Researchers in Schools

X-ray Vision:
Modelling the molecules that make you
Key Stage 4 Programme

Pupil Name	
Coursebook Designed by	Dr. Taylor

Contents

Uni Pathways launch event 1
Timetable and Assignment Submission 5
Timetable – Tutorials 5
Timetable – Homework Assignments 5
Assignment Submission – Lateness and Plagiarism 5
Course Rationale 6
Uni Pathways Mark Scheme 2020 – Essay-based assignments 7
Baseline Assignment (essay based): Pupil Feedback Report 9
Final Assignment (essay based): Pupil Feedback Report 10
Subject Vocabulary 11
Tutorial 1 – The Roles of Proteins 12
What is the Purpose of Tutorial 1? 12
Tutorial 2 – Enzymes 17
What is the Purpose of Tutorial 2? 17
Tutorial 3 – Enzyme Inhibitors 21
What is the Purpose of Tutorial 3? 21
Tutorial 4 – X-rays and Crystals 24
What is the Purpose of Tutorial 4? 24
Tutorial 5 – X-ray Crystallography 28
What is the Purpose of Tutorial 5? 28
Tutorial 6 – Feedback tutorial 32
What is the Purpose of Tutorial 6? 32
Final assignment feedback from your Uni Pathways Teacher 32
Tutorial 7 – Final tutorial 34
Appendix 1 – Referencing correctly 36
How do I reference? 37
Notes 38

Uni Pathways launch event

Welcome to Uni Pathways! We are delighted to be able to launch the Uni Pathways programme with you. We hope that you are ready to embark on your Uni Pathways journey and that you enjoy the video.
You will be asked to pause the video at times to complete some work in this workbook, so make sure you have a pen / pencil to hand when you start the video.

By the end of the video, you will have

- Learnt about what studying at university means
- Learnt about some of the skills that you will develop during Uni Pathways
- Heard from pupils who have participated in Uni Pathways or The Scholars Programme (which is the same programme!)
- Heard from current university students talking about what life is like at university

If you are in school your teacher will play the video. If you are at home and logged in to a session with your teacher, your teacher will play the video and show it to you. If you are participating independently your teacher will email you the link to the video or the video file. There are opportunities for you to answer some questions, and you will be told when to pause the video to answer them.

Introduction to Uni Pathways

1. Write down what you think a supra-activity is

_____
_____
_____

2. Independent learning is

_____
_____
_____

3. Write down in your own words what resilience means, and come up with a different example to the one mentioned in the PowerPoint.

_____
_____
_____
_____

4. Why do you think analysis and evaluation skills are useful in your academic career? _____
_____
_____
_____
_____
_____

5. Why do you think analysis and evaluation skills are useful in life in general? _____
_____
_____
_____

6. What are the different types of learning that university students do?

Pupils' experience of Uni Pathways
You will now watch some pupils talk about their experience of learning a PhD topic and producing a final assignment. Some may refer to The Scholars Programme rather than Uni Pathways. As you heard in the introduction PowerPoint, The Scholars Programme is a very similar programme to Uni Pathways. Listen carefully and then respond to the questions below. Be prepared to share some of your responses with your peers.

1. How did the pupils describe talking about writing a long essay for their final assignment?

2. Write down something that one of the pupils mentioned was particularly interesting in their course.

3. What were some challenges that the pupils met?

Virtual campus tours
You will now go on a virtual tour of some universities! Once you have seen some of the university campuses, respond to the questions below.
Note down something that you liked out of any of the campus tours you saw. It may be a particular building, space, city etc.

1. Were there any similarities between the different university campuses? If so, what are the similarities?

2. If you had to pick one of those universities to go and visit in person, which one would it be and why?

3. Note down some of the societies that you could join at different universities

Meet university students!
You are about to virtually meet or hear from some current university students.
If you are virtually meeting them, think about what questions you would like to ask the students, share your questions with a partner and note those questions down in the space below.

If you are not meeting them but watching some videos that they have made, use the space below to note down what else you would like to find out about university. You can then ask your teacher during Uni Pathways tutorials!

Reflection
Congratulations on completing the launch of the Uni Pathways programme. Before you go, take some time to reflect on what you have learnt by answering the following questions:

1. Are there any aspects of university style learning that you would look forward to? If so, what are they?

2. What challenges do you think students face when learning at university? How would you try to overcome these challenges?

3. What skills do you hope to develop during your Uni Pathways course?

4. What part of Uni Pathways seems the most challenging for you?

5. What are you most looking forward to about Uni Pathways?

Timetable and Assignment Submission

Timetable – Tutorials

Tutorial	Date	Time	Location
1	19/3/20	15:15	
2	25/3/20	15:15	
3	23/4/20	15:15	
4	30/4/20	15:15	
5	7/5/20	15:15	
6 (Feedback)	21/5/20	15:15	
7 (Feedback)	11/6/20	15:15	

Timetable – Homework Assignments

Homework Assignment	Description	Due Date
Tutorial 1	A tale of two proteins	25/3/20
Tutorial 2	Enzymes and substrates	23/4/20
Tutorial 3	Designing enzyme inhibitors	30/4/20
Tutorial 4	Chocolate and sugar crystals	7/5/20
Tutorial 5	A letter to the CEO of *Moolah & Co.*	Draft 14/5/20 Final 28/5/20

Assignment Submission – Lateness and Plagiarism

Lateness	
Submission after midnight on due date	10 marks deducted
Plagiarism	
Some plagiarism	10 marks deducted
Moderate plagiarism	20 marks deducted
Extreme plagiarism	Automatic fail

Course Rationale

What does your DNA look like? Have you ever seen it? How do you know?

Humans are often very visual creatures. The first thing we say when we come across a problem is "Let me see" or "Let's take a look". But what if the problem is on the molecular scale?

For roughly 100 years X-ray crystallography has allowed us to "look" at accurate 3D models of molecules that surround us and make us.

This course will reveal what X-ray crystallography is and the importance of structural biology. From establishing the structure of DNA, to developing anti-viral drugs that treat the flu and HIV, X-ray crystallography has been essential for vast leaps in knowledge about the bodies we inhabit.

By the end of this course you will be able to:

- Describe the roles of proteins throughout life

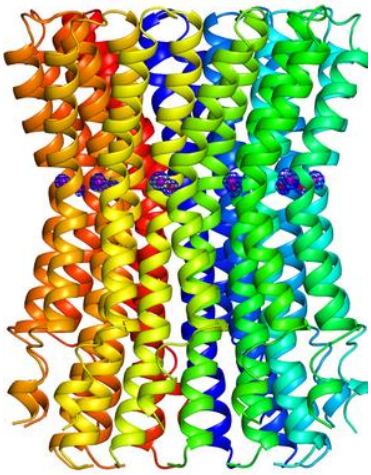
- Explain how the shape of drugs is important for their function

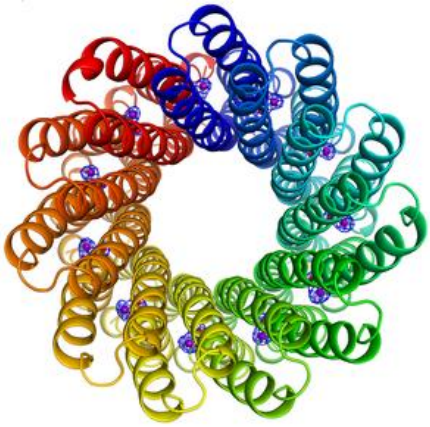
- Describe the molecular properties of crystals

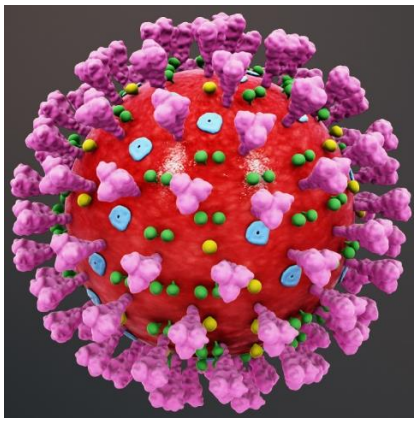
- Grow crystals of your own

- Assess the use of X-ray crystallography in modern medicine

The story involves beams of light brighter than the sun, Nobel prizes going to the wrong people (arguably), and reactions that should take longer than the age of the universe (happening every second in **your** body).







Images of ATP synthase by Schulz et al.

Schulz et al., 'A new type of Na(+)-driven ATP synthase membrane rotor with a two-carboxylate ion-coupling motif', *PLoS Biol.*, 2013.

Uni Pathways Mark Scheme 2020 – Essay-based assignments

	Subject Knowledge	Critical Thinking	Written Communication
1st	The essay shows a breadth of knowledge and understanding of the key concepts and issues, through engaging with and interpreting a wide range of relevant sources. Knowledge is used to build and support highly effective arguments.	Analyses, key ideas, information, and arguments. Interprets meaning and makes connections. Identifies and critically evaluates key arguments and statements, deciding on their credibility, strength and relative significance, drawing convincing conclusions.	The essay has a clear and engaging structure, taking the reader on a journey from the introduction to the conclusion. The writing style is appropriate; key terms are used with fluency. There are no, or very few, errors in spelling or grammar. Referencing is used consistently and matches the style taught in the course.
2:1	The essay shows an understanding of key concepts and issues, drawing on a range of relevant sources Knowledge is used to build and support effective arguments	Analyses key ideas, information and arguments. Identifies relevant arguments and statements, deciding on their credibility and strength, drawing reasonable conclusions. Shows some understanding of the relative importance of arguments.	The essay has a clear structure and the arguments are easy to follow. The introduction outlines the essay effectively and the conclusion summarises the arguments. The writing style is appropriate; key terms are used correctly. There are few errors in spelling or grammar. Referencing is mostly consistent and matches the style taught in the course.
2:2	The essay shows an understanding of key concepts and issues, with no major misconceptions. Beginning to apply this knowledge to build and support arguments.	Begins to analyse ideas, information and arguments. Identifies some arguments and statements and attempts to evaluate their quality. Not yet showing understanding of the relative strengths and weaknesses of arguments.	The essay structure could be made clearer to better guide the reader through the arguments. The writing style can sometimes be informal. Occasionally key terms are not used when it would be appropriate to do so. There are some errors in spelling or grammar, but they do not get in the way of communicating the content.

			There is some consistency to the referencing.
3rd	Shows a developing understanding of key concepts and issues, with some misconceptions. Not yet applying this knowledge to build and support arguments.	Begins to analyse ideas and information. Describes statements and arguments while not yet evaluating them.	The grammar, spelling, style, and structure of the work need improving in order to communicate ideas to the reader. The essay has no or a limited introduction and conclusion. Key terms and references are not always used correctly.

Baseline Assignment (essay based): Pupil Feedback Report

Name of Pupil	
Name of School	Ark Bolingbroke Academy
Name of RIS teacher	Dr. Taylor
Title of Assignment	A tale of two proteins

How your assignment is graded:

Grade	Marks	What this means
1st	70+	Performing to an excellent standard at A-level
2:1	60-69	Performing to a good standard at A-level
2:2	50-59	Performing to an excellent standard at GCSE
3rd	40-49	Performing to a good standard at GCSE
Working towards a pass	0-39	Performing below a good standard at GCSE
Did not submit	DNS	No assignment received by The Brilliant Club

Lateness	
Any lateness	10 marks deducted
Plagiarism	
Some plagiarism	10 marks deducted
Moderate plagiarism	20 marks deducted
Extreme plagiarism	Automatic fail

Marks

OVERALL MARK / 100		FINAL MARK / 100 (including any deductions)	
DEDUCTED MARKS		FINAL GRADE	

If marks have been deducted (e.g. late submission, plagiarism) the teacher should give an explanation in this section:

Mark Breakdown and Feedback

Subject knowledge	
	mark
Critical thinking	
	mark
Written communication	
	mark

Final Assignment (essay based): Pupil Feedback Report

Name of Pupil	
Name of School	Ark Bolingbroke Academy
Name of RIS teacher	Dr. Taylor
Title of Assignment	A letter to the CEO of *Moolah & Co.*

How your assignment is graded:

Grade	Marks	What this means
1st	70+	Performing to an excellent standard at A-level
2:1	60-69	Performing to a good standard at A-level
2:2	50-59	Performing to an excellent standard at GCSE
3rd	40-49	Performing to a good standard at GCSE
Working towards a pass	0-39	Performing below a good standard at GCSE
Did not submit	DNS	No assignment received by The Brilliant Club

Lateness	
Any lateness	10 marks deducted
Plagiarism	
Some plagiarism	10 marks deducted
Moderate plagiarism	20 marks deducted
Extreme plagiarism	Automatic fail

Marks

OVERALL MARK / 100		FINAL MARK / 100 (including any deductions)	
DEDUCTED MARKS		FINAL GRADE	

If marks have been deducted (e.g. late submission, plagiarism) the teacher should give an explanation in this section:

Mark Breakdown and Feedback

Subject knowledge	
	mark
Critical thinking	
	mark
Written communication	
	mark

Subject Vocabulary

Word	Definition	In a sentence
X-ray	Type of electromagnetic wave (similar to light waves or radio waves) that has many uses.	X-ray waves cannot pass through bone.
Molecule	A group of atoms chemically joined together. A common component of matter.	Water is a molecule made of 1 oxygen atom and 2 hydrogen atoms.
Protein	A large molecule made of amino acids chained together. Essential part of all living things with lots of different roles.	Certain foods are packed with proteins. Each protein has a specific shape.
Amino acid	The building blocks of proteins. Different combinations are used to make different proteins.	Amino acids found on Mars may indicate presence of basic life.
Enzyme	A protein used by living things to speed up a reaction.	The enzyme "catalase" speeds up a reaction to breakdown hydrogen peroxide.
Substrate	The substance that an enzyme acts upon.	Hydrogen peroxide is the substrate for the enzyme "catalase".
Crystal	A solid with molecules arranged in a repeating pattern and geometry.	Carbon can form crystals, known as diamonds.
Active site	A part of an enzyme that interacts with another molecule.	The substrate fits perfectly into the active site of an enzyme.
Inhibitor	A substance that slows the action of an enzyme.	The speed of the enzyme was reduced by the inhibitor.
Competitive inhibitor	An inhibitor that works by blocking the active site of an enzyme.	The substrate could not interact with the active site, due to the presence of the competitive inhibitor.
Diffraction	The bending of electromagnetic waves when they interact with an object or pass through a gap	The diffraction of the laser produced a scattered array of lights.

Tutorial 1 – The Roles of Proteins

What is the Purpose of Tutorial 1?

By the end of this tutorial I will be able to…

- Describe what a protein is
- Describe the 4 main roles of proteins in the body
- Explain that a protein is distinguished by the sequence of its amino acids

Starter – What are the similarities between these vehicles? What functions do they perform? How does their shape affect their ability to perform different functions?
Discuss in pairs the answers to these three questions.

Fill in the following as it appears on screen:
The definition of a protein is…

Activity 1 – Fill in the following table for the four main functions of proteins as they appear on screen

Category	Function	Example
	Forms supporting frameworks inside cells and forms body structures	
		ATPase: speeds up the breakdown of ATP Cellulose synthase: catalyses the formation of cellulose from glucose molecules
Hormones		
	Part of the immune system. They are produced by white blood cells and can bind to specific bacteria and viruses to label them for destruction by other types of white blood cells	

Do you think one of these functions is more important than the other functions proteins perform? (Yes/No)

Explain your answer

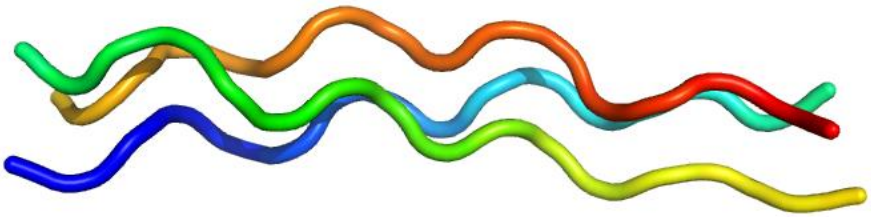
Activity 2 – Match the protein to its function

Amylase

Found in saliva. Speeds up the breakdown of starch into sugars.

Structural **Enzyme** **Hormone** **Antibody**

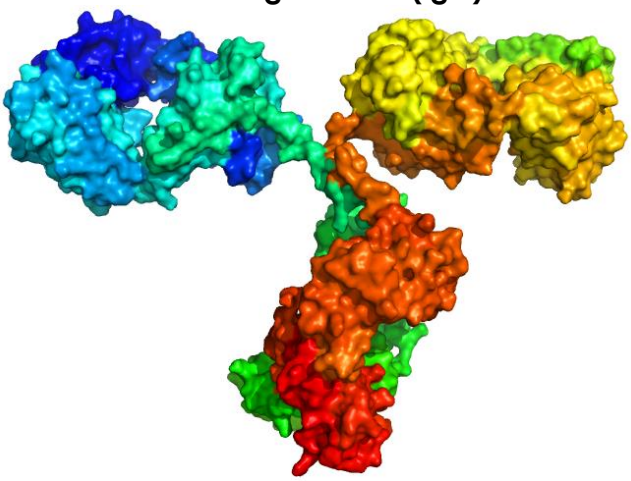
Collagen



Found in bones and cartilage. Can coil together to form very strong fibres

Structural **Enzyme** **Hormone** **Antibody**

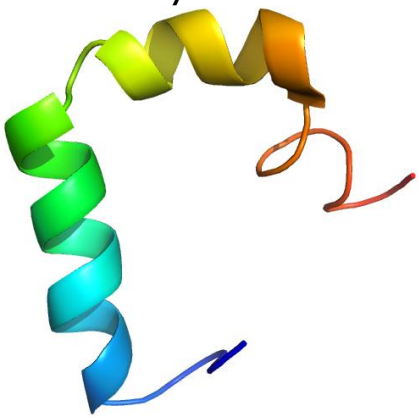
Immunoglobulin G (IgG)



Found in blood. Binds strongly to bacteria, immobilising them.

Structural **Enzyme** **Hormone** **Antibody**

Amylin



Released by the pancreas after eating to signal to the brain we are full.

Structural **Enzyme** **Hormone** **Antibody**

Amino acids are the building blocks of proteins. The shape of the protein depends on the sequence in which the amino acids are linked.

Name some other things that will change if you rearranged the order of their parts.
E.g. 1. different beads on a necklace will change its shape. E.g. 2. Music will sound different if you reordered the sequence of the notes.

Activity 3 – Arrange the building blocks in front of you according to the instructions. Compare the shape of your structure to other groups

Proteins are made up of only 20 different types of amino acids, they can be in any order and be used more than once. This means that a protein that is 20 amino acids long can be arranged in over 10,000,000,000,000,000,000,000,000 different sequences!

Homework – A tale of two proteins

Proteins are all made from the same building blocks, amino acids. Through your own research find 2 example proteins. Make sure these two are from different categories (do **not** use the example proteins already seen in the tutorial today).

In a short essay (400-500 words), explain how these 2 proteins can be made of the same amino acids but carry out different functions.

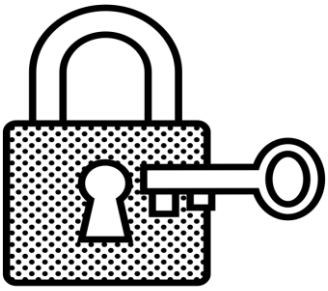
In this essay you should:

- Define what a protein is.
- Name the 2 example proteins and what category they fall into.
- Define what an amino acid is, in regard to proteins in general.
- Describe how the sequence of amino acids can change the overall structure of proteins in general.
- Include an analogy of something that relies upon the order in which its parts are arranged. (Feel free to use one we came up with in Tutorial 1.)
- Describe the role of each of your 2 example proteins within the body; what job does the protein carry out?
- Describe how a change in the overall structure of a protein may affect the function of the protein, using your 2 proteins as examples. What could happen if that protein stopped working? Could we survive without it?

Good starting points might be
How Hormones Work: https://www.youtube.com/watch?v=-SPRPkLoKp8
What are Antibodies?: https://www.youtube.com/watch?v=Cvu1ApHkhYM
Functions of Proteins: https://sphweb.bumc.bu.edu/otlt/MPH-Modules/PH/PH709_BasicCellBiology/PH709_BasicCellBiology7.html

Make sure to reference all your sources.

Tutorial 2 – Enzymes



Created by b farias
from Noun Project

What is the Purpose of Tutorial 2?

By the end of this tutorial I will be able to…

- Define an enzyme and substrate
- Explain what an active site of a protein is
- Describe how the shape of an active site is complementary to the substrate

Starter – Complete the table

What are the four roles of proteins in the body?	Give an example of a protein that performs this role.
1.	
2.	
3.	
4.	

An enzyme is…

A substrate is…

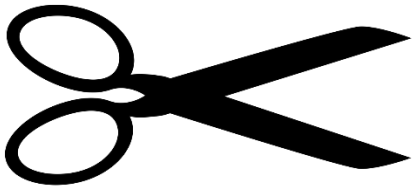
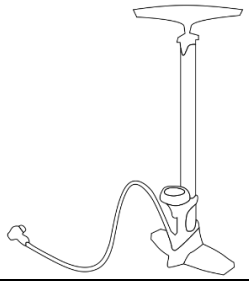
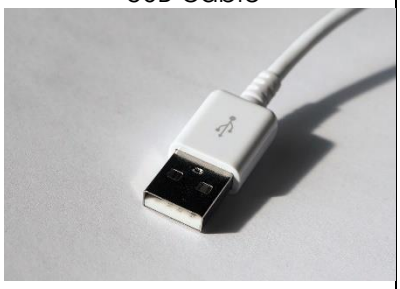
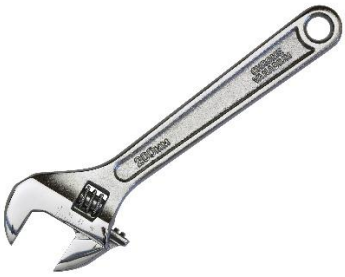
Activity 1 – In pairs discuss and list some of the day-to-day things you use that rely on their shape to work

E.g. 1 Opening a lock with a key. E.g. 2 Putting gloves on the right hand

Fill in the following as is appears on screen:

The active site is…

Activity 2 – Circle the "active site" on these everyday objects

Bottle opener	Key	Screwdriver
Headphones	Scissors 	Bicycle pump 
USB cable 	Can opener	Spanner 

If each of these objects were an enzyme, what would their "substrate" be?

Bottle opener – Cork

Key –

Screwdriver –

Headphones –

Scissors –

Bicycle pump –

USB cable –

Can opener –

Spanner –

Homework

Describe the relationship between an enzyme and a substrate, using **your own** analogy that we have **not** seen in today's tutorial.

Use an example enzyme when describing this analogy (this can be the same enzyme as in your baseline assignment if you researched an enzyme).

This analogy must include an enzyme (e.g. lock), a substrate specific to that enzyme (eg. key) and the enzymes active site (e.g. keyhole/locking mechanism). Detail what takes place in this analogy and how it is similar to the relationship between enzyme and substrate.

Whilst describing this analogy make sure to relate each stage and structural feature back to how enzymes and substrates interact.
(200-300 words)

Tutorial 3 – Enzyme Inhibitors

What is the Purpose of Tutorial 3?

By the end of this tutorial I will be able to…

- Describe how an effective inhibitor has a complementary shape to its target protein.
- Explain how competitive inhibition occurs using drugs.
- Describe X-ray crystallography's role in designing drugs, using the lock and key model.

Starter – 1. Describe the relationship between an enzyme and a substrate.

2. Discuss in pairs how different drugs could be seen as a good thing or a bad thing.

Fill in the following as is appears on screen:
An enzyme inhibitor is…

Activity 1 – Dress the mannequin

In this game some items of clothing represent **substrates**. Other items represent **inhibitors**.

Split into 2 teams.
Choose 1 team mate to be "the mannequin". They will not move for the duration of the game.

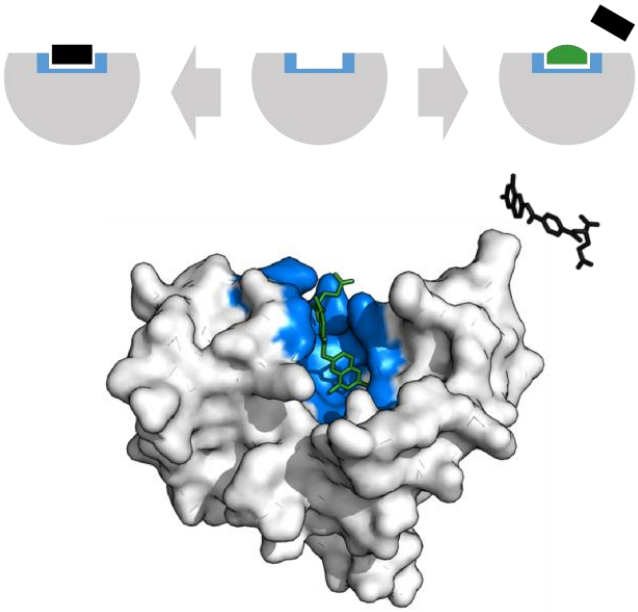
Round 1 –
The other members of the team must **carefully** put the **substrate** items provided onto "the mannequin" team mate.
The first team to have a fully dressed mannequin wins.

Round 2 –
Reset "the mannequin" team mate by removing the **substrate** items.
Inhibitor items will now be added to the mannequin team mate. These **must** stay on the mannequin team mate.
Once again, the other members of the team must **carefully** put the **substrate** items provided onto "the mannequin" team mate.

Which round was easier to dress the “mannequin”?

Why was the other round so much more difficult?

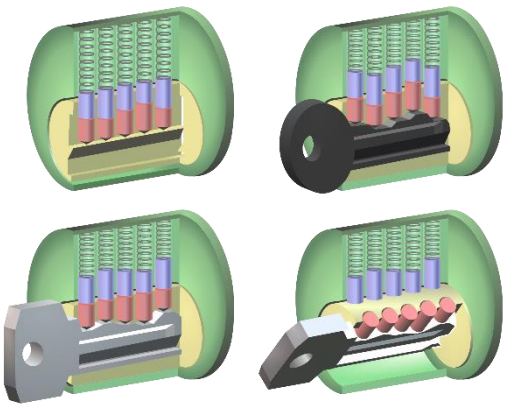
An example of an enzyme inhibitor is penicillin. Penicillin is an antibiotic that inhibits an enzyme only found in certain bacteria. The shape of penicillin allows it to block the active site of the enzyme.



Cartoon and 3D model of an inhibitor blocking a substrate. The active site is shaded blue.

Much like substrates, inhibitors rely on their shape to match the active site. Scientists can alter the shape of inhibitors to improve them. If they know what shape the active site is they can use this information to develop better inhibitors.

If you were designing a key to fit a lock, it would be a lot easier if you knew what the inside of the lock looked like!



One of the ways scientists can find out the shape of an enzyme (and active site) is **X-ray crystallography**.

In your own words state the similarities between the mannequin activity from todays tutorial and the action of enzyme inhibitors.

Homework

When designing an enzyme inhibitor, scientists will often use the structure of the enzyme's substrate as a starting point.

Explain why this might be a good idea.

You will want to include:

- Comparing the similar relationships of enzyme and substrate vs enzyme and inhibitor (i.e. both are very specific).
- How an enzyme inhibitor might benefit from having a similar shape to that enzyme's substrate. (If it were totally different would it fit in the active site?)
- Why the inhibitor shouldn't have a structure EXACTLY like the substrate.
- Describe how this technique could save time and money for the scientist.

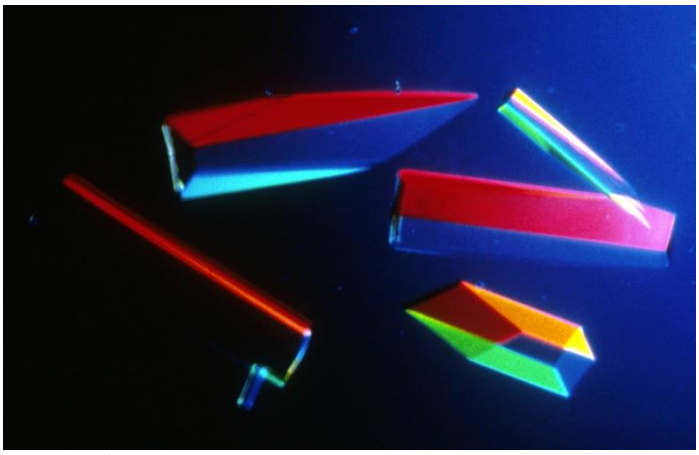
(200-300 words)

Make sure to reference all your sources

A good starting point might be:
https://en.wikipedia.org/wiki/Enzyme_inhibitor#Discovery_and_design_of_inhibitors

Between minute 3 and 5 of the following video:
https://www.youtube.com/watch?v=attNofZ7AnY

Tutorial 4 – X-rays and Crystals



Protein crystals under a microscope

What is the Purpose of Tutorial 4?

By the end of this tutorial I will be able to…

- Describe what an X-ray is.
- Define a crystal as a repeating lattice of molecules with the same geometry.
- Recall that proteins can form crystals under certain conditions.

Starter – 1. Describe how an inhibitor slows down the action of an enzyme.

2. Why might a scientist want to know the precise shape of an enzyme?

The first ever X-ray image

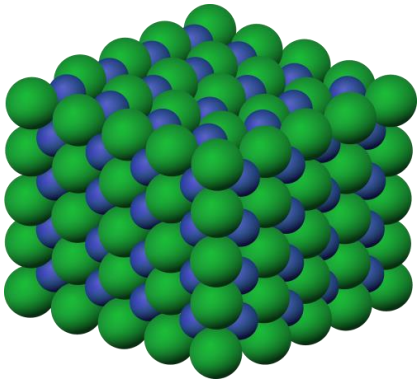
Fill in the following as they appear on screen:

X-ray waves are…

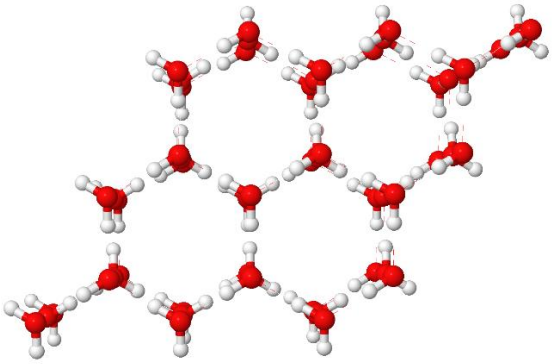
X-rays are similar to light waves and radio waves but with a much smaller wavelength.

Copper sulphate crystal

A crystal is…



Structure of a salt crystal (sodium chloride)



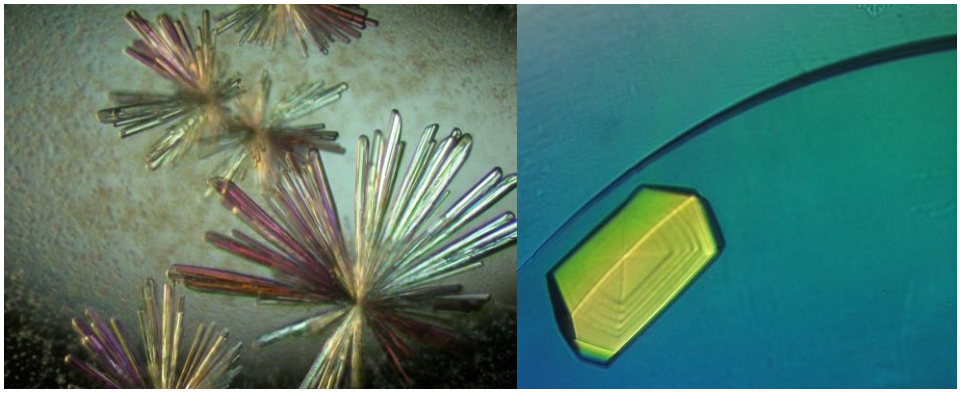
Structure of a water crystal (ice)

Activity 1 – Growing crystals

Follow the experiment handout to grow some crystals!

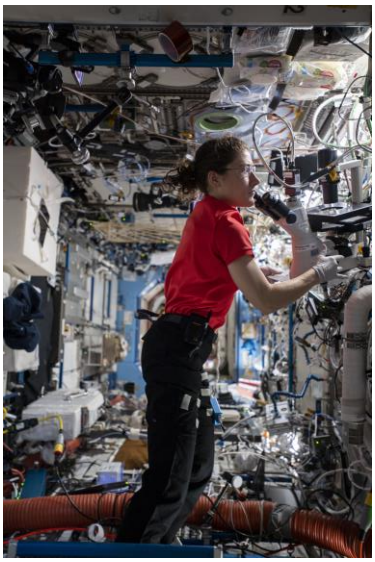
Activity 2 – Which of these solids are crystals?

	Crystal	Non-crystal
Snow flake		
Diamond		
Wood		
Salt		
Metal		
Plastic		
"Tempered" chocolate		



Examples of protein crystals

Proteins can also form crystals, but it can be quite difficult. The crystals are usually very small and delicate. Each protein needs very precise conditions to grow. Finding those conditions can take a long time. Sometimes they will only grow when in space!



Astronaut Christina Koch works on a Microgravity Crystals experiment

Fill in the following as they appear on screen:

It can be difficult to crystallise proteins because…

Homework

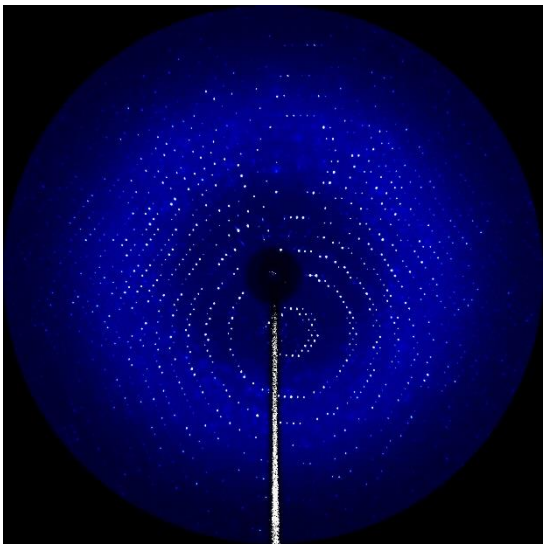
1. In a few sentences compare and contrast the molecular structure of "tempered" chocolate and ordinary chocolate.
   Are the molecules similar/the same between the two versions? How are the molecules arranged in each version of chocolate?
   (Maximum 50 words)

2. Grow your own sugar crystals by following the instruction in this video:
   https://www.youtube.com/watch?v=HYRbtnqvteQ

Ensure adult supervision whilst boiling sugar mixture.

The biggest crystals get extra house points!

Tutorial 5 – X-ray Crystallography



X-ray diffraction pattern of the enzyme glutamate (Patrick Baker)

What is the Purpose of Tutorial 5?

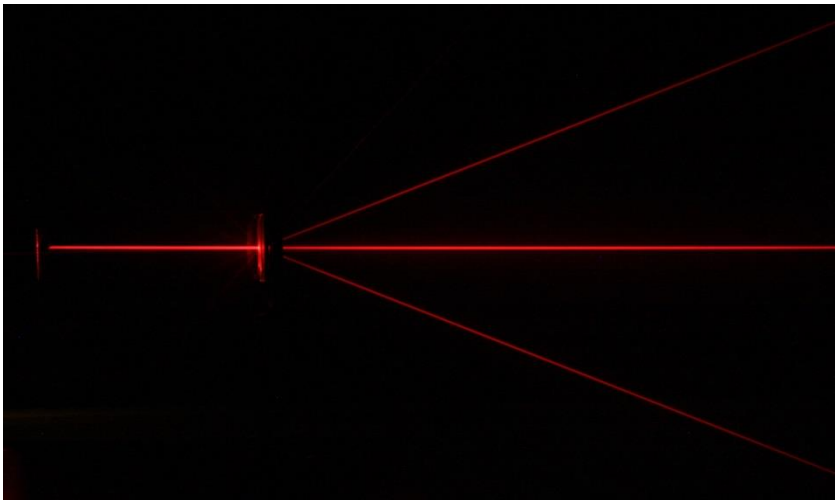
By the end of this tutorial I will be able to…

- Describe how X-rays behave when fired at a crystal (diffraction).
- Recall that the shape of the molecule in the crystal changes the diffraction of the x-rays.
- Assess the pros and cons of using X-ray crystallography.

Starter – 1. What is the definition of a crystal?

2. What is an X-ray?

3. Give as many examples of a crystal as you can.



Diffraction of a red laser

Fill in the following as it appears on screen:

Diffraction is…

Activity 1 – Watch the video and answer the following questions

1. How bright a light can be produced by the Diamond Light Source?

2. What property of crystals is important for how X-rays diffract when they hit a crystal?

3. What is the diffraction pattern dependent on?

Activity 2 – Discuss in pairs why a scientist that is interested in designing a new inhibitor drug might use X-ray crystallography (hint: think about the lock and key analogy)

Notes:

Activity 3 – The Pros and Cons of Protein X-Ray Crystallography

What two things do you need to perform X-ray Crystallography?

Fill in the table of pros and cons of X-ray Crystallography as they appear on screen:

Pro	Con

Homework: A letter to the CEO of *Moolah & Co.*

Imagine you are a scientist in the drug company *Pharmforce*, working within the X-ray crystallography department.

Your company has recently been bought by the large bank *Moolah & Co.* and the CEO has very little scientific knowledge. The CEO has asked each department to explain what they do and why they are an asset to the company.

You are required to write a letter (1800-2200 words) to your new CEO explaining how your work in X-ray crystallography is important.

In order to convince your new CEO, you will need to include:

An Introduction and Background –

- What proteins are
- Their role in the body
- Why their shape is important
- How drugs act to inhibit proteins/enzymes

A description of what your department does –

- What X-ray crystallography is used for
- How X-ray crystallography works

A discussion of the pros and cons of your department –

- Equipment or resources your department might need to use
- What the difficulties and benefits of using X-ray crystallography are
- The potential costs and income your department might have

A conclusion –

- Summarise the content of your letter in a few sentences to convince your new CEO to continue funding your department

Ensure to use multiple examples and diagrams or images throughout your letter to strengthen your points, remembering to reference your sources.

Tutorial 6 – Feedback tutorial

What is the Purpose of Tutorial 6?

- To receive feedback on your final assignment
- To respond to the feedback from your Uni Pathways teacher
- To write targets for improvement on your final assignment

Final assignment feedback from your Uni Pathways Teacher

(Remember to look at the mark scheme to help you understand what you have done well so far, and how you can do even better in your final assignment)

Here are three things that my Uni Pathways Teacher thought I did well in my draft assignment
•   •   •

Here are three things that my Uni Pathways Teacher thinks that I could do to get a higher mark in my final assignment
•   •   •

Tasks from my Uni Pathways Teacher to do during the feedback tutorial to help me improve
•   •   •
My response:

Actions I will take to improve my final assignment after this tutorial…
•   •   •

Hand in date for my final assignment:	

Tutorial 7 – Final tutorial

What is the Purpose of Tutorial 7?

- To receive feedback and a grade on your final assignment.
- To reflect on the programme including what you enjoyed and what was challenging.
- To ask any questions you may have about university.

Final assignment feedback from my Uni Pathways Teacher

Final mark:	University style grade:
Feedback: Here are three things that my Uni Pathways teacher thought I did well in my final assignment • • •	

Here are three things that my Uni Pathways teacher thinks I should remember for when I am doing this kind of study in the future
• • •

University

What questions do you still have about University after taking part in Uni Pathways?
•   •   •

Reflecting on Uni Pathways

What did you most enjoy about Uni Pathways?
•   •   •

What did you find challenging about the programme?	How did you overcome these challenges?
• • •	• • •

Appendix 1 – Referencing correctly

When you get to university, you will need to include references in the assignments that you write, so we would like you to start getting into the habit of referencing in your Brilliant Club assignment. This is really important, because it will help you to avoid plagiarism. Plagiarism is when you take someone else's work or ideas and pass them off as your own. Whether plagiarism is deliberate or accidental, the consequences can be severe. In order to avoid losing marks in your final assignment, or even failing, you must be careful to reference your sources correctly.

What is a reference?

A reference is just a note in your assignment which says if you have referred to or been influenced by another source such as book, website or article. For example, if you use the internet to research a particular subject, and you want to include a specific piece of information from this website, you will need to reference it.

Why should I reference?

Referencing is important in your work for the following reasons:

- It gives credit to the authors of any sources you have referred to or been influenced by.
- It supports the arguments you make in your assignments.
- It demonstrates the variety of sources you have used.
- It helps to prevent you losing marks, or failing, due to plagiarism.

When should you use a reference?

You should use a reference when you:

- Quote directly from another source.
- Summarise or rephrase another piece of work.
- Include a specific statistic or fact from a source.

How do I reference?

There are a number of different ways of referencing, and these often vary depending on what subject you are studying. The most important to thing is to be consistent. This means that you need to stick to the same system throughout your whole assignment. Here is a basic system of referencing that you can use, which consists of the following two parts:

1. **A marker in your assignment**: After you have used a reference in your assignment (you have read something and included it in your work as a quote, or re-written it your own words) you should mark this is in your text with a number, e.g. [1]. The next time you use a reference you should use the next number, e.g. [2].
2. **Bibliography**: This is just a list of the references you have used in your assignment. In the bibliography, you list your references by the numbers you have used and include as much information as you have about the reference. The list below gives what should be included for different sources.

    a. **Websites** – Author (if possible), title of the web page, website address, [date you accessed it, in square brackets].

    E.g. Dan Snow, 'How did so many soldiers survive the trenches?', http://www.bbc.co.uk/guides/z3kgjxs#zg2dtfr [11 July 2014].

    b. **Books** – Author, date published, title of book (in italics), pages where the information came from.

    E.g. S. Dubner and S. Levitt, (2006) *Freakonomics*, 7-9.

    c. **Articles** – Author, 'title of the article' (with quotation marks), *where the article comes from* (newspaper, journal etc.), date of the article.

    E.g. Maev Kennedy, 'The lights to go out across the UK to mark First World War's centenary', Guardian, 10 July 2014.

Notes

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