural and industrial roles of bacterial enzymes, and allows participants to conduct a simple assay revealing enzymes at work, thereby emphasizing the positive impacts of microbes on everyday life. This activity has been conducted on three occasions at a two-day public engagement event entitled Magnificent Microbes (4), held at the Dundee Science Centre in 2010, 2012, and 2014. It is suitable for children (aged 9 to 14 years) and adults with little or no knowledge of microbiology. The activity can be recreated in the classroom, where it may serve to enrich the school curriculum.

PROCEDURE

Materials

Preparation for this activity (additional instructions provided in Appendix 2) requires Biosafety Level 1 facilities and access to hand-wash facilities. The specifications of the materials listed assume that up to three children could take part in the activity simultaneously. The activity may also be adapted to allow senior school pupils to explore the topic further by assessing the impact of changing incubation temperature or substrate concentration.

- Stock of Bacillus subtilis NCIB3610 (Biosafety Level 1, Bacillus Genetic Stock Centre BGSCID: 3A1)
- Three Luria-Bertani (LB) + 1% (w/v) soluble starch agar plates (60–90 mm ideal)
- 20 mL Lugol’s iodine solution (available in pharmacies)
- Three 50-mL plastic centrifuge tubes and rack
- Approx. 10 3-mL plastic Pasteur pipettes
- One large plastic tray, lined with paper towel
- One bag-lined biohazard bin
- One large plastic tub (for chemical waste)
- Three pairs of safety goggles
- Three laboratory coats
- One box of laboratory-grade disposable nitrile gloves (large size)

Supporting Materials (optional)

- Rotten cucumber (left at 4°C for 20–30 days), sealed in a plastic bag
- Biological washing detergent
- Three LB + 1.5% (w/v) skimmed milk powder agar plates (60–90 mm)

Prior preparation

Demonstrators should have a basic knowledge of microbial enzymes and their industrial applications. To enable this, background notes are provided (Appendix 1). Bacillus subtilis NCIB3610 is a non-recombinant strain safe for use in any laboratory. Fresh colonies of B. subtilis are streaked onto the LB + starch plates (and LB + milk plates, if using) in patterns of the demonstrators’ choice. Note that older children in the context of laboratory classes may participate in this priming activity. Streaked plates are incubated at 30°C for 48 hours or at room temperature for 72 hours.

Set up the activity on a stand that is a suitable height for younger children, with sufficient room for three children to participate simultaneously. Assemble the stand as follows (Appendix 2, Fig. 54): place three of the prepared LB + starch plates on the tray, spaced such that each child...
may access one plate. Place tubes containing Lugol’s solution and a pipette in a rack behind the tray. The nitrile gloves, waste containers, and any supporting materials are stationed around the tray.

**Activity**

Begin the activity by determining participants’ existing knowledge of how microbial enzymes contribute to everyday life. This may be achieved by engaging participants with a question, for example, asking if they can identify a connection between a rotting cucumber and biological washing powder (allowing younger participants to handle these items enhances the hands-on component of the activity). Demonstrators should then explain how digestive enzymes work. This explanation may be aided by reference to a poster (Appendix 3) and to the “halo” visible on the prepared LB + milk plates (Appendix 1, Fig. S3). The diversity of bacterial enzymes is then highlighted using the LB + starch plates. Participants are asked if they would like to conduct an experiment to reveal enzymes at work and the activity proceeds as follows:

1. Give each participant a laboratory coat, gloves, and safety goggles.
2. Remove the lids from the LB + starch plates and explain the materials.
3. Allow participants to pipette Lugol’s onto the plates.
4. Tip off excess solution into the waste bin before asking participants what they observe, explaining again how the assay works (see Fig. 1). Return to the question asked at the beginning of the activity, then lead on to discuss the natural and industrial significance of microbial enzymes. It should be emphasized that while microbes have negative effects (e.g. on the food in our kitchens!), they can also be useful (see Appendix 4 for examples).

At the conclusion of the activity, participants should discard their gloves and wash their hands. Younger participants interested in exploring the topic further may be offered a hand-out (Appendix 5). Used plates are collected and ultimately disposed of by either autoclaving or placing in a chlorine solution made up with Chloros (Sanichlor) tablets according to manufacturers’ instructions.

**Safety issues**

Participants should be advised to take care when handling Lugol’s solution as it stains clothing and skin and is poisonous if consumed.

**CONCLUSION**

This activity utilizes a simple and fun chemical assay to elicit an awareness of the importance of microbes in everyday life. The activity is economical and safe, and is suitable for use in both the classroom and external environments. By allowing participants a hands-on experience in detecting enzymatic activity, “Enzymes in Action” promotes an enhanced understanding of enzyme function to support the school curriculum, and affords all participants an insight into how microbes are integrated with human life. The interactive nature of this activity is beneficial to demonstrators as well as participants, in fostering the development of science communication skills. Thus far, the activity has been conducted by more than 2,000 people at Magnificent Microbes events and has received much positive feedback. Participants particularly enjoy performing what “feels like a real experiment”!

**SUPPLEMENTAL MATERIALS**

- Appendix 1: Background information for demonstrators
- Appendix 2: Instructions for activity preparation
- Appendix 3: Microbes and plant rot poster
- Appendix 4: Enzymes in our homes poster
- Appendix 5: Supermarket challenge hand-out
ACKNOWLEDGMENTS

We thank Dundee University, and the Biotechnology and Biological Sciences Research Council for funding (BB/I006915/1; BB/I019464/I). The authors declare that there are no conflicts of interest.

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