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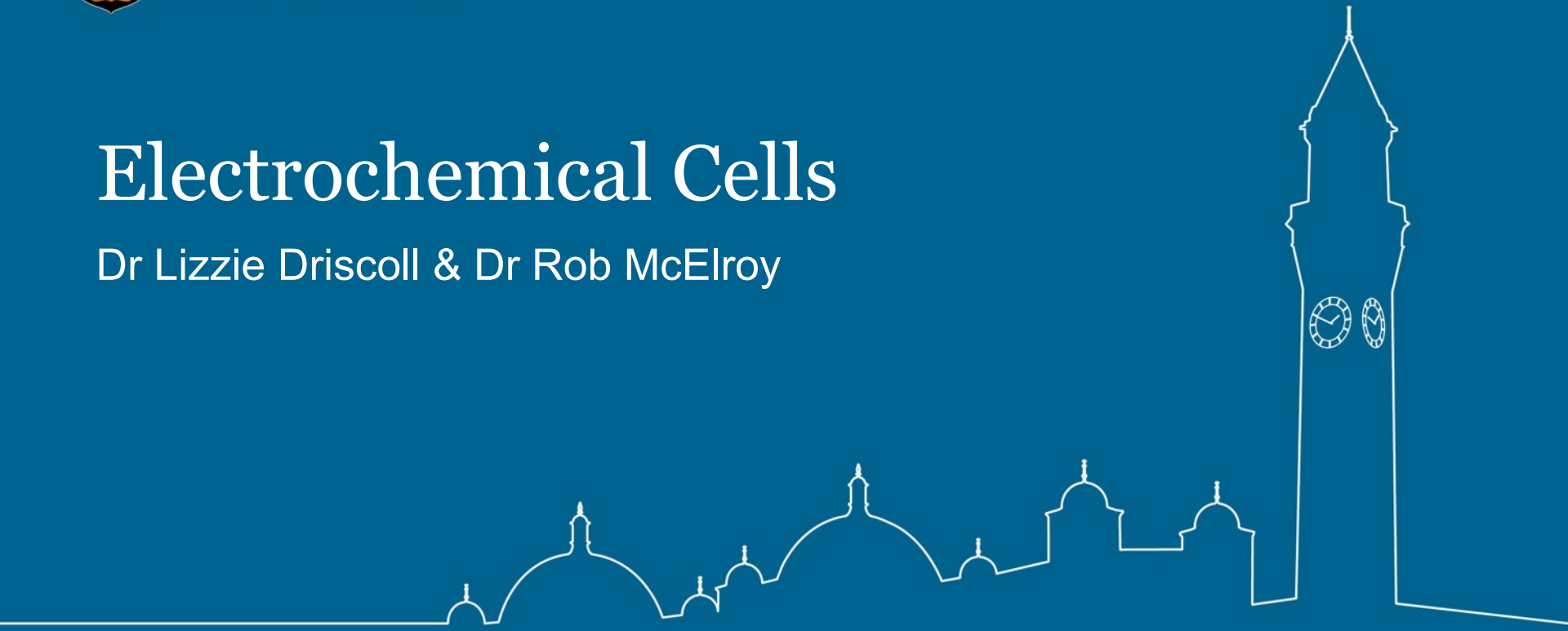
Electrochemical Cells

Dr Lizzie Driscoll & Dr Rob McElroy



What is an electrochemical cell?

- A cell which produces energy via an **electrochemical reaction**, i.e. a **chemical reaction** takes place which generates a **current**.

- A battery typically describes multiple cells, but its loosely used to describe a single cell.

Types of Electrochemical Cells

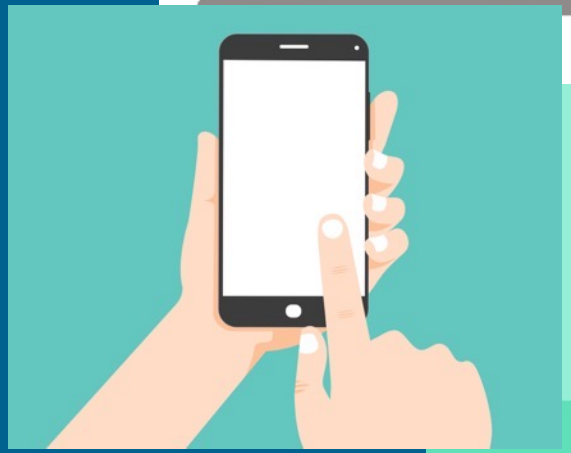
In the energy sector, there are a variety of electrochemical cells, from batteries to fuel cells.

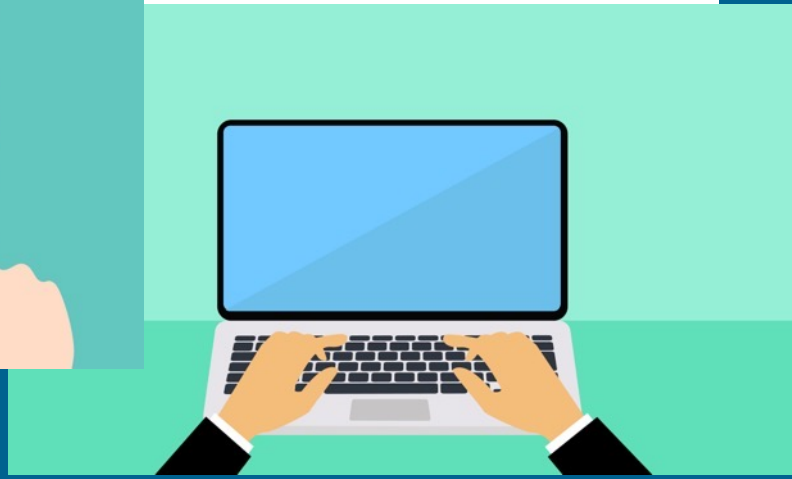
Batteries can be non-rechargeable or rechargeable. They are a form of energy storage.

Fuel cells require a fuel to operate, such as hydrogen (and oxygen), to generate electricity and water as a product.

Li-ion Batteries

- Lithium-ion batteries are: light, high energy dense batteries.
- In these applications (phones, tablets and electric cars) they're all rechargeable.





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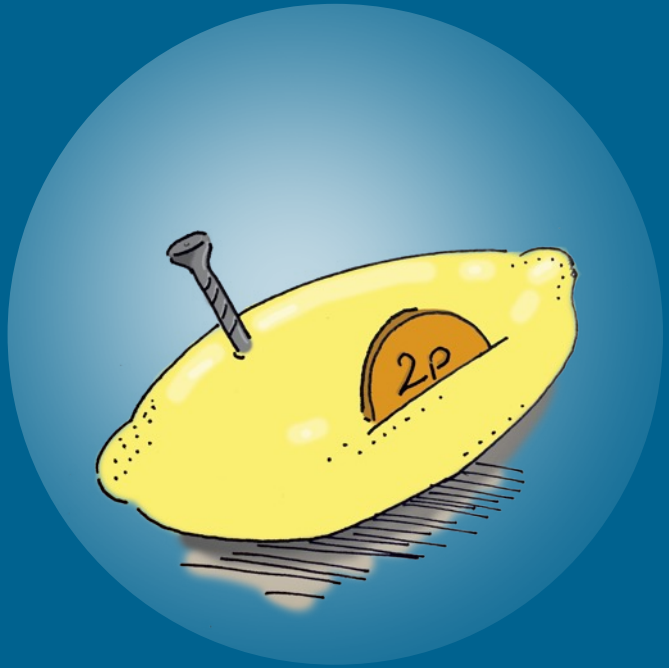
Experimental: Making your Fruity Cells

- Li-ion batteries require a lot of expensive equipment and not the nicest materials to make. But instead we can make a non-rechargeable fruit cell!

- You will need:
  - 3 crocodile clips and wires
  - 2 copper coins
  - 2 zinc-coated nails (in DIY stores look for galvanised nails)
  - 2 pieces of fruit or veg
  - 1 Voltmeter
  - 1 LED



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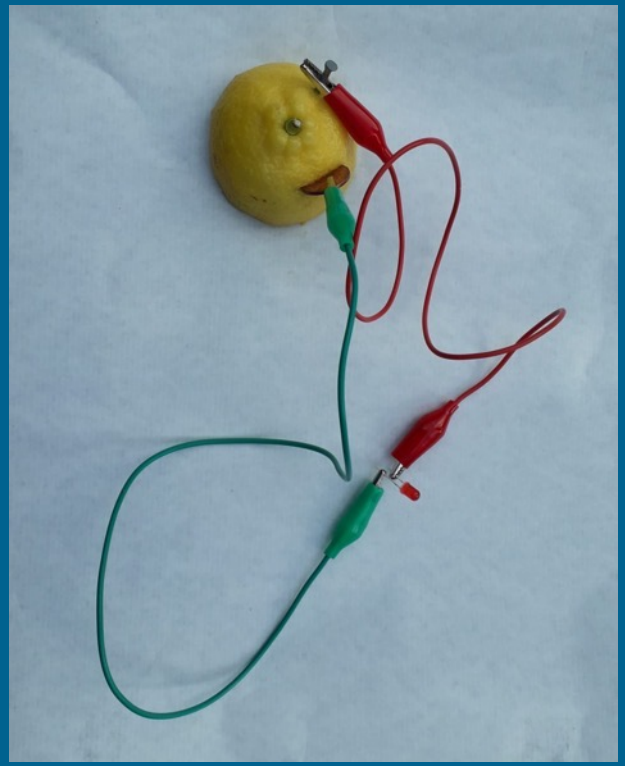
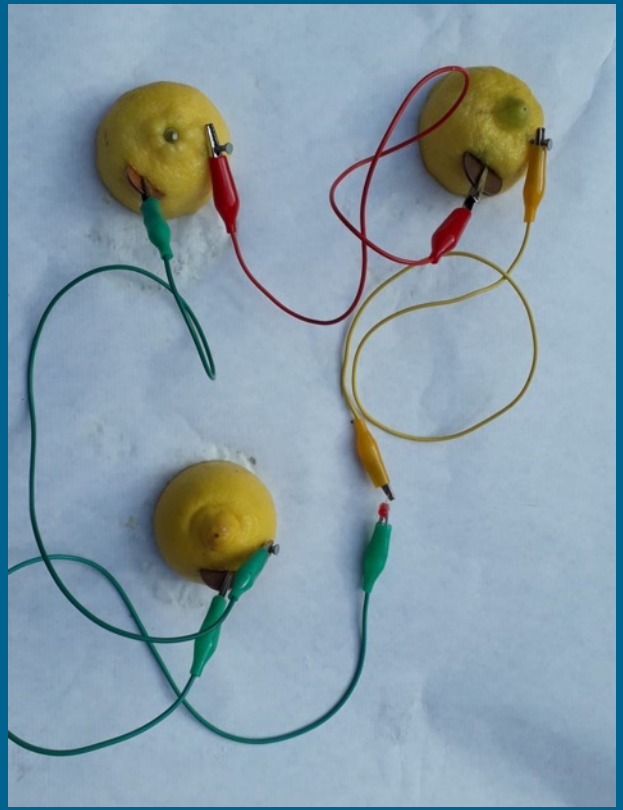
Experimental: Photos of Set-Up



- One nail and copper coin into the lemon.
- Connect two of the crocodile clips to the nail and the coin.
- The LED has two different length legs. Connect the crocodile clip wire on the copper coin to the longer leg (in the photo this is the green wire).
- You have made one lemon cell, but we need more lemons to power our LED!

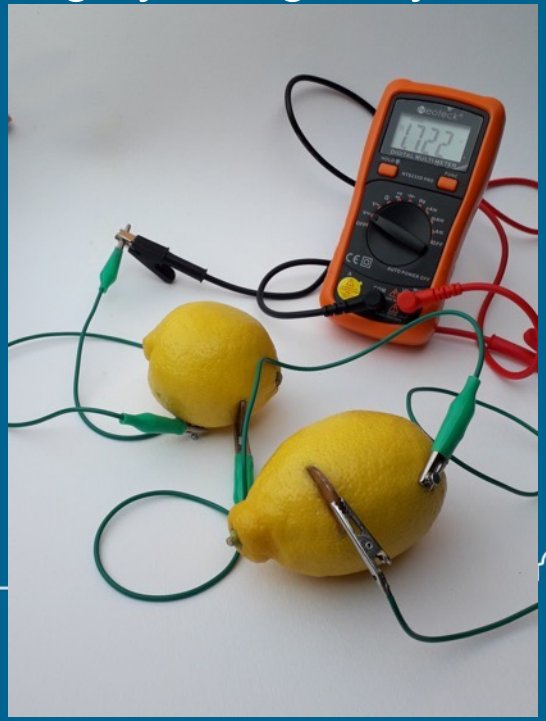
Experimental: Photos of Set-Up



- For every lemon cell, you'll need one extra crocodile clip wire.
- Connect the copper coin in one lemon, to the nail on the second lemon. It should always alternate
- You'll need maybe 2-3 lemon cells to power an LED. You can get the class to make one lemon cell and connect in series.
- Turn off the lights and see if it lights!

To show the class if we had a voltmeter

- The voltage increases every time you add a cell! You could get the class to work out what voltage you'd get if you had so many lemons.



Experimental: Fruity Cells

- Connect your fruit cell to a voltmeter using the crocodile clips.

  What voltage do you get?

- Connect your fruit cell to a second cell.

  Can you power your LED?

Note: LEDs only allow current to flow in one direction. Connect the longer leg of the LED to the copper coin.

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Experimental: Fruity Cells – what's going on?

We're reacting the zinc (Zn) nail with acid (H^+) from the fruit/veg to form Zn ions (Zn^{2+}) in solution and evolving hydrogen gas (H_2).

We can write this in what we call chemical formulae:

$$Zn_{(s)} \rightarrow Zn^{2+}_{(aq)} + 2e^-$$
$$2H^+_{(aq)} + 2e^- \rightarrow H_{2\,(g)}$$

This reaction will produce 0.76 V but can vary due to the pH. Try using different fruit and veg, with a new nail and see what voltage you get.

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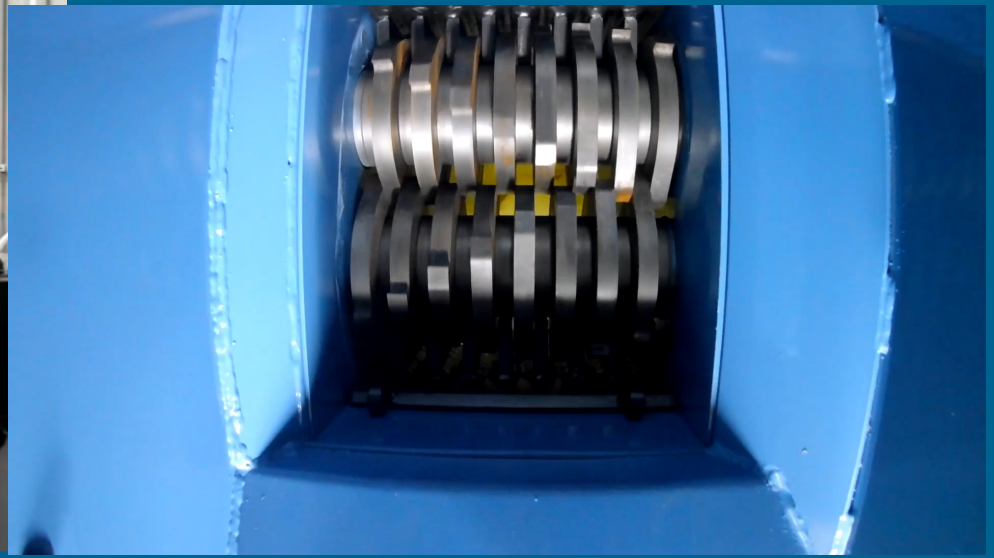
How do we recycle Li-ion Batteries?

- The aim is for end-of-life batteries to be recycled, rather than be sent to landfill.
- The most common method is to shred them!



Shredding Batteries – it's quite messy!

- Shredding is fast, but will result in a mixture of your battery materials.

Shredded material
(sealed in epoxy resin)

Separated Electrode Materials

- Lithium-metal-oxide on the left
- Graphite on the right

Experimental: Recycling– materials required

- You will need:
  - Kitchen foil
  - Plastic Bubble Wrap
  - Sugar Cubes
  - Paper Clips
  - Magnet
  - Balloon
  - Jug of Water
  - Tweezer
  - Sieve

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Experimental: Recycling

- Mix the kitchen foil, plastic, sugar cubes and paper clips together! You may want to tare some pieces to make them smaller (this is you being the shredder).

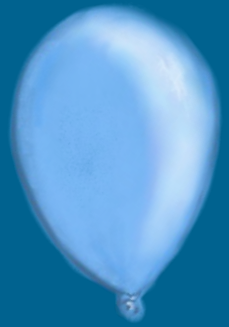
- Using the magnet, balloon, tweezers, sieve, and jug of water:

  How will you separate all the components out?

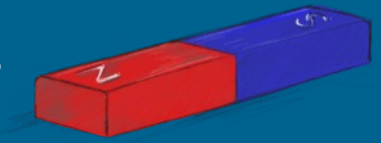
Experimental: Recycling – what's going on?

- With the different materials in the mix, there will be different properties we can make use of.

Sieving helps produce different sizes



The magnet can remove magnetic materials such as the paper clips.



The balloon can remove the plastics through static.

The jug of water can dissolve the sugar.

The tweezers can remove everything but this is very slow!

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Conclusions

- Batteries are everywhere. They can be non-rechargeable or rechargeable.
- Of interest are Li-ion batteries as they are lightweight and very energy dense!
- While there is a growing demand for these batteries, we do need to think about what will happen to the battery packs at the end of their life.