

# Bug power!

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**MANY BIOLOGY SYLLABUSES mention the use of mediators such as methylene blue or tetrazolium salts in practical studies of respiration. Here is a novel method of undertaking such work, using yeast to generate electricity in a microbial fuel cell. Alternative substrates to glucose, different temperatures and types of yeast may easily be compared, giving ample scope for individual projects at advanced level. This work is also highly motivating for younger students and is supported at this level by two recent television broadcasts.**

## Materials

*Complete fuel cells, including carbon fibre electrode material, cation exchange membrane and pre-cut neoprene gaskets are available from the NCBE.*

Perspex fuel cell, cut from 4 mm thick sheet  
Rubber gaskets, 2  
Cation exchange membrane, cut to fit between chambers of the fuel cell (available from BDH, Catalogue No. 55165). *Pre-soak the membrane in distilled water for 24 hours before use. The membrane may be re-used indefinitely, but will melt if autoclaved.*  
Carbon fibre electrodes, cut to fit inside cell, 2  
*J-Cloth*, cut to fit inside cell, 2 pieces  
10 cm<sup>3</sup> plastic syringes, 2, for dispensing liquids  
Petri dish base or lid on which to stand fuel cell  
Electrical leads with crocodile clips, 2  
0–5 V voltmeter or multimeter and / or a low current motor  
Scissors

**All the solutions listed below should be made up in 0.1 M phosphate buffer, pH 7.0, instead of water**

Dried yeast, made into a thick slurry in 0.1M phosphate buffer (*do not* add glucose solution without first resuscitating the yeast in buffer)  
10 mM methylene blue solution, 5 cm<sup>3</sup>  
1 M glucose solution, 5 cm<sup>3</sup>  
0.02 M potassium hexacyanoferrate (III) solution, 10 cm<sup>3</sup> (also called potassium ferricyanide)

**To make 0.1 M phosphate buffer, pH 7.0**

Dissolve 4.08 g Na<sub>2</sub>HPO<sub>4</sub> and 3.29 g NaH<sub>2</sub>PO<sub>4</sub> in 500 cm<sup>3</sup> distilled water.

## Practical details

1. Cut out two carbon fibre electrodes as shown on the opposite page.
2. Cut out two pieces of *J-Cloth* to fit inside the fuel cell.

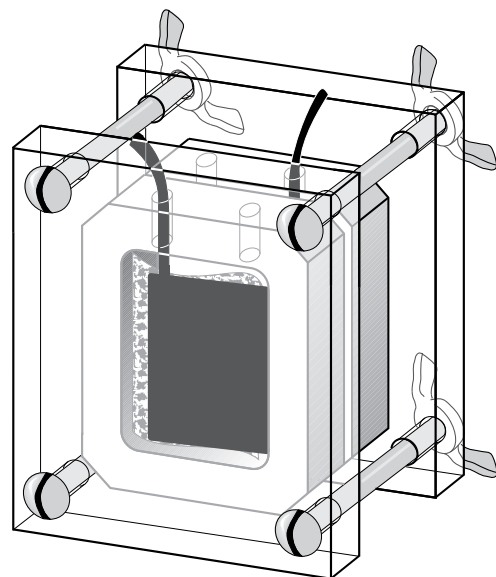
3. Assemble the fuel cell as shown on the accompanying page.
4. Stand the assembled fuel cell on a Petri dish base or lid to catch any liquid which may leak.
5. Combine the yeast slurry, glucose and methylene blue solutions. Syringe the mixture into one chamber of the fuel cell.
6. Syringe potassium hexacyanoferrate (III) solution into the other side of the cell.
7. Connect a voltmeter or multimeter (via the crocodile clips) to the electrode terminals. Fuel cells of this type typically generate between 0.4–0.5 V. *A current should be produced immediately — if the meter registers zero, check the connections and ensure that the carbon fibre electrodes are not touching the cation exchange membrane.*

## Safety

Potassium hexacyanoferrate (III) is poisonous. Eye protection should be worn when handling this material. If the solution comes into contact with the eyes, flood them with water and seek medical attention. If swallowed, give plenty of water to drink and seek medical attention.

## Further activities

1. Several fuel cells may be joined together to give a greater voltage. Increasing the size of the cell (or the electrode area) will increase the current generated (but not the voltage).
2. Different mediators and / or types of yeast may be used. *NOTE: For safety reasons, the use of this fuel cell with other microorganisms is not recommended.*
3. Investigate the effect of temperature on the action of the fuel cell (remember to consider what 'controls' are necessary when making comparisons of this type).



## ADDITIONAL INFORMATION

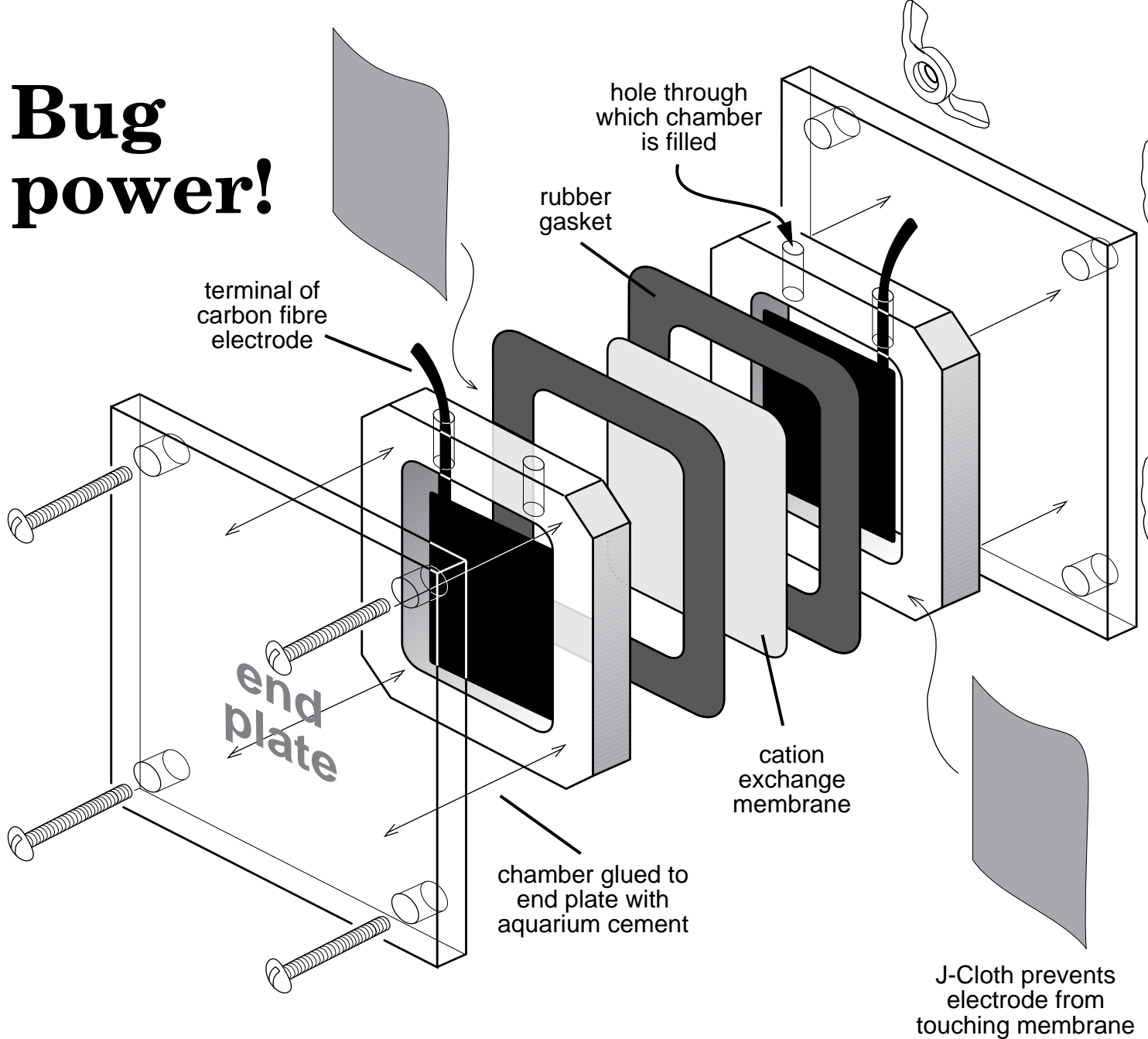
Bennetto, P. (1987) 'Microbes come to power', *New Scientist*, 16 April, pp.36–39.

Bennetto, P. (1991) 'Electricity generation by micro-organisms', *BIO/technology Education*, 1, (4) 163–168.

'Current affairs', *BBC TV Science in Action*, Series 2. (Broadcast Spring 1990).

'What is life?', *Yorkshire TV Scientific Eye*, Series 2. (Broadcast Spring 1990). Video recording (PAL VHS) available from Video Sales, Yorkshire TV, Leeds, LS3 1JS.

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## Setting up the fuel cell

(Refer to the instructions on the accompanying page)

- Fill one chamber with a mixture of equal volumes of methylene blue solution, glucose solution and yeast slurry.
- The other chamber should be filled with potassium hexacyanoferrate (III) solution.
- Connect the carbon fibre electrodes to a voltmeter.

## How it works:

