PUPIL
RESEARCHER
INITIATIVE

Lock and Key

Setting the Scene

You will carry out one or more investigations on the properties of enzymes. Your investigation(s) will be based on a question, hypothesis or prediction, relating to the science of enzymes.

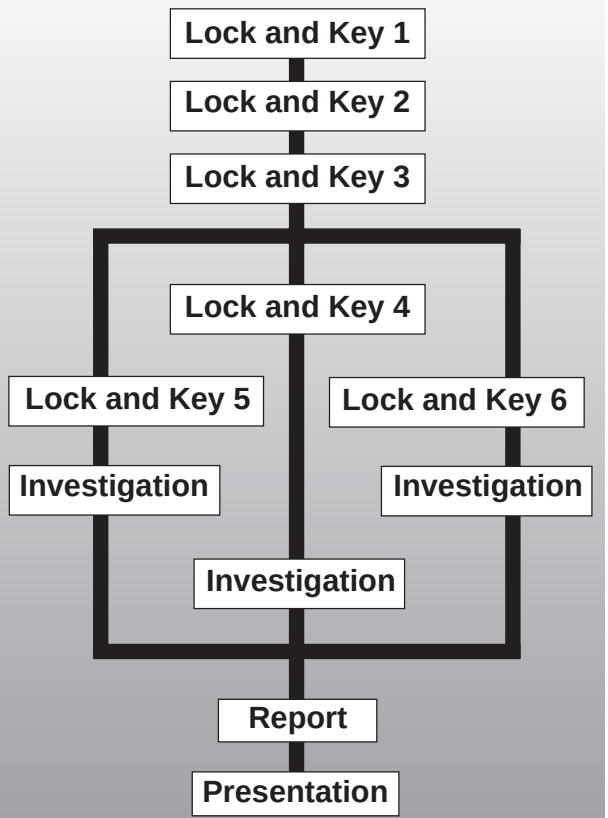
Pupil Research Brief

Study Guide

Syllabus Targets *Science you will learn about in this Brief*

- ❑ the breakdown of large molecules into smaller molecules is speeded up (catalysed) by enzymes
- ❑ carbohydrase enzymes catalyse the breakdown of starch into sugars
- ❑ protease enzymes catalyse the breakdown of proteins into amino acids
- ❑ lipase enzymes catalyse the breakdown of fats into fatty acids and glycerol
- ❑ a catalyst increases the rate of a reaction but is not used up during the reaction
- ❑ living cells use chemical reactions to produce new substances
- ❑ yeast cells convert sugar into carbon dioxide and alcohol in a process called fermentation
- ❑ fermentation is used to produce alcohol in beer and wine, and to produce the bubbles of carbon dioxide which make bread rise
- ❑ bacteria are used to make yoghurt from milk
- ❑ bacteria convert the sugars in milk into lactic acid
- ❑ the chemical reactions brought about by living cells are quite fast in conditions which are warm rather than hot, because cells use catalysts called enzymes
- ❑ enzymes are proteins which are usually damaged by temperatures above 45°C

Route through the Brief



Outcome Checklist

You will carry out one or more investigations based on a question, hypothesis or prediction. You will write a report on your findings and plan a short presentation to the class. You can use the Investigation Flowchart to help you plan your investigation. You should make sure you produce the following items as you work through the Brief.

Lock and Key 1 and 2

- ❑ brief notes summarising the information in the papers

Lock and Key 4, 5 and 6

- ❑ report on investigation(s)
- ❑ presentation

misfold. This happens in some circumstances, and is the cause of such conditions as Alzheimer's disease. This is a disease of the nervous system, particularly in old people. Its main symptom is a deterioration in the sufferer's mental abilities.

Other research scientists studying the physical properties of enzymes have discovered that they have a particular temperature and pH at which they work best. This is called the *optimum* temperature or pH. At extreme temperatures or pH the active site shape of the enzyme changes so that it no longer fits the substrate molecule. This means that the enzyme can no longer work. It has been **denatured.**

Using Enzymes

We have been using the enzymes in living cells of microorganisms for thousands of years in the production of food and drink. For example, enzymes in yeast break down sugar to produce carbon dioxide and alcohol. This process is called **fermentation** (see **Figure 1** below). Yeast was used by the Egyptians to produce the alcohol in wine and beer. It has also been used in bread making for thousands of years because the carbon dioxide produced causes dough to rise. Bacteria are used to produce yoghurt from milk. The enzymes present in the bacteria convert lactose sugar in the milk into lactic acid, which gives unsweetened yoghurt its characteristic taste.

Using enzymes while they are still inside living cells such as yeast is not a very efficient way of making use of them. This is because some of the substrate is used for yeast cell growth or is converted into unwanted products. So, many of the enzymes used today are *extracted* from the cells of bacteria, fungi, plants or animals. Enzymes in germinating seeds, for example, can be extracted by crushing the seeds in a little water. The filtered solution will contain enzymes, as well as other substances. The use of protease enzymes in"biological" washing powders was one of the first industrial uses of extracted enzymes. It has a world-wide market of $300 - 400 million per year. The table below shows the wide range of sources and uses of enzymes in industry and medicine today. Some of these enzymes such as rennin can be produced by genetically engineered bacteria grown in large fermenters. This is cheaper and production is easier.

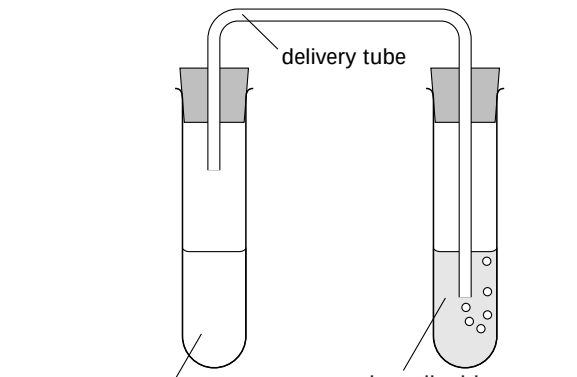


Figure 1. Yeast fermenting sugar

Enzyme	Source	Use
Protease	Microbial/ plant/ animal	Biological washing powders, leather softening, meat tenderisation, contact lens cleaners, digestive aids, anticoagulants
Amylase	Fungal/ bacterial	Glucose production from starch in sweet manufacture, wallpaper removal, preparation of some baby foods
Pectinase	Fungal	Fruit juice extraction from fruits
DNase	Microbial	Treatment of Cystic fybrosis
Asparaginase	Microbial	Treatment of certain cancers
Renin	Stomach of calves	Cheese manufacture

Table 1. Some enzymes used in industry and medicine

Lock and Key 4 Asking Questions

You are going to plan and carry out an investigation to find out the answer to the scientific question set out below. Enzymes usually speed up only one particular chemical reaction.

Enzymes in seeds help to speed up the chemical reaction which turns stored food into simpler substances needed when the seed starts to germinate. (These chemical reactions are in fact similar to digestion taking place in your body following a meal.)

What substances in foods will enzymes in germinating seeds digest?

Use the **Investigation Flowchart** to set out your ideas.

When you have finished the investigation, write a report on your work. Use your results to help you answer the question. The answer is **not just the results** - you have to **think** about what the results mean - this will give you your answer. The answer may mean you now know something new about enzymes. Write a report, or plan a short presentation to the class, to tell them what you have learned.

Lock and Key 6 Making Predictions

You are going to plan and carry out an investigation to test this prediction:

if fermentation is a chemical reaction, then the rate at which the fermentation takes place should increase with temperature.

The science knowledge that the prediction is based on is:

chemical reactions occur if the right molecules with sufficient energy collide with each other. The higher the temperature, the faster the molecules move, and so the more often a collision will occur.

You now have to think about how you can get evidence to see if the prediction is correct or not.

Use the **Investigation Flowchart** to set out your ideas.

When you have finished the investigation, write a report on your work. Use your results to think about whether the prediction was correct or not. The answer is **not just the results** - you have to **think** about what the results mean - this will give you your answer.

You could then use your new knowledge to think of a new prediction about enzymes and how they work.