Researchers in Schools

The Ocean and the Ice Age

Key Stage 4 Programme

Pupil Name

Coursebook Designed by Dr P. Eardland

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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	11th March 2021	15:45	SMCS Rm 24
2	25th March 2021	15:45	SMCS Rm 24
3	22nd April 2021	15:45	SMCS Rm 24
4	29th April 2021	15:45	SMCS Rm 24
5	6th May 2021	15:45	SMCS Rm 24
6 (Feedback)	20th May 2021	15:45	SMCS Rm 24
7 (Feedback)	10th June 2021	15:45	SMCS Rm 24

Timetable – Homework Assignments

Homework Assignment	Description	Due Date
Tutorial 1	Baseline Assignment: How does the ocean's overturning circulation work?	18th March 2021
Tutorial 2	The Return Flow	22nd April 2021
Tutorial 3	Carbon dating the ocean	29th April 2021
Tutorial 4	Global warming in a water bottle	6th May 2021
Tutorial 5	Final Assignment – What caused the rise in CO2 at the end of the last Ice Age?	14th May 2021

Assignment Submission – Lateness and Plagiarism

Lateness	
Submission after midnight on 28th May	10 marks deducted
Plagiarism	
Some plagiarism	10 marks deducted
Moderate plagiarism	20 marks deducted
Extreme plagiarism	Automatic fail

Course Rationale

Climate change is one of the biggest threats we face as a species. Understanding future changes in our climate and oceans is key to how we prepare for what is to come. Our understanding relies on using climate models to make forecasts of future climate and weather. We also need to know what happened to the climate hundreds or thousands of years ago, so we can check if our climate models can capture real events.

The end of the last Ice Age happened around 11,000 years ago. The Earth warmed by several degrees and lost its huge ice sheets. It was the largest climate event in the last 130,000 years. However, measuring the climate thousands of years ago is a real challenge, because humans only began writing 5000 years ago, and did not often record the climate in detail.

In this course you will learn some of the key concepts of climate change, ocean circulation and radioactivity. We will then learn how, using fossilised corals and a simple ocean model, we can investigate the causes of global warming at the end of the last Ice Age. By the end of the course you will have a good understanding of the climate system, know how radioactivity is used to learn about Earth history, be able to use maths to build simple scientific models, and write scientific reports.

Uni Pathways Mark Scheme 2020 – Science-based Assignments

	Subject Knowledge	Critical Thinking	Written Communication
1st	The work shows a depth of knowledge and understanding of key concepts and scientific methods, through engaging with relevant sources. Knowledge is used to build and support highly effective scientific arguments and explanations.	Analyses key scientific evidence, arguments, and reasoning. Interprets meaning and makes connections. Identifies and critically evaluates key scientific arguments and evidence, deciding on their credibility, strength, and relative significance, drawing convincing conclusions.	The work has a coherent flow and is well structured. The writing style is appropriate; scientific language and key scientific terms are used accurately and effectively to support the arguments and explanations made. There are no, or very few, errors in spelling or grammar. Consistent referencing, appropriate paragraphing and use of correctly labelled tables and graphs matching the style taught in the course.
2:1	The work shows an understanding of key concepts and scientific methods, drawing on relevant sources. Knowledge is used to build and support effective scientific arguments and explanations.	Analyses relevant scientific evidence, arguments, and reasoning. Identifies and critically evaluates relevant scientific arguments and evidence, deciding on their credibility and strength, drawing reasonable conclusions. Shows some understanding of the relative value of evidence and arguments.	The work is well-structured. The writing style is appropriate; scientific language and key terms are used correctly. There are few errors in spelling or grammar. Mostly consistent referencing and use of tables and figures; matching the style taught in the course.
2:2	The work shows an understanding of key concepts and scientific methods, with no major misconceptions. Beginning to apply this knowledge to build and support effective scientific arguments and explanations.	Identifies and uses basic scientific evidence, arguments, and reasoning. Showing some understanding of the quality of scientific arguments and evidence. Not yet showing understanding of the relative value of evidence and arguments.	The work has some structure. The writing style can sometimes be informal; occasionally scientific language and key terms are not used when it would be appropriate to do so. There are some errors in grammar and spelling do not get in the way of communicating the content. Referencing has some consistency; matching the style taught in the course Limited use of tables and graphs.
3rd	Shows a developing understanding of key concepts and scientific methods, with some misconceptions. Does not yet apply this knowledge to build and support scientific arguments and explanations.	Beginning to analyse scientific evidence, arguments, and reasoning. Describes evidence 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. Scientific language, key terms and references are not always used correctly. Limited, or no use of tables and graphs.

Baseline Assignment (essay based): Pupil Feedback Report

Name of Pupil	
Name of School	
Name of RIS teacher	
Title of Assignment	

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	
Name of RIS teacher	
Title of Assignment	

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:

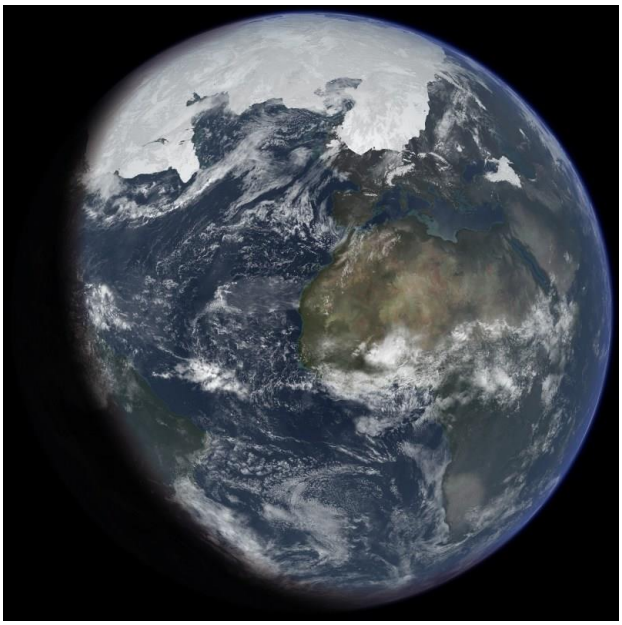
Mark Breakdown and Feedback

Subject knowledge	
	mark
Critical thinking	
	mark
Written communication	
	mark

Subject Vocabulary

Word	Definition	In a sentence
Biological Pump	The role that ocean life plays in carrying carbon from the atmosphere into the deep sea.	A stronger biological pump could solve our climate problems.
Glacial	In studies of past climate, 'glacial' refers to the times we know as the Ice Ages.	It was very cold in glacial times.
(Scientific) Model	A mathematical or written description of how we think something works.	My model of how gravity works turned out to be totally wrong!
Overturning circulation	A flow that includes water or gas moving up and down, not just from east to west or north to south.	The flow of water in a boiling pan is an example of overturning circulation.
Palaeo-	A prefix meaning old or ancient. Often used to talk about studying the ancient Earth (e.g. palaeontology, the study of fossils).	I am a palaeoceanographer, which means I study ancient oceans.
Primary Productivity	The growth of creatures that rely on sunlight to photosynthesise.	The amount of primary productivity is greatest where there are the most nutrients.
(Climate) Proxy	A proxy is an indirect measurement of some property such as temperature.	We measured the width of tree rings as a proxy for the temperature the tree experienced when it was alive.
Radiocarbon	The radioactive form of carbon, also called carbon-14 or 14C.	Radiocarbon dating shows that this Roman house was built around 2000 years ago.
Residence time	The average time that a substance/quantity stays in one place.	The residence time of customers in my shop is about ten minutes.
Steady state	A situation where the flow of a material or energy into a box is equal to the flow out of that box. The amount of material or energy in that box therefore remains the same.	The number of customers in a shop with a one-in, one-out system is in steady state; it is constant.

Tutorial 1 – Ice Ages and the Ocean



[1]

What is the Purpose of Tutorial 1?

By the end of the tutorial, I will be able to:

- Recognize the most important drivers of the ice ages and modern climate change.
- Summarise how the ocean overturning (thermohaline) circulation works.
- Illustrate the ice and ocean feedbacks that led to global warming during the deglaciation.

Starter

Read the following paragraph and then draw a diagram to illustrate the processes that are described:

Almost all the energy at the Earth's surface comes from the Sun in the form of **solar radiation**. All the energy in the food we eat, in the wind and the rain, comes from the Sun's light travelling through space. When light from the Sun reaches the Earth, two things happen. Some of the light is reflected back into space by bright surfaces, such as snow, ice and clouds. This effect is known as **albedo**. Darker surfaces, like leaves, earth, rocks and tarmac absorb the Sun's light instead, and warm up. These surfaces emit infra-red radiation (heat), that is trapped by **greenhouse gases**, warming the atmosphere. Without any greenhouse gases, the Earth would be a chilly -15 °C on average.

[1] Artist's impression of ice age Earth at glacial maximum. (By Wikipedia user Ittiz, CC BY-SA 3.0)

Activity 1

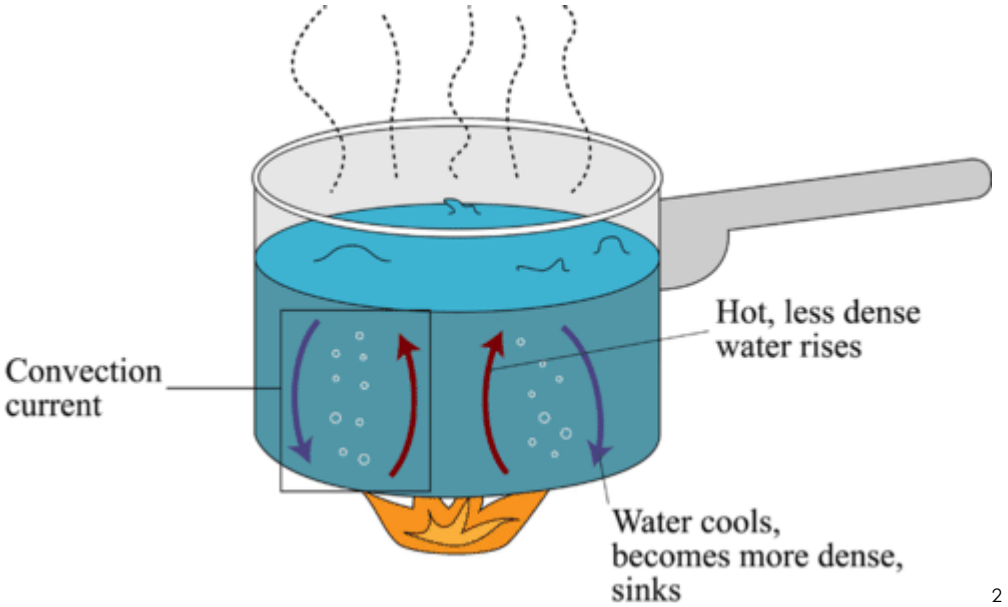
In pairs, discuss the three main causes of climate change on your post-it notes and put them in order of importance for a) today, and b) for the Ice Ages.

Solar radiation reaching the Earth
Change in Earth's albedo
Changes in greenhouse gas concentration

21st Century	Ice Ages
Most important	Most important
Least important	Least important

Activity 2

How is a pan of water on the hob similar to and different from the ocean? Write some bullet points below after discussing with a partner.



[2]

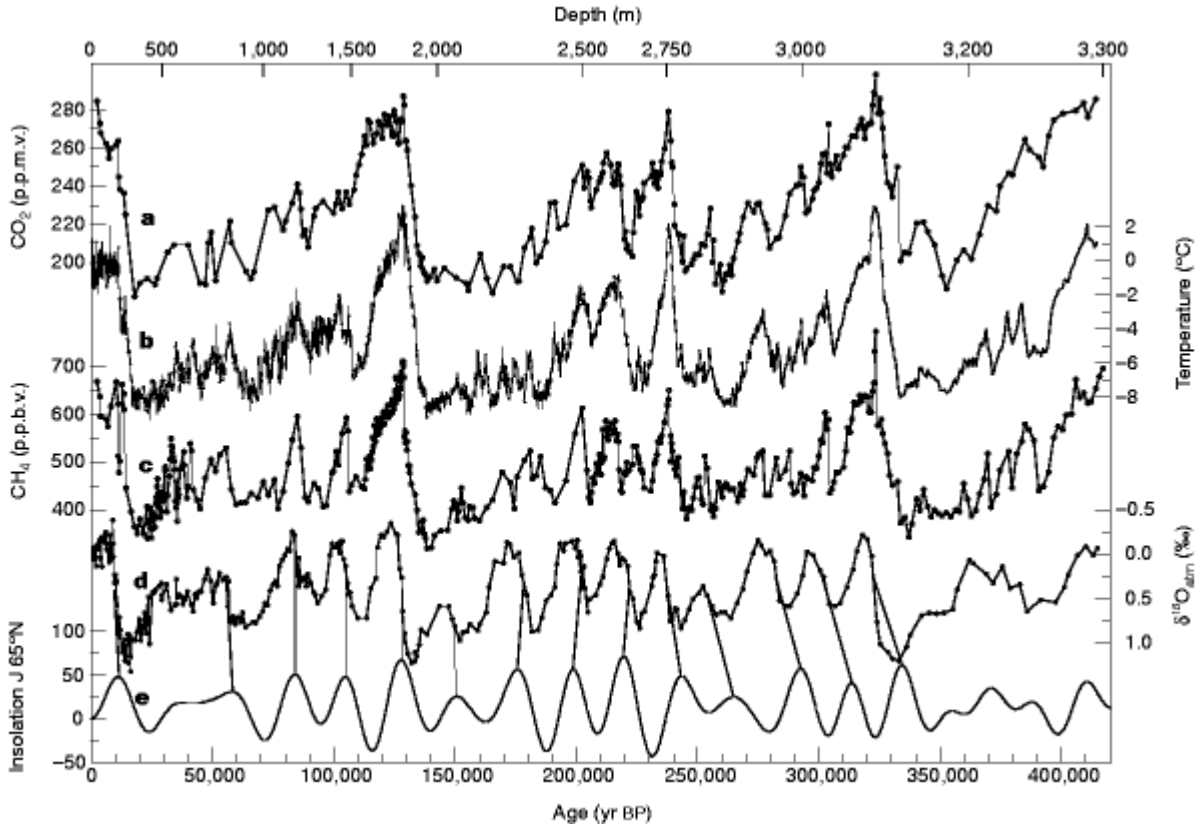
- In a pan, water is heated from…

Use the space below to draw a sketch of how convection works in the ocean.

[2] Zachary Wilson; Image copyright Jackie Smithson, 2014: CC BY-NC 3.0

Activity 3

Look at the graph of temperature and carbon dioxide concentration in the atmosphere. How are temperature and greenhouse gases related? Can you identify any repeating patterns? Highlight each pattern repeat and note how many years it lasted for.



[3]

Activity 4

On the A3 paper provided, sketch a picture or a series of pictures of the Earth, showing the processes that led to the last deglaciation.

[3] Petit et al., (1999), Nature **399,** pp 429–436

Baseline Assignment – How does the ocean's overturning circulation work?

Write a brief report of up to 500 words explaining the ocean's overturning circulation.

Organise your report into short paragraphs. Each paragraph should talk about one point. You can use tables, graphs or calculations to illustrate your points.

Your report should contain a short conclusion, summarising your answer to the question.

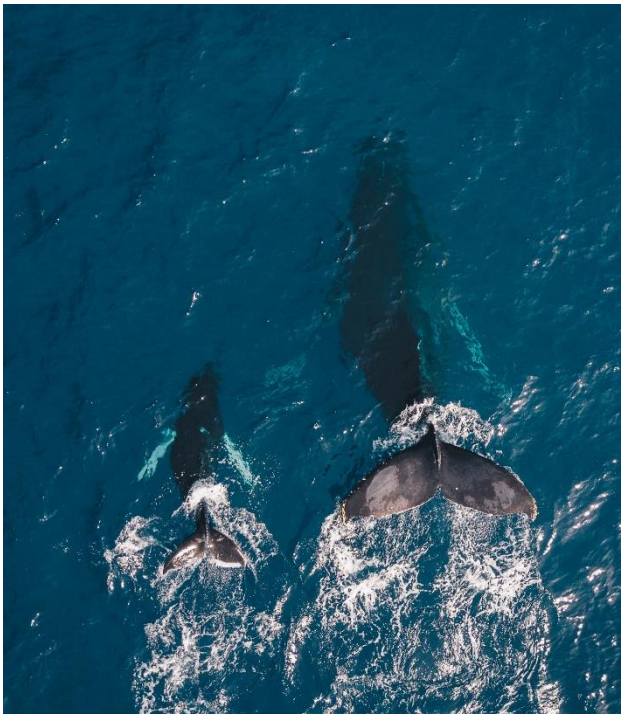
Key Points to include:

- What is the overturning circulation?
- Why is it important?
- A description of how the overturning circulation works.
- Some evidence for how we know the ocean works this way (scientific measurements and theories).

Success criteria:

- Your report answers the main question and addresses the key points above.
- Demonstrate a critical understanding of the science.
- Use technical vocabulary from the tutorial and workbook correctly.
- Use a variety of sources to support your points.
- Structure your report clearly and logically.
- Have a short introduction which introduces the main ideas of the report and a conclusion which summarises your answer to the title question.
- Use correct spelling, punctuation and grammar.
- Use correct scientific and mathematical notation, units and symbols.

Tutorial 2 – The Ocean Carbon Cycle



[4]

What is the Purpose of Tutorial 2?

By the end of the tutorial, I will be able to:

- Describe the role of marine life in storing carbon in the ocean.
- Construct a picture of how carbon is transported around the oceans.
- Outline the impacts of ocean acidification on marine organisms (e.g. corals).

Starter

Fill in the equations for photosynthesis and respiration on the next page. Use the following lists to help you:

Water	H_2O
Carbon dioxide	CO_2
Glucose	$C_6H_{12}O_6$
Oxygen	O_2

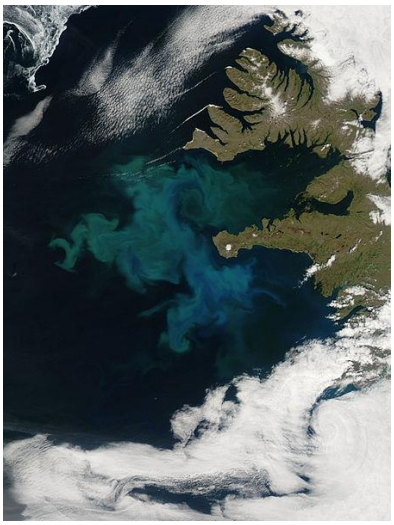
[4] Guille Pozzi, Unsplash, https://unsplash.com/license

Photosynthesis [5]	
Word Equation	Water + => Glucose +
Chemical Equation	
Respiration [6]	
Word Equation	Oxygen + => Water +
Chemical Equation	

Activity 1

In the ocean, microorganisms such as algae photosynthesise. What happens to these algae? Think about their whole life cycle. Use the picture below to help you.

What happens to marine algae?	• As they grow, algae… • When they die, the algae…



[7]

[5] Kumiko Shimizu, Unsplash, https://unsplash.com/license

[6] Del Barrett, Unsplash, https://unsplash.com/license

[7] Phytoplankton bloom, NASA Goddard Space Flight Centre, CC BY-NC 2.0

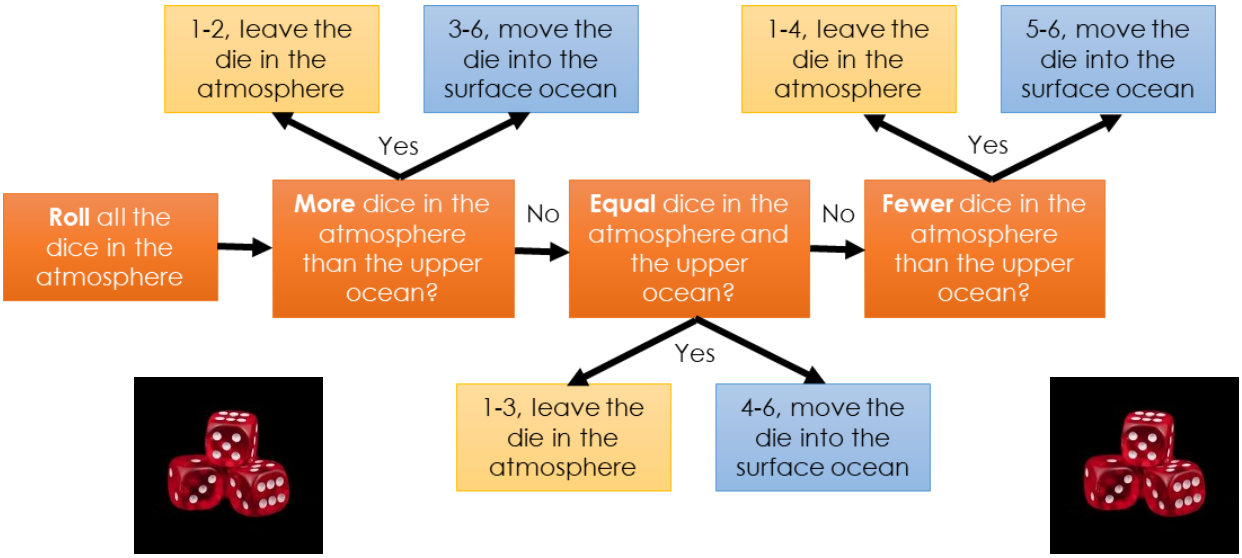
Activity 2

Take the different cut-outs from the pouch. Begin to assemble your picture by placing the volcano, algae, ocean sediment.

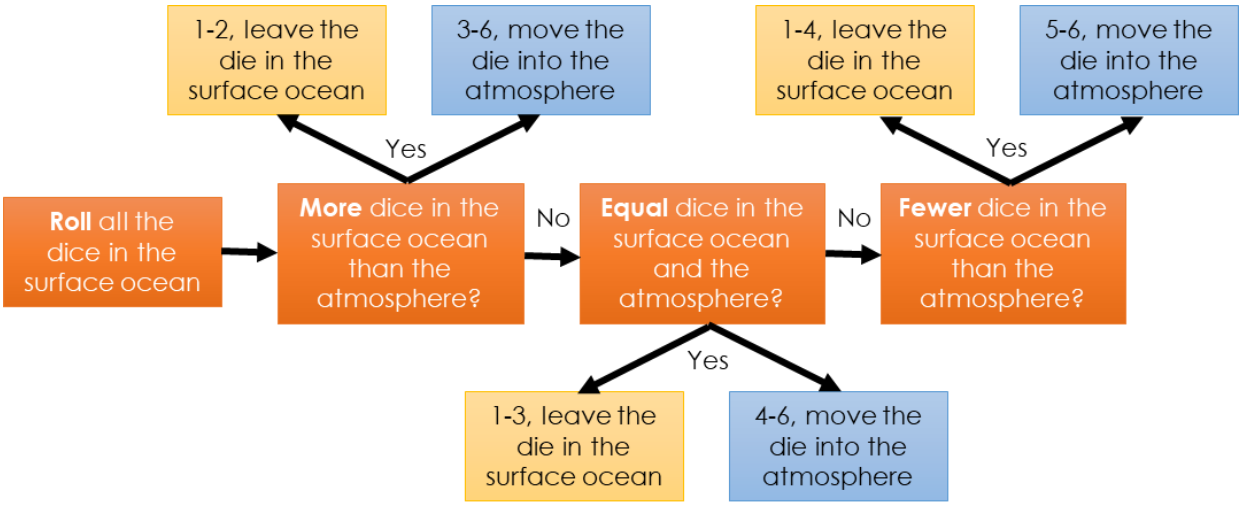
<u>Carbon Game instructions:</u>

Begin by placing 10 carbons in the atmosphere, 5 in the upper ocean and 5 in the deep ocean. Then, follow the steps below to see where carbon travels:

1)



2)



3) Roll a die for each carbon in the surface ocean. On a 5-6 it has been consumed by organisms and transferred to the deep ocean. Move the counter into the deep ocean.

4) Every 3 turns add a carbon to the atmosphere from the volcano.

5) Play for 6 turns.

Play the game through once and then write a reflection on the processes we have simulated. What is the inevitable conclusion of this model of the carbon cycle? What could we add to this model to make it more realistic? Be ready to share your ideas with the group.

Activity 3

Match the organism with the effect of ocean acidification:

Organism		Effect of Ocean Acidification
Stoney Coral (calcium carbonate skeleton)		May out compete other types of plankton as they will not be affected directly.
Radiolarian (silica skeleton)		A mixture of impacts. Some may benefit, some may not.
Crabs and lobsters		More carbon in the water may mean these organisms can photosynthesize and grow faster.
Shellfish (calcium carbonate shell)		Acidification is likely to have harmful impacts, but ocean warming is the more immediate threat.
Seaweed (Algae)		The ability of some of these organisms to navigate may be adversely affected.
Fish		Major fisheries of these organisms are likely to be negatively affected.

Homework – The return flow

Using what we have learned so far and your own research, write 250 words to describe how carbon in the deep ocean could be returned to the surface.

Key points to include:

- Ocean Mixing.
- Upwelling.
- Where in the ocean do these processes take place?

Then create a new rule for the carbon game that captures the process or processes that you have described.

Homework Success Criteria:

- Use technical vocabulary from the tutorial and workbook correctly.
- Use a variety of sources to support your points.
- Structure your report clearly and logically.
- Play-tested game rules that reflect ocean processes.

Tutorial 3 – Back to the Future

[8]

What is the Purpose of Tutorial 3?

By the end of the tutorial, I will be able to:

- List five key climate archives and five proxies that we can use to learn about past climates.
- Explain the use of carbon-14 dating in oceanography.
- Predict the 'age' of the deep ocean using our simple model of ocean carbon.
- Discuss what it is like to be an oceanographer.

Starter

List some key instruments that we can use to measure weather and climate:

Instrument	What it measures

[8] NOAA, Unsplash, https://unsplash.com/license

Activity 1

Identify the climate archive in each picture. Write down some ideas about how each one might record information about the climate/oceans:

Archive	Proxies	Age determination
[9]	Layer thickness to determine snowfall Trapped gas bubbles contain composition of ancient atmosphere.	Layer counting to determine age
[10]		
[11]		
[12]		

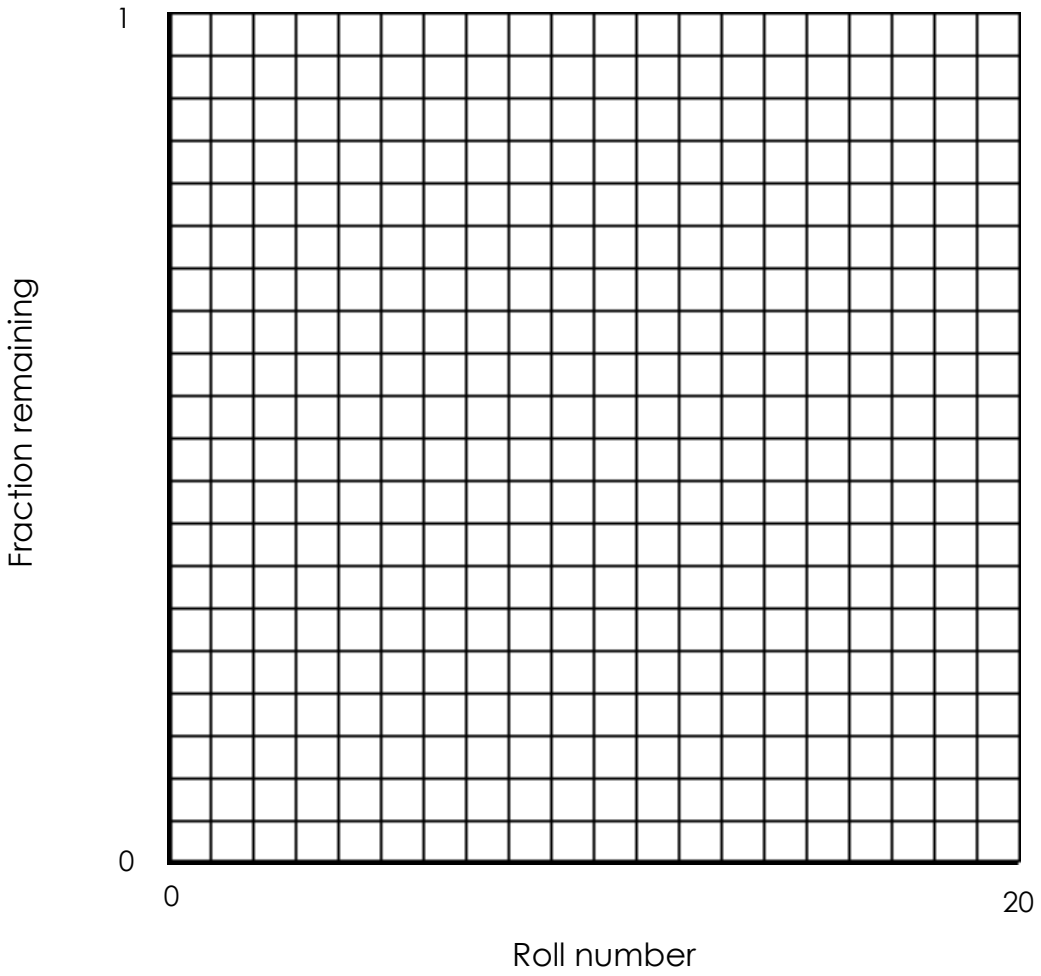
[9] Ice core, Eli Duke, CC BY-SA 2.0
[10] Tree Rings, Arnoldius, Wikipedia user, CC-by-sa-2.5
[11] Sediment core, Wikipedia user Blastcube, CC BY-SA 3.0
[12] Public domain

Activity 2

In this exercise, we will use dice again to simulate how a radiocarbon decays over time. We will carry out periodic measurements of our dice to work out the $^{14}C/^{12}C$ ratio.

Start with 200 dice. Each die represents one ^{14}C atom that has been trapped inside a sample. Roll the dice 20 times. Each time you roll the dice represents about 1400 years. Each time you roll, remove any sixes and count up the remaining number. Record this number as a fraction of the starting number: so, if you had 10 dice left your fraction would be 10/30 = 0.3333. Use the table below to help you. Then draw a graph of your results with a line of best fit.

Turn number	Number of dice left after rolling and removing 6s	Fraction of original number (30)
0	200	200/200 = 1
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		



Use the box below to write a few sentences about how radiocarbon measurement can determine the age of a sample.

Activity 3

Carbon dating in the ocean is more complicated, because of what happens to the water.

Find your model from Tutorial 2. You will now be given cut-outs of small 'parcels' of water and tokens to represent radiocarbon. The only place the water parcels can get radiocarbon is at the ocean surface.

Move the water parcels around your model following the flow pattern that we discovered in Tutorial 1. Thinking back to the radioactivity game we have just finished, what will happen to the radiocarbon in each water parcel? Discuss as a group and write down your thoughts below.

Homework – Carbon dating the Ocean

Write 350 words about using carbon dating on ocean materials.

Key points to include:

- What is the problem with using radiocarbon dating on a coral or other ocean sample?
- What other methods could we use to date corals?
- How could we use this information with the radiocarbon data to find the 'age' of the ocean?
- What can using carbon dating on corals and sediments tell us about ocean circulation?

Success Criteria:

- Use technical vocabulary from the tutorial and workbook correctly.
- Use a variety of sources to support your points.
- Structure your report clearly and logically.
- Play-tested game rules that reflect ocean processes.

Tutorial 4 – Models

[13]

What is the Purpose of Tutorial 4?

By the end of the tutorial, I will be able to:

- Describe the use of box models in Earth Sciences.
- Understand the concept of equilibrium and its relation to the climate system.
- Construct a simple box model of the ocean containing two different flows of carbon.

Starter

How do weather forecasters predict the weather?

Read the following piece of information about weather forecasts and fill in the blanks below:

Weather forecasts are made by supercomputers that run highly advanced computer **models** of the atmosphere. In a weather model, the Earth is broken down into small **boxes**. Scientific **equations** tell us how heat, air and moisture move from one box to another. To get the model started, we need to make **observations** of the weather at as many locations as possible. The model then takes these observations and puts them into the equations to predict what will happen in the future. However, even a small mistake or gap in our observations can cause the equations to predict the wrong weather! This idea is called 'chaos theory'.

Accurate weather forecasting relies on having a lot of precise_____from around the world. Data is then fed into _____ run by supercomputers. In each model the Atmosphere is broken down into small_____, so that _____ can be used to predict what the weather will do next.

[13] Grianghraf, Unsplash, https://unsplash.com/license

Activity 1 – Equilibrium in a box (bottle)

Take your pre-prepared plastic bottle, which has been modified to have a leaky bottom! Try and fill the bottle from a tap, starting with a slow water flow.

What do you notice about the level in the water in the bottle?

What happens if you increase the tap flow to a higher setting?

Write your notes in the space below.

[14]

Activity 2 – A Mathematical Model

As scientists, our job is to take a real-life phenomenon, and to try to describe the processes that are occurring using maths or scientific writing. We can think about our bottle example in this way.

First think about the words 'Steady State', which mean that there is no change in the system we are observing. We could also say the system is in 'Equilibrium'. When do these words apply to the water in the bottle? Discuss in groups of three and write your answer below.

At steady state, what must be true about the flow of water into and out of the bottle? Discuss in pairs and write down an equation that shows this relationship:

We don't only want to know about the flows into and out of the bottle. We also might want to be able to predict what level the water will reach for a given tap flow. Fill in the following sentence. Use the words 'does not change' and 'increases'.

[14] Nappadon Manadee, Unsplash, https://unsplash.com/license

The flow of water out of the bottle_____as the amount of water in the bottle increases. The amount of water coming from the tap_____ as the amount of water in the bottle increases.

Because the amount of water flowing out depends on the amount in the bottle, we can write down an equation that links these two things. For example, I could write:

Amount flowing out = M x Amount in bottle

In this equation, M is a number that tells us how the amount flowing into the bottle and in the bottle are related. If M is huge, the amount flowing out will be very big. If M is small, the amount flowing out would be very small. We could measure the value of M by doing experiments, but for now we don't need to.

Your next task is to look at the two equations we have made, and write down a new equation that links the amount of water coming in with the amount of water in the bottle. With this equation, we could control our tap flow and predict how much water will be in the bottle.

Activity 4 – A box model for the ocean

Now we are going to make our own model of the ocean. But wait! We have already started doing this. Go back and find your ocean picture from Tutorial 1 and 2. This is your box model. Redraw this model in a simplified way below. You should have two boxes: one for the upper ocean and one for the deep ocean.

If the upper ocean and deep ocean are in steady state, we can work out some equations that tell us how carbon is transported between the two. Fill in the blanks below:

Flows in and out of the upper ocean:

$$C_d \times F = C_{up} \times F + _____$$

Flows in and out of the deep ocean:

$$C_{up} \times F + _____ = C_d \times F$$

Homework – Global warming in a water bottle

Write 250 words outlining how we could alter our water bottle experiment to represent global warming. Think of the water from the tap as energy from the Sun.

Key Points to Include:

- Should we change the amount of water coming from the tap?
- What could we do to simulate greenhouse gases?
- What could we do to simulate albedo?

Write a description of your choices and their effect when you try them at home.

Success Criteria:

- Present your ideas clearly, using diagrams where appropriate.
- Show critical understanding of how the bottle is an analogy for heat in our atmosphere.
- Show an ability to adapt the analogy to include more aspects of the climate system.

Tutorial 5 – Simulating the end of the Ice Age

[15]

What is the Purpose of Tutorial 5?

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

- Use the simple box model to evaluate the impacts of biology and circulation on ocean carbon.
- Assess the effectiveness of the model at simulating ocean carbon.
- Criticise specific elements of the model, and suggest improvements.

Starter

Look back at the equations you filled in at the end of the last tutorial. Use the first equation to write down what you think will happen if we:

1) Increase the biological pump strength.
2) Increase the amount of ocean overturning.

[15] Wolf Schram, Unsplash, https://unsplash.com/license

Activity 1 – Computer Exercise

Using the Excel template that I have provided, try some different numbers for the size of the biological pump.

What happens to atmospheric CO_2 when the pump is increased and decreased? Can you explain the answer?

What happens to atmospheric CO_2 when ocean overturning is increased and decreased? Can you explain the answer?

Activity 2

Add enough data to your model so that the two graphs have ten data points each. You will use these graphs in your final assignment.

Activity 3

In pairs, discuss how you could improve the model if you had more time. What would you need to know in order to do so? Write some notes below:

Final Assignment – What caused the rise in CO_2 at the end of the last Ice Age?

As you have learnt, the end of the last Ice Age was originally caused by a change in the solar radiation reaching the Earth, but most of the global warming was caused by an increase in carbon dioxide levels in the atmosphere.

Your task is to write a 2000-word essay assessing the cause of this rise in carbon dioxide. Compare and contrast the importance of the biological pump and ocean circulation. Using the ocean box model data set that we have created, as well as evidence from deep-sea corals and other scientific sources to inform your answer.

Key points to include:

- A brief introduction to the last deglaciation.
- Ocean overturning circulation and its impact on atmospheric greenhouse gases.
- The biological pump and its effect on greenhouse gases.
- Measuring the age of the ocean using corals and radiocarbon.
- The design of your box model.
- Use the box model data set to show how changing the biological pump and ocean circulation affected atmospheric carbon dioxide concentrations. Use graphs to show your results. Compare your findings with real data provided in the tutorials to decide which explanation is the most likely to explain the observations.
- Critically assess the box model. Is anything is missing? How could it be improved?
- Can you think of anything else that might have caused carbon dioxide levels to change?
- Make sure you reference your sources of information (see the referencing guide).

Success criteria:

- Your report answers the main question and addresses the key points above.
- Demonstrate a critical understanding of the science.
- Use technical vocabulary from the tutorial and workbook correctly.
- Use a variety of sources to support your points.
- Structure your report clearly and logically.
- Have a short introduction which introduces the main ideas of the report and a conclusion which summarises your answer to the title question.
- Use correct spelling, punctuation and grammar.
- Use correct scientific and mathematical notation, units and symbols.

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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