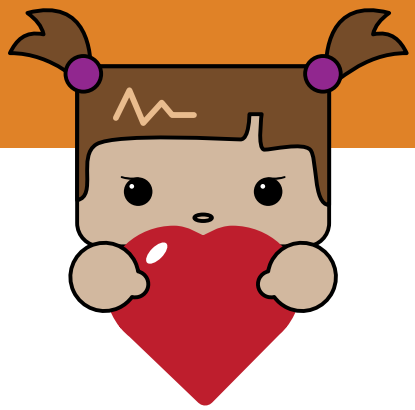
Too many broken hearts:
Fat, sugar and heart attacks

Scientist Toolkit for Public Engagement:
Biochemistry and Genetics

The Royal College of Pathologists
Pathology: the science behind the cure

Too many broken hearts:
Fat, sugar and heart attacks



What is included in this kit?

- A brief for scientists delivering this session, a guide to the materials included in this pack and instructions on how to run this session
- Materials for GCSE students
- National Curriculum links for GCSE

Who are these sessions for?

The target audience for these sessions will be GCSE science students.

GCSE Curriculum links

AQA

- Science A: Biology Unit 1a - Human Biology
- Science B: Unit Biology 1
- Additional Science: Unit Biology 2
- Applied Science (Double Award): Unit 2 - Science for the Needs of Society
- Applied Science (Double Award): Unit 3 - Developing Scientific Skills
- Additional Applied Science: Unit 2 - Science at work

Edexcel

- Additional Science: Unit B2 - Topic 1 - Inside Living Cells
- Science: Unit B1a - Topic 2 – Genes

OCR

- Applied Science (Double Award) - 2.2 Humans as Living Organisms
- Gateway Science - Additional Science B - Module B3: Living and Growing
- Gateway Science - Biology B: Module B1 - Understanding Ourselves
- Gateway Science - Biology B: Module B3 - Living and Growing
- Gateway Science - Biology B: Module B5 - The Living Body
- Gateway Science - Science B: Module B1 - Understanding Ourselves
- Twenty First Century Science - Additional Applied Science A: Module AP1: Life Care
- Twenty First Century Science - Biology A: Module B2 - Keeping Healthy
- Twenty First Century Science - Science A: Module B2 - Keeping Healthy

KS4 Teacher's Guide for Citizenship: Scheme of Work

- Pupils can consider power and limitations of science in addressing industrial, ethical and environmental issues.
- Pupils can explore how different groups have different views about the role of science.
- Pupils can explore the social and moral dilemmas surrounding scientific advances.
- Pupils can learn to recognise hazards, assess risks and take action to reduce risk to themselves and others.

Learning Outcomes

Students will:

- learn about risk factors associated with heart disease
- learn about inherited conditions (familial hypercholesterolaemia)
- learn about the role of pathologists in diagnosis and treatment of heart disease
- develop their communication, team work, enquiry and decision making skills

Resource format

- Facilitator notes – Parts One and Two
- Alternative start sheet – Part One
- Pupil sheet – Part One
- Family member information cards – Part One
- Family member clinic cards – Part One
- Information sheet for The Clinic station – Part One
- Information sheet for The Lab station – Part One
- Discussion sheet: Interesting facts and information – Part One
- Pupil sheet – Part Two
- Answer sheet – Part Two
- Basics of pathology and inheritance of familial hypercholesterolaemia and diabetes information sheet
- About Each Family Member – Answer Sheet
- Associated PowerPoint presentation/slides
- Urine samples, dipsticks, stickers for graphs (not provided by College)

Total time: 1 hour 45 minutes

"Journey of a patient": approximately 1 hour
"Journey of a patient" plus "It's in the genes": approximately 1 hour 45 minutes

Starter activity: 10 minutes

- Ask the students what they know about 'pathology' – is it just what they see on television? Mention a few of the programmes they might have seen.
- Quickly go around the room asking everyone to mention an organ, or procedure or technique that they would associate with pathology. This might be interesting to find out perceptions, and also tackle any misconceptions.

Part one:
The Journey of a Patient (1 hour)

This activity will allow pupils to follow different patients from one family on their journey through clinics and labs to find out the various techniques used by pathologists and scientists to make their diagnoses. This could be run as a role-play activity, allowing the students to use their imagination when acting out the roles.

An alternative method for beginning this activity is provided as well on page 6.

Setting the scene, describing the activity and choosing groups - 10 minutes

First of all, set the scene.

Tell the students that some of them are family members of a 40-year-old patient, Mr. Williams, who had a serious heart attack three months ago. All family members want to know if they are at risk of the same happening to them.

The other pupils will take on the roles of chemical pathologists, biomedical scientists and clinical scientists.

Split the students into three groups of seven (if more than 21 in a class, students can double up to play the roles; if fewer, clinic/lab staff groups can be reduced).

- **Group 1** plays the family of a patient, Mr. Williams who has had a heart attack.

- **Group 2** (The Clinic) plays the chemical pathologists at the cardiac risk factor clinic.

- **Group 3** (The Lab) plays the biomedical and clinical scientists in wthe lab.

There are associated materials that will need to be set up at The Clinic and The Lab stations.

Give each student in Group 1 a family member information card, a urine sample* and a clinic card. Clinic cards can be placed into envelopes for extra effect. (*Urine samples are just small samples of weak tea, with added glucose for those that are going to have diabetes – see 'About Each Family Member – Answer Sheet)

Tell the pupils that the family member information and clinic cards mirror genuine data. Ask them to choose the name of their character (and a first name for Mr. Williams if they wish).

The information card has some notes provided (to help them with their role playing) but the gaps need to be filled in with the help of the scientists at the clinic and lab. The clinic card has the information that in a real situation the chemical pathologist would discover, so here each family member is providing this individual information. At the end all the collated information will be discussed.

Each pupil playing a staff member in the clinic group and lab group can be matched up to one family member, in order that everyone has the chance to collect and analyse results. Otherwise family members can just choose which station to go to first and staff members at those stations can split who works with whom accordingly. (Format here will depend on the size of your group).

Ask each pupil in Groups 2 and 3 to read the information provided at their stations (The Clinic and The Lab).
You can run through briefly what will happen at each station (information given below) so all pupils know what they have to do.

Attending stations - 15 minutes

Each family member will then visit each station.

The Clinic (Group 2 running this station):

Each clinic staff member asks their patient whether they smoke (the family member knows this from their information card), takes a blood pressure reading (given on the clinic card handed over by family member), and calculates Body Mass Index (BMI; from height and weight data given on information card).

Details for how to calculate the BMI will be provided at the station, but some pupils may require extra assistance. You may need to explain the equation and then indicate the range of BMIs from underweight to seriously obese.

Details on blood pressure will also be provided at the station, but mention that a normal healthy blood pressure is less than 140mm Hg/90mm Hg. This will allow students to think about whether their characters have a high blood pressure or not.

The family member pupils will fill in their information cards accordingly.

The Lab (Group 3 running this station):

The Lab students take the 'urine' sample provided by the family member, and test it using a urine dipstick. Students are all asked to look at the colour and determine whether glucose is present.

The Lab students will also take a fasting blood sample to analyse for cholesterol levels (an absorbance reading is provided on each family member's clinic card).

Using the Cholesterol Standard Curve provided at the station, lab students can read off the absorbance reading to find out each family member's total serum cholesterol level.

If you wish to discuss this cholesterol graph later, perhaps ask the lab students to stick a sticker on the line to show where their patient is.

The family members with the help of the lab staff will fill out their information cards accordingly.

Note: Absorbance values and cholesterol levels with a gradient value are also provided below so if you are working with advanced students, or have enough time to run through drawing a standard curve and calculating cholesterol levels. Whilst only a single point is required, two points are included to allow students to practice plotting values on a graph, if wished.

Once everyone knows their roles, the pupils should be ready to carry out the activities, with you and contact teacher on hand to answer any questions.

Absorbance (AU)	Cholesterol (mmol/l
0	0
0.3	4
0.7	9.3

Gradient: 13.28

Answers and discussion - 15 - 20 minutes

When all family members have obtained their results, ask the group to convene for a discussion. Ask all students to make sure they are able to see a filled family member information card.

Give out the 'Interesting facts and information sheet' to prompt discussion.

Discuss how the BMI was calculated and ask for a show of hands: how many family members are thought to be normal weight, obese etc. How many have high blood pressure? High cholesterol? And who is thought to have diabetes?

You may wish to have the Answer Sheet to hand, or projected onto the screen to help with discussions. And feel free to use the 'Basics of pathology and inheritance of familial hypercholesterolaemia and diabetes' information sheet as a guideline of what you might like to include in your discussions with the students.

Make sure the students understand what normal levels are with all these tests, what they were looking for and how they would proceed further. For example, the urine dipstick is only a guide in the diagnosis of diabetes. To confirm diabetes, a fasting blood plasma glucose level would be needed.

If you asked students to stick a sticker on the cholesterol standard curve as to where their patient was, it would be useful to run through here what the levels mean. For example, a total cholesterol level of 7.5mmol/l or more in an adult (or less in a young person, e.g. for a ten-year-old boy, 5.7mmol/l or more) is highly suggestive of familial hypercholesterolaemia (FH), although there are other causes of a high cholesterol level.

Explain here what FH is, i.e. familial hypercholesterolaemia (FH) is an inherited condition (hence familial) resulting in high (hyper) levels of cholesterol in the blood (cholesterolaemia). Then find out who the students think may have FH?

Mention that total cholesterol levels of around 15mmol/l may be seen in those who are homozygous for this condition, along with other clinical features. Those without FH should consult the risk tables in the British National Formulary where they can use information such as their blood pressure, HDL cholesterol levels and state whether they are male/female, smoker/non-smoker etc.

This would lead into the extra activity on the genetics of familial hypercholesterolaemia, if you have time (see Part Two: It's in the Genes).

Otherwise, discuss with the students about which family members they think have a high cardiovascular risk. And ask the family members about their concerns and lifestyles (as mentioned on their information cards). What do the students think about these?

Summary and close - 5 minutes

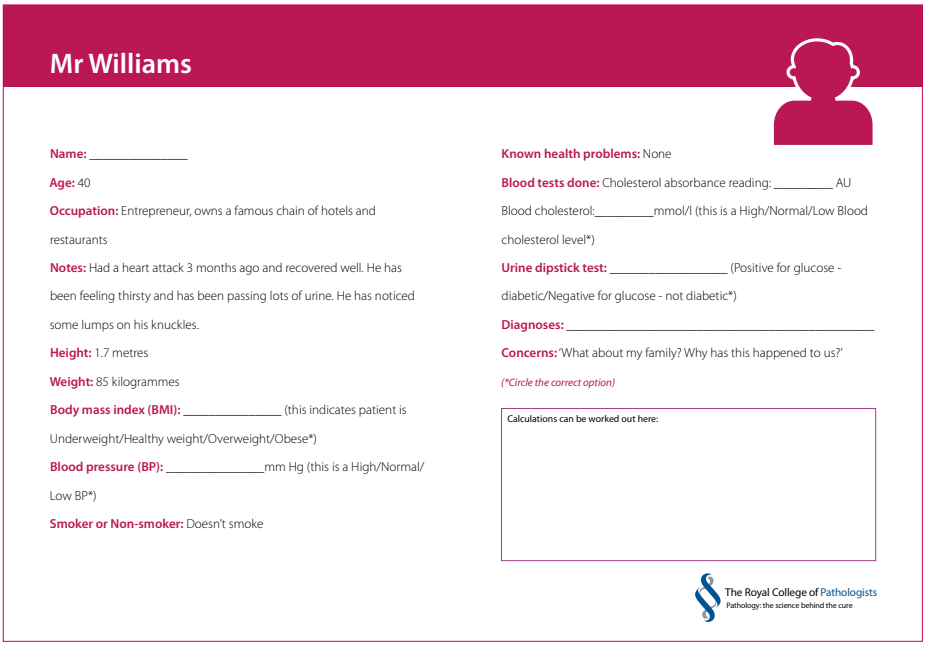
End the session with a summary of the activities and the take home messages:

- Pathology is central to modern healthcare
- Making a diagnosis is difficult
- The continuing role of pathologists – they don't just make the diagnosis they also play an important role in treatment and helping keep people healthy

Alternative start:

If you prefer to start off the activity going through one patient, the following information for Mr. Williams could be provided as a PowerPoint slide.

Here you can run through what happens at The Clinic and The Lab, the patient's diagnosis and to ask the pupils some questions (i.e. find out whether they know about the presence of glucose in the urine as an indication of diabetes, the various cardiovascular risks, a patient's BMI etc.). There is no need to use this card if Mr. Williams is going to be another family member visiting the clinics in this activity.



Patient name: Mr. Williams
Age: 40
Occupation: Entrepreneur, owns a famous chain of hotels and restaurants.
Notes: He had a heart attack 3 months ago and recovered well. He has attended the Cardiac Risk Factor Clinic and was seen by a Consultant Chemical Pathologist.
Mr. Williams is overweight (BMI 29)
He has been feeling thirsty and has been passing lots of urine.
He has a family history of heart disease.
His blood pressure is high (160/95).
He does not smoke.
He has noticed some lumps on his knuckles.
Tests done: Blood – including tests for cholesterol; Urine – including tests for glucose
Concerns: 'What about my family? Why has this happened to us?'
Diagnoses: Familial hypercholesterolaemia (FH) and diabetes mellitus.

Explain that at the end, the results are collated by the clinic, lab teams and the family, and we find out what happened to Mr. Williams; he was seen by the chemical pathologist and given the diagnosis of:

- Diabetes mellitus (his urine tested positive for glucose)
- Familial hypercholesterolaemia (FH) (he has a high blood cholesterol level)

Then ask the students to get into their roles and diagnose the other family members.

Part two:
It's in the Genes (45 minutes)

This part of the workshop is for those who have time or for advanced groups.

The Inheritance of Familial hypercholesterolaemia

Setting the scene / initial discussion of FH and inheritance - 10 minutes

Using the briefing notes provided on the 'Basics of pathology and inheritance of familial hypercholesterolaemia and diabetes' give the students a little background on the inheritance of FH and diabetes. They will already have an idea based on Part One of this activity.

Mention that:

- Familial hypercholesterolaemia (FH) is an inherited condition (hence familial) resulting in high (hyper) levels of cholesterol in the blood (cholesterolaemia).

- It affects 1 in 500 of the population, many of whom do not know they have it.

- Those with FH have high levels of cholesterol and so have a high risk of heart disease. Many have a heart attack by the age of 40.

- It is important to diagnose FH to avoid future heart disease for the patient and to find out if other family members are at risk.

- People with FH have very high levels of low density lipoprotein (LDL) or 'bad' cholesterol.

- A high level of these fats building up in the walls of the arteries contributes to atherosclerosis. This is when areas of the artery walls burst, causing blood clots to form therefore blocking the arteries which can lead to a heart attack.

- LDL levels are raised in the blood in FH because LDL is not removed by the liver, as there is something wrong with the liver's LDL receptors.

- The patient is likely to have a mutated LDL-receptor gene. Inheritance of FH is autosomal dominant, which means that you only need one faulty copy of this gene to have the disease. If you have both, i.e. homozygous FH, it is much more serious.

Ask the students if they have any idea how we find out which other family members have FH? And if Mrs. Williams is pregnant, what is the likelihood of her unborn child having FH?

Mention that this is a very unfortunate family with both parents having FH.

This is where genetics and inheritance diagrams come in. Most GCSE students will have covered Punnett Squares and Inheritance diagrams (genetic-cross) in their science lessons, but it could be worth refreshing their memories.

Begin by explaining phenotypes and genotypes. Whilst we can know someone's phenotype (what characteristics we 'see' them having e.g. hair colour, eye colour, symptoms of a genetic disease), we do not know always know someone's genotype i.e. what genes they have inherited from their parents. The genotype is written as two allele forms, usually a capital letter for the dominant allele, and a small letter for the recessive allele.

So if we say F=Faulty LDL-receptor gene and f=normal LDL-receptor gene, and that since Mr. Williams' mother has FH, but his father has not; their genotypes will be Ff and ff respectively.

You may need to explain that FF is homozygous for the dominant allele, and therefore the individual will be affected, i.e. have familial hypercholesterolaemia. Homozygous FH (i.e. FF) has a recessive inheritance pattern - two mutant alleles are required to express the disease.

Those with ff genotype (homozygous for the recessive allele) will not be affected. Ff is heterozygous (one dominant and one recessive allele), and as F is the dominant allele, anyone with the Ff genotype will be affected.

Fill out inheritance diagrams part 1 (all) - 10 minutes

Ask the students how they would fill out the inheritance diagrams to find out what the genotypes for Mr. Williams and his sister could be?

To help explain genetic cross diagrams, the following has been provided which can be used in conjunction with the answer sheets:

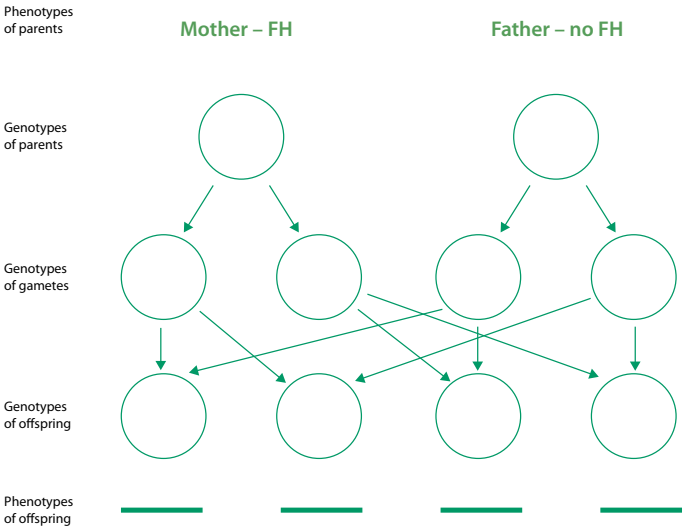
Explain that the phenotypes are given at the top for the first generation, here it is Mr. Williams' mother and father: 'FH' and 'No FH' respectively.

The possible genotypes for them can be filled in the next line, here it will be Ff for Mr. Williams' mother and ff for Mr. Williams' father.

Then the genetic contents of the gametes are given in the next line, splitting the Ff (mother's genotype) into F and f, and ff (father's genotype) into f and f. These alleles are written in the appropriate circles.

In the next line, the possible allele combinations giving rise to the possible genotypes will be written by filling in the alleles based on the cross-overs. Below this, students can write the predicted phenotypes, based on what they know of dominant and recessive alleles.

This first part could be done as a group activity.



Fill out inheritance diagrams part 2 (small groups) - 10 minutes

Then allow students to work out themselves the possible phenotype and genotype of Mr. and Mrs. Williams' unborn child in the second diagram, using the same method. Looking at the possibilities can the students write down the likelihood of the unborn child having familial hypercholesterolaemia?

Ask students to then fill out the family tree diagram provided with family member genotypes. Ask them to colour in the shapes of those family members who are affected with FH.

Discussion of results and ethical decision on prenatal testing, summary and close - 15 minutes

Finish off by discussing the ethics of whether Mr. and Mrs. Williams should get a prenatal genetic diagnosis on their unborn child (what are the costs, what decisions could they make, what about the possibilities