STEM Connections

Battery Research

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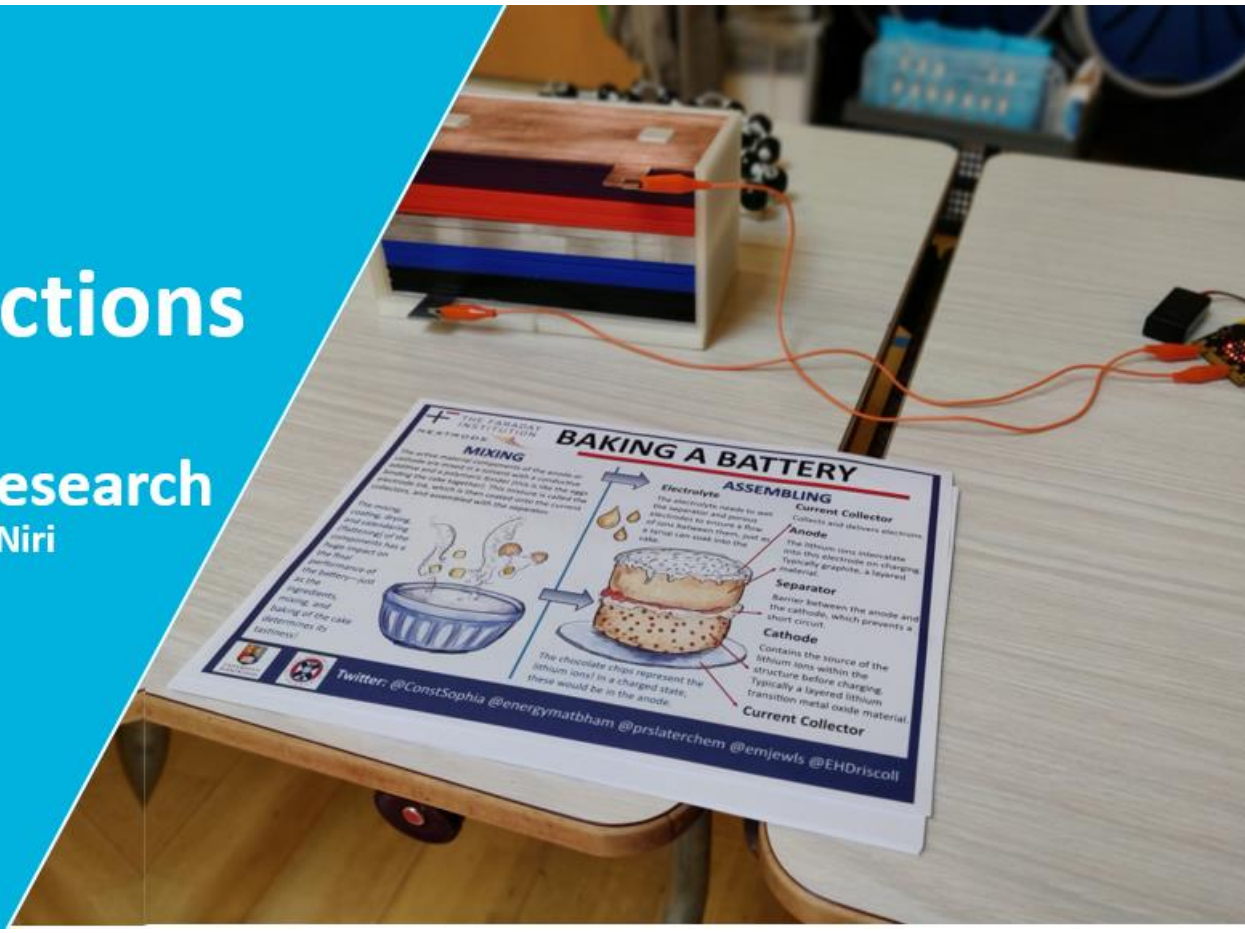


How do batteries work?

Rechargeable Lithium-ion batteries come in different shapes and formats, (a) cylindrical, (b) coin, (c) Prismatic, (d) pouch battery cells, Image 1.

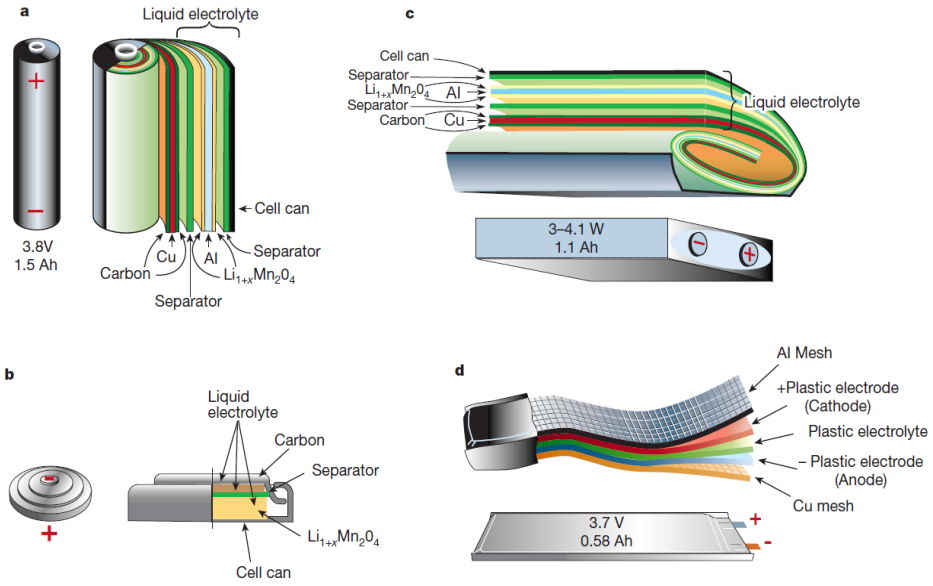


Image 1: Lithium-ion battery configurations, Image source

No matter the configuration, all Lithium-ion batteries are made up of 5 main layers, Image 2

1. (Negative) Current collector
2. Anode
3. Separator
4. Cathode
5. (Positive) current Collector

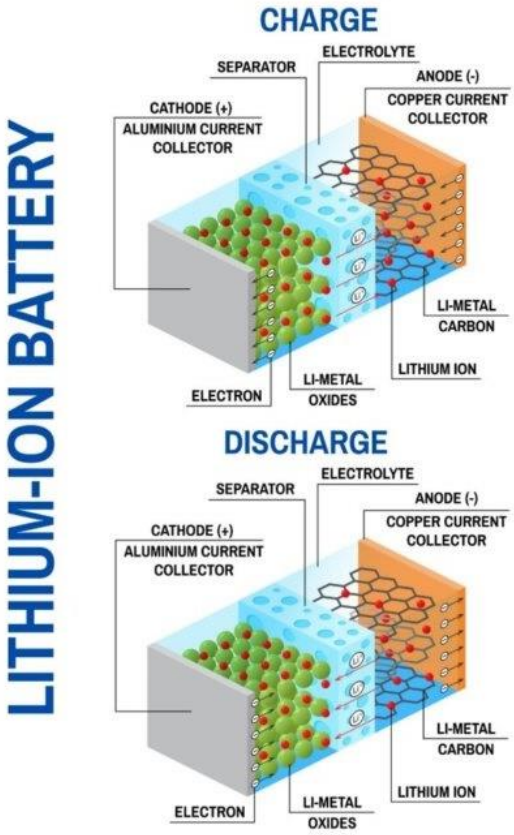


Image 2: Lithium-ion battery layers, Image source

Lithium-ion batteries are charged and discharged by lithium ions moving between the negative and positive electrodes.

Every single layer of a Li-ion battery is essential, and it cannot function when one of the components is missing. The electricity is generated through the chemical reactions of lithium in the battery.

The layer than contains the lithium is called **cathode**. (Actually, it contains lithium oxide as lithium itself is unstable). Lithium oxide is called the active material for a battery cathode. A thin Aluminium foil is used to hold the frame of the cathode. This is called (positive) current collector. Cathode is an important layer in battery as it defines the characteristics such as energy capacity, voltage range and lifetime.

Similar to cathode, **anode** is made up of a copper film (current collector) coated with active material. The active material in anode is responsible for enabling the electric current to flow the external circuit when allowing the reversible emission of lithium ions released from the cathode. Anode is made up of graphite, conductive additive, and a binder. Graphite has a very stable structure, low electrochemical reactivity, and ability to store much lithium ions considering its price.

The movement of lithium-ions happen through electrolyte and the movement of electrons happen through wires. The electrolyte in fact serves as a medium for the movement of ions between cathode and anode. It is made up of high ionic conductivity material, (salts, solvents, and additives).

When cathode and anode determine the performance of cell, the separator determines the safety of the battery. It is a physical barrier between the cathode and anode. It plays an important role in preventing the direct flow of electrons and only lets the passage of ions through the internal microscopic pores. Separators are made up of synthetic resins such as polyethylene.

Batteries are an inseparable part of our daily life in electric vehicles, electric motorcycles, e-bikes, smartphones and many more things, Image 5.

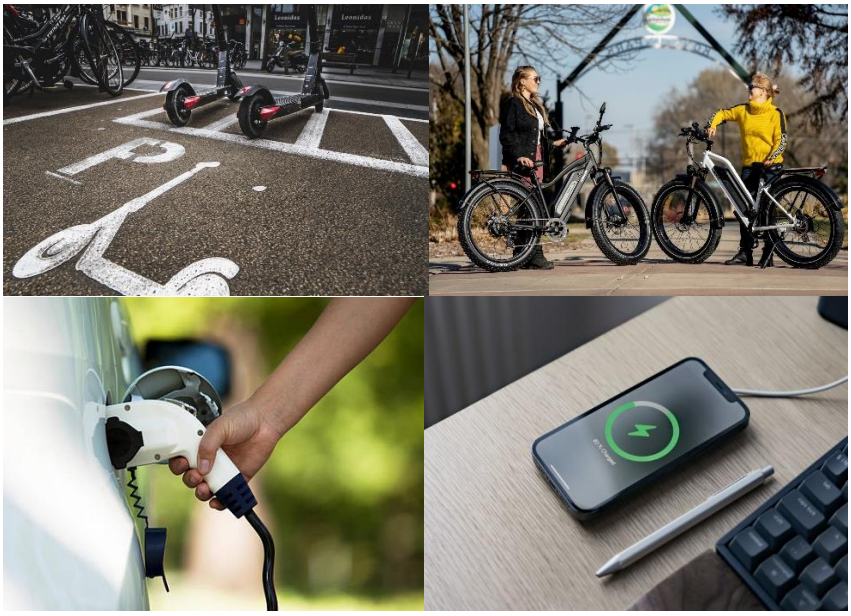


Image 5: Example applications of lithium-ion batteries in daily life, Images source

How to make your own battery

Suitable year groups: Year 4, Year 5, Year 6, Year 7, Year 8 and Year 9

Learning Objective:

- To learn different names of circuits (e.g. close, open, short, parallel and series circuit). (KS2)
- To learn how different circuits work and identify which circuit works the best in certain conditions. (KS2)
- To identify and understand different names and symbols of components. (KS2)
- To calculate energy transfer in current. (KS3)

Materials required:

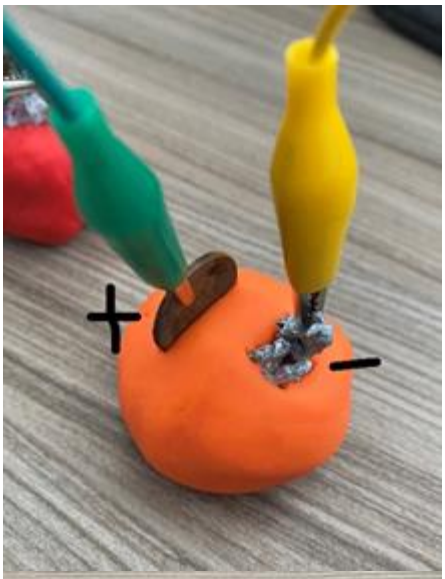
- Copper coins
- Galvanised nail
- LED
- Crocodile clips and wires
- Volt meter
- Playdough (can also use lemons/potatoes/salt water
- 3V battery

Estimated time: 15-20 minutes

Step by step instructions:

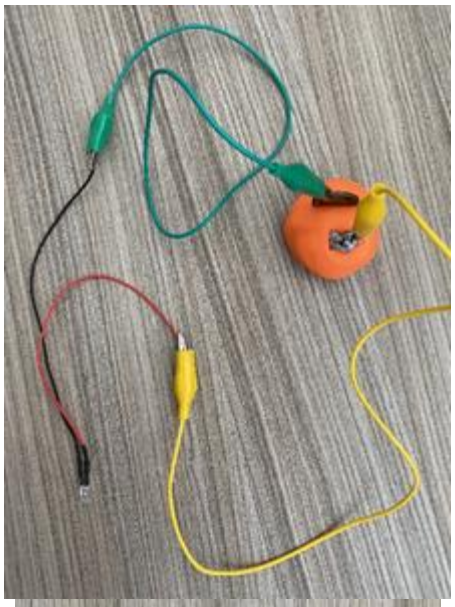
1. Get two sections of playdough. Connect one on the battery terminals and one of the LED connections to one of the sections of playdough. Do the same for the other two connections. The LED should light up but if it doesn't switch the wires connecting to the battery around.

2. Make one ball out of playdough and on one side insert the copper coin and on the other insert a galvanised nail which are coated in zinc. Alternatively use another object made out of zinc. Connect one crocodile clip to each.



3. To test how much electricity is flowing through your playdough battery connect the crocodile clips to a voltmeter. For this example it was 0.758 V.

4. To connect it to the LED it is similar as for the battery. One LED needs around 2V to turn on so it didn't turn on with just one of the playdough battery cells. Try making a few more battery cells and then measuring the voltage to see how it changes.



5. To make one big circuit with multiple battery cells make sure that one the LED connections is connected to the first coin and the other is connected to the last piece of zinc. Connect the battery cells in between from the zinc to the copper.

Ideas to explore the concept further

- What happens if you use more than one LED?
- How does the size of the playdough affect the voltage measured?
- Try to make a battery in the same with other materials such as lemons and see how it differs.