ON THE HUNT FOR NEW KNOWLEDGE

The challenge

We’re looking for a person or small team who can think like a scientist, be creative and methodical, and learn something new about cancer research.

In this challenge, we’ll be asking you to design and run an experiment – looking at how a natural enzyme works. We suggest that you keep a notebook with records of your methods and results. You will then present your results in the form of a poster, something scientists use to let people easily and quickly see their experiments and results.

What is the challenge?

You will be trying to find out more about how enzymes work, by analysing patterns you discover in an experiment.

Who are we?

The Institute of Cancer Research, London, is one of the world’s most influential cancer research institutes, with a record of discoveries and achievement dating back more than 100 years.
Our Cancer Research UK–ICR Centre is part of a national network of centres funded by Cancer Research UK aiming to translate new research into treatments for patients.

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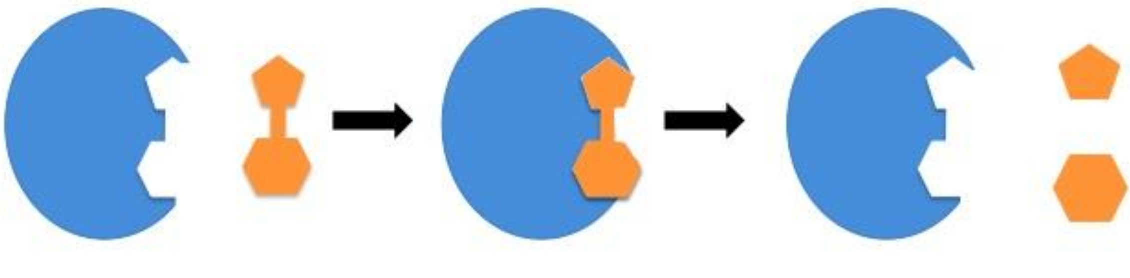
WHAT ARE ENZYMES AND ENZYMES IN CANCER

What are enzymes?

Enzymes are proteins that are made by our cells to help make reactions happen faster. They are natural catalysts – something that makes a reaction work faster, but isn't changed by the reaction. Enzymes were some of the first catalysts to be discovered.

Generally, each enzyme will only speed up one reaction, because it only fits only one specific substrate (the molecule that it reacts with.) Enzymes and substrates are like keys and locks, with the substrate slotting into the active site.



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One example of an enzyme you might use every day is in washing powder – these biological enzymes help to break down stains that come from your foods - proteins, fats and carbohydrates.

In your body, enzymes speed up the chemical reactions of digestion –they help break down proteins, fats and carbohydrates.

You can experience this for yourself – if you chew a piece of bread for a long time, it will start to taste sweet. That's because the enzymes in your saliva have broken down some of the carbs in the bread into smaller sugar molecules.

Another enzyme that your body makes is catalase. This is an enzyme that helps break down hydrogen peroxide, a bleach that is a poisonous by-product of reactions in our own cells. In fact, almost every living thing that is exposed to oxygen makes catalase – they need it to break down that hydrogen peroxide. Catalase helps to break it down into oxygen and water.

$$2H_2O_2 \xrightarrow{\text{CATALASE}} 2H_2O + O_2$$

In your experiment, you will be looking at the things that effect this reaction, and how fast it is able to work.

Why are cancer researchers interested in enzymes?

Your whole body is made up of tiny cells. Cells divide to replace old cells and to help you grow, but if they start to divide in an uncontrolled way they can crowd out healthy cells and spread to other parts of the body. Cancer is a disease where cells multiply too much.

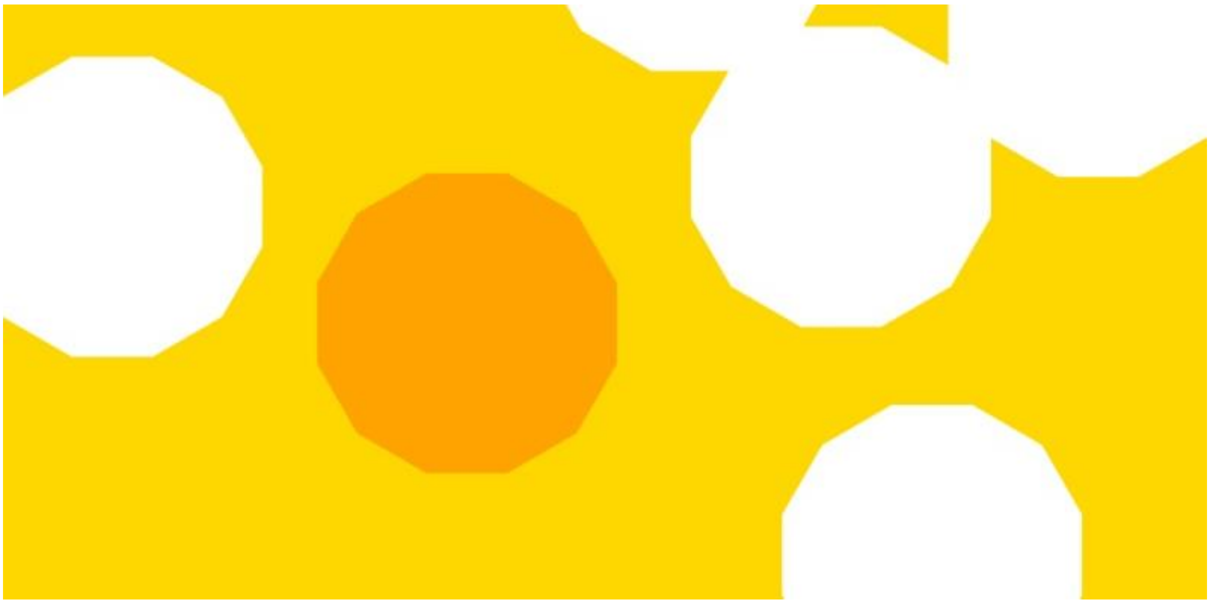
We look at how cells use enzymes to grow and multiply. Often in cancer there is a problem with an enzyme - perhaps a mutation that means that it is switched on all the time - which is causing the cells to grown in this way.

Because enzymes are often involved in helping cancers to spread, some cancer scientists develop drugs that can block their active sites, stopping them from working.

For example, one enzyme called a tyrosine kinase helps to send growth signals to cells. In cancer this enzyme may be signalling too much, causing cells to grow out of control. A drug that blocks this enzyme stops the cells growing and dividing.

In the lab, we need experiments to measure how enzymes are working so we can see what is happening in both healthy cells and cancer cells, investigating the pathways that cells use to make the things they need.

GUIDE TO THE EXPERIMENT



We want you to design an experiment to find out what affects how an enzyme works.

Below, we've detailed a basic experiment which will let you calculate the rate of an enzyme-controlled reaction. Once you understand how to find this rate of reaction, you can look at what affects it – and figure out what's affecting how well your enzyme works.

The experiment

Below is a way to look at how well the enzyme catalase (which is found in high quantities in potatoes) is working.

This investigation looks at the rate of oxygen production by the catalase, by collecting the oxygen produced over a 30-second period.

Enzymes work quickly –and in fact, catalase might be one of the fastest enzymes that exist. You can calculate its rate of reaction using the experiment below.

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Guide to your experiment:

You need:

- Clamp stand
- Conical flask
- 50cm^3 measuring tube
- Pen that can write on measuring tube (ideally)
- Two-holed rubber bung
- Pureed potato
- 2cm^3 Hydrogen peroxide solution
- Measuring syringe
- Stopwatch

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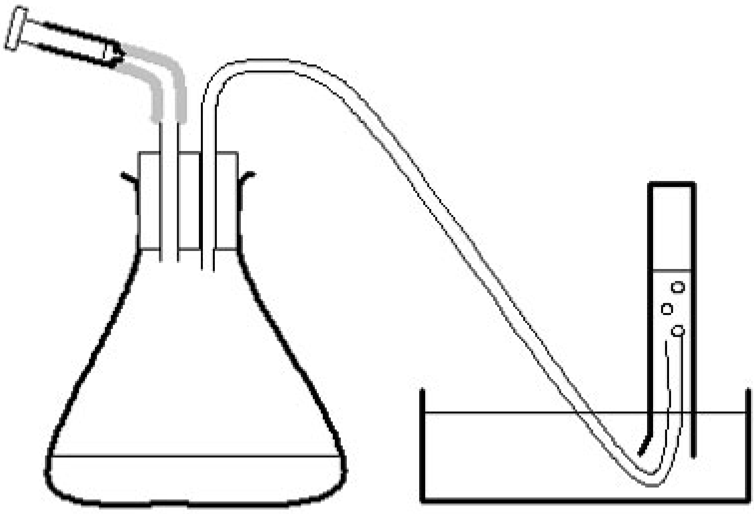


SAFETY NOTE: Wear eye protection and protect your clothing from hydrogen peroxide. Rinse any splashes of peroxide and pureed potato off your skin as quickly as possible.

Setting up:

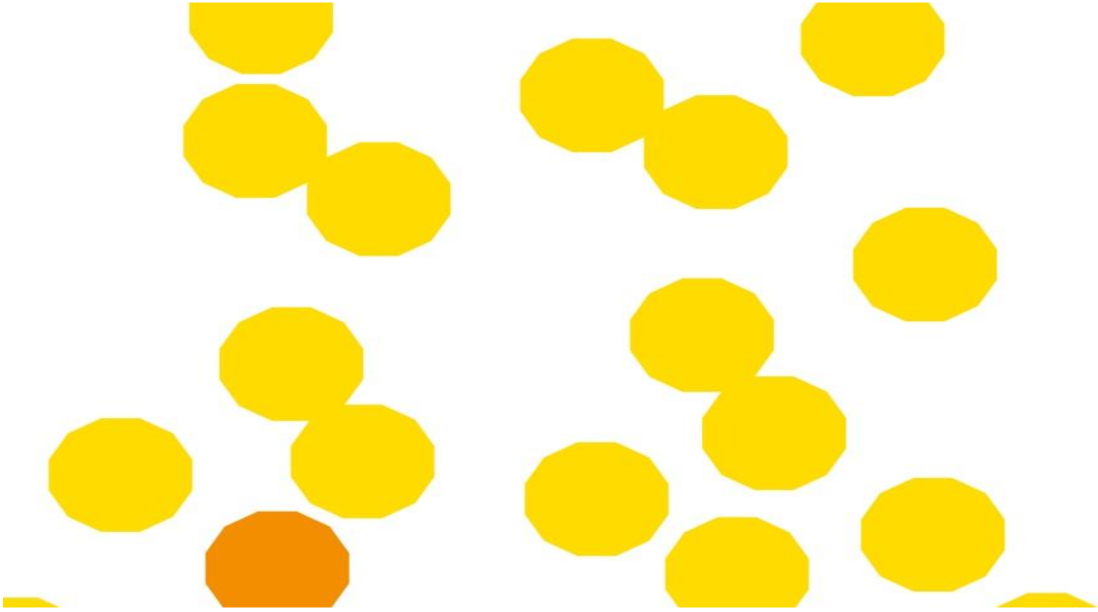
You need to collect the oxygen gas produced by the reaction – this is how you'll measure how the enzyme is working.

- Start by filling your boiling tube with water, then quickly inverting it over the water tank. Have a friend clamp it in position.
- Measure 20cm^3 pureed potato into the conical flask.
- Make sure that the bung is tightly inserted, and that one end of the tube goes into the water bath, and into the upheld boiling tube.

Doing the experiment

- Measure out 2cm^3 of the hydrogen peroxide solution,
- Add it to your conical flask through the tube. You will need to work quickly after this! Watch what happens to the potato – you should see bubbles as oxygen is produced.
- Note where the oxygen level has got too in your boiling tube after 30 seconds.
- Calculate the rate of reaction. Divide the cm^3 of oxygen you collect by the time in seconds it took to produce. This will give you a rate of reaction in cm^3/s.

$$\text{Rate of oxygen production} = \frac{\text{cm}^3 \text{ of oxygen collected}}{\text{time in seconds it took to produce}}$$



Designing your Experiment

In this challenge, you can design your own experiment to change some of the experimental conditions, and see how they affect the rate the enzyme works. Each type of enzyme has its own specific optimum conditions under which it works best.

You'll need a hypothesis - a prediction of what you think your experiment will show. Then you think of a way to test it.

You can do this by changing the variables – change something about the experiment. Think about what you'll record and how you'll display it to show that your hypothesis was right.

You could even do preliminary experiments, to suggest what might be interesting to test.

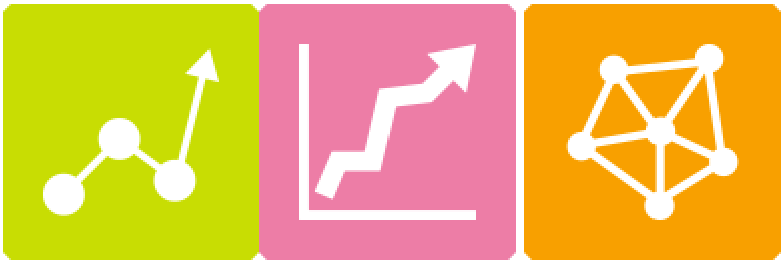
Collecting and analysing your results

- Before you start, think about what data to collect – if you're changing a variable, you need to keep a record of how you changed it.

- Collect your data in a sensible way as the experiment progresses. If you're collecting multiple oxygen readings, use a stopwatch to time the intervals between them, for example.

- Think about how you'll display your data afterward. We suggest plotting a line graph.

- The variable you are changing should go on the x axis – it is the independent variable, and because you're changing it, you know it won't change based on what happens in the experiment. The variable you're measuring should go on the Y axis – in this case, it's probably going to be the rate of reaction you calculated before.



Some examples to get you thinking:

- Does time make a difference? Will the experiment eventually stop producing oxygen? Why would that occur?

- Does the concentration of hydrogen peroxide, the substrate, make a difference to the initial rate of reaction? What if you increase the amount of substrate until it is more than the available catalyst?

- Generally, the concentration of enzyme is important - the more enzymes there are to catalyse a reaction, the quicker the overall reaction. Does the concentration of pureed potato variable make a difference? If not, why not? What might you need to change to see it making a difference?

- What happens if you try a new type of potato?

- Temperature is a key factor – if the experiment is too cold, there's not enough energy for a reaction. But too much heat can also be bad for enzymes, changing the shape of their active site.

- If you do a preliminary experiment, you might notice that the basic experiment itself is exothermic – it heats up. Could different temperatures effect how the experiment progresses?

- Each particular enzyme works best at a particular pH. If the conditions are too alkaline or acidic then the activity of the enzyme is affected. This happens because the enzyme's shape – particularly the active site - is changed. It is denatured, and cannot hold the substrate molecule.

- Enzymes can degrade when cells are mashed up and exposed to the air. Does how fresh your potato is affect the reaction?

- Sometimes, if too much product accumulates, the reaction can also be slowed down. The products of this reaction are oxygen and water. Is this a factor here?

- Enzymes are not changed by the reaction they catalyse. That means they should be reusable. What happens if you keep adding more hydrogen peroxide?

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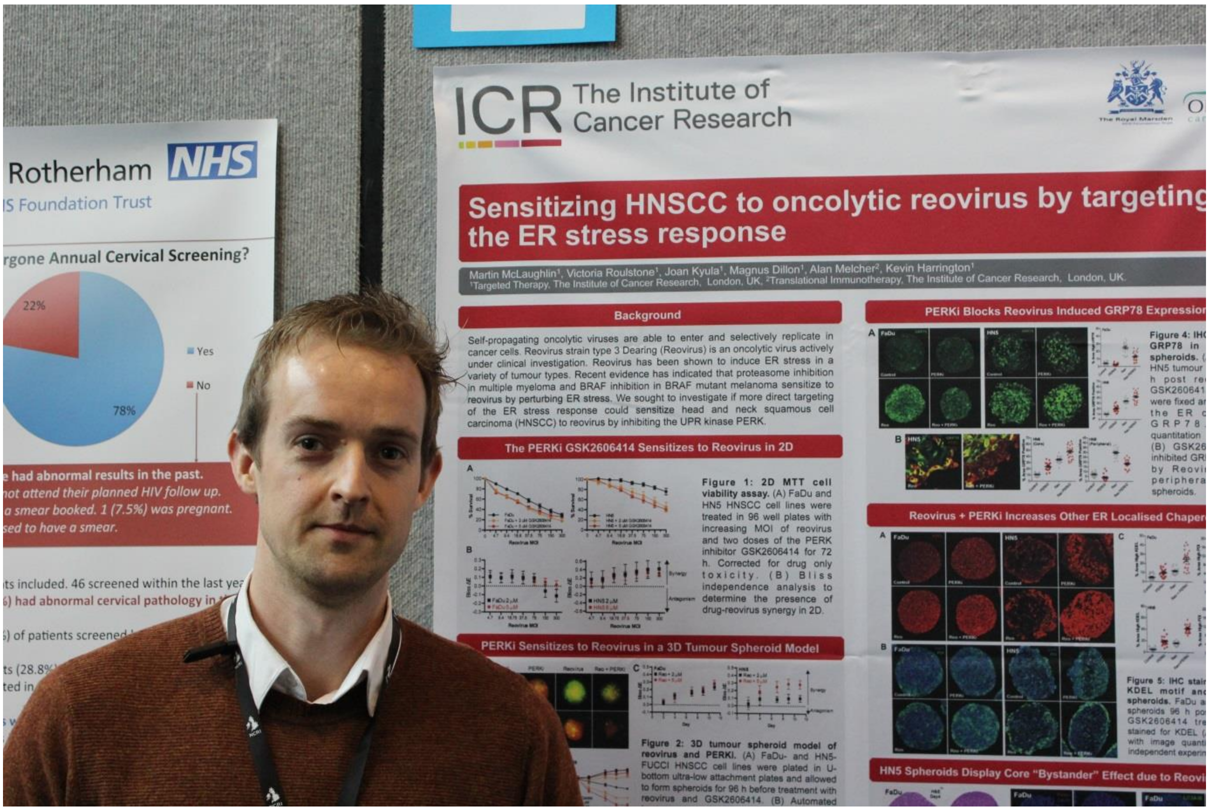
Guide to writing up your experiment

Scientists at the ICR need to share their work, and explain it to others.

One way to share your experiments and research is to create posters to present your scientific work to other scientists at conferences and meetings. Creating a poster lets people see at a glance how you planned your research, and the results of what you have found out.

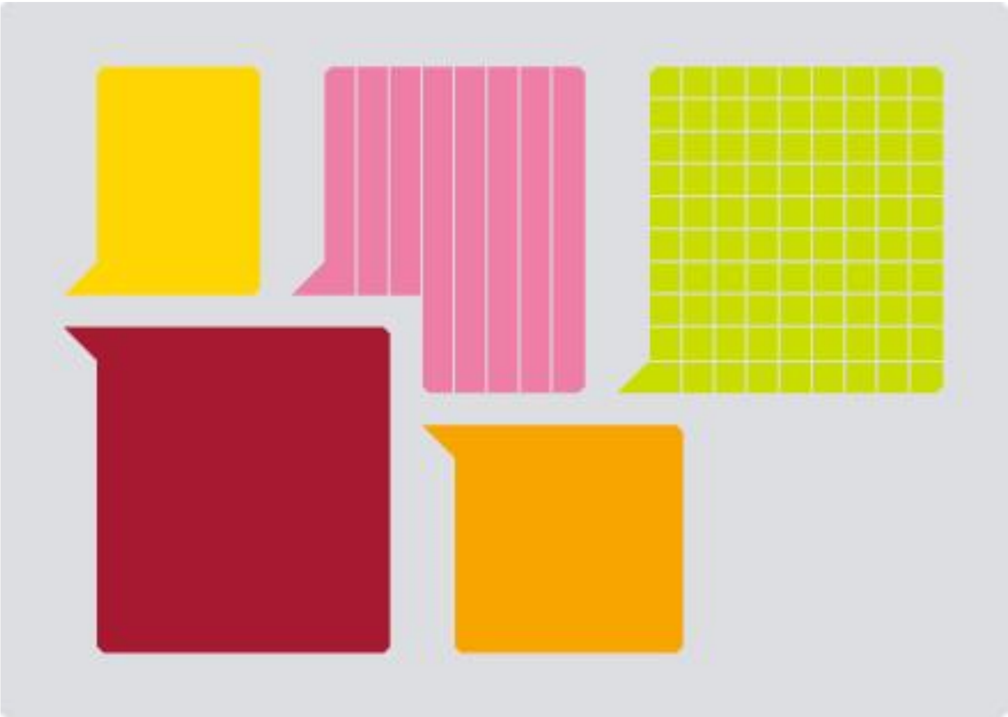
Here's an example of ICR researcher Martin McLaughlin presenting his research at a conference:



Posters often include pictures, graphs, and writing about research. We're hoping that you can create a poster describing your experiment, and using some graphs and images to show your results.

What makes a good poster?

- It should be clear and easy to read
- There shouldn't be too much text
- It should use graphics, colours, and layout to draw the eye
- It should be understandable to people who haven't done your project



Structure

Your poster should include:

- A catchy title
- A summary of what you are trying to achieve
- An introduction to your hypothesis

- A short section describing your experiment, and why it was new and exciting
- Your results in graphical form
- Some thoughts about what your results mean
- Suggestions for ways to expand this project in future.

Title

Make it clear what you were trying to discover.

Hypothesis

What were you trying to test?

Your experiment

You need to describe your experimental method in a clear way. Why did you do it this way? Why did you think the result would prove your hypothesis?

Tables and graphs

Tables are useful because they let you show your raw data – you could include a table of data from your notebook, if you have space. However, you may not need to.

Graphs are useful because they can show your data in a visual way, and reveal connections you might not be able to spot. We would advise you to include at least one graph of your data.

You can use a line graph to show a trend over time

Interpreting your results

Remind the reader of your hypothesis and the results that you found.

Then make some suggestions about what these results might mean.

To do this, try to find a pattern in your data – your graphs will help with this. Then draw a conclusion from this pattern. You can also suggest limitations that might have affected your experiment.

Construct a possible explanation for what you have seen.

Suggestions for expansion

Think about other experiments you could do and how they could support your hypothesis and confirm your results, building on what you've already seen.